LANDSCAPE 2021

DIVERSITY FOR SUSTAINABLE AND RESILIENT AGRICULTURE

BOOK OF ABSTRACTS

Online conference | 20–22 September 2021

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Welcome to Landscape 2021 – Diversity for Sustainable and Resilient Agriculture

Sustainable and resilient agriculture means integrating multiple goals of high productivity with minimal use of external resources, stable provisioning of ecosystem services and protection of biodiversity. Solutions need to be context-specific and adaptable to climate change as well as market volatilities and shocks. They must support rural communities, offer robust economic opportunities and enable recreational spaces. The solutions are as diverse as the landscapes for which they need to be developed. While specialization and simplification of agricultural production systems and landscapes have led to enormous productivity increases in recent decades, the environmental and social costs have become inacceptable. Smart diversification may help to minimize such adverse impacts and create more synergies instead.

Landscape 2021 brings together international scientists from the needed diversity of scientific disciplines to explore whether and how diversity and diversification can contribute to a more sustainable and resilient agriculture. The conference addresses research to the diversification of agricultural systems across organisational levels and spatio-temporal scales:

- Cropping and grassland systems
- Farming systems
- Landscape management systems
- Public and private governance systems
- Food systems
- Cross-scale systems

The overarching hypothesis is that the synergies and challenging trade-offs among social and environmental objectives become most tangible at the landscape or territorial level.

The Landscape 2021 Conference assembles 390 delegates from 42 countries. Contributions include two keynotes, 175 oral and 85 poster presentations in 38 sessions. 11 masterclasses enable further in-depth discussion and mutual learning. A roundtable discussion with participants from three continents representing agricultural practice, policy and science will debate about challenges and opportunities related to the implementation of diversification in practice. A special marketplace is dedicated to presentations of research products and tools for utilization in practice and policy.

We are looking forward to exiting scientific insights, ideas, critical thoughts and stimulating discussion. We would like to thank the Scientific Committee for the extraordinary support in the conference preparation. This group of 20 internationally renowned scientists was engaged in the selection of sessions and masterclasses and helped to ensure the scientific quality, thematic wealth and international balance of the conference program.

The Landscape 2021 conference is a follow-up of the 2018 conference “Frontiers of Agricultural Landscape Research” with the intention to establish a regular conference series for the international agricultural landscape research community. We are excited about strengthening the joint research community in support of a sustainable transformation of agricultural landscapes across the globe.

Frank Ewert (ZALF) and Peter H. Feindt (Humboldt-Universität zu Berlin); **Conference Chairs**

Katharina Helming, Viola Kranich, Sibylle Krickel, Bettina Matzdorf, Klaus Müller, Moritz Reckling, Heike Schobert, Heidi Webber, Sabrina Weinert, Elena Vinco (ZALF); **Local Organising Committee**

TABLE OF CONTENTS

TABLE OF CONTENTS

TABLE OF CONTENTS

TABLE OF CONTENTS

TABLE OF CONTENTS

TABLE OF CONTENTS

TABLE OF CONTENTS

TABLE OF CONTENTS

TABLE OF CONTENTS

TABLE OF CONTENTS

TABLE OF CONTENTS

TABLE OF CONTENTS

TABLE OF CONTENTS

TABLE OF CONTENTS

TABLE OF CONTENTS

TABLE OF CONTENTS

TABLE OF CONTENTS

TABLE OF CONTENTS

SESSION 6: CROSS SCALE SYSTEMS

6.1 Digital tools for site specific and diversified field arrangements to increase ecosystem services and biodiversity

Orals

6.1 Digital tools for site specific and diversified field arrangements to increase ecosystem services and biodiversity

Poster

TABLE OF CONTENTS

TABLE OF CONTENTS

TABLE OF CONTENTS

TABLE OF CONTENTS

MASTERCLASSES

TABLE OF CONTENTS

MARKETPLACE

POST-CONFERENCE WORKSHOPS

Sustainability and resilience of Europe's diverse farming systems

Miranda Meuwissen

Business Economics, Wageningen University & Research – WUR, The Netherlands

Abstract

Farming systems in Europe face accumulating economic, environmental, institutional, and social challenges. Examples include the impact of extreme weather events, reduced access to markets and value chains (e.g. due to trade wars, political boycotts or Brexit), less stable and less protective policy environments, increasing controversies about agricultural mainstream practices, and more recently the interruptions caused by the COVID-19 pandemic. These uncertainties exacerbate demographic issues such as a lack of successors to enable generational renewal at farm level, and insufficient availability of qualified seasonal and permanent labour. The compounding challenges raise concerns about the resilience of Europe's farming systems.

The SURE-Farm approach is a systematic approach to assess the resilience of farming systems. The approach consists of the SURE-Farm framework and the systematic consideration of regional contexts, the collaboration of multiple disciplines and the deployment of mixed methods. The SURE-Farm resilience framework builds on the social-ecological tradition of resilience thinking and defines the resilience of a farming system as its ability to ensure the provision of its desired functions in the face of often complex and accumulating economic, social, environmental and institutional shocks and stresses, through capacities of robustness, adaptability and transformability. Guiding questions in the SURE-Farm approach are: (1) characterization of the farming system – resilience of what? (2) identification of challenges – resilience to what? (3) analysis of system functions – resilience for what purpose? (4) evaluation of system responses – what resilience capacities? and (5) examination of resilience attributes – what enhances resilience? The SURE-Farm approach was applied to eleven farming systems which represent different challenges, farm types, agro-ecological zones, produce and affected public goods.

The presentation zooms in on the farm economic perspective. A liveable income for farmers and farm workers is one of resilience attributes. For instance, if there is sufficient income, farmers have room to experiment with production practices which are possibly less harmful for the environment. Analyses using the Farm Accountancy Data Network (FADN) panel dataset show that about 75% of the European farms was short-term viable. However, less than half of the farms was long-term viable. Qualitative SURE-Farm methods confirm that relatively low profitability was perceived as challenging in the majority of regions. Subsidies from the Common Agricultural Policy (CAP) were found to have mixed impacts. For instance, findings show that direct payments decreased the probability of being long-term viable in almost all countries. Also, they constrained farm robustness as measured by the recovery rate, number of shocks and speed of recovery of farm income. On the other hand, we found that rural development payments enhanced farm robustness. In most European regions, subsidies did not affect adaptation and transformation of farms.

If current subsidies are not the answer to the needed transformation of farming systems, then what can be done to enhance the sustainability and resilience of Europe's diverse farming systems? The presentation ends with recommendations for policy makers and farming system actors. They are not quick fixes.

Selected refences:

EuroChoices (2020). Towards more resilient agricultural systems in Europe, Vol 19(2), 76 p. https://doi.org/10.1111/1746-692X.12226

Meuwissen, M. P. M., Feindt, P. H., … and Reidsma, P. (2019). A framework to assess the resilience of farming systems. Agricultural Systems 176, 102656. https://doi.org/10.1016/j.agsy.2019.102656

Paas, W., Coopmans, I., Severini, S., Van Ittersum, M. K., Meuwissen, M. P. M. and Reidsma, P. (2021). Participatory assessment of sustainability and resilience of three specialized farming systems. Ecology and Society 26 (2):2. [online] URL: www.ecologyandsociety.org/vol26/iss2/art2

Slijper, H. T., de Mey, Y., Poortvliet, M. P., Meuwissen, M. P. M. (2021). Quantifying the resilience of European farms using FADN. Manuscript in preparation.

Short Biography

Miranda Meuwissen is professor of risk management in food supply chains at the Business Economics group of Wageningen University, the Netherlands. She is a senior scientist of Wageningen Graduate School of Social Sciences and organises the Summer School 'Risk analysis and risk management in agriculture: updates on modelling and applications'. She coordinates the H2020 SURE-Farm project on resilience of EU farming systems.

Designing Agricultural Landscapes for Biodiversity and Ecosystem Services

Dourglas A. Landis

Michigan State University, United States of America

Abstract

Sustainable and resilient agricultural systems are needed to feed and fuel a growing human population. However, the current model of agricultural intensification which produces high yields has also resulted in a loss of biodiversity, ecological function, and critical ecosystem services in agricultural landscapes. A key consequence of agricultural intensification is landscape simplification, where once heterogeneous landscapes contain increasingly fewer crop and non-crop habitats. Landscape simplification exacerbates biodiversity losses which leads to reductions in ecosystem services on which agriculture depends. In recent decades, considerable research has focused on mitigating these negative impacts, primarily via management of habitats to promote biodiversity and enhance services at the local scale. While it is well known that local and landscape factors interact, modifying overall landscape structure is seldom considered due to logistical constraints. I propose that the loss of ecosystem services due to landscape simplification can only be addressed by a concerted effort to fundamentally redesign agricultural landscapes. Designing agricultural landscapes will require that scientists work with stakeholders to determine the mix of desired ecosystem services, evaluate current landscape structure, and implement targeted modifications to achieve desired goals.

Short Biography

Douglas A. Landis is a University Distinguished Professor of Insect Ecology in the Department of Entomology at Michigan State University. His research focuses on the role of landscape structure in shaping insect and plant interactions in agricultural landscapes and the implications for pest suppression and pollination services. He is the author of 168 peer-reviewed journal articles, 25 book chapters and 58 Extension bulletins.

SESSION 1
CROPPING AND GRASSLAND SYSTEMS

SESSION 1:
CROPPING AND GRASSLAND SYSTEMS

1.1 Climate-resilient agriculture: is multi-scale diversification and land use extensification the key?

Convenors:

Sarah Redlich, Julius-Maximilians-Universität Würzburg (JMU), Germany

Maria Hänsel, University of Bayreuth, Germany

In many parts of the world, high yield outputs through landscape simplification and intensified agriculture has come at environmental and societal costs. Previous research has shown that associated species decline threatens ecosystem functions that farmers rely on, such as nutrient cycling, crop pollination and the regulation of agricultural pests. But the loss of biodiversity and ecosystem services may also lower the resilience of farming systems against climate change. For instance, genetically narrow monocultures and species-poor pollinator communities may be unable to adapt to extreme weather events, respectively causing yield instability and pollination deficits. Invasive pest species favoured by climate warming may not meet their match within depauperate native natural enemy communities, requiring increased pesticide application rates to cope with the sudden pest pressure. In this session we pursue the question whether genetic, crop and habitat diversification and land use extensification at farm, landscape and regional scale can result in climate-resilient and sustainable agriculture. We aim to understand how climate, land use and multilevel diversificati on interactively shape farmland biodiversity, ecosystem services and yields. As linking these drivers has rarely been done, our session offers the opportunity to present novel research findings that help to develop strategies for climate change mitigation and regional adaptation of farming systems.

Orals

Agricultural Intensification and Climate Change are Rapidly Decreasing Insect Biodiversity

David Wagner[1]; Peter Raven[2]

[1] University of Connecticut, United States of America; [2] Missouri Botanical Garden, United States of America

Insect declines are being reported worldwide with most reports coming from western and northern Europe, where the insect fauna is well-studied and there are decades of demographic data for many insect lineages. More recent reports have come from North America and the Neotropics. I will review common geographic and temporal patterns of losses, the rates of reported declines, and discuss what these could mean for agriculture, ecosystem services, and ecosystem function. Principal anthropogenic stressors responsible for insect decline include deforestation and grassland conversion, agricultural intensification (including pesticide use), global nitrification, climate change, and still others. To mitigate the effects of the Sixth Mass Extinction event that we have caused and are experiencing now, the following will be necessary: arrive at a stable (and almost certainly lower) human population, embrace sustainable levels of consumption, and promote social justice that empowers the less wealthy nations of the world, where the vast majority of us live.

Positive effects of different semi-natural habitats in agricultural landscapes to support wild bee diversity and compensate negative effects of pesticide use

Justine Rivers-Moore; Emilie Andrieu; Aude Vialatte; Carrié Romain; Ladet Sylvie; Annie Ouin

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Keywords: Landscape composition, Wooded habitats, Wild-bees, Functional diversity, Pesticides

Wild bees are the most important pollinators and their decline in diversity and abundance is reported worldwide. The use of pesticides and the lack of resources caused by the simplification of landscapes are often cited as the main drivers of this dramatic loss of essential auxiliary species. Few studies have yet simultaneously investigated local and landscape effects on wild bees and pollination in agricultural landscapes. In this study, we test the following hypotheses: (i) the complexity of the landscape and the presence of wooded semi-natural habitats like hedgerows or woods around the crop counterbalance the negative effect of pesticide use on the diversity of wild bees, (ii) landscape composition and farming practices also influence functional diversity and composition of bee communities, and (iii) bee taxonomic and functional diversity have a positive impact on pollination potential in agricultural landscapes.

Our study took place in south-western France, in the LTSER « Vallées et Côteaux de Gascogne », a region characterized by a mosaic of small woodlands, permanent grasslands and crop fields. To test the hypotheses, we investigated a data set of 104 cultivated plots (cereals and sunflower) on the edge of which wild bees were captured once in Spring, using pan traps, between 2013 and 2019. Botanical surveys were carried out in each plot (weeds), and phytosanitary treatments on the crop were listed over the year. At the landscape level, the proportions of different types of land use were calculated in two radii of 500m and 1374m, including different types of crops and semi-natural elements such as hedgerows, woods and permanent grasslands. Finally, the pollination potential at the field level was measured at the edge of the crop using phytometers. We built generalized linear mixed-effect models (GLMM) to test the impacts of landscape and local variables and their interactions on wild bee diversity at specific and functional levels. We also used RLQ analysis to assess the link between the environmental descriptors (landscape composition and farming practices in the crop) and wild bee traits.

We caught 1508 wild-bees of 86 different species during six years of sampling. We found that the presence of woods in a 500m-radius had a positive impact on wild bee abundance and species richness. Moreover, permanent grassland proportion compensated for the negative effect of the number of phytosanitary treatments in the crop on taxonomic and functional diversity of bees. Oligolectic and small bee species were favoured in heterogeneous landscapes with more semi-natural habitats, and were absent or underrepresented in landscapes dominated by crops and when local farming practices were more intensive. None of our studied variables had any effect on pollination potential. This study may help to better understand how diverse habitats in agricultural landscapes complement each other to increase wild bee diversity and mitigate the detrimental consequences of agricultural activities.

Earlier flowering of winter oilseed rape mitigates higher pest pressure in warmer climates

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Keywords: Climate warming, land use, oilseed rape, pest control

Background: Global change challenges plants and insects at their current locations [1], yet consequences for the cultivation of important crops, such as oilseed rape, have not been fully elucidated. Climate projections predict increases of oilseed rape pest infestation periods and pathogen incidence, while anthropogenic land use change causes loss of semi-natural habitats, which may reduce biological control in oilseed rape [2]. However, reports on land use effects on oilseed rape pests and biological control are partly contradictory [3] and a systematic assessment in different climates is missing. This study aims to elucidate consequences of climatic variation for pest densities and biological control in winter oilseed rape and to identify landscape characteristics promoting pest reduction in different climates.

Methods: Twenty-seven winter oilseed rape (OSR) fields were investigated along climate gradients across Bavaria (range of multiannual average temperatures: 7–10°C). At full flowering, plants were sampled and pest abundance, parasitism and plant damage were assessed. Close to crop ripeness, plants were sampled and dried for yield assessment. Landscape parameters (proportion of oilseed rape, forest and grassland) were calculated based on detailed land use data.

Results: Preliminary results indicate differences in pest regulation among climates zones. First results show earlier flowering, higher pollen beetle abundance and damage, as well as higher incidence of phoma leaf lesions of OSR in warmer compared with cooler climates. Pollen beetle parasitism and stem weevil abundance and damage were similar across the observed climate gradient. However, crop yields were not reduced under warmer climate. Earlier flowering went along with higher plant yield despite higher pollen beetle damage indicating non-linear responses to flowering phenology. No mitigating effects of landscape composition on climate-dependent increases in pest abundance and damage were identified. Surrounding landscape composition (300m–2000m) did not affect pest abundances nor biological pest control in winter oilseed rape.

Conclusion: Pest pressure of pollen beetles was higher in warmer than cooler climates. Interestingly, early flowering OSR plants in warm climates yielded higher in those climate zones despite higher pollen beetle damage, suggesting overcompensation through compensatory growth or reduced damage by pollen beetles due to already opened flowers. Farmland management and breeding efforts promoting earlier flowering and regrowth capability may contribute to more sustainable OSR production, but possible trade-offs with climate-change driven increased risk of late frost damage needs to be taken into account.

References:

[1] Halsch, C. A., Shapiro, A. M., Fordyce, J. A. et al. (2021). Insects and recent climate change. Proc Natl Acad Sci USA 118:e2002543117. https://doi.org/10.1073/pnas.2002543117

[2] Rusch, A., Valantin-Morison, M., Sarthou, J.-P., Roger-Estrade, J. (2011). Multi-scale effects of landscape complexity and crop management on pollen beetle parasitism rate. Landsc Ecol 26:473–486. https://doi.org/10.1007/s10980-011-9573-7

[3] Skellern, M. P., Cook, S. M. (2018). Prospects for improved off-crop habitat management for pollen beetle control in oilseed rape. Arthropod Plant Interact 12:849–866. https://doi.org/10.1007/s11829-018-9598-9

Cultivating crop diversity across agricultural landscapes in the United States

Kaitlyn Spangler[1]; Emily Burchfield[2]; Claudia Radel[1]

[1] Utah State University, United States of America; [2] Emory University, United States of America

While United States (US) agricultural production has exponentially increased, this productivity has come at the cost of ecological health and has widened long-standing social injustices. The need for more sustainable and just agriculture has become urgent, whereby enhancing crop diversity is a crucial step. On-farm crop diversification encompasses both temporal and spatial diversity and has been shown to support wide-ranging benefits, such as improved pest management and soil health, increased crop yields and pollinator diversity, and support for alternative seed networks and often undervalued knowledges. However, there is a critical research gap in understanding the processes of crop diversification beyond the field scale and across agricultural landscapes, as well as identifying what constitutes and influences the management of these landscapes. This paper assesses the barriers and bridges to how and why US agricultural landscapes do or do not become diverse through a multiscale approach. First, we estimated a series of random forest regression models for nine distinct regions in the US to identify factors that are associated with agricultural diversity and how these factors vary across regions. We used a novel panel dataset constructed from several open-source databases for all counties in the coterminous US for the most recently available Census years (2012 and 2017). Predictor variables included six themes: 1) farm(er) characteristics, 2) farm inputs, 3) land use, 4) assistance and income, 5) soil characteristics, 6) climate. Response variables measured agricultural land use diversity through three metrics, computed using only the agricultural land pixels from USDA NASS Cropland Data Layer and aggregated for each county. We then compared variable importance for response variable categories to illustrate broader lock-ins within which farmers operate and make land management decisions. Second, we conducted in-depth, semi-structured interviews with 15 conventional and organic farmers and 13 key informants in southern Idaho's "Magic Valley" – a diverse and productive cluster of eight agriculturally-dominant counties. Through these interviews, we identified 1) how and why farmers enact temporal and/or spatial strategies to maintain crop diversity, and 2) barriers and bridges to alternative diversification strategies. We employed open and closed coding to assess emergent trends across farmers' lived experiences and linked these trends to the findings from the regional models. Through both approaches, we found that farm inputs, land use characteristics, and climate were the strongest predictors of agricultural diversity overall. However, the importance of these factors varied widely across regions, representing spatially explicit dynamics that both promote and inhibit diversification. Further, farmers face a suite of localized and structural constraints to managing current crop diversity, as well as envisioning and enacting alternative diversification strategies. In particular, the need to balance on-farm demands (e.g., labor) with sociopolitical pressures and cultural norms (e.g., market prices and commodity contracts) limits farmers' ability to explicitly manage for diversity within and beyond their field boundaries. Ultimately, this study contextualizes qualitative inquiry within large-scale, geospatial data trends to advance our understanding of how to enhance crop diversity within current agricultural landscapes and, eventually, a more sustainable US agri-food system.

Increasing the Resilience in Swiss Agriculture using Agroforestry Systems

Sonja Kay; Felix Herzog

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Producing food and feed while protecting the environment and increasing climate-resilience – is that possible? – Yes, and agroforestry is one option, combining agriculture and woody elements on the same land. Adding trees to agricultural land reduces temperature and water evaporation while improving micro-climatic conditions and soil water holding capacity. In addition, agroforestry can mitigate carbon emissions whilst at the same time reducing the negative effects of climate change on crops and agriculture. These systems harness agricultural ecosystem services and reduce environmental impacts (e.g. nutrient and soil losses).

The Swiss agricultural policy has set itself ambitious goals: reduction of the environmental impact, higher added value through stronger market orientation and an increase in operational efficiency. However, like many places in Europe, Switzerland has not managed to abate environmental pollution from agricultural activities (nitrate surplus, loss of biodiversity, etc.) to the desired levels. Against this background we (1) identified areas affected by environmental deficits in Swiss farmland; (2) propose agroforestry systems which can contribute to improving these negative environmental impacts, and (3) estimate the potential of agroforestry systems to capture carbon and mitigate climate change.

Our results are based on eleven national deficit maps for the environmental sectors of biodiversity, landscape, climate, air, water and soil. All indicators were spatially aggregated into a heatmap of farmland environmental deficits, according to which three or more deficits occur simultaneously on 13.3% of the farmland. Due to their diverse design and application possibilities, agroforestry systems offer a high solution potential in arable farming, animal husbandry as well as in specialized crops such as fruit and wine growing. They can be established as rows of trees in arable fields, short rotation trees or shade/fodder trees for animals. Converting these 13.3% of farmland into agroforestry systems could offset up to 13% of the agricultural sector‘s greenhouse-gas emissions while simultaneously enhancing climate resilience and environment.

We conclude that agroforestry has the potential to both mitigate and adapt to the challenges of future climate change and secure an unremitting, sustainable, and climate-smart agricultural production. The use of the aggregated maps and the major potential offered by agroforestry systems will enable to develop strategies geared to local conditions and to environmental targets.

Poster

Understanding the effects of landscape complexity on natural pest control: potential and limitations of applying generic models to local case studies

Marta Bonato[1]; Bartosz Bartkowski[1]; Michael Beckmann[1];
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Keywords: Agro-ecosystems, natural pest control, non-crop habitats, landscape complexity

The functioning of agro-ecosystems and the associated provision of natural pest control is undermined by historic and ongoing simplification and intensification of agricultural landscapes. The need to ensure the stability of agricultural production against pest outbreaks, which are predicted to increase in frequency due to climate change, is leading to a continuous increase in input intensity (i.e. pesticides application). This goes in sharp contrast with the shift toward a more sustainable agriculture aimed in the context of the European Green Deal, and in particular with the targeted reduction in pesticides usage by 2030. Managing agricultural landscapes to support farmland biodiversity in general and populations of ecosystem services providers (i.e. natural enemies) in particular is therefore a key element to enable the achievement of the objectives set by the European Union.

Non-crop diversification has been long recognized as a favorable strategy to support natural enemies. Non-crop habitats within the agricultural landscape act as supplemental food resources, nesting locations and overwintering sites for such organisms. Not only the presence but also the spatial configuration of non-crop habitats is increasingly suggested to influence the final provision of pest control service. So far only few studies have tried to develop spatially explicit models at the European scale that link landscape complexity (i.e. landscape composition and configuration) to the presence of natural enemies and to the provision of natural pest control. Moreover, it is still open whether these available generic models are applicable to local case studies.

Further advancing in this direction, we have applied in different locations across Europe an existing model (Rega et al., 2018) that allows the calculation of a Pest Control Potential Index based on the presence and configuration of various types of semi-natural habitats (e.g. herbaceous and woody, linear and areal habitats) within the landscape. The model has been applied using high resolution land use maps. The ranking of the pest control values resulting from the index calculation has been subsequently compared with the ranking of in-field natural pest control observations compiled in a recent meta-analysis (Martin et al., 2019) and collected at the same locations in Europe. The purpose of the analysis is to verify to what extent variations in natural pest control provision across systems can be modelled considering only landscape properties, or if models should also consider other factors at the local scale (e.g. crop diversification, management intensity).

Our presentation will discuss the potential and limitations of generic state-of-the-art approaches for modelling natural pest control at the local/regional scale and provide an outlook how these could be used to develop local management plans for a sustainable agricultural production that meets the targeted reduction in pesticides usage.

References:

Martin, E. A. et al. (2019). The interplay of landscape composition and configuration: new pathways to manage functional biodiversity and agroecosystem services across Europe. Ecology Letters, 22(7), 1083–1094.

Rega, C. et al. (2018). A pan-European model of landscape potential to support natural pest control services. Ecological Indicators, 90(April), 653–664.

Land cover and climate changes drive regionally heterogeneous increases in US insecticide use

Ashley Larsen[1]; Sofie McComb[2]

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Global environmental change is expected to dramatically affect agricultural crop production through a myriad of pathways. One important and thus far poorly understood impact is the effect of land cover and climate change on agricultural insect pests and insecticides. Here we address the following three questions: 1) how do landscape complexity and weather influence present-day insecticide use, 2) how will changing landscape characteristics and changing climate influence future insecticide use, and how do these effects manifest for different climate and land cover projections? and 3) what are the most important drivers of changing insecticide use? We use panel models applied to county-level agriculture, land cover, and weather data in the US to understand how landscape composition and configuration, weather, and farm characteristics impact present-day insecticide use. We then leverage forecasted changes in land cover and climate under different future scenarios to predict insecticide use in 2050. We find different future scenarios – through modifications in both landscape and climate conditions – increase the amount of area treated by ~4–20% relative to 2017, with regionally heterogeneous impacts. Of note, we report large farms are more influential than large crop patches and increased winter minimum temperature is more influential than increased summer maximum temperature. However, our results suggest the most important determinants of future insecticide use are crop composition and farm size, variables for which future forecasts are sparse. Both landscape and climate change are expected to increase future insecticide use, yet better understanding of future crop composition and farm economics is necessary to effectively predict and mitigate projected increases in chemical pest control.

References:

Larsen, A. E., McComb, S. (2021). Land cover and climate changes drive regionally heterogeneous increases in US insecticide use. Landscape Ecology, 36: 159–177.

Can shelterbelt trees reduce evapotranspiration and ecophysiological stress of grapevines? – A transcontinental experiment in the Western Cape, South Africa and Lower Lusatia, Germany

Maik Veste[1]; Kerry-Anne Grey[2]; Nadine Gottschalk[3]; Katja Trachte[3]; Guy F. Midgley[2]

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In the context of ongoing climate change and increasing population, there is an urgent need to optimize the water consumption of surface and groundwater in agricultural production. In recent years, intensive irrigated viticulture and horticulture have faced increasing demand pressure in many water-limited areas including the Western Cape Province in South Africa. It has also been shown that the number of consecutive dry days between precipitation events has increased in the Western Cape. Increased temperatures imply increased evaporation as a result of increased vapor pressure deficits, which in turn may reduce soil moisture and the availability of water resources in the long term. Shelterbelts of trees and agroforestry are often used to reduce water demands as an eco-engineering measure directly influencing soil evaporation and crop transpiration. How effectively could agricultural landscapes be redesigned through the introduction of specially designed obstacles to airflow, via significant impacts on the near-ground wind field? And how especially the surface energy budget, together with the local temperature and wind regime is influenced? Objectives of our experiments are (i) to evaluate the extent of impacts of wind speed from shelterbelts at canopy level in crop species and (ii) to assess shelterbelt effects at leaf level (including leaf temperature and related ecophysiological performance) in irrigated vineyards. Experiments are underway in the Winelands of Stellenbosch, South Africa, and comparative studies on the interaction between microclimatic and ecophysiological conditions are also carried out on a vineyard in the post-mining site in Lower Lusatia. It is hypothesized that the proximity of tree shelterbelts reduces vineyard evapotranspiration, leaf conductance, and photosynthetic capacity. The quantum efficiency of photosystem II and stomatal conductance of leaves were measured to test for effects of shelterbelts on leaf-level performance. Preliminary results indicate that shelterbelts significantly enhance the physiological function and photosynthetic performance of vines.

Mitigating future reactive nitrogen losses to the environment through farm level management practices

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The emissions of reactive nitrogen (Nr) into the environment through fertilizers lies at the heart of conventional intensive agricultural production systems. In the future, the contribution of agricultural land to Nr emissions will change under a warming climate because climate change contributes firstly to altered growing conditions (changes in precipitation and temperature), and secondly to shifting circumstances surrounding the political framework that support agriculture mitigation and adaptation policies, and finally to impacts on global markets and therefore to altered farm gate prices. The extent and magnitude of these combined impacts to Nr losses into the water, soil and atmosphere are not yet known. The NitroClimAT project evaluates and provides a cost estimation of agricultural management strategies for Austrian agricultural systems that are able to minimize reactive nitrogen (Nr) losses to the environment under future climate and future socio-economic and policy scenarios.

For this research, an integrated modelling framework (IMF) for simulating Nr losses into the environment under future changes has been developed. The IMF consists of a biophysical process model (EPIC), an economic land use model (PASMA[grid]), and two hydrological models (MONERIS and SWAT) that are loosely coupled to quantify economic costs, crop selections, crop spatial allocation, crop yields, and Nr stocks and flows from agricultural systems.

The IMF was applied to all of Austria using the aggregated MONERIS model and to 3 case-study watersheds, each in a main agricultural production region using the more process-based SWAT model. In all applications, the IMF was applied to a reference period (1981–2000) and as well as using a suite of scenarios including 4 climate simulations (2041–2070), and different socio-economic and policy framework conditions.

The IMF quantifies the regional agricultural production volumes and gross margins as well as the related regional N balance by determining the Nr input, the total nitrogen (TN) and NO3-loads into water bodies and NOX, NH3 and N2O emissions into the atmosphere. Various agricultural management practices targeted at increasing the N-use efficiency and reducing Nr losses will be considered. The economic trade-offs between different N management options and indicators such as agricultural gross margins (i.e. including production volumes, prices, and costs) as well as Nr losses to surface waters and atmosphere will be evaluated.

The result of the research will be a ranking of agricultural management strategies for specific agricultural systems that minimize future Nr losses to the water, soil and atmosphere, together with an economic value of the losses and a quantification of the uncertainty of the simulated Nr losses under future scenarios. The outcomes of the research will assist regional adaptation of farming systems by determining strategies at farm level that reduce Nr losses into environment and that are socio-economically acceptable for farmers.

SESSION 1:

CROPPING AND GRASSLAND SYSTEMS

1.2 Follow the shift! How research can be part of transformation in agricultural practice

Convenors:

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A shift in agricultural practice is required to meet current and future challenges towards a climate-resilient and sustainable agricultural landscape.

However, traditional agricultural landscape research is sometimes not closely linked with decision making processes in agriculture, neither at farmers' field nor at policy level. In fact, academic research and farmers' needs and innovations are often detached from one another. While research usually ends with recommendations for action based on its findings, the actual implementation often take place after the research process has ended.

Hence, the activities, how recommendations manifest in practice, are mostly not evaluated and not regarded as an outcome or part of the process.

Transformative research uses methods that can handle complexity in agricultural multi-actor systems. It promotes resilience by adaptation and empowerment of all actors by creating a participatory and impact-oriented setting right from the beginning. Transformation research approaches enable academia and farmers equally to jointly work as co-researchers using an interdisciplinary mixed method approach, combining for example social and natural sciences, and generating problem and transformative knowledge.

We cordially invite you to contribute to this session focusing on prerequisites for impact-oriented science-practice dialogue to enable a shift towards transformation in crop systems and how fundamental research can be used effectively in this interplay.

Orals

The three freedoms required by transformative agricultural research

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Societies' calls for addressing the urgent problems of climate change, biodiversity loss and other environmental crises are becoming ever louder. Responding to this, and to the growing severity of global threats to agricultural and food systems, national and international research funders are increasingly demanding that funded projects achieve real-world transformation of farming systems towards true sustainability and resilience. This development is not only a new funding opportunity for researchers. Because separating the roles of knowledge generation and knowledge exchange with practice will often fail to achieve the necessary transformation, (at least some) researchers will need to engage in this transdisciplinary process of transformative agricultural research. As a consequence, the roles of these researchers need to shift towards stronger integration in farming practice, and deeper exchange with practitioners, adding a new key role to teaching and research. We argue that meeting the goals of the mission of transformative research in agriculture requires three essential freedoms. First, researchers need to be free to engage in this transformative research. This entails a freed mindset, which enables researchers to leave behind traditional roles, e.g. for true knowledge exchange, co-design of projects, and learning from farmers. In addition, there needs to be a stronger appreciation for transdisciplinary and transformative research in the research community, accompanied by a reduced pressure to perform in other currently dominating assessment categories. Second, farmers need to be free to engage in this process as well. Again, this requires an open mindset, e.g. to engage in, and learn from collaborative research, but also available funds and time to engage in the process. Third, transformative agricultural research needs freedom in the project structure and in administrative rules. This includes the permission to fail and to tolerate errors, so that the people involved in the process are able to learn from mistakes. In addition, this is required so that projects are not set up to avoid risks, and can really be transformative and contain innovative elements. Finally, funders will need to show trust in the parties and to reduce administrative burden. Within this framework we discuss the success factors and limitations of transformative agricultural research using examples from various recent national and international projects.

Concepts to include farmers as co-researchers – the living lab approach of the project "NutriNet"

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A key characteristic of current and future challenges towards a climate-resilient and sustainable agricultural landscape is their complexity, that leads to difficulties in implementation of scientific findings in agricultural practice. The implementation of new strategies in nutrient management on organic farms is such a complex challenge due to regional differences in perception and soil resources as well as individual prerequisites on farms. The project "NutriNet: competence- and co-research network for development of nutrient management in organic farming" meets this challenge by building a living lab according to Dell'Erra & Landoni (2014) and Rose et al. (2018) and aims i) to derive region-specific nutrient management advice for organic farms from scientific findings in field trials (nutrient management research), ii) to ensure implementation of these advice through group motivation and enable an exchange of expert knowledge in Field Schools (transformative research), iii) as well as to evaluate key methods, roles, competences and resources for an implementation-oriented co-research process (process research).

Sixty farmers organized in six regions in Germany build the basis of the "NutriNet" living lab, each accompanied by a regional consultant and a group of scientists on a joint level. All actors are involved in the co-research process to varying degrees depending on the stage of the process and can take on different roles. Process steps are ideation, development of the experimental question and design, trial implementation, data analysis, interpretation of data and implementation and transfer of results. The living lab character is especially addressed in the structure of the co-research process for conducting field trials in the "NutriNet" project as it describes a learning system within the system.

The co-research concept allows to take different experimental designs into account, namely field trials with a demonstrative character that provide methodological skills for farmers and pre-test results as well as field trials with spatial and temporal repetitions that meet scientific requirements. In order to reduce the scientific framework conditions to such an extent that, on the one hand, scientifically valid results and, on the other hand, the highest possible feasibility of the experiments by the farmers can be guaranteed, so-called regional and network trials are being tested in NutriNet. The concept is based on taking randomization and spatial repetition into account by repeatedly setting up the trial at several locations. In order to take environmental influences (soil, climate) into account, the possible sites are divided into groups according to site characteristics by using a cluster analysis. By involving not only one but many farmers throughout the whole co-research process and enabling exchange among them in Field-Schools, methodological training and implementation of findings are addressed as a part of the research.

After one year of field trials two regional trials with ten and seven farmers were set up as well as one network trial on thirteen farms in four regions. Methodological evaluation of the process led to adjustments in experimental design, data collection and coordination between experts that are implemented in a new series of network trials starting in autumn 2021.

Inspiring change in agricultural practices

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An international group of 15 organic and biodynamic farmers have collaborated since early 2015 to develop their own strategies and learning concepts to increase health on their farms. After jointly formulating ten core statements as their own practical principles for managing healthy farming systems, they went on to develop a training strategy to transfer this knowledge about promoting health on organic farms, describing a co-learning concept to collaborate with their peers in a long-term process.

Most suitable, appropriate methods and optimal conditions were discussed for successfully spreading such complex tacit knowledge among other farmers, and crucially, for invoking change in behavior. One core concept emerged as being most critical for success – inspiration. It was the group members' or peers' ability to inspire, which, in their experience, was key to stimulate their own change of practices, motivate trials with new methods, or adopt a new perspective or philosophy for managing their farm. They described that it was not only the reading about different techniques, or seeing new machinery in action during a farmer field day – the actual spark that triggered their own action was in most cases personal interaction. The personal exchange and inspiration among peers, who have established a sound level of trust, who share their experiences, as well as passions and failures seemed to be most likely the key element of farmer learning.

This was particularly true for learning and enhancing soft skills, such as intuition, gut-feeling or self-reflection – all essential skills for running healthy organic farms according to the farmer group. The farmers of this project series have attributed great value to learning with and from each other during a co-learning process, in particular when the group is regularly stimulated by and collaborating with interdisciplinary researchers who are embedded in this co-learning process. We could therefore conclude that not only participatory-/action research or multi-actor approaches, but agricultural research in general benefits from a deep connection and understanding between researchers and farmers, to successfully inspire change in practices, and the adoption of new philosophies and perspectives that trigger long lasting transformation.

Multi-actor exploration of transformative pathways for the cooking banana value chain in Uganda

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Keywords: East-African Highland banana, *Musa spp.*, co-learning

Cooking banana is one of Uganda's main staple foods. Its cultivation has intensified and gained important commercial value to farmers. Yet, challenges along the value chain persist, including declining soil fertility and limited cooperation among value chain actors. Transition towards a more sustainable system is desirable. Perceptions of various stakeholders on the desired future system may differ. In this study, we combined participatory, ex ante impact assessments with actual implementation of interventions to plan, assess and discuss potential pathways leading to a desirable future for the banana value chain in Uganda.

Interdisciplinary, mixed methods were employed: a participatory visioning and back-casting workshop with value chain actors in southwestern and western Uganda led to the development of a shared vision on the future of the banana value chain and the steps needed to reach that vision. Stakeholders selected one intervention for direct implementation. The intervention and other potential changes discussed in the workshop were used in a scenario analysis, to quantitatively assess their effects under different plausible futures. Results were fed back and discussed with the same stakeholders. A qualitative ex-ante assessment was held to discuss expected impacts and perceived differences between groups of stakeholders. A second round assessed how the expectations were met with the intervention.

The intervention, a training on Integrated Soil Fertility Management (ISFM) and improving access to a banana-specific mineral fertilizer blend ("banana-fertilizer"), was jointly implemented with a private company which recently released a banana-fertilizer. During the training, farmers were connected to their local agro-dealers. The training and demonstration notably increased demand for the banana-fertilizer. The effects of ISFM were assessed in an *Intensification* scenario, against four other scenarios (*Baseline, Marginalisation, Business-as-usual* and *Transformation*), on the indicators food self-sufficiency, farm gross margin, nutrient balances and labour demand. Food self-sufficiency and gross margin both increased as a result of ISFM, but with increased labour demand as trade-off. Bananas require large potassium (K) inputs, but nutrient balances for K remained negative while nitrogen (N) was oversupplied. In *Transformation* we therefore balanced nutrition, with K offtake completely compensated with mineral fertilizer and N coming from organic sources only. The relatively favourable K-balance in *Marginalisation* resulted from reduced yields in this scenario.

The scenario analysis indicated that the nutrient composition of the banana-fertilizer may need to be reconsidered. In turn, this may have effects on the costs of the blend. The deliberations led to a common interest of researchers and private sector to explore an improved blend. The feedback session focused on the potential to achieve desirable targets in each scenario, and trade-offs including increased investment costs and labour requirements.

The ex-ante assessment showed differences in perceived benefits of the intervention between men and women, which resulted in an additional training on gender aspects related to ISFM.

The participatory and impact-oriented approach helped researchers to adjust the scenarios to improve local relevance, stakeholders to foresee consequences of certain decisions, and a joint planning of next steps towards a desirable future, including information sharing with higher-level policy makers.

The role of research and extension to foster agroforestry scaling-up in Colombia

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Agroforestry systems (AFS) have been recognized as sustainable land management strategies that integrate trees within farming systems. Some examples include home-gardens, silvopastoral systems, and other shaded tree-crop systems. These systems have been proven to contribute toward resource use efficiency, assurance of livelihoods, and biodiversity conservation, mainly based on case study research and field experiments. This has drawn considerable attention to scaling-up these systems. However, the literature suggests that this process will not be achieved by promoting few agroforestry practices or arrangements that have been successfully tested. Instead, the process needs to consider the complex interactions occurring within agroforestry systems and between them and the environment, the varying biophysical conditions of sites, and the specific socio-economic needs and traditional knowledge of farmers. In this study, we review the evidence on how effective research and extension efforts to foster agroforestry scaling-up have been in Colombia and then explore how innovative approaches for research and extension can address the limitations that emerge. We use a multi-method approach that includes institutional document analysis, questionnaires with AFS professionals using the ScalA tool, and semi-structured interviews with AFS farmers. Although AFS have been integrated into planning instruments of the environmental and rural development portfolios, AFS professionals and farmers perceive that agencies in charge have limited efficiency or physical absence to support them. AFS have also not effectively integrated into the formal curricula of future agricultural researchers and extensionists. AFS scaling-up is a challenge for research and extension since it involves a comprehensive and complex view of agricultural systems and landscapes. AFS scaling-up efforts are encouraged to tailor research and extension programs to local circumstances using farmer-centered, community-based, and social learning approaches to dealing with the complexity of AFS.

Mapping available agricultural equipment to enable farmers' and manufacturers' interactions for an agroecological transition. The case of legume crops in Hauts-de-France region

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Keywords: Forage crops, transformative research, multi-actor approach

In the broad spectrum of the shift towards sustainable agriculture, agroecological transition is widely targeted by policy guidelines and addressed by farmers in western Europe. Among the most known transformative factors, there are plant breeding, the achievement of nitrogen autonomy, crop diversification, and agricultural equipment. Insofar, the latter appears to be widely neglected in the literature. The availability of suited machinery and implements might be the simplest prerequisite for developing and deploying agroecological farming practices and cropping systems. This to decrease the existing gap between the design of equipment and of farming systems. In this vein, protein production raises specific challenges for the cropping systems.

The main goal of this study is the achievement of a shared perspective between farmers and machinery manufacturers. This study is contributing to the design of an analytical framework for the adaptation of equipment to the agroecological transition for legume crops. Our case study is in northern France (Hauts-de-France region), characterized by large crop farms (27400 farms with an average area of 78.5 ha which is 1.4 higher than the national average) and engaged in the quest for protein autonomy. As so, we will focus on the availability of agricultural equipment for forage legumes in the region. It will require involving multiple agricultural actors concerned by the agroecological transition, especially from the agricultural equipment sector.

We carried out two parallel actions. On one hand, we retrieved all the institutional and commercial structures in the region based upon documents available online to map the actors in the region and the possible interactions between them. On the other hand, we carried out an exhaustive inventory of all the 166 dealers in the region as experts to describe the available agricultural equipment for local farmers. The output of these two actions of information will be an integrative knowledge base. To study the interactions between these actors, as well as to check the equipment availability and their adaptation to agroecological transition, we conducted about 20 semi-directive surveys.

The main result will be a mapping of stakeholders and a catalogue of available equipment as an intermediate object to represent the sector considering all its complexity, thus mixing agronomic and social sciences towards a shared perspective.

Alternative crops for a climate-smart food production system in Switzerland

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Agricultural covers an area of 14.817 km2 in Switzerland (35.9% of the whole country). The largest part of this area is thereby used for fodder production in connection with livestock farming, where Switzerland reaches a very high degree of self-sufficiency (100%). On the downside, livestock farming contributes substantially to greenhouse gas emissions. Transformation towards a more climate-smart Swiss food system may imply an increase in the share of food crops for regional consumers. To achieve this, farmers would have to extend their portfolios of food crops for cultivation – ideally on the basis of crops that are well-adapted to changing climate conditions and have high nutritional value.

The aim of this study was thus to evaluate possible alternative crops (1) with regard to their climatic suitability for cultivation at selected sites across the agricultural zones of Switzerland, and (2) with regard to their nutritional values. These evaluations were based on FAO’s ecocrop model in combination with several food composition databases. Results indicate persisting and even increasing climatic yield potential for 2–86 alternative crops, depending on local climate conditions. The results of this study can provide an important decision-basis for innovative farmers willing to experiment with alternative crops, thus initiating developments towards a climate-smart transformation of the Swiss food system.

Assessing sustainability of farming systems with a new method integrating ecosystem services indicators

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Keywords: Ecosystem services, indicators, multi-criteria assessment, sustainability

In the 21st century, consumers are more and more concerned by health, sanitary quality and agricultural sustainability issues. To support the design and development of sustainable farming systems, numerous indicators and sustainable assessment methods have been proposed since the 90s. A broad review of 262 methods assessing environmental sustainability showed that most methods were based on environmental indicators assessing impacts (nitrate losses, greenhouse gas emissions, etc.) and included very few indicators of ecosystem services (pest regulation, pollination, water storage and release, etc.). Ecosystem services can be mobilized by farmers to better benefit from the ecological processes of the agricultural ecosystem and reduce their anthropogenic impact. To help farmers in this way, we built a new multicriteria assessment method based on environmental impact indicators, ecosystem services indicators and economic performances indicators. The structure of the method is inspired from the conceptual framework of the MASC method based on a wide range of sustainability themes covering environmental impacts, economic and social performances, and integrating additional themes addressing ecosystem services. Themes are assessed by predictive indicators to enable ex ante and ex post evaluation. This type of indicator also has the advantage of being able to trace the cause-effect relationships (Bockstaller et al., 2015). The spatial scales chosen are for the spatial resolution the cropping system and for the spatial extent the geographical area covered by an agricultural cooperative in the Aube department in East of France. Concerning the temporal scales, the evaluation will be conducted at the scale of the cropping year for the temporal resolution and the crop rotation for the temporal extent.

A first step was the creation or selection of new indicators to add at the conceptual framework of the MASC method. For instance, we have integrated ecosystem services indicators such as carbon storage or pest regulation. The second step will be the application of the method to a farm sample of the agricultural cooperative and its validation. This step will allow us to study if there are synergies or antagonisms between the environmental impacts, ecosystem services and economic performances, and to identify whether there is an effect of farm localization on the results.

The output of this research project will provide to advisers and farmers of the cooperative more insights in the sustainability of farms, and avenues to farmers who wish to improve their practices by integrating ecosystem services in their decision (e.g. water quality regulation) and for society (e.g. regulation of the global climate).

References:

Bockstaller, C., Feschet, P., Angevin, F. (2015). Issues in evaluating sustainability of farming systems with indicators. OCL – Oilseeds fats 22. https://doi.org/10.1051/ocl/2014052

Entering Interdisciplinary Landscape Science: Insights from Early Career Researchers

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Since the end of the 20th century, interdisciplinary research approaches have increasingly gained popularity within academia (Heberlein, 1988). With its mix of novel approaches, holistic systems thinking has challenged so-called classic disciplinary research concepts. Meanwhile, sustainability researchers have admitted to the fact that interdisciplinarity is a must to tackle current environmental and societal issues (Lach, 2014). Interdisciplinary research groups emerging at universities or private organisations attempting to push this cooperation between disciplines forward. In parallel, new academic education programmes are offered, that mix theories and methods of various disciplines (e.g., master programs in sustainability science, environmental management, or ecosystem services). When entering academia from these programs, candidates find it increasingly difficult to position themselves within a certain research field, giving their mixed education. Especially early-career researchers face challenges when trying to orientate themselves in the context of an interdisciplinary working group (Haider et al., 2018).

In our research, we set out to illustrate the challenges that early-career researchers are facing, based on their educational background. Therefore, we invited early-career researchers working in the exemplary field of landscape science to take part in a quantitative online survey. In total, more than 50 respondents provided insights into their backgrounds, challenges and benefits of interdisciplinarity, perception of professional identity, and their definition of the term 'interdisciplinarity'. As social-ecological research is one field that is dependent on interdisciplinary approaches, we investigated, where challenges lie when bridging from classic disciplines to interdisciplinary working, where the differences lie, and how this affects one's work. We claim that frequent exchanges with academic peer groups and supervisors experienced in interdisciplinary approaches are crucial for developing and conducting cross-cutting and impactful research. Furthermore, shared understanding, exchange, and collaboration between disciplines are necessary to learn skills, achieve shared knowledge, and harness opportunities for interdisciplinarity. Overall, working interdisciplinary appears to be a deliberate decision that is mostly based on interdisciplinary academic education. Thus, we conclude that promoting innovative research approaches such as interdisciplinarity needs an educational background that balances the understanding of classical scientific methods, with the understanding of socio-ecological system thinking. Finally, we argue for the numerous benefits of entering interdisciplinary research in an early stage of academic education. When guided well, early-career researchers can contribute with innovative mindsets to overcome rigid thinking patterns dominating science and practice.

References:

Haider, L. J., Hentati-Sundberg, J., Giusti, M., Goodness, J., Hamann, M., Masterson, V. A., Meacham, M., Merrie, A., Ospina, D., Schill, C., Sinare, H. (2018). The undisciplinary journey: early-career perspectives in sustainability science. Sustainability Science 13 (1): 191–204. https://doi.org/10.1007/s11625-017-0445-1

Heberlein, T. A. (1988). Improving interdisciplinary research: Integrating the social and natural sciences. Society & Natural Resources 1 (1): 5–16. https://doi.org/10.1080/08941928809380634

Lach, D. (2014). Challenges of interdisciplinary research: reconciling qualitative and quantitative methods for understanding human-landscape systems. Environmental management 53 (1): 88–93. https://doi.org/10.1007/s00267-013-0115-8.

Poster

A method to study complex agroforestry landscapes: illustration in Madagascar

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The transition from shifting cultivation to perennial crop cultivation is observed in many regions across the tropics, to meet environmental and socio-economic challenges. In some areas, small-scale farmers have engaged in crop diversification through agroforestry, a practice that enables production for self-consumption and income, while coping with environmental constraints and heterogeneity. This is the case in a zone of Vavatenina commune of Madagascar, where the Betsimisaraka small-scale farmers have abandoned the traditional shifting rice cultivation on hills (tanety) in favor of agroforestry, mainly based on clove tree cultivation. These different tanety land uses shape complex agricultural landscapes that seems to result from various types of agroforests. Despite the major interest Vavatenina original landscapes may have from a sustainability perspective, its composition and spatial structure have not been studied so far. However, the high heterogeneity of these landscapes, at different scales (the plot, the village territory, the commune), raises methodological challenges. Similarly, scale related environmental factors, such as topography, slope and proximity to the road, appear to play on this heterogeneity, and thus required to be identified and their effect assessed. Our study applied an original method to meet this challenge by combining a landscape spatial analysis with a participatory mapping of agroforests. First, we described the composition and spatial organization of agroforestry at two scales, from that of agroforests in the landscape to that of species within agroforestry plots. Second, we analyzed the effects of topography and isolation level on the landscape and agroforests heterogeneity. We used a remote sensing method to quantify the proportion of the different tanety land uses, and analyze how agroforestry especially fits into the landscape and according to which environmental determinants. Then, we applied a participatory mapping method to study the spatial organization of species in 17 agroforests in a village of the study area. This method gave data on the species richness and the species associations in micro-zones related to topography. The results of the remote sensing analysis highlighted 10 different classes of tanety land uses, including more or less dense diversified agroforests, cloves tree and wood tree plantations. The results also indicated that the type of agroforests, the proportion of space they cover, and their insertion in the landscape differ very strongly between the localities of the study area. It seems that, while some areas have engaged massively in diversified and complex agroforestry, this is not the case in other nearby areas, where other less sustainable land uses seem to be favored (e.g. monoculture). The analysis of participatory maps showed that farmers managed between 8 and 22 species in their agroforests, and that they associated and spatially distributed these species according to topography. The combined results obtained with both methods contribute to better understand the heterogeneity of landscape and agroforests and its determinants. This approach would be of interest for supporting agroforestry transitions in other areas where farmers already engaged in such practices, to make a diagnostic of existing agroforestry and identify where and how support could be brought in priority.

A multi-disciplinary approach to understand the potential and limitations of smallholder farmers in sustainably intensifying maize production in southern Africa

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Sustainable intensification (SI) of low input, rainfed farming is promoted as a key strategy to improve the livelihoods and food security of smallholder farmers in southern Africa. It has been argued, however, that due to the increasing frequency and severity of droughts (Conway et al., 2015), irrigation will be a prerequisite for sustainable yield improvement and stability for many smallholders (Cassman and Grassini, 2013). A key question is, to what extent is this feasible for smallholder farmers in the region? Restricted access to water and irrigation infrastructure necessitates the investigation of alternative management options suited to smallholder systems. Using the Limpopo province South Africa as a case study, we combine qualitative survey data (140 households) and detailed quantitative agronomic measurements and observations (116 georeferenced on-farm plots) – data collected from five villages across a climate gradient – to understand production limitations in maize-based smallholder systems. Participatory agronomic measurements included soil characteristics (e.g. CN ratio and texture) and management aspects such as weed type and soil cover, as well as maize planting density and yield. While quantitative data led to a well-grounded understanding of biophysical production limitations, qualitative insights into the current adaptation methods used and those that farmers considered useful ensured further investigations addressed questions asked by the farmers this research serves. Combined insights from the interviews and detailed on-farm observations were used to benchmark the agro-ecosystem model APSIM. Simulation runs were set up for different levels of input, including the status quo (no irrigation, zero to low fertilisation, little weeding, no pest management, and low plant densities), and a combination of advanced practices that involved the application of irrigation (around 200 mm), fertiliser (50 kg ha-1 at sowing), improved weed management, and optimal planting density feasible for the smallholder systems studied. An additional scenario investigated the impact of weather forecast-aided decisions on input use – surveyed farmers expressed a special interest in weather forecasts to help guide their season-specific cropping practices and risk management.

Overall, input intensity levels were low or non-existent. Farmers from all villages expressed similar challenges to adapt maize cultivation to climate variability. Survey results showed that farmers adjusted sowing time and planting density according to rainfall and perceived risk. Most farmers lacked knowledge about drought avoidance measures, and only very few had access to water for crop irrigation. Existing irrigation systems relied solely on groundwater accessed via boreholes, many of which had dried up.

Simulation results showed that irrigation alone could increase maize grain yields, although this varied for each village (two ton ha-1 increase across all villages under current management practices). Seasonal forecasts were linked with investment in mineral nitrogen fertiliser and seeds, e.g. fertiliser application based on rainfall projections. Such season-specific recommendations proved highly productive, especially when looking past absolute yields alone.

This case study implements a novel method of linking qualitative and quantitative data to ensure the assessment of SI in smallholder cropping systems is guided by a combination of farmer insights and agricultural science, creating transformative knowledge and sustainable impact.

FInAL – an agroecosystem living lab approach towards insect friendly landscapes

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Insect diversity and abundance are decreasing with negative consequences for important ecosystem services. Especially changes in cultivation practices, often summarized as intensification, are discussed as major drivers of insect decline. Recent agri-environmental schemes fail to counteract the declining trends as a) ecologically effective measures proposed by ecologists are rarely implemented into farming practices; b) insect-friendly management plans often fail to consider the landscape context which can substantially affect the effectiveness of implemented measures.

Within the FInAL project we apply an "agroecosystem living laboratories" (ALL) approach to develop and demonstrate innovative and effective agricultural cultivation practices at the landscape scale that sustain, support and increase diversity, biomass, and ecosystem services of insects.

In 2021, we launched a long-term transformation process within three 3x3 km size ALLs across Germany. In a co-designing process that involved researchers and stakeholders, especially farmers, locally adapted insect friendly measures were compiled and are being implemented. Measures are designed to diversify crop rotations, mainly by integration of renewable resources into cropping plans, increase the amounts of suitable insect habitats and habitat connectivity, increase and diversify the availability of resources, support cultivation systems via innovative methods of integrated pest management, as well as to decrease disturbances of soils and insect mortality in general. Measures are implemented in both, productive and non-productive areas. Geodata and modelling tools were used to evaluate the baseline situation and provide a scientific basis for management plans on the landscape scale.

The impact of the transformations on insect populations and ecosystem services are monitored and evaluated using a BACI-design. The monitoring scheme we developed is suitable for assessments on the landscape scale. In parallel, the economic viability and the social acceptance of implemented measures are evaluated by an interdisciplinary research team.

The status of the ALL-landscapes will be repeatedly evaluated to feed the ongoing iterative co-designing process that aims to refine the implemented insect friendly measures and management plans towards an insect-friendly agricultural landscape. By involving stakeholders actively in the research process and acknowledging economic and social realities, we seek to increase the probability of innovative agricultural cultivation practices to be accepted and implemented beyond the boundaries of the research project.

Determining optimal combination of nitrogen and phosphorus microdosing to increase maize productivity, nutrient and water use efficiency in the sub-humid zone of Benin

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Nitrogen and phosphorus limits maize productivity, especially in the West-Africa sub-Saharan zone. It is therefore necessary to know the contribution of these nutrients, and their optimal combination to maximize maize productivity and its resource use efficiency. This study aims to identify the optimal combination of nitrogen and phosphorus fertilizer using microdosing technique for maximum crop productivity, nutrient and water use efficiency. The experiments were conducted at the Agricultural Research Station of Northern Benin during the 2018 and 2019 seasons, and parameters such as maize grain and stover yields, nutrient and water use efficiency were evaluated. Four nitrogen rates (urea: 0, 25, 35 and 45 kg N ha-1) and four phosphorus rates (triple super phosphate: 0, 4, 8 and 12 kg P ha-1) were tested on drought tolerant (TZE-Y POP STR) and drought-sensitive (DMR ESR W) maize varieties with 90 days cycle. The results show that the above-ground biomass and the leaf area index were higher under N35 and P8 fertilization compared to the other treatments. Grain yields increased by 95% and 122% for the treatments N25 and N35, and by 28% and 53% for the treatments P4 and P8, respectively, compared to the N0P0 control (without fertilizer). However, grain yield was higher and similar for the combinations N25P8, N35P4 and N35P8. Drought tolerant maize variety had the best yield performance which was 11% to 34% higher compared to drought sensitive variety. In short, micro-dosing with N35P8 under drought tolerant variety has best yields, nutrients use, and water use efficiencies. N35P8 under drought tolerant variety can be a good adaptation strategy in the present context of climate change, though more trials must be conducted to test this combination in smallholder farms.

Potential implications of irrigation on actual agricultural performance

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Especially under the prospective changes in environmental conditions, as expected for the ongoing climate change, agricultural resilience to drought can be enhanced by appropriate water management measures. To this end, crop-soil system models can be an efficient way of predicting the impact of management practices and therefore, contributing to decision-making processes. Water balance models can vary in the way they define the soil-plant-atmosphere system, where some emphasize on plants as a mediator of soil and atmosphere and others focus on the soil-atmosphere interaction per se. The objective of this study was to analyse irrigation recommendations from two models with different functioning principles and compare them with real-time field measurements. By a combined experimental and simulation study, we focused on generating and comparing irrigation recommendations from: Hermes2Go, a process-oriented, agroecosystem model, which simulates the water- and nitrogen-dynamics between soil-plant-atmosphere and WEBBEREST, a web-based, irrigation-scheduling model, which also simulates crop growth depending on evapotranspiration and water shortage stress. The models' recommendations in terms of date and amount of water to be applied and their resulting simulations of daily soil water availability, crop water uptake, and crop growth were used for inter-model comparison and for an empirical comparison with field measurements of crop water uptake and final yield. The actual agricultural implementation and monitoring employed the experimental site at Marquardt (near Potsdam, Germany) over a vegetation period of two years, considering two different crops (silo maize and winter rye) grown under four fertilization treatments with four replicates (a total of 16 plots, each of size 20m x 8m). Preliminary results showed that in most situations, both models overestimated the amount of water to be applied compared to conventional irrigation recommendations based on practitioners' expertise. Information based solely on initial soil conditions and crop phenology seemed insufficient and therefore, a gradual, real-time calibration around irrigation dates and amounts was adopted. While the two models responded sensitively to changes in irrigation amounts and fertilization treatments, the on-site measurements were more diverse when grouped by soil texture classes. The study also provided insights on the irrigation potential implications for alleviating water shortage and heat sensitivity of different crops, while maintaining a certain degree of nitrogen uptake sufficiency as a consequence of water availability. The findings of this study corroborated the need for a trade-off between models' irrigation recommendations and actual agricultural implementation through real-time model calibration, leading to a series of adaptation scenarios for forthcoming risk assessments.

Using a Parish Level Approach to continually inform Dynamic Nutrient Management

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Keywords: Nutrients, Policy, Agricultural Parish

The implementation of the EU Nitrates Directive (91/676/EEC) in Scotland has led to the development of Nitrate Vulnerable Zones (NVZs) in catchments where freshwater is expected to exceed 50 mg NO3/l (Scottish Government, 2014). The success of the policy has been measured by benchmarking nitrate concentrations in surface water over time. It is often challenging to relate surface water nitrate concentrations directly to farm nutrient management practice. However, it is important for future policy making to understand what changes in farm management have led to observed changes in nitrate in surface waters. Here we take a new approach using existing data on land use and combining it with data collected on farm and from national statistics to address changes in nutrient management in agricultural catchments over time. In terms of water quality, most studies focus on nitrogen (N) and phosphorus (P) but we also include potassium (K) because of its relevance to productivity.

In this work, a nutrient budgeting approach which uses agricultural parish (municipality) level data has been developed. Data used to produce the parish nutrient budgets were drawn largely from government datasets at a range of scales for example, the June Agricultural Census (JAC), and the British Survey of Fertiliser Practice (BSFP) as well as, non-governmental but publicly available data. Farmers were also surveyed to provide farm data such as cropping patterns or livestock numbers and consequently these data were used to cross-reference findings gained through secondary data. The Ythan hydrological catchment is a typical example of an agricultural catchment in Eastern Scotland and is part of one of the first hydrological catchments to be designated as a NVZ in Scotland (Domburg et al., 1998; Raffaelli, 2000). We selected eleven agricultural parishes in the catchment covering cropping and grassland systems and calculated N, P and K budgets pre and post the introduction of the NVZ.

This work has shown that nutrient balances for N (kg N ha-1 yr-1) have largely decreased between the pre and post NVZ implementation periods, in response to a reduction in applications of inorganic N fertiliser. In addition, nutrient balances have shown that P and K deficits have been experienced in some agricultural parishes. It was also identified that better use of excreta in some agricultural parishes post-NVZ could support a further reduction of inorganic P and K use. Moreover, another outcome is the methodology structure itself – the parish level nutrient budget approach is key.

The work has shown that it provides an opportunity to transform agricultural practice and reduce the burden on policymakers and farmers, by linking agricultural management to nutrient surpluses and deficits. It is beneficial because the method re-uses data that is already collected by government. To conclude, the approach has the potential to be used beyond the research period, integrating farmer data and giving farmers a purpose in the process.

References:

Domburg, P., Edwards, A. C., Sinclair, A. H., Wright, G. G., Ferrier, R. C. (1998). Changes in fertilizer and manurial practices during 1960–1990: Implications for N and P inputs to the Ythan catchment, N.E. Scotland. Nutrient Cycling in Agroecosystems. https://doi.org/10.1023/A:1009787618943

Raffaelli, D. (2000). Interactions between macro-algal mats and invertebrates in the Ythan estuary, Aberdeenshire, Scotland. Helgoland Marine Research, 54(2–3), 71–79. https://doi.org/10.1007/s101520050004

Scottish Government (2014). The Nitrates Directive Review of Nitrate Vulnerable Zone Designated Areas in Scotland – 2013, Edinburgh.

Participatory knowledge mapping as a basis of decision making for sustainable agrarian land use systems

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Keywords: Participatory knowledge mapping, social-ecological systems

Agricultural systems world-wide are facing an increasing level of uncertainty and risk in light of unprecedented climate and environmental change. The ecological challenges for agrarian sectors are further complicated by social factors such as growing world population and an expanding demand for biomass-based products. Formalized knowledge structures can benefit from approaches that consolidate informal local knowledge networks in understanding social and ecological change related causal chains (Tengö et al., 2013). This is especially relevant for the research-policy interface concerning sustainable agrarian system management.

As part of the junior research group TRANSECT, which investigates the social-ecological effects and interdependencies of agrarian transformations in Central and South Asia, a framework for knowledge mapping on sustainable land use systems is under development. We aim to bring together knowledge from local land users and other relevant stakeholders to develop future policy scenarios related to bio-based economy in the agrarian sector and to critically assess their social and ecological consequences on the ground. Our proposed framework is inspired by previous experiences with the MARISCO method (Ibisch and Hobson, 2014; www.marisco.training), a methodology for the adaptive management of risk and vulnerability, developed at the Center for Econics and Ecosystem Management in the Eberswalde University for Sustainable Development. This approach has been applied in various projects of natural resource management as a tool that allows the collection of complex and diffused knowledge from different sources, and to structure, evaluate, and prepare for the development of integrated solutions. The visual presentation of existing knowledge in the form of 'knowledge maps' that raise awareness of ignorance, and the systemic identification of knowledge gaps and risks are central features of MARISCO method (Ibisch and Hobson, 2014).

While the original methodology provides an established and proven toolbox for evaluating the ecological dimension of complex socio-environmental challenges, our inspired methodology elaborates on the social dimension of environmental and societal threats as well as policy interventions, for which we find it crucial to put a stronger emphasis on equity. In contrast to the more ecosystem-focused MARISCO method, a central feature of our approach is a socially differentiated analysis that distinguishes between different social groups or strata when evaluating social (and ecosystem) services and the (social) impact of stresses or threats.

We will introduce and elaborate on our proposed participatory and socially differentiated approach for knowledge mapping on sustainable land use systems with illustrative examples from experiences in Central Asia. As our current experience shows, a key challenge in designing and implementing such approaches is to take social-ecological complexity seriously while keeping the method manageable for regular workshop settings without overburdening participants.

References:

Ibisch, P. L., Hobson, P. R. (eds.) (2014). MARISCO: adaptive MAnagement of vulnerability and risk at conservation sites. A guidebook for risk-resilient, adaptive and ecosystem-based conservation of biodiversity. Eberswalde: Center for Econics and Ecosystem Management.

Tengö, M., Malmer, P., Brondazio, E. et al. (2013). The multiple evidence base as a framework for connecting diverse knowledge systems in the IPBES. Stockholm Resilience Centre (SRC), Stockholm, Sweden.

SESSION 1:

CROPPING AND GRASSLAND SYSTEMS

1.3 Knowledge Synthesis to obtain robust scientific evidence on the impacts of crop diversification

Convenors:

Marta Pérez-Soba, European Commission Joint Research Centre

David Makowski, INRAE, Paris, France

Crop diversification is promoted to increase biodiversity while providing various ecosystem services, through different practices such as crop rotation or intercropping. Unfortunately, the diversity of crops is being lost at an alarming pace mainly due to the intensification of agriculture. As a result, scientists and policy makers around the world have a renewed interest in promoting crop diversification. However, there is still a lack of sound scientific evidence to determine the best diversification strategy (e.g., intercropping, agroforestry, rotation) and the level of diversification required (e.g., number of crop species in a rotation) to achieve tangible environmental and climate impacts. Knowledge synthesis is a rapidly developing research field in both the environmental and health sciences for evidence-based policy. This session will illustrate novel applications of knowledge synthesis methods, such as systematic literature reviews, meta-analysis, evidence map, text mining, to obtain robust evidence and identify knowledge gaps, about the impact of crop diversification practices on biodiversity, environment, and climate change. We will discuss their advantages and limitations, particularly to match the short term demands of policy with the best available scientific evidence. All contributions presenting the results of knowledge syntheses regarding one or more diversification strategies are welcome in this session.

Orals

The impacts of Agroforestry on climate, environment and crop yield: scientific evidence from multiple meta-analyses

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Identifying sustainable agricultural practices for policy development requires a rigorous synthesis of scientific evidence based on the experiments carried out around the world. Meta-analysis (MA) has become a reference method of quantitative research synthesis, and the number of MAs published in the field of agricultural science has increased markedly over the past two decades. The growing number of MAs available gives us the opportunity to provide agricultural policy-makers with the evidence they need to make decisions based on large number of available results. Here, we propose a methodological framework for assessing farming practices based on an "umbrella review" of published MAs. The framework includes six steps: 1) search available systematic reviews or meta-analyses; 2) select using exclusion criteria; 3) identify impacts on climate, environment and crop yield assessed in the MAs; 4) full text analysis; 5) data extraction for each type of impact; and 6) reporting. We illustrate this framework for agroforestry. The search returned 57 systematic reviews, from which w finally selected 33 MAs assessing the impacts of agroforestry on several key environmental outcomes (biodiversity, carbon sequestration, soil nutrients, soil erosion, reduction of pests and diseases, pollination, water retention) and on crop yield. The systematic review of the MAs provides strong evidence for an overall positive effect of agroforestry on the climate and environmental impacts, when compared to land use without trees (i.e., croplands and pasturelands). However, when compared to forests, the evidence shows a negative effect of agroforestry on carbon sequestration and biodiversity. Results obtained on crop yield are variable. The proposed framework can be implemented quickly, within timeframes compatible with the demands from policy makers, while limiting the risk of bias in impact assessments of agricultural practices.

The impact of crop, farming and agricultural diversification on food security in low- and middle-income countries: Where is the evidence?

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Diversity and diversification in agricultural systems are often presented in the literature as having benefits for multiple purposes such as enhancing resilience, increasing food production and decreasing risks in production systems and is often postulated to benefit food and nutrition security in low- and middle-income countries. Our study aims to provide an overview of the potential for agricultural diversification to improve food security status as reported in 87 research articles analysing the diversity-food security relationship. We consider results for different scales, from individual to global and for different food security dimensions: availability, access, stability and utilisation.

We carried out a literature review that includes exhaustive, comprehensive searching. We search for peer-reviewed publications in the Web of Science core collection (v.5.32) written in English, between 2010 and February 2020 on the association between diversity in agricultural systems and at least one dimension or measure of food security. From the original list of articles we exclude all publications that (1) focus on a study area outside a low- to middle income country; (2) did not include at least one metric of farm-, regional-, or global-level diversity as specified with the search terms; (3) did not explicitly measure at least one food security dimension, or (4) were exclusively focussed on describing drivers and trends in diversity or food security.

We find 328 diversity-food security relationships analysed in 87 research articles using one or more statistical modelling approaches. About half of them are positive (54%) and mostly refer to the diversity-food access relationship on the individual, household and farm scale as this was the food security dimension and spatial scale most analysed. Of all results for food access 60% were positive relationships and only 4% were negative relationships with the remainder having no or ambiguous relationships. Twenty-nine studies used household dietary diversity as a measure of food access and 10 studies used at least one food access indicator validated as a proxy for nutrient adequacy. Positive relationships were more often reported for food availability (65%) than for food utilisation (33%) also because for food utilisation there are a lot of mixed findings for different measures of anthropometric and nutritional status. The most common spatial scale assessed was the household and farm scale (58%).

There is no food security dimension that primarily has a negative relationship with agricultural diversity but there is a considerable number of relationships that are found to be neutral or ambiguous. Diversity can be an important driver of social and environmental outcomes and of food security, but the magnitude of the contribution depends on the broader socio-economic and biophysical characteristics of the local farming system. We conclude that farmers mostly see diversification as a potential strategy to improve livelihoods, agricultural production and/or food and nutrition security where other strategies are more expensive but not as a desirable characteristic of the agricultural systems at all costs especially in the presence of other strategies that can achieve the same outcome.

Research topics in crop diversification research at the landscape level: early evidence from a text mining approach

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Keywords: Agricultural landscapes, review

Crop diversification has many benefits both at the cropping system and the food system levels and has been addressed in agricultural research (Hufnagel et al., 2020). Landscape design and management in agricultural regions can support crop diversification by building bridges with scientific domains like ecology and geography (Benoit et al., 2012). Though, little is known on how the research community has addressed crop diversification from a landscape perspective. In this paper we investigated a bibliographic corpus retrieved from the Scopus database papers coupling crop diversification and landscape (in title, abstract and keywords), retrieving 461 papers for the period 1990 to 2020. The corpus was analysed using the CorText platform (e.g., Ruiz-Martinez et al., 2015). First, natural language processing was used to extract multi-terms from title, abstract and keywords. Then, we mined the temporal dynamics and co-occurrence of the 100 most frequent terms. Our findings showed that species richness emerges as the main topic in this corpus and that natural enemies, crop types and natural control increased in importance. In the last years, genetic diversity, climate change and agricultural production also gained attention. On the contrary, land use and some of the terms related to diversity (landscape, plant and farmland) were marginal or decreasing. By analysing the terms co-occurrence on the three decades, we observed that the papers addressing crop varieties and agroforestry system split into two streams: one about agricultural production in relation to climate change and the other about farm size and land use. Instead, the functional diversity and field margin disappeared from recent literature. Land use patterns and landscape diversity converged mainly on studies about biological pest control. Altogether, the corpus highlighted that the spatial configuration lost importance when addressing crop diversification. In addition, the species diversity gained attention finally catching a large part of the literature in the corpus. From a landscape approach perspective, we might point out the apparent lack of a major topic: the involvement of local communities and stakeholders. Our simple and rapid text mining approach yielded early evidence of knowledge gaps about the landscape level in crop diversification literature. The expected contribution of approaching the crop diversification at the landscape level would be to provide a relevant framework for the characterisation of the baseline system to be diversified. In particular, the landscape agronomy perspective stressed the need to define the scale and target area for crop diversification consistently with (natural and cultivated) species diversity embedded in a local socio-technical system.

References:

Benoît, M., Rizzo, D., Marraccini, E., Moonen, A. C., Galli, M., Lardon, S., ..., Bonari, E. (2012). Landscape agronomy: a new field for addressing agricultural landscape dynamics. Landscape ecology, 27(10), 1385–1394.

Hufnagel, J., Reckling, M., Ewert, F. (2020). Diverse approaches to crop diversification in agricultural research. A review. Agronomy for Sustainable Development, 40(2), 1–17.

Ruiz-Martinez, I., Marraccini, E., Debolini, M., Bonari, E. (2015). Indicators of agricultural intensity and intensification: a review of the literature. Italian Journal of Agronomy, 10(2), 74–84.

Case study Lower Saxony – more than 30 years of action against water pollution with nitrates: all in vain?

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Research Question: The German federal state Lower Saxony is characterized by intensive animal production and a large number of biogas plants. The spreading of manure and digestates exerts strong pressure on water quality. Catch and cover crop(c&c) cultivation is one measure to reduce nitrogen leaching and run-off. Since the early 90ies, the cultivation of c&c was supported by various schemes. During 30 years, water suppliers and politicians opted for cooperation and voluntary measures combined with financial or technical support to increase c&c cultivation. However, drinking water quality mostly stagnated, despite increasing efforts and costs. We therefore ask whether subsidising c&c as voluntary measure is a cost-efficient strategy to improve drinking water quality.

Materials and Methods: Various regional reports are available which analyse c&c schemes during the last decades. We conduct a document analysis and combine our findings with available quantitative data. We review scientific papers as well as grey literature and reports to thoroughly evaluate the different programmes, such as cooperations, agri-environmental or greening measures.

Results: C&c cultivation started in water protection cooperations on a voluntary basis, supported by advisory services. Approximately 15 years later, c&c cultivation was added to the portfolio of agri-environmental measures (AEMs) as second pillar of the CAP. Since 2015, c&c cultivation became the most popular greening measure, resulting in a further increase of c&c area. Altogether, implementation costs are high with 4.0/11.9/143.7 mio €/year (cooperations, 40.000 ha in 2016/AEM, 143.100 ha in 2015/greening, 276.400 ha in 2015). The particular high subsidy level for c&cs as greening measure explains by the relation of the greening fee to the total UAA of a farm in case conditions are fulfilled. After the introduction of the greening, the AEM-scheme was adapted and focussed on winter hardy, legume-free catch crops with restricted fertilization.

With respect to c&c as AEM, Reiter et al. (2016) concluded a low cost-efficiency and a windfall effect, as prior to 2017 it was eligible to fertilize cover crops in late autumn – also with manure. The reason why particularly c&cs are popular as greening measure in Lower Saxony also is linked to their good fitting into traditional cropping patterns. While groundwater quality increased for a while since one decade this trend reversed.

Recently, with the changes in legislation on fertilization, 24.5% of the UAA in Lower Saxony was identified as vulnerable area, in which, from 2021 onwards, catch crop cultivation before planting summer crops is compulsory. Moreover, with the CAP reform beginning in 2023, an enhanced conditionality includes as “GAEC7” the requirement of “no bare soil in most sensitive period(s)“.

Due to pressure from European environmental legislation, a new strategy in Lower Saxony is apparent, putting stronger emphasis on mandatory, full-coverage measures. Evaluating the rate of c&c cultivation in Lower Saxony we conclude, that measures like c&c cultivation over winter, which are simple to introduce and easy to control, are increasingly implemented as mandatory measure to achieve a wider uptake.

SESSION 1:

CROPPING AND GRASSLAND SYSTEMS

1.4 Cropping system diversification with legumes

Convenors:

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Frederick Stoddard, University of Helsinki, Finland

Christine Watson, Scotland's Rural College (SRUC), United Kingdom

Etienne-Pascal Journet, CNRS/INRAE, France

Nynke Schulp, Vrije Universiteit Amsterdam, The Netherlands

Daniel Plaza-Bonilla, University of Lleida (UdL), Spain

Sonoko D. Bellingrath-Kimura, Humboldt-Universität zu Berlin, Germany

Legumes contribute to the diversification of cropping systems and farm businesses, enhancement of sustainable diets, reduction in fertilizer and pesticide use, mitigation of greenhouse gas emissions, and prevention of biodiversity loss. Despite these widely recognized benefits, legume production is often low, underdeveloped or part of unsustainable systems, partly due to inadequate value chains and low yields with high fluctuations compared to cereals. To ensure food and nutritional security under climate change and reduce pressures on natural resources, the full potential of legumes to diversify agricultural systems should be utilized.

This session will contribute to further explore the potential of legumes in cropping systems by

- identifying the contribution of relatively neglected species (e.g. soybean in cool regions),
- evaluating novel management practices (e.g. intercropping, no-tillage),
- using farmers' knowledge to help close the yield gap and protein shortfall,
- reducing the observed yield variability, and
- optimising the environmental performance.

We call for contributions with a systems approach, where biophysical and socio-economic limitations, opportunities, and their interaction are considered. Contributions can include different methodological approaches, field experiments, modelling, surveys, co-design with farmers and other stakeholders in the value chain, and analyses of big data. We especially encourage early career scientists to use this opportunity and submit posters and presentations to this session.

Orals

The role of farmers' knowledge in closing the yield gap for legumes: results of a large scale EU survey on faba and soya beans

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The potential of legumes to simultaneously contribute to several production, environmental, and nutritional objectives, is well known by science and policy. Legumes are currently underutilized, despite their high potential to increase the resilience of cropping systems and farm businesses through diversification and to enhance the sustainability of cropping systems via reduction in fertilizer and pesticide use, increase in protein self-sufficiency, and contribution to healthy diets (Watson et al., 2017).

The low shares of grain legumes in current agricultural systems are often attributed to yield gaps and high yield variability in legume production (Cernay et al., 2015; Reckling et al., 2018). These phenomena are associated with numerous and diverse factors, such as limiting pedoclimatic conditions, sub-optimal management practices, low investments in breeding, occurrence of pests and diseases, and farmers' experience, knowledge, and attitude in growing grain legumes. The relative contribution of these different factors on current yield gaps and yield variability remains underexplored. In particular the 'knowledge gap', as we term the difference between yields achieved by experienced farmers and those achieved by novices, requires assessment in order to evaluate the potential contribution of knowledge in closing the yield gaps and reducing yield variability in grain legume production.

The LegumeGap project analyses the different components and underlying factors of the legume yield gap, in order to propose appropriate interventions. To this purpose, a large-scale farmer survey was conducted in nine European countries to explore the effect of different yield gap factors and evaluate, for the first time, the influence of farmers' knowledge on yield gaps and yield variability. The survey focused on faba and soya beans, two crops with high production and environmental potential, growing popularity, broad adaptability and high protein concentration in the seeds. It was conducted in countries that comprise areas with different history in cultivating faba and soya beans in north-western (Finland, Sweden and Latvia), north-eastern (UK and Netherlands), central (Germany and Poland), and southern Europe (France and Spain). The survey was run between February 2020 and May 2021.

In this talk, we will present results of the survey on:

- The relative role of different factors (climate, soils, cultivars, management, pests and diseases, knowledge, attitudes) on yield gaps for faba and soya beans.
- The interactions between these different factors.
- The relationship between achieved yields and various indicators of experience, knowledge, and attitude of growing the crop.
- Farmers' outlook for the future of grain legumes in Europe.
- Country and regional differences on all the above.
- Recommended actions for closing yield gaps.

Our study identifies the role of knowledge, amongst other factors, in closing the yield gap of grain legumes and provides valuable insights for improving the uptake and cultivation of grain legumes in the future.

Does glocalism work? Identifying spatial (mis-)matches between the local demand for and local production of legumes in Europe

Franziska Komossa[1]; Marthe Derkzen[2]; Nynke Schulp[1]; Daniel Plaza-Bonilla[3]; Sonoko D. Bellingrath Kimura[4]; Christine Watson[5]; Marloes van Loon[2]; Moritz Reckling[4]; Peter Verburg[1]; Frederick Stoddard[6]

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While there is a large demand for legumes in Europe, supply currently depends on the import of large quantities mainly from South America. With regards to soy bean meal for instance, EU is 5% self-sufficient compared to 79% for rapeseed meal. In recent decades, so called 'glocal' food movements have, with increasing reverberation – and only more so since the COVID-19 crisis, advocated the advancement of localized food chains of production and consumption of various crops. Increasing European legume production would contribute to a sustainable future for European agriculture with greater crop diversity in agrarian landscapes, and higher carbon storage and nitrogen fixation. It would also stimulate an efficient global distribution of labour and fair trade.

In this study we investigate the potential of 'glocal' legume food chains in Europe. We identify spatial (mis-)matches in local production of and demand for legumes in Europe using spatial analysis. Maps for potential legume production are based on modelled yields of various legume types for an expert selection of European land systems. Maps for actual legume demand are based on spatial indicators for human consumption and animal feed using national and European statistics for legume consumption.

Our results are a first audit of the potential for localized legume food chains in Europe. The identified spatial (mis-)matches will show the possible alignment of legume production and their consumption in terms of animal feed and human consumption. Based on these findings, we will recommend several science-policy pathways to improve this alignment, and with that, help facilitate the transition to a sustainable agricultural future in Europe.

Legumes are specialists in the root economics space

Joana Bergmann

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Keywords: Root traits, legumes, mycorrhizal fungi

During the last decades ecologists accumulated immense amounts of data on plant features to characterize species based on their functioning rather than their evolutionary history and position in the tree of life. These 'traits' are measured at the individual level and are widely used to describe community shifts along environmental gradients, functional biodiversity or species-specific ecological strategies. In 2004 Wright et al. coined the term 'leaf economics spectrum' to describe a major gradient of variation in plant strategies worldwide: Plants vary along a gradient between two opposing economic strategies. They either invest in relatively cheap but short lived leafs for fast uptake of atmospheric carbon or they slowly build more costly leafs that are better protected and hence assure a longer rate of return on investment. This fast-slow economic trade-off has been assumed to also occur in belowground fine roots which take up water and nutrients from the soil. Recently, it has been shown that root traits and their corresponding ecological and economical strategies vary along multiple dimensions which together build the 'root economics space' (Bergmann et al., 2020). This space encompasses a conservation gradient from fast to slow, analogous to the leaf economics spectrum but also a collaboration gradient that refers to a plants´ economic strategy that is unique to the belowground resource uptake: the outsourcing to a fungal partner. Plant strategies and the corresponding root traits thereby vary between outsourcing and do-it-yourself. Globally, plants associated with nitrogen-fixing bacteria – mainly legumes – occupy an area in the root economics space ranging over the entire collaboration gradient. Along the conservation gradient they significantly shift towards 'fast'. This is mainly because of the fact, that their roots are rich in nitrogen which accompanies the fast strategy as a proxy for metabolic activity. Within nitrogen fixers itself, the collaboration gradient is clearly the largest source of variation in fine-root traits. Recent results suggest that within this collaboration gradient an efficient do-it-yourself strategy can also be achieved by increasing length and incidence of root hairs at the acquisitive fine roots. In an experiment with German grassland species, interspecific variation of these traits was found to be highly phylogenetically conserved with legumes representing a taxonomic group with few and short root hairs compared to grasses and forbs. Resource uptake is assured by strong mycorrhizal collaboration characterized by high colonization rates. Interestingly, legumes show a higher intraspecific variation in root-hair incidence than grasses and forbs. When taking a closer look, it appears that intraspecific plasticity of root hair incidence follows the same trade-off as interspecific variation: Individuals that are less colonized by mycorrhizal fungi have more root hairs. This might be a mechanism characteristic for outsourcing plants such as legumes that compensate the lack of nutrient uptake when the fungal partner is absent or less effective. The extent to which this mechanism is balancing the lack of nutrients delivered by mycorrhizal fungi remains to be tested.

References:

Bergmann, J. et al. (2020). https://doi.org/10.1126/sciadv.aba3756

Wright, I. J. et al. (2004). https://doi.org/10.1038/nature02403

Climate change impacts and possibilities of adaptation for soybean cultivation in France

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The soybean acreage has increased in France over the last 12 years, shifting from 22,000 to 186,000 ha. This increase has been possible thanks to several agronomic and environmental benefits the crop provides (low pesticide inputs, symbiotic nitrogen fixation, water use efficiency, low GHG emissions) and its high grain protein concentration (~41% DM). The context of global warming results favourable to the expansion of the crop toward northern parts of the country, supported by the market availability of early maturing varieties. At the global level, soybean yields appear to be less affected by climate change compared with those of other field crops (wheat, maize), due to the availability of irrigation water and/or intensive cropping across humid tropical climates. Our objective was to assess the impacts of climate change on the soybean cropping potential that helps diversify current cropping systems and look for the possibilities of adaptation, in temperate pedo-climatic contexts such as those in France. Our work is based on ecophysiological and agronomic studies carried out in southwestern France. To this objective, a simple phenology algorithm has also been developed for predicting the phenological stages and positioning of crop cycles while the STICS crop model has been evaluated and optimised for soybean (including an original approach using regression models for yield prediction).

We showed that soybean establishment could be affected with late sowings, as drought stress in the seedbed tends to increase in these periods under climate change. Several agronomic levers have been evaluated for the adaptation of soybean crops to climate change. Phenotyping showed varying stomatal responses to water deficit among a range of varieties, indicating potential availability of cultivars better adapted to different drought scenarios. Some root traits and early vigour have also been proposed as indicators of drought tolerance. Moreover, early sowing allows summer drought escaping and reduces irrigation water requirements. On average, early sowings provide yields that are slightly lower than those of the conventional one while the grain protein content is higher in early sown crop. While irrigation water use efficiency is very good in soybean (0.8–1 t/ha per 100 mm applied) with 30–50 mm lower water need than for maize, soybean crop development under climate change will depend on the availability of future water resources.

The lengthening of the growing season due to global warming allows soybean to be cultivated as a double crop (sole or relay crop) following a cereal. Field trials are ongoing to assess the feasibility, current and future performance, and stability of these new systems. Finally, inter-comparison of crop models (including STICS) is being carried out on an international scale within the AgMip project to explore the impacts of climate change and propose adaptation measures.

Within the Era-Net 'LegumeGap' project we study, in collaboration with other European research groups, the current and future potential of soybean crop introduction into the current cropping systems as main crop and double crop, with regard to agronomic performance (incl. attainable yield and yield gap), and contribution to protein self-sufficiency in Europe.

Effects of increased soy cultivation on ecosystem services and land use in a central European region

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Keywords: Ecosystem services, soy cultivation, multi-objective optimization, land use allocation

In recent years, a debate about the cultivation and trading schemes of soy products has emerged among scientists, policymakers and the public. Above all, export-orientated soy production is associated with large-scale deforestation and ecosystem destruction in exporting countries in South America. Nevertheless, soy is an essential source of animal fodder in the EU. Hence, various policymakers are developing schemes to support and enhance sustainable domestic soy cultivation. For instance, in the State of Bavaria, Germany, an initiative engages with the uptake of protein plant plantation by means of crop science and promotion of local supply chains. However, little attention has been brought to the opportunities to enhance soy cultivation in areas that both provide successful yield and promote environmental benefits from introducing soy plantation.

Therefore, we explored possibilities for soy expansion in Bavaria from an ecological perspective by applying the spatial optimization tool CoMOLA. The aim was to select “ideal” crop areas for soy cultivation where the delivery of ecosystem services associated with soy can be enhanced. Hence, we formulated four objectives that cover different impacts of soy on ecosystem services, including food production, erosion prevention, water purification and biological control. We utilized spatial environmental data to assess the fitness of the available agricultural fields in terms of the objectives. The spatial optimization resulted in a Pareto Front of soy allocation options that show trade-offs and synergies among the ecosystem services that are related to soy cultivation in the particular region. The spatial realization of the optimal solutions visualized synergies between food production and water purification as well as between erosion prevention and biological control. Trade-offs occurred between food production and erosion prevention and biological control, while the trade-offs between water purification with the two latter services were less pronounced. These results imply that the environmental benefit of nitrogen fixation from soy plants can easily be reconciled with food productivity, whereas the benefits from the diversification of crop rotations can be exploited best in areas of Bavaria with lower soy yields.

Besides analyzing possible allocation options for enhanced soy cultivation in Bavaria, we discussed potential implications of this process. It was noticed that increased soy plantation could locally displace other crops, which could in turn lead to changes in cultivation patterns as well as indirect land use changes. Here, the strongest concern was found to be the potential competition for land between food and fodder production from soy and bioenergy production from maize.

The potential of soybean to diversify highly productive irrigated Mediterranean cropping systems

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Keywords: Soybean cultivars, weed management

In the dry and hot Mediterranean areas, irrigation enlarges both the range of potential crops and the period to grow them. In Spain, 22% of the agricultural surface is irrigated. Arable crops represent around 40% of these areas, being grain cereals the main ones. Cereals are continuously grown as single or double cropping systems (SCS and DCS with one or two cash crops per year, respectively), consisting of a winter cereal or maize (SCS, it can include a cover crop during fallow periods) or winter barley followed by maize (DCS). Continued cereal growing may lead to agronomical and environmental drawbacks such as nitrate leaching (Cavero et al., 2003) or increased weed and disease pressure because of scarce crop diversity (Krupinsky et al., 2002). Although there are some well-known alternative grain crops for the winter season (e.g. pea, canola, etc.), little is known about summer alternative grain crops and their management. Soybean is a summer grain legume, with high protein content and large market value and could therefore present great potential for SCS and DCS.

To assess soybean production feasibility and maximize its yield, we set up two field experiments in northeast Spain devoted to the evaluation of different cultivars and management practices. We evaluated 22 soybean cultivars (maturity groups: 00 to II) for SCS and DCS during summer 2019 and 2020. The experiments, flood irrigated and set up in fine-textured soils were arranged in a randomized complete block design with four replications. Five-year mean annual air temperature and precipitation were 14.4 ºC and 405 mm, respectively. Among others, biomass accumulation, phenology stages, and grain yield were measured. Photothermic time to each phenological stage was calculated for each cultivar. Besides, an on-farm experiment was established (April 2019 – November 2020) under solid set sprinklers irrigation in a clay-loam soil. At this site, five-year mean annual air temperature and precipitation were 14.4 ºC and 352 mm, respectively. Four cropping systems were compared, including soybean in SCS and DCS after barley. In summer 2020, within the SCS soybean; row width (75 vs. 37.5 cm), chemical weed control (yes/no) and use of rye cover crop terminated with roller-crimper (yes/no) were assessed in a Split-Split-Plot design with four replications. Soybean emergence, biomass, grain yield and weed soil coverage throughout the season were measured.

Results from 2019 and 2020 and under SCS and DCS showed that the longer the crop cycle, the greater the yields i.e. cultivars of MG II had higher yields than cultivars of MG 0 and I, although the latter were normally recommended in the area studied. During the crop development, the use of cover crops or chemical control successfully controlled weeds. Out of 30 weed species detected, only Chenopodium album L. Bosc, Datura stramonium L. and Amaranthus spp. caused severe infestations in treatments without chemical control or rye cover crop. Our results demonstrate that soybean production is feasible when using cultivars able to exploit all the potential growing period and innovative management practices (such as cover crops).

Agro-economic and environmental benefits of integrating legumes into European cropping systems

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Integrating grain and forage legumes into cropping systems can improve their environmental performance and resource-efficiency, as well as increase the protein self-sufficiency of Europe. There is the need to evaluate the overall effects of legumes in crop rotations and to foster discussions with stakeholders about their benefits and challenges. Within Legumes Translated, a thematic network in Horizon 2020, a multi-criteria assessment framework was applied linking research and practice-based actors to assess the role of legumes in crop rotations under real farm situations. A range of legume-experienced actors all over Europe represented value chains with soybean, pea, faba bean, lupin and forages for food and feed. They provided relevant cropping systems with and without legumes which were evaluated in three impact areas – economy, environment and production. The assessment results allowed comparisons between legume-supported and reference cropping systems and showed on average across all regions more benefits in the environmental impact area for cropping systems with legumes. Crop rotations with legumes reduced nitrous oxide emissions by 21% and 26% and N fertilizer use by 26% and 45% in arable and forage systems, respectively. While protein output was increased by 13% and 5%, energy output was reduced by 10% and 9% in arable and forage systems. There was no evidence for an increase or decrease in yield stability for legume-supported crop rotations. Gross margins were variable, site specific and clearly increased when considering the legume feed value, subsidies for legumes and CO2 taxes in different scenarios. The results provided evidence for benefits and disadvantages when integrating legumes into cropping systems and highlighted the advantage for involving local actors to place the potential of legumes in a regional context.

Performance of locally isolated Bradyrhizobium strains on soybean growth in cool growing conditions of Northeast-Germany

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Soybean (Glycine max [L.] Merr.) consumption as food and feed for livestock in Europe has increased significantly in the last few decades, although domestic production has increased marginally. In Europe, commercial inoculants are employed to inoculate field-grown soybean plants. However, nodulation efficiency has often been low compared to the origin where the strains were isolated. To enhance biological nitrogen (N) fixation and increase domestic legume production, native or established rhizobia strains that can effectively adapt to local conditions could be targeted for the development of inoculants. The objective of this study was to assess the ability of locally isolated Bradyrhizobium strain(s) to enhance soybean productivity in varying growing conditions of Northeast Germany. Three Bradyrhizobium isolates (GMF14, GMM36, GEM96), which were isolated from German soils were tested in combination with three soybean cultivars (Merlin, Sultana, Siroca) in field and greenhouse experiments in 2019 and 2020. Non-inoculated soybean was set as negative control and a reference Bradyrhizobium diazoefficiens USDA110 inoculation was set as a positive control. Two moisture levels were set for the pot experiment, i.e. irrigated condition (80% field capacity) and drought condition (40% field capacity) using soil from the same location as the field experiment. Soybean plants were cultivated under rainfed conditions in the field experiment.

Independent of the Bradyrhizobium strain, inoculated greenhouse-grown soybean plants showed high nodulation, and that corresponded with increased N uptake compared to field-grown soybean. Inoculation resulted in up to 68% higher shoot N uptake in the greenhouse and up to 39% in field conditions compared to the non-inoculated control. Consistently higher significant nodule number and nodule dry weights were observed in GMF14 and GMM36 under irrigated conditions. However, under drought conditions, minimal differences in nodulation were observed among the strains. Inoculation with strain GEM96 induced the highest nodulation in field conditions.

Altogether, inoculation with the present strains significantly increased protein content and grain yield up to an average of 24% and 32%, respectively compared to the non-inoculated control. While USDA110 was consistent in improving the grain yield of both Sultana and Siroca, GMM36 and GEM96 inoculation to Sultana and Siroca, respectively resulted in similar yields. The ability of the present isolates to induce nodulation and enhance soybean yield to a similar extent as the standard strain in field conditions suggests their potential use as inoculum to increase soybean cultivation. There is a need to invest more in identifying more effective strains from sites with longer field-grown inoculated soybean cultivation histories as they could provide a means to expand the pool of inoculum resources in Europe.

Short-term mixture effects on various agroecological services in a model of two legume species

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In intercropping systems, increased species diversity is a strategy to buffer agro-ecosystems against environmental disturbance, securing higher productivity, weed management, and stress resistance in the long-term. Nevertheless, the potential advantages of mixing plant species depend on the number of the mixed species, species traits, species density, and field management practices. Practically, in arable systems, mixing cereals and legumes is adopted to assure complementarity with different functional groups. However, evidence of mixture effects (MEs) in only-legume mixtures remains scarce. We selected two legume species, alsike clover (AC; Trifolium hybridum L.) and black medic (BM; Medicago lupulina L.), as a model, to understand the role of species asynchrony and response diversity on seed germination, weed suppression, allelopathy, drought resistance and resilience. While both species belong to the same functional group through their ability to fix nitrogen, the selection was done to maximize the functional complementarity with respect to the response to water availability ('response diversity'). AC is described as a slow-growing drought-sensitive perennial, best adapted to cool and wet areas. Conversely, BM is a fast-growing perennial and well-adapted to warm and dry areas. Different trials were conducted to determine MEs on the above targeted agroecological services. On average of two field experiments and three harvest times, no ME was detected on crop biomass demonstrating that adaptability and plasticity of AC and BM to the environmental variability would cancel out the effect of species asynchrony or response diversity. Only in one year, with stressful soil and weather conditions, a significant ME was observed on weed suppression. In a series of pot and lab trials, comparing a 1:1 mixture against the two monocultures demonstrated an allelopathic ME of root leachates on the overall growth of both legume species indicating autotoxicity and heterotoxicity. Also, an allopathic ME was observed on the weed fat-hen (Chenopodium album) but not on barnyard grass (Echinochloa crus galli) indicating a selective allelopathic effect. Furthermore, in response to a constant drought, no ME was detected suggesting that triggering the stress memory by the slowly imposed drought may allow adapting to dry conditions for both species and canceling out any positive ME. However, after a transient drought, a significant ME was detected on drought resilience due to the high resilience of AC that was, additionally, able to show resilience to drought in the monoculture, namely without response diversity. Besides, during seedling growth both positive and negative MEs on germination were observed, with the direction of the ME depending on abiotic context. We conclude that, in the short term, in this only-legume mixture, species identity may be more important than species diversity. The contributions of species asynchrony and response diversity to agroecological services are time and condition dependent and may be of less importance when the mixed-species possess high adaptability and plasticity to the varied conditions. Concluding, designing mixtures based on species-specific traits may improve sustainability by increasing the ability to resist or rebound in the face of unexpected effects of climate change.

Measures for biodiversity in legume-grass leys – practice, success and future perspectives

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Keywords: Small-scale measures, field birds, skylark, flower-visiting insects, organic farming

Agricultural management is a key factor for the preservation of wild plants and animals and their habitats. The 'Farming for Biodiversity' project is designed to improve biodiversity on organic farms (Gottwald and Stein-Bachinger, 2018). Specific measures are currently being implemented into common practice on 140 farms (2021, 52,000 hectares) and evaluated. Here, we examine the effects of organic farming and conservation measures in legume-grass leys.

The decline of common species such as the skylark is alarming. Their abundance on organic arable fields was high on a landscape level with distinct differences between various field crops. Legume-grass leys are very attractive for skylarks and serve as an important breeding habitat because of high abundance and extended suitability for breeding. But frequent mowing in legume-grass leys poses a risk for ground breeding birds. An undisturbed period of about 8 weeks before or between the first and second cut is necessary for sufficient skylark reproduction. In 35% of the suckler cow farms in the project, the 8-week period is implemented at least on parts of the farmland. Dairy farms can hardly implement this measure because of their need for a high fodder quality.

Blossoms of fodder legumes are highly attractive for various insects foraging on nectar. When legume-grass leys are cut, the supply of nectar resources suddenly disappears on a large scale. Butterflies and bumblebees benefited significantly from unmown strips: after mowing they almost completely left the mown sites, whereas their abundance in unmown strips increased many times over. The positive effect of the strips was highest on field edges bordering south exposed hedges.

Conclusions: Organic farming per se is much more favourable for biodiversity than conventional farming (Stein-Bachinger et al., 2020). Nevertheless, targeted measures additionally improve reproduction conditions and promote specialized species. Sound consultation for the farmers is essential for the effective design and positioning of measures on the farms. Agri-environmental schemes are required to support measures for biodiversity in legume-grass leys.

References:

Gottwald, F. and Stein-Bachinger, K. (2018). Farming for Biodiversity – a new model for integrating nature conservation achievements on organic farms in north-eastern Germany; Org. Agr. 8, 79–86.

Stein-Bachinger, K., Gottwald, F., Haub, A., Schmidt, E. (2020). To what extent does organic farming promote species richness and abundance in temperate climates? Org. Agr. https://doi.org/10.1007/s13165-020-00279-2

Mobilisation of functional properties of diverse legumes species at various scales in the CA-SYS Long Term Experimental Platform on Agroecology: expected services and prospects

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Agroecological principles are to value the ecosystemic services delivered by enlarged planned and natural biodiversity to sustain regulation and support services for agricultural production. Maximizing the biological functions provided by biodiversity requires to profoundly re-design agricultural systems, considering the management of both cropping systems within cultivated fields and their surrounding semi-natural habitats.

INRAE has recently set up an ambitious long-term Agroecological System Experiment platform CA-SYS (www.inrae.fr/plateforme-casys) that covers 125 ha near Dijon, France. It tests several prototypes of pesticide-free agroecological systems using cropped and wild biodiversity as mean to produce, targeting multi-performance from an agronomic, economic, environmental and social point of view. These new agroecological systems comprise fields of the four tested cropping systems and their interactions with adjacent semi-natural habitats in the landscape. Four cropping systems combining a large diversity of farming practices were co-designed with a vast array of actors (farmers, extensions, researchers) to explore two main agricultural ways (with two different prototypes for each way) : i) no-plowing and cover crop based-systems inspired from conservation agriculture; ii) tillage and cover crop-based systems inspired from organic agriculture. These two options require to finely tune and manage biodiversity, across time (through crop rotations), and space (with species or variety mixtures), both within fields and their margins. All systems were designed to maximise the use of biological processes to halt pesticides and to drastically reduce the dependency to nitrogen and water. Legumes have a specific role to play in the delivery of the expected services. One of the tillage-based system of CA-SYS targeting auto-fertility ban fertilization with exogenous mineral N inputs. Still, the cropping system has to be finely managed to limit potential losses and pollution linked to their shallow root system and to this surplus of N mineralisation. Especially, spatial and temporal arrangement with other crops should target a better synchronization between this nitrogen supply and other plant needs and ability to retrieve it.

Diversifying rotations with legumes contributes to break the biological cycle of pests and diseases frequently encountered in simplified cropping systems. Nevertheless, increasing the proportion of legumes in the rotation may increase their specific pests and diseases. As dicotyledonous plants with flowers often rich in nectar, legumes are major plants contributing to nourishing and sheltering insects and pollinators both within fields and in semi-natural habitats. The introduction of legumes in the CA-SYS plateform was designed to value those specific properties, using a wide array of species, either in pure stand, in mixtures, as companion or cover crop or permanent cover in semi-naturel habitats.

New prospects linked to the development of more legumes in agroecological systems will also be raised, concerning: i) the management of their biological functions (and/or limitations) ii) methodologies and tools for the evaluation of their expected services and impacts, iii) breeding new varieties adapted to agroecological conditions. Embedded factorial experiments within the four systems tested will help in a better understanding of specific questions, such as the enhancement of beneficial plant-microbe interactions specific to or stimulated by legumes.

Ecological enhancement of maize (Zea mays L.) production by intercropping with sainfoin (Onobrychis viciifolia Scop.)

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Maize grown as a single crop requires intensive management and has several negative repercussions for the environment and biodiversity, including arthropods and their ecosystem functions. Integrating maize in intercropping systems with legumes can lead to increased productivity per unit of land and has the potential to ecologically enhance maize production by providing additional habitat structures and food resources for arthropods. On the other hand, competition for soil resources in mixed cropping may also lead to reduced yields of maize in these systems. The legume sainfoin may be of special interest for intercropping, because besides N2 fixation, biomedical properties of secondary metabolites in sainfoin offer benefits for feed use that go beyond that of other legumes. In addition, it may enhance biogas production of maize silage due to its tannin content.

Here, we investigated whether intercropping maize with sainfoin can facilitate arthropods and their ecosystem functions and which trade-offs occur in terms of yield. We hypothesized that intercropping compared to maize monocultures increases activity-density of generalist predatory arthropods and increases biocontrol potential. Further, we expected that intercropped sainfoin provides attractive flowering resources for pollinators.

On an experimental field we established 48 plots with maize and sainfoin in pure and different mixed variants. In each plot, we assessed activity-density of epigeic predatory arthropods, together with biocontrol potential determined with seed cards, insect baits, and artificial caterpillars on three occasions. Further, insect pollinator visitation was assessed on sainfoin flowers in one square meter subplots located within plots.

To assess the agronomic potential of the mixtures, total biomass yield, plant developmental stages, and ground coverage was assessed for pure maize and sainfoin stands as well as for mixtures.

Our data shows that activity-density of epigeic predatory arthropods and biocontrol potential were higher in mixtures, compared to pure maize plots. Pollinators visited flowers of sainfoin in mixed plots frequently and flower visitation rate of sainfoin during bloom did not differ between plants in monoculture and those intercropped with maize.

Total dry matter yield was strongly reduced in mixtures as compared to maize monoculture. The reduction amounted to 1/3 to 2/3, depending on the type of management. On the other hand, yield of the mixtures was clearly higher or at least comparable to pure sainfoin, although pure sainfoin was cropped repeatedly. Relevant ground cover was given throughout the year for mixtures as well as sainfoin stands, so that potential soil erosion was strongly reduced as compared to maize monoculture. Feed quality of mixtures was similarly high as for pure maize stands.

We conclude that, while yield level of intercrops is lower than in maize monocultures, intercropping of maize and sainfoin may be a possibility to promote pollinators and generalist arthropod predators as well as their pest control. Optimization of cropping practices and a further yield quality evaluation is necessary to thoroughly determine the value of sainfoin as mixture partner in intercropping systems.

Effect of cover crops mulch management on weed density, soil moisture and water infiltration rate in northern Benin

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Keywords: Conservation agriculture, cover crops, legume species, soil physical properties, West Africa

Conservation agriculture involves reduced tillage, permanent soil cover and crop rotation to enhance soil fertility and supply food from a declining land resource. In Benin, West Africa, there are several cover crops used as mulch to maintain soil fertility and control weeds. However, few quantitative data exist on their management. This study aimed to assess the effects of selected cover crops on soil moisture, water infiltration rate and weed dynamics in two agro-ecological zones of northern Benin (Parakou and Kandi). The experimental design was a two-factor split-plots with three replications installed in 2018 and 2019 cropping seasons. The main factor was cover crop species and the sub-factor was mulch management (mowed, M or lived, V). Seven species were studied including Brachialaria ruziziensis, Crotalaria retusa, Stylosanthes guianensis, Crotalaria juncea, Sesbania rostrata Cajanus cajan and Mucuna pruriens. Results showed that the cover crops species and the mulch management method strongly influenced ($p < 0.001$) the ground cover, soil moisture, water infiltration, hydraulic soil conductivity and weed density. B. ruziziensis performed best with 60% and 84% ground cover under mowed and lived mulching, respectively, followed by S. guianensis (respectively 67 and 68%). As a consequence, plots with the best ground coverage showed high soil moisture (7–13%) and hydraulic conductivity (0.0015 cm/s–0.002cm/s) but also low weed densities (55–69 weed/0.25m^2).

S. guianensis and S. rostrata species exhibit better soil moisture (respectively 11 and 13%), followed by C. juncea (9%), M. pruriens (10%) and B. ruzisiensis (13%). The mowed mulching method offers good performances in term of moisture, water infiltration and weed control than the lived mulching. The present study reveals that cover crops can improve soil physical properties such as moisture, water infiltration and hydraulic conductivity when managed well and can participate in weed control. Further future studies must evaluate the impact of the best cover crops studied on other physical properties of the soil such as soil compaction, bulk density, and porosity; and possibly on soil chemical properties.

Poster

Diversification of Mediterranean winter cropping systems through intercropping with grain legumes under conservation agriculture

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Keywords: Conservation agriculture, grain legumes, intercropping

Mediterranean arable agriculture, cradle of paradigmatic grain legumes, has evolved in the recent decades towards the simplification to monospecific winter cereal-based cropping systems, highly reliant on external inputs such as fuel, synthetic N fertilizers and pesticides. In the Mediterranean basin, abiotic factors such as scarce and variable precipitations, high evapotranspiration and high temperatures during grain filling limit crop productivity. Winter cereal continuous cropping biotic factors such as grass weeds represent nowadays one of the main limitations for crop productivity given the use of reduced tillage or no-till practices, the inputs cost and the reduction of available herbicide active ingredients. In that context, cropping systems diversification through intercropping and adoption of conservation agriculture practices represents an interesting strategy to overcome some of these limitations while valuing alternative crops such as grain legumes for different puroposes. Intercropping with grain legumes can reduce N fertilizer needs, and enhance weed control of cropping systems, while increasing grain quality in low-input scenarios (Corre-Hellou et al., 2011; Bedoussac and Justes, 2010; Bedoussac et al., 2015). However, to our knowledge, few initiatives have been devoted to intercropping for grain production in Spain. Therefore, in the framework of the EU Biodiversify project (PRIMA call), an on-farm field experiment testing intercropping alternatives was established the autumn of 2020 in the Eastern area of the Ebro valley (Lleida, Spain; 41.700225, 0.447945), in collaboration with producers and other local stakeholders. Durum wheat/pea (Triticum durum Desf./Pisum sativum L.)., durum wheat/chickpea (Cicer arietinum L. pedrosillano type), and pea/rapeseed (Brassica napus L.) intercrops – based on a replacement design – as well as the respective sole crops were compared under two scenarios of synthetic N fertilizer availability (0 control and 75 kg N ha-1 as top-dressing with the use of urea-ammonium nitrate) in a completely randomized design with 3 blocks. A control without herbicide was implemented within each intercrop as a sub-plot. Management practices, with active participation of farmers, were carried out by commercial machinery and were based on the conservation agriculture framework. In this work we will present the first season results (2020–2021) on crop above-ground biomass at flowering and harvest, grain yield, land equivalent ratio of intercrops, and grain quality (protein concentration), as well as weed density and weed cover. Furthermore, limitations and potentialities of intercropping for grain production as a commercial practice in the area of study will also be discussed by systematizing the feedback received from stakeholders during the development of management practices, informal contact and participatory meetings.

How to grow grain legumes as a means to enhance biodiversity and ecosystem services for sustainable and resilient agriculture in the Mediterranean?

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The Mediterranean basin is an area of diversity and particularity in many terms. It is one of the world's 25 most important areas for global biodiversity conservation because of it's species richness and endemism. Additionally, Mediterranean landscapes are widely recognised for having evolved from a "co-evolution" of biophysical conditions and human management. Thus they are often referred to as complex adaptive social-ecological systems delivering a range of different ecosystem services (ES), such as habitat provision, water regulation or aesthetic values. But on-going land abandonment on the one hand and agricultural intensification on the other threaten the supply of many of these services. Lastly, the present Mediterranean climate is characterized by an asynchrony of periods with highest rainfall and maximum temperature, resulting in water scarcity in summer, which challenges conventional farming practices. Looking into the future, the Mediterranean basin has been identified as a climate change hotspot, where drier conditions are likely to occur more often. In agriculture, this leads either to an even higher water demand for irrigation or to terminal drought stress for crops in rainfed systems. Thus, finding and mainstreaming sustainable management approaches for Mediterranean landscapes and agro-ecosystems is urgently needed and key to protect biodiversity, ES supply and landscape resilience.

Legumes have a long and important history in Mediterranean agriculture and diet. Amongst all grain legumes, chickpea and lentil have the highest share of cultivated area in the Mediterranean. They are grown on residual soil moisture and are identified as being relatively drought-tolerant. Nowadays legumes are mainly grown on Mediterranean fields for their nitrogen fixation ability and to widen the crop rotation or replace the fallow year. But their unstable yields in comparison with other main crops, i.e. cereal, and their weak competitiveness against weeds are often seen as difficulties for cultivation and create a tendency of preferring cropping systems based on stable-yielding crops, instead of grain legumes. In such decisions, the economic revenue is playing a decisive role, while the connected ES (or their loss) are not yet quantified or valued in a way that could change farmers preferences and policies. To address this deficit in legume valorization, we will present the results of a literature review that answers the following questions:

1. What is the state of knowledge about quantifying ES and biodiversity provided by grain legume cultivation in the Mediterranean?
2. Which influence have different agro-ecological practices that include grain legumes on ES and biodiversity in the Mediterranean?
3. Which impact have abiotic factors, such as precipitation and soil properties, on pulse-related biodiversity and ES?

The review especially focusses on studies that are conducted in rain-fed annual cropping systems that utilize pulses, particularly lentil or chickpea, in areas with Mediterranean climate. We also put a strong emphasis on the (positive or negative) interplay between provisioning services and agro-biodiversity. From the findings of the review possibilities and constraints for the development of sustainable farming and legume-based cropping systems in the Mediterranean and the development of decision-supporting models for farmers will be deduced.

Evaluation of the sustainability of minor crops in Normandy region, France

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Crop production in Normandy is highly specialized and based on a few crops (e.g. soft wheat, flax, rapeseed, sugar beet, …), which raises the issues of agricultural sustainability. This issue of sustainability is of great concerns when we consider protein autonomy issue at French and European levels. Thus, the development of alternative crops could help in the diversification of crop rotations and contribute in the increase of the proportion of plant-based proteins. Because of their protein content, grain legumes, cereals and oilseeds would offer benefits for human health (Becerra-Tomás et al., 2017), the environment (Springmann et al., 2016), and global food security (Erb et al., 2016). Increasing the proportion of grain legumes in cultivated areas could reduce the current protein deficit and contribute to sustainable farming systems.

PROVEG project aims to evaluate the potential of protein-rich crops that are absent or poorly established in Normandy region. The consortium includes two reserach partners (UniLaSalle and Normandy University) and three agricultural stakeholders (Natup, CerFrance and lycée agricole Yvetot) that represent key player in the local and regional scale. In this context, the project will focus on the potential of five minor crops including four grain legumes (pea, faba bean, lupin, lentil), and a pseudo-cereal crop (quinoa) will be evaluated in the pedoclimatic context of Normandy. The challenges consist in the identification of crop management adapted to these five crops based on a systemic approach to optimize cropping practices and maximize the potential benefits of these crops. This approach involves the consideration of climatic conditions, soil biological state, crop vulnerability and socio-economic obstacles related to their introduction and sustainability in Normandy region.

The expected findings will include i) the identification of suitable crop managements and the causes of yield losses for production and, ii) the assessment of crops vulnerability under climate change by taking into account the nature, the magnitude and the rate of climate change as well as the agro-ecological and socio-economic aspects of crops.

The results of the project will allow us to make propositions to farmers and agricultural advisers to support the introduction of protein crops during transitional pathways on a broader spectrum of farms. Therefore, the findings will contribute to the territorial dynamic by offering to decision-makers information about potential crop suitability and geographical distributions to make strategic investments in infrastructure, and market protein-rich crops produced in Normandy area.

References:

Becerra-Tomas, N., Diaz-Lopez, A., Rosique-Esteban, N., Ros, E., Buil-Cosiales, P., Corella, D., Estruch, R., Fito, M., Serra-Majem, L., Aros, F., Lamuela-Raventos, R. M., Fiol, M., Santos-Lorenzo, J. M., Diez-Espino, J., Portoles, O., Salas-Salvado, J. (2017). Legume consumption is inversely associated with type 2 diabetes Incidence in Adults: a Prospective Assessment From the PREDIMED Study. Clin Nutr In Press.

Erb, K.-H., Lauk, C., Kastner, T., Mayer, A., Theurl, M. C., Haberl, H. (2016). Exploring the biophysical option space for feeding the world without deforestation. Nat. Commun. 7, 11382.

Springmann, M., Godfray, H. C. J., Rayner, M., Scarborough, P. (2016). Analysis and valuation of the health and climate change cobenefits of dietary change. PNAS 113, 4146–4151.

Assessing the impacts of introducing cover crops into organic crop rotations using the ROTOR model

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Introducing cover crops into crop rotations provides several agroecological benefits to diversify cropping systems. Cover crops can help to reduce nitrogen leaching, weed infestation and soil erosion, as well as increase nutrient use efficiency, carbon sequestration and enhance biodiversity. However, field experiments to study the characteristics of all possible combinations of cover crops for various farm settings require detailed and precise measurements that are usually very time-consuming and expensive. This has led to an increased use of crop models to assess and explore the long-term effects of cover crops on various impacts.

The objective of this study was to explore the potential of cover crops to diversify rotations adapting an existing crop rotation planning tool. Such tools can assist farmers in their decision making process to explore the role of specific changes in farm management, such as the effects of integrating cover crops on nutrient management and organic matter status prior to testing them on the farm. The static and rule-based crop rotation tool ROTOR (Bachinger and Zander, 2007; Reckling et al., 2020) was adapted for evaluating site-specific crop rotations for thirteen organic arable farms from five federal stats of Germany. The model uses a set of algorithms to calculate indicators on crop production, nutrition flows and weed suppression. Data has been collected from the project “Climate effects and sustainability of organic and conventional farming systems – investigations a network of pilot farms” and project “Increasing resource efficiency by optimising crop and milk production on whole farm level under consideration of animal welfare quality aspects”

In this talk, we present different scenarios from a farmers’ perspective and supported by calculations with ROTOR, to introduce cover crops into rotations. Cover crops were either perennial grass-legume mixtures or annual winter-hard or not winter-hard crops consisting of legume and non-legume species. We then evaluate the implications of these strategies with different legume percentages on nitrate leaching, the nitrogen and soil organic carbon balance, and weed infestation risk. We conclude with a discussion on the benefits and limitations of different cover crop strategies to diversify cropping systems and on the role of using simple decision tools.

SESSION 2

FARMING SYSTEMS

SESSION 2:
FARMING SYSTEMS

2.1 Digital innovations for more sustainable agricultural landscapes

Convenors:

Robert Finger, ETH Zürich, Switzerland

Robert Huber, ETH Zürich, Switzerland

Yanbing Wang, ETH Zürich, Switzerland

Madhu Khanna, University of Illinois, United States of America

Digital innovations in agriculture can be vital to rendering agricultural systems and landscapes sustainable. Digitalization can contribute to lower environmental footprints, lower costs, more diversity, higher profits of farming, greater animal welfare, and to better agricultural policy. Digitalization has long been enacted in precision farming technologies. Yet, technology alone is insufficient. The new technologies need to be considered in conjunction with the diversity of agricultural systems and landscapes as well as markets and policies in which agriculture is embedded. Only then sustainable (and 'smart') futures of farming in the digital era can be achieved. Moreover, the current production-oriented focus of 'precision farming' on producing more with less cost needs to be expanded to a 'precision conservation' focus, targeting conservation practices that maximize environmental and economic benefits. To this end, the on-farm focus also needs to be expanded into a diverse agricultural landscape focus.

In this session, we will present cutting-edge interdisciplinary research on precision farming and precision conservation that aims to support sustainable landscape management systems.

This session aims to bring together aspects from agronomy, ecology, earth system sciences and economics. Contributions will combine field-, farm-, and landscape-level perspectives on digital innovations. Farmers' behaviour shall play an important role in this session as well as the economic and ecological assessment of new technologies. Finally, the session aims to show how effective and efficient policies can be designed. We encourage participation from contributors from across world regions.

Orals

Digital innovations for more sustainable agricultural landscapes

Robert Finger[1]; Yanbing Wang[1]; Madhu Khanna[2]; Robert Huber[1]

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Digital innovations in agriculture can be vital to rendering agricultural systems and landscapes sustainable (e.g. Walter et al., 2017). Entry points to develop more sustainable agricultural systems are to increase efficiency, substitution and the re-design of current systems. This is where digital innovations come into the picture. Digitalization can contribute to lower environmental footprints, lower costs, higher profits of farming, greater animal welfare, and to better agricultural policy (Weersink et al., 2018). Yet, technology alone is insufficient. The new technologies need to be considered in conjunction with the diversity of agricultural systems (e.g. crop and livestock systems) and the markets and policies in which agriculture is embedded. Only then sustainable (and 'smart') futures of farming in the digital era can be achieved (Walter et al., 2017). The digitalization of agricultural sector can also play a massive role in making agricultural policy more effective and more efficient (e.g. Ehlers et al., 2021).

Yet, to untap the full economic and environmental potential of digitalization, the current production-oriented focus of 'precision farming' on producing more with less cost needs to be expanded to a 'precision conservation' focus, targeting conservation practices that maximize environmental and economic benefits. To this end, the on-farm focus also needs to be expanded into a diverse agricultural landscape focus. Sustainable farming practices and conservation actions are increasingly part of farmers income, for example, due to targeted direct payments and/or compensation from industry. Precision agriculture will increasingly meet 'precision conservation' (Capmourteres et al., 2018) via uses of technology, data, and algorithms to target conservation practices that maximize environmental and economic benefits. Yet, the integration of precision conservation efforts in economic and policy assessments of precision farming are lacking so far.

We here present an interdisciplinary research agenda on precision farming and precision conservation that aims to support sustainable landscape management systems. We highlight the important role of farmers' behaviour and policies to untap the potential of digital innovations for more sustainable agricultural landscapes.

References:

Capmourteres, V., Adams, J., Berg, A., Fraser, E., Swanton, C. and Anand, M. (2018). Precision conservation meets precision agriculture: A case study from southern Ontario. Agricultural systems, 167, 176–185.

Ehlers, M.-H., Huber, R., Finger, R. (2021). Agricultural Policy in the Era of Digitalization. Food Policy. In press. https://doi.org/10.1016/j.foodpol.2020.102019

Walter, A., Finger, R., Huber, R., Buchmann, N. (2017). Smart farming is key to developing sustainable agriculture. Proceedings of the National Academy of Sciences USA 114 (24) 6148–6150.

The future is now – Delphi forecasts for the adoption of precision agriculture enabling technologies in Swiss outdoor vegetable production

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Precision farming technologies are a promising means to tackle the increasing global challenges such as climate change, water pollution or soil degradation (Finger, Swinton, El Benni and Walter, 2019). These technologies can also help revolutionising agricultural production and thus make it more sustainable. However, although these technologies have been in development for more than 20 years now, penetration globally and in Switzerland is still low (Barnes et al., 2019). Building on this knowledge, we conducted a two-stage Delphi study between October and December 2020. We invited 34 experts who have expertise in the fields of vegetable production and digital technologies to identify the key drivers and barriers, the most promising technologies and possible measures to support technology adoption in Swiss outdoor vegetable production. The Delphi method is an established tool for scientific forecasting consisting of a series of survey rounds, offering the experts the possibility to change or modify their opinions. The experts are anonymous and their identity remains unknown. With that, group interactions such as group pressure or domination of the process by few individuals can be avoided. In Round 1 of the Delphi survey, we used open-ended questions to collect expert opinions. We then transformed these into close-ended questions for Round 2, where controlled feedback about the results obtained in the first round was provided to the experts. A total of 26 experts participated in both rounds, resulting in an overall high response rate of 76%. The results show that experts see great potential in the use of electronic measuring systems in irrigation and hoeing. While a recent Agroscope study by Groher, Heitkämper, Walter, Liebisch and Umstätter (2020) has identified adoption rates of these technologies to be around 10% in 2018, experts estimated the adoption rates to range between 50 and 60% in 10 years from now. In addition, supported by the qualitative feedback from the experts, the results suggest that technology adoption is driven by climate change (irrigation) and societal or political pressure limiting the use of pesticides (hoeing). The experts, on the other hand, saw little potential in the use of spray drones for outdoor vegetable production. Most of them estimated the adoption rates for spray drones in 10 years to be no higher than 10%. The experts see barriers for the use of drones in the expertise required to operate them, regulatory hurdles and less efficiency (e.g., filling capacity, area covered per minute) compared to other technologies. They see more potential in technologies such as Spot Spray. We further found that economic factors were important drivers and barriers of adoption. While resource saving can motivate technology adoption, high technology costs are a substantial barrier. Consequently, experts recommended financial measures to support technology adoption. Practical relevance provided through communication or training holds further potential to promote new technologies. These findings are valuable beyond research. Educators and policy makers can build on these insights to tailor their efforts to optimally support technology adoption and contribute to a more efficient and sustainable food production.

Digital Agricultural Knowledge and Information System: the DAKIS decision support platform for management design and ecosystem services provision

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Agricultural production is expected to ensure food security, contribute to the production of bio-based materials and energy, and respect the environment. This multiplicity of purposes increases pressure on agricultural lands and can potentially give rise to conflicts between the profitability of farming and the provision of biodiversity and ecosystem services such as erosion control, climate regulation, or recreation. Spatially and functionally diversified agricultural systems can consolidate diverse targets within agricultural landscapes. Spatially diversified systems take into account the landscape specifications and pedoclimatic conditions of agricultural lands. Functionally diversified ones consider the varying potentials of land for the provision of different ecosystem services. To successfully design such complex systems, the use of digital technologies can be a critical support.

Opportunities offered by digital technologies need to be harnessed in a holistic and harmonized manner, for such systems to be sustainable from both an environmental and a socio-economic perspective. This implies encompassing farm economics, societal demands, and potentials for the provision of ecosystem services and biodiversity. The utilisation of digital smart technologies, such as sensors, artificial intelligence, and online communication platforms, offers new ways towards monitoring and adapting to the status of, and demands from, agricultural lands. It offers, thus, the potential to support sustainable and diversified agricultural systems via three distinct contributions:

i) Enhanced communication between stakeholders and land use actors, enabling information exchange on societal demands on biodiversity and ecosystem services along the value chain and reducing conflicts on the future use of agricultural land;
ii) Improved agricultural management design, for multifunctional diversified agricultural landscapes to consolidate diverse targets on yields, ecosystem services, and biodiversity, and deliver resource use efficiency improvements;
iii) Effective and transparent monitoring of biodiversity and ecosystem services provision, facilitating the understanding of cause-effect relationships in agroecosystems and the establishment of result-oriented policy measures.

In this contribution, we will present the Digital Agricultural Knowledge and Information System (DAKIS) decision support tool for management design and ecosystem services provision.

DAKIS integrates digital agriculture technologies (sensors, artificial intelligence, robotics), farm economics planning modules, the interactive monitoring of ecological and societal demands, modelling of ecosystem services, agent-based modelling, Bayesian belief networks and stakeholder-based sustainability impact assessment to support the design of future agricultural systems and enable progress in line with all three contributions (management design, communication, monitoring) of digital agriculture.

DAKIS offers a digital knowledge-based tool to provide farmers with recommendations on how to design their cropping systems to optimize their incomes and improve the sustainability of agricultural landscapes.

With the help of digital technologies, it enables site-adapted small-scale agriculture, where plants are grown where optimal conditions prevail and resources are being used only where and when they are needed. At the same time, it indicates to its users where ecosystem services are demanded and can be specifically promoted. Processes considered within DAKIS span from sub-field to regional levels in an interconnected spatially explicit approach. Ultimately, DAKIS offers a one of a kind tool that taps on digital agriculture technologies and combines diverse methods in an inter- and transdisciplinary way to simultaneously support farmers' economic objectives and society's demand for biodiversity and ecosystem services.

Poster

Digital innovations for resilient coffee systems in Uganda

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Coffee is a major cash crop in Uganda, supporting over 3.5 million households and accounting for about 25% of foreign exchange earnings. Smallholder farmers whose average farm sizes range from 0.5 to 2.5 hectares produce 90% of Uganda's coffee (IITA, 2013). Low adoption of good agricultural practices characterizes farmers' management which has contributed to low annual yields of 700kg/ha compared to the average potential of improved varieties (KR 1–10) of 3.0 tons/ha (Musoli et al., 2013; UCDA, 2019). Due to climate variability, temperatures in Uganda have increased by 1.3°C since 1960 and could rise by up to 2.5° by 2050. Seasonal rainfall has become more variable which causes fluctuating coffee yields and quality and this is exacerbated by increasing problems of pests and diseases thereby impacting smallholder farmer livelihoods. As a result, enhancing the resilience of coffee systems to agroecological and economic shocks is becoming important especially focusing on building the capacities of producers, among others unfortunately, traditional advisory and extension services supposed to address this challenge are often scattered piece-meal and provide farmers with generic recommendations and technologies without considering their unique socio-economic conditions.

Since 2016, IITA has developed and tested various climate-smart agriculture technologies, working closely with public and private partners. One key technology now being scaled in Uganda is the Stepwise approach, supported by an ICT decision support tool – the Stepwise Smartphone application. Stepwise considers specific agro-ecological variables and individual farmer needs and aspirations to guide incremental investment in specific sets of climate-smart agricultural technologies. By better understanding specific farmer characteristics through farmer segmentation, more effective extension service delivery models and sequences of practices are being targeted. We describe the Stepwise Smartphone application, which provides a step-by-step guide on how to improve coffee yields and quality, as well as results of our initial work. The Stepwise approach was tested with 560 farmers in Central and Eastern Uganda (2016–2019) through their producer organizations at 16 purposively selected locations. Preliminary results indicate increased adoption of coffee good agricultural practices and yields by 58% and 73% respectively, both attributed to Stepwise. IITA and its partners are currently scaling up the Stepwise approach and Stepwise smartphone Application to reach at least 80,000 farmers in 26 Ugandan districts by 2025.

References:

IITA (2013). The impact of climate change on coffee in Uganda. Ibadan, Nigeria: International Institute of Tropical Agriculture.

Musoli, P. C., Nalukenge, A., Kagezi, H. G, Magambo, B., Olal, S., Aluka, P., Olango, N. and Wagoire, W. W. (2013). Technical report on candidate wilt Resistant varieties of Robusta coffee, due for commercialization. Entebbe: National Agricultural Research Organization.

UCDA (2019). Robusta Coffee Handbook. Kampala: Uganda Coffee Development Authority.

Measuring nitrogen in crops at different scales and levels: a comparison of sensors

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Crop sensing technology is in continuous development. Proximal and remote sensors measuring different physical properties of plant tissue, as surrogates for nutritional and health status are being developed in response to the ever-increasing need of quick and reliable crop monitoring for precision agriculture. A recently developed fluorescent-based device, Multiplex, is of particular interest for high spatial resolution modeling and managing systems, given its capacity of measuring fluorescence properties of chlorophyll and other pigments at both leaf and canopy levels, and both in discrete ("one-shot") and continuous ("on-the-go") measuring modes.

The goal of this research was to assess the ability of Multiplex to measure nitrogen (N) content of different crops and compare it with the performance of other well-established sensors.

Several fields with spring and winter barley and corn at three locations in Brandenburg representing different levels of N fertilization were chosen for the measurements. Leaf N content (% weight) from plant samples was compared to measurements of: Fluorescence (Multiplex Research sensor), light transmittance (SPAD sensor), and reflectance (ASD Field Spectrometer). Additionally, direct canopy fluorescence (Multiplex Research sensor) was compared to canopy reflectance (ASD Field Spectrometer), light transmittance of leaf composites (SPAD sensor) and remote reflectance from multispectral sensors on remotely piloted aircrafts (RPA) or drones.

Out of the 25 variables Multiplex produces at each reading, the Chlorophyll Index, the Flavonoid Index and the Nitrogen Balance Index showed the closest relationships to N. All these variables contain infrared and red fluorescence components suggesting that these have a key role in chlorophyll and N determination. In general, however, SPAD showed higher accuracy than fluorescence as a predictor of N content in leaves. Despite of this, Multiplex seems particularly convenient for fast on-field assessment of crop canopy status.

At the canopy level, drone-based sensors can be as accurate as Multiplex to assess the N status of the crops under study. In the case of Multiplex, however, since the device reads are taken below the canopy and parallel to the ground, measurements are not affected by canopy density and soil background, which can be an inconvenience for vertical reflectance measurements as provided by drones and spectrometers.

Development of an automated module for in situ soil analysis using an Arduino board and a handheld Energy Dispersive X-Ray Fluorescence (EDXRF)

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The Intelligence for Soil (I4S) is an initiative that aims to develop an integrated system for in situ soil analysis and to use this system to improve soil functions and fertilizer recommendations. This system is composed by different sensors and spectroscopic techniques that provides a detailed assessment of soil properties and processes. Considering the soil as a sustainable resource for the bioeconomy, this assessment is essential for a site-specific, resource-saving, and ecofriendly soil management [1]. The Energy Dispersive X-Ray Fluorescence (EDXRF) is a non-destructive spectroscopic technique that allows a fast multielemental analysis. It is suitable for in situ measurements due to a minimum sample preparation and to a handheld equipment version which provides the portability needed [2]. In this work, a module for in situ soil analysis have been developed. A handheld equipment of EDXRF (Olympus, Vanta C series) was fixed inside of plastic control cabinet, made by glass fiber reinforced unsaturated polyester that promotes a full insulation, special corrosion resistance and weather resistance. A polypropylene film was used to protect the measuring window of EDXRF from dusty and possible contamination from different samples. A microcontroller (Arduino, Mega 2560) was employed to control a stepper motor that rolls the polypropylene film, ensuring there will be a piece of clean film in front of the measuring window at each new analysis of soil sample. A Peltier cooling unit and a thermostat normally open contact for fan control were selected to be coupled in the XRF module to cool and ventilate it. On the next step, the module will be placed on a mobile platform and tested in the field. In parallel, some calibration studies using pre-defined methods have been performed with Certified Reference Materials (CRM) and the averaged data from X-ray characteristic emission lines intensities have been compared with certified mass fraction data, and also with the values obtained by a validated Wavelength Dispersive X-Ray Fluorescence (WDXRF) comparative method. Some elements such as Al, Si, S, P, Ca K, Mn, Ti, Fe, Cu, Ni and Zn could be properly determined, but validation requires robust calibration models in order to circumvent the matrix effects and guarantee reliable results. A guidance for an adequate and on site-specific fertilization is expected when the module be placed on the mobile platform and all results be integrated.

References:

[1] I4S (Intelligence for Soil) – Integrated System for Site-Specific Soil Fertility Management. (n.d.). Accessed on October 28th, 2020, from www.bonares.de.

[2] Beckhoff, B., Kanngießer, B. et al. (2006). Handbook of practical X-ray fluorescence analysis. Berlin: Springer.

Determination of soil parameters by laser-induced breakdown spectroscopy and multivariate regression methods

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Spatial variations of soil properties on agricultural land, especially the different chemical soil parameters, are relevant for the soil's fertility and thus for crop yields. The usually homogenous fertilization of fields can lead to local over- or underdosing. This can be prevented by using precision agriculture. It is based on measuring the spatial variations within a field by, e. g., chemical sensors, which avoids the time-consuming and cost-intense soil sampling and laboratory analyses. The latter is, for instance, avoided by using laser-induced breakdown spectroscopy (LIBS). It delivers direct, precise and spatially well resolved data on the nutrient content without any sample preparation. It is therefore a suitable tool for cost- and time-efficient on-side analyses in precision agriculture. Most of the recently published work that focuses on the application of LIBS on agricultural soils is based on multivariate methods. This is because of the strong matrix-dependence of the LIBS signals. Multivariate analysis intrinsically takes these matrix effects into account. In this work four regression methods of multivariate analysis were used to predict the soil parameters. Two linear methods, PLS- and Lasso-regression, and two non-linear, non-parametric methods, Gaussian process (GP)- and SVM-regression. This, combined with the high sampling frequency of LIBS which results in a high spatial resolution of the soil characterization, provides the basis for in-field measurements.

The first part of the presented work focuses on the characterization of soil samples from two different locations, two fields near Wilmersdorf (Brandenburg, Germany) and one field near Bölingen (Nordrhein-Westfalen, Germany) [1,2]. The soil properties, directly quantified using LIBS, were the total amount of metal nutrients (K, Ca, Mg, Mn, Zn, Cu and Si) and non-metal nutrients (N, P, S). Additionally it was possible to indirectly determine soil parameters such as plant-available nutrients (K(p.a.) and P(p.a.)), humus content, pH-, and silt and clay content (defining the texture) by using multivariate methods. This is supported by the results from two feature selection methods, CARS and VIP, that were used to improve the regression results of all these soil parameters.

The second part focuses on the comparison between three different LIBS instruments. The first being a commercially available handheld instrument. The second being a high-energy laser combined with a high-resolution Echelle spectrometer and an ICCD camera. And the third one using the same laser in combination with a multichannel CMOS spectrometer. This was done to find the best fit for developing a sensor prototype that eventually can be implemented on a sensor platform.

References:

[1] Riebe, D., Erler, A., Brinkmann, P., Beitz, T., Löhmannsröben, H.-G., Gebbers, R. (2019). Comparison of Calibration Approaches in Laser-Induced Breakdown Spectroscopy for Proximal Soil Sensing in Precision Agriculture. Sensors 2019, 19, 5244.

[2] Erler, A., Riebe, D., Beitz, T., Löhmannsröben, H.-G., Gebbers, R. (2020). Soil Nutrient Detection for Precision Agriculture Using Handheld Laser-Induced Breakdown Spectroscopy (LIBS) and Multivariate Regression Methods (PLSR, Lasso and GPR). Sensors 2020, 20, 418.

Digital tools for monitoring and increasing earthworm driven ecosystem services in agricultural soils

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Earthworms are key indicators of soil fertility and provide essential ecosystem services in soils. Sustainable agricultural management should therefore focus especially on this soil biota group. Yet, reliable data about earthworm activity and distribution are hard to obtain.

Digitalization can contribute to earthworm monitoring and promote earthworm friendly management in several ways. A digitized analysis of soil structure using X-ray computed tomography reveals quantitative information about presence and activity of earthworms under different management schemes. Machine learning technologies applied to CT scan slices will enable to automatically identify soils subject to earthworm burrowing and to predict earthworm affected soil structure in different soils, climates and management constellations. Finally, digitized prescription maps may be applied for site-specific management, e.g. organic manuring, which will directly promote earthworm populations in farmer`s fields.

Examples for each of these digitalization tools will be presented from an on-farm long-term tillage experiment in the Komturei Lietzen, on sandy soils near Müncheberg.

References:

Joschko, M., Barkusky, D., Wieland, R., Krolczyk, A., Willms, M., Hierold, W., Fritsch, G., Hildebrandt, Th. B., Elles, L., Li, L., Schmidt, O., Filser, J., Jimenez, J., Faber, J., Epperlein, J., Schirrmann, M., Fox, C. A., Budras, M., Gerlach, F., Beblek, A. (2019). X-ray CT assessment of soil structure: a tool for monitoring soil biota driven ecosystem services in agricultural soils. Conference on Soil Biota driven Ecosystem Services in European Agriculture, 22nd–23rd October 2029, Commonwealth Scientific and Industrial Research Organisation (CSIRO)-Institut, Braunschweig, Germany.

Schirrmann, M., Joschko, M., Gebbers, R., Kramer, E., Zörner, M., Barkusky, D., Timmer, J. (2016). Proximal Soil Sensing – A Contribution for Species Habitat Distribution Modelling of Earthworms in Agricultural Soils? PLOS ONE. https://doi.org/10.1371/journal.pone.0158271

Wieland, R., Ukawa, C., Joschko, M., Krolczyk, A., Fritsch, G., Hildebrandt, Th. B., Schmidt, O., Filser, J., Jimenez, J. J. (2021). Use of Deep Learning for structural analysis of CT-images of soil samples. Royal Society Open Science.

SESSION 2:

FARMING SYSTEMS

2.2 Assessing crop diversification potential under climate change

Convenors:

Christoph Gornott, Potsdam Institute for Climate Impact Research (PIK), Germany

Abel Chemura, Potsdam Institute for Climate Impact Research (PIK), Germany

Now and under future climatic conditions, specially-explicit quantitative assessments of crop diversification are key for adaptation planning as crop diversification is among the most promising adaptation measures. This session provides state of the art current scientific developments in assessing diversification potential under climate change in farming systems using various methods and scales. These range from modelling tools, field methods and qualitative tools that inform crop diversification potential or likelihood. The viability and contributions of various types of crop diversification systems will be presented. It is expected that the session will provide a platform to increase traction of diversification through scientific data. Such information will also help to provide a framework to measure progress towards crop diversification between different times and locations, and in cost and benefit analysis of crop diversification in national climate change adaptation plans.

Crop diversification is among the easiest, most effective and cheapest adaptation measures and yet its implementation is limited by lack of quantitative data. In addition, diets in many countries consists of crop combinations, making it important that these are available under climate change. Quantitative and qualitative assessments of diversification potential are important in providing evidence based and science-informed adaptation planning that will reduce food insecurity.

We warmly invite you to submit abstracts for our session: “Assessing crop diversification potential under climate change”. The session will be held in a mixed format including one keynote presentation from the invited speaker, presentations and a general discussion on best practices, challenges and opportunities for assessing crop diversification potential under climate change. We especially invite early career researchers and postgraduate students, NGOs and development practitioners working on crop diversification under climate change to submit an abstract for a contribution in this session.

Orals

Assessing crop diversification potential under climate change: learning from the past using machine learning approaches

Gunnar Lischeid; Heidi Webber; Michael Sommer; Claas Nendel; Frank Ewert

Leibniz Centre for Agricultural Landscape Research (ZALF), Germany

In order to assess the diversification potential under climate change in farming systems machine learning approaches have been used to study the climatic and soil hydrological drivers of spatial and temporal crop yield variability, comprising 40 years yield data from 351 counties in Germany, and comparing results for winter wheat, winter barley, winter rapeseed and silage maize. Random Forests and Support Vector Machines were applied in parallel. Comprehensive feature selection approaches were followed to identify the prevailing drivers of the observed spatial and temporal variance. Special emphasis was placed on a thorough analysis of the uniqueness of the best models which proved to be a major problem in spite of the comprehensive and sophisticated feature selection approaches used.

The best models captured about 60% of the variance of silage maize yield, and about 80% of the variance of winter barley, winter rapeseed and winter wheat. The functional relationships between mean precipitation of single months and crop yield exhibited optimum curves with a clear decline of crop yield for excess rainfall. Optimum precipitation values for the summer months tended to be higher compared to the winter months. Air temperature of single winter months was positively, although not necessarily linearly, related to crop yield. In contrast, excess air temperature during the summer months had detrimental effects on yield of all four crops. Given the negligible effects of soil moisture, this seems to be primarily due to a direct heat effect rather than a drought effect. Special emphasis was placed on comparing the functional relationships of the four crops studied in order to draw conclusions on crop diversification potential under future climate conditions.

Impact of crop diversification on the soil carbon balance of woody cropping systems under semiarid areas

María Martínez-Mena[1]; Carolina Boix-Fayos[1]; Efrain Carrillo-López[1]; Elvira Díaz-Pereira[1]; Raul Zornoza[2]; Virginia Sánchez-Navarro[2]; Jose A. Acosta[2]; Silvia Martíne-Martínez[2]; María Almagro[1]

[1] CEBAS-CSIC, Spain; [2] UPCT

We assess the short-term effect of diversified vs. monoculture practices in low input rainfed and highly intensively irrigated woody crop systems on the soil carbon balance. The study was conducted in three nearby sites representing an intensification land-use gradient: i) a natural shrubland, ii) a low input rainfed almond (Prunus dulcis Mill.) crop cultivated on terraces and iii) a levelled highly intensively irrigated citrus (Citrus reticulata Blanco) crop with street-ridge morphology. Two diversifications were implemented in the almond trees: i) intercropping with Capparis spinosa and ii) intercropping with Thymus hyemalis while one diversification practice was implemented in the irrigated citrus orchard: intercropping a crop rotation of barley and vetch (Hordeum vulgare and Vicia sativa) followed by fava bean (Vicia faba). To assess the effect of diversified vs monoculture practices on the annual soil organic carbon (SOC) accumulation rate of our rainfed and irrigated woody cropping systems, we adapted a conservation mass approach, whereby any change in the carbon (C) stored in the soil per unit of time is given by the difference between C inputs (plant C inputs and depositional SOC inputs) and losses from the soil (CO2 released to the atmosphere and erosional loss of SOC). Results show that land use change (from shrubland to rainfed agricultural systems) and agriculture intensification promoted higher carbon outputs from ecosystems to the atmosphere, acting all the systems as carbon sources. At the short-term and on an annual basis, diversification in the low-input rainfed system led to a reduction of the outputs by 23% and 45% for CO2 emissions and lateral fluxes by erosion, respectively. In addition, diversification increased about twice the OC inputs to the system, independently of the type of diversification implemented. Both rainfed diversified systems were closer to the carbon budget of the shrubland reference site than the high-input irrigated system, diversified or not. Diversification under this highly-intensive farming systems did not significant change the soil carbon budget besides carbon outputs by erosion were reduced by 53% respect to the monocrop and plant carbon inputs increased.

Climate change and suitability of multiple food crops in Africa: A spatial modelling assessment

Abel Chemura; Christoph Gornott

Potsdam Institute for Climate Impact Research (PIK), Germany

Climate change is projected to impact food production in many tropical countries especially in Africa where crop yields are already low and variable. Agricultural diversification is considered one of the most promising climate change adaptation strategies for food systems. However, there are challenges in understanding how climate change will affect crop diversification potential at various scales. In this study we present results from our assessment of the agro-climatic suitability of multiple food crops in Ghana, Ethiopia, Burkina Faso and Niger under current and future climatic conditions. We report that the potential for multiple will be impacted by climate change more than the impact on individual crops in these countries and this has severe implications on ability of farming households to meet food requirements. In Ghana, areas with optimal suitability for producing two and three crops will decrease by 12% as areas having moderate and marginal conditions for multiple crops increase compared to current suitability. In Ethiopia, 23% of the country is suitable for producing four crops (maize, sorghum, wheat and teff). Under projected climatic conditions, this area will decrease by 13% (RCP2.6) and 16% (RCP8.5) as areas suitable for three crops increase as many areas lose suitability from four to three crops. Our results also show that, there will be an increase of 7% (RCP2.6) or 8% (RCP8.5) of areas that are marginal for the production of any of the four crops in Ethiopia due to climate change by 2050. In Burkina Faso, our model show that by 2050 the potential for multiple crop suitability will decrease as fewer crops will become suitable under climate change. Multiple crop suitability will shift southwards under climate change with more severe shifts under RCP7.0. Many areas that are currently suitable for at least 3 crops will decrease as more areas become optimally suitable for only 2 or 1 crop in Burkina Faso. We therefore conclude that climate change will have a significant impact on the potential for multiple cropping and this will limit diversification potential and adaptation planning should take this into account.

Crop diversification as a strategy for adaptation to climate change: potential and limits on the case of pistachio in the French Mediterranean region

Marta Debolini; Tiago Teixeira da Silva Siqueira

INRAE – UMR EMMAH – EQUIPE DREAM

Keywords: Pistachia vera, farmers' preferences, PACA Region, innovation

Climate change effects are leading farmers to rethink their strategies in terms of cultivated crops, also on the case of specialized and perennial farming systems. In fact, these systems are not always capable to cope with the increasing climatic impacts, particularly in the Mediterranean area (Pouffary et al., 2019). The main forecasting scenarios show summer rainfall decreasing by 10 to 30% on and more often extreme events (heat waves, droughts, floods and fires). For the agricultural activities, the consequences on the phenology are already visible and become an important concern. Diversification seems to be an interesting adaptation strategy, both in economic and environmental terms (Altieri et al., 2017; Gunathilaka et al., 2018). Most of the recent literature focuses on diversification in arable lands, in terms of different annual crop added to the rotation, or on agroforestry as adaptation strategies. However, there is lack of studies about the introduction of new species on specialized orchard farms. At the same time, species diversification in arboriculture seems to emerge as a strategy to explore different production possibilities in the expectation of increasing climate change constraints in the future. In this work, we aimed to study farmers' perception about the potential and limits on the introduction of new tree species as adaptation strategy to climate change impacts in the French Mediterranean region. Our case study is based on the production of pistachio (Pistacia vera L.). The plant is resistant to adverse climate conditions thanks to it physiological characteristics (Amara et al., 2017). This perennial species, already cultivated in the Mediterranean areas of Tunisia, Turkey and Spain, disappeared from France as a commercial production in the 20th century. Few farmers in French Mediterranean area, mainly on the PACA Region, chose the pistachio as adaptation solution in the last few years. Today, about 30 commercial farms has pistachio trees and it represents around 100 hectares in the region. Our study aims to identify the most relevant drivers for the introduction of new tree species in Mediterranean orchard farming systems. In particular, we explored the following research questions: (1) are the reasons for diversifying in perennial farming systems more related with agri-environmental factors (e.g. drought resistance, low water needs, pest resistance) or economic ones (e.g. market opportunities, better income)?; (2) what are the main farmers typologies in the study area and which typology is more prone to innovation through crop diversification? (3) which are the main limits to the adoption of climate adaptation strategies? In order to explore these questions, we will interview farmers and key actors of this emerging value chain, and we will statistically analyse the data obtained through multiple correspondence factor analysis to build up farmer profiles. The study area is located on the Vaucluse department, where most of the new pistachio trees were planted on the last few years, and where a network of farmers involved the local agricultural chamber for following the development of the new production chain.

How much can silvopastoral systems successfully contribute to Colombia's national climate targets?

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Keywords: Silvopastoral systems, Colombia, carbon footprint

The Colombian government committed in 2020 to reduce national emissions by 51% by 2030 compared with business as usual, the most ambitious target of all Latin America and Caribbean countries. Addressing emissions from deforestation and agriculture is a significant part of this commitment given that Colombia's Agriculture, Forestry and Other Land Use (AFOLU) sector is responsible for 46% of national emissions. Pastureland, predominantly for cattle, makes up 13% of national land area and its expansion is a leading driver of deforestation.

Introducing silvopastoral systems (SPS) is a priority activity proposed by the National Livestock Federation (FEDEGAN) as a method of reducing agricultural emissions and pressures on deforestation. However, there is still uncertainty around the effectiveness of SPS at both the landscape and farm scales in contributing to climate targets while protecting the livelihoods of farmers. The aim of this study is to analyse the climate impacts of cattle farms with SPS, investigate the challenges and opportunities of implementing SPS at the farm scale, and compare that analysis with the geo-climate suitability of SPS at the landscape scale in the Colombian state of Caquetá. The study incorporates agricultural systems modelling for farm scale analysis and geospatial data analysis for the landscape scale.

We collected data from 140 cattle farms across Caquetá, a heavily deforested region within the Colombian Amazon listed as at high risk of further deforestation. Almost 10% of the forest cover in Caquetá in 2000 was cleared in the last 20 years. Farms in this region have low productivity, high grazing intensity and consequently tend to exhibit severe soil degradation. The mean carbon footprint of farms surveyed was 1.8 tonnes CO2eq per hectare per year, however this increases to 65 tCO2eq per hectare per year when considering the mean annual emissions produced through land-use change on each farm between 2000–2019. In addition, 73% of farms reported that their soil had degraded over the last five years, representing a further emission source from the loss of soil organic carbon.

While the IPCC gives a default sequestration rate from SPS of 14 tCO2 per hectare per year, we present field data from farms that adopted SPS over 5 years ago to enable the production of more accurate models of carbon sequestration in these systems. Using survey data also collected from these farms we can better understand their land-use management, productivity, and the success of SPS. This informs a realistic outlook of the potential benefits of SPS at farm scale. We also present topographical, soil and climate analyses of the region in order to assess the opportunity of SPS at a landscape level.

References:

FEDEGAN (2014). Sustainable Colombian Livestock. Available at: www.fedegan.org.co/programas/ganaderia-colombiana-sostenible (Accessed: 14.03.2021).

Gobierno de Colombia (2020). ACTUALIZACIÓN NDC COLOMBIA-2020. Available at: www4.unfccc.int/sites/ndcstaging/PublishedDocuments/Colombia First/NDC actualizada de Colombia.pdf (Accessed 14.03.2021).

Navarrete, D., Sitch, S., Aragão, L. E. O. C., Pedroni, L. (2016). 'Conversion from forests to pastures in the Colombian Amazon leads to contrasting soil carbon dynamics depending on land management practices', Global change biology, 22, p.3503–3517.

Multiple cropping as an opportunity for crop diversification in climate change adaptation and sustainable land use

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Multiple cropping, defined as harvesting more than once a year, is an important characteristic of land management in tropical and subtropical agriculture. It can increase crop production, spare land for other uses and increase the resilience of cropping systems. A recently developed global spatially explicit data set shows that in the period 1998–2002 multiple cropping systems accounted for 134.5 Mha of global cropland (12%), 130.4 Mha under double cropping and 4.1 Mha under triple cropping (Waha et al., 2020). Most areas under multiple cropping are located in East Asia (44.1 Mha) and South Asia (37.8 Mha). Double and triple cropping are two specific types of multiple cropping where crop diversification with different crops can occur along a temporal, not a spatial dimension. There is a large variety in the number of different crops, management intensity and objectives of such multiple cropping systems.

Harvesting a second time in places with currently only one crop harvest per year could increase global harvested areas by 90–395 Mha, which is > 45% lower than previous estimates. This lower estimate is a result of distinguishing between single and multiple cropping areas rather than measuring cropping intensity overall. Still, this additional area could be enough to avoid expanding physical cropland in response to increasing demand. However, this could come with high environmental costs and will depend on the crop yields attainable in the second cycle. The four possible implications for environmental outcomes when cropping intensity increases are that intensification (i) reduces the need for cropland expansion with positive outcomes for biodiversity elsewhere, (ii) increases economic incentives to expand current cropland with negative outcomes for biodiversity, (iii) increases resource use, potentially beyond sustainable levels and has negative implications for biodiversity and (iv) occurs jointly with diversification leading to a decreased use of resources for example where crop rotations and management systems are chosen to increase soil water storage and soil nutrients.

Under climate change, diversification and intensification potentials are projected to change, as suitable growing seasons in parts of the world change (Minoli et al., 2019), possibly allowing for an expansion of multiple cropping systems in currently cooler regions or preventing multiple cropping in others. Where double cropping is already practiced in sub-Saharan Africa, the average impact on crop yields is smaller than in single cropping systems (6–17% compared to 11–24%) (Waha et al., 2013). This is because the growing season for the system overall is longer in double cropping systems and they make more efficient use of energy input. However, the risk of crop failure is also higher in double cropping systems so that many of them can be expected to be less resilient against negative climate change impacts than single cropping systems. The choice of a crop and cropping system depends on many different factors and the farmer's risk averseness will determine whether to plant a second or third crop in a more variable climate. Projections of future management systems need to better account for different crop production systems, including multiple cropping options.

Poster

The Determinants of Common Bean Variety Selection and Diversification in Colombia

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Variety selection and diversification are climate change adaptation practices pursued by Colombian common bean producers. We investigate the drivers behind common bean variety selection and diversification in one of the most important common bean production regions in Colombia —Santander. The effects of climate change on this region are expected to be elevation driven. Exploiting the relationship between elevation-driven weather variations and climate change perception in Santander, we estimate an alternative-specific conditional logistic regression model to identify the determinants of common bean variety selection from a survey of producers. Using an ordered-logistic regression model, we also investigate the drivers behind common bean variety diversification within this farming community. We find that farms' elevation, household composition, and seed certification are some of the most important drivers behind farmers' common bean variety selection in Santander. We also find that varieties that sell at higher prices and have shorter vegetative cycles tend to be more preferred by farmers. Finally, farmers who receive more help from family members and own a tractor tend to grow more than one variety in the same production cycle. Common bean breeding programmes can exploit these drivers to design communication strategies to maximize uptake of newly developed common bean phenotypes.

Dealing with seasonal livestock feed gaps in smallholder mixed-farming systems: A case study from Limpopo

Sala Alanda Lamega[1]; Martin Komainda[1]; Munir Paul Hoffmann[2]; Jude Julius Odhiambo[3]; Kwabena Kingsley Ayisi[4]; Johannes Isselstein[1]

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Keywords: Climate risk, forage crops, farming system, Southern Africa

In the southern areas of Africa, climate events such as prolonged drought is among phenomena that have negatively affected the farming systems which are mostly smallholder mixed crop-livestock enterprises. Having in mind that the more the farmers are environmentally exposed to this climate-driven event with inadequate adaptation strategies, the greater their livelihoods are constrained. Therefore, it is arguably important that we understand how mixed crop-livestock farmers are vulnerable to climate uncertainty and how they cope with it – an understanding which requires a sound assessment of the farming systems. In the Limpopo region of northern South Africa, livestock productivity is largely constrained by the lack of forage supply in the dry season. Opportunities to cope with the seasonal feed gap for smallholder farmers rely on natural resources (e.g. rangelands) translating into land degradation. Against this background, we investigated 90 farms along a climate gradient in Limpopo to assess the seasonal occurrence of feed gaps. Firstly, we used a survey to derive specific on-farm information regarding seasonal feed availability and current adaptation options among smallholders. We linked the survey information to vegetation modelled data of the surveyed sites and elemental nutrient analysis of grazed grasses during the winter period. Secondly, during the dry season, we collected on-farm data (e.g. rangeland grasses, soil samples, dung samples, cattle tail hair, feed samples) and samples were analyzed to assess and identify the triggers of feed gaps and impacts on the farming systems. Here, we used isotopic signature techniques ($\delta^{15}N$ and $\delta^{13}C$) to highlight livestock nutritional stress/differences across sites. Stable isotopes are an important tool that can be used to describe and quantify different diet sources. Particularly, hair tissues contain dietary archive information that can temporally and spatially inform us on the environment. Dietary information across all sites together with the analysis of farmers' perception on feed gaps then provide a sound assessment in regards to livestock feed gaps and avenues for potential coping strategies. However, in an attempt to close the seasonal livestock feed gap in Limpopo, we thirdly explored an intervention option through the integration of cool-season forage crops aiming at improving livestock feed-basis. In this line, we conducted, a field experiment with selected C3-species (winter rye, clover, vetch, and winter rape) which are commonly under temperate climate to assess biomass yield potential in South Africa at two distinct sites in Limpopo. In the last step, we tested the Agricultural Production Systems sImulator (APSIM) model against the field experiment and applied the model in a simulation scenario for the surveyed sites using long-term climate records. To identify whole-farm effects (e.g. economic, biophysical impacts of integrating forage crops to alleviate feed gaps) for smallholders, integrated analysis is used – combining simulation analyses – and further discussed.

Using remote sensing to identify monoculture and agroforestry coffee systems to support climate adaptation information

Gina Maskell[1]; Abel Chemura[1]; Huong Nguyen[2]; Pinki Mondal[3]; Christoph Gornott[1]

[1] Potsdam Institute for Climate Impact Research (PIK), Germany; [2] Tay Nguyen University, Vietnam;
[3] University of Delaware, United States of America

Coffee is grown in a variety of systems – from sprawling, homogeneous plantations to small, mixed-used plots, patchworked between natural forest, other tree crops and annual cropland. There is growing evidence linking mixed agroforestry systems, where multiple tree species are planted simultaneously in one plot (shade-grown coffee, intercropping, boundary tree planting), to diverse co-benefits. These benefits span from sustaining insect biodiversity and temperature regulation to livelihood diversification. Information on where and how coffee is grown has multiple applications for sustainability certification, forest (deforestation) and biodiversity monitoring, and as supplement to climate adaptation studies.

Remotely sensed data can support dynamic and precise mapping of monoculture coffee and multiple agroforestry systems. We will focus on the added value this has specifically for climate adaptation data and monitoring, where information is primarily collected at the household or community level and longitudinal data is not the norm. Remote sensing and earth observation can offer open, spatially continuous, and time series data to supplement household surveys or other field-based methods. We will present our study that uses open remote sensing data (Sentinel-1 and 2) to map newly planted coffee, monoculture (sun) coffee, and agroforestry (intercropped) coffee over multiple time steps in the Central Highlands in Vietnam and discuss the implications this has as an additional information layer in climate adaptation and vulnerability studies.

SESSION 2:
FARMING SYSTEMS

2.3 Quantifying the impacts of diversity on the resilience of agriculture

Convenors:

Pytrik Reidsma, Wageningen University & Research – WUR, The Netherlands

Miranda Meuwissen, Wageningen University & Research – WUR, The Netherlands

According to resilience theory, diversity enhances resilience. Farming systems can be diverse at different levels: in cultivars, crops, ecosystem services, farm and off-farm activities, farm types, landscapes and supply chains. While there is little doubt about the importance of diversity for resilience, quantitative empirical evidence is still scarce. Long time series are needed, which are not available for all relevant indicators. While time series data are increasingly becoming available for crop yields and farm income, data on environmental and social indicators are more difficult to obtain. In addition, the data should allow to compare diverse with non-diverse systems, and correct for other characteristics. Further, resilience is a complex concept that is not easy to measure. A resilient farming system shows robustness, adaptability and transformability. For each of these resilience capacities, different measures are needed for quantification. This session invites presentations that use empirical data to quantify the impacts of diversity on the resilience of agriculture. This should strengthen the knowledge base and improve our understanding on the relation between diversity and resilience.

Orals

Agriculture models resilience: biodiversity-based are stable while intensified ones are performing

Manon Dardonville; Christian Bockstaller; Jean Villerd; Olivier Therond

UMR 1132 – LAE "Laboratoire Agronomie et Environnement" – INRA – Université de Lorraine

New agriculture models have emerged in response to societal demands to reduce the environmental impacts, increase food quality and reduce dependence on non-renewable resources. These different models can be classified according the relative weight of using anthropic inputs or biodiversity and associated ecosystem services as agricultural production factors. Anthropic input-based systems can compensate some biophysical hazards by input use (e.g. irrigation). Systems based on ecosystem services tend to be emancipated from non-renewable resources squarcity. Both are exposed to climate changes, price volatility, pest outbreaks and other disturbances. Ability of these different models to cope with the diverse hazards they face with, i.e. their resilience, is decisive for their large adoption and the support by institutions. However, few is known about their respective level and the drivers of resilience.

In this study, we assessed resilience of 30 very contrasted cropping systems of North-Est France. They represent the range, from simplified and intensified to complex and biodiversity-based agroecosystems. We carried out resilience assessment through quantitative analysis of the dynamics of the three key functions and associated performances along 8 years: production (yield), economic (gross margin) and social (workload) performances. An original set of different adapted criteria of dynamics was used to assess their dynamics: level, variability, trend and resistance. We combined partial least square analysis, multiple regression tree and pareto ranking to decipher relationships between the characteristics and performance resilience of these systems.

Our results show that biodiversity-based agroecosystems (crop diversified, presence of semi-natural habitat and mixtures of species), with high level of ecosystem services provided to farmers, or natural capital increasing tend to have stable performances. These systems also require little work compared to intensified systems. On the other hand, anthropic intensive systems, especially irrigated and tillage-intensive systems, have higher yields and gross margins and are rather resistant to major impacting disturbances but are less stable. While our results converge with studies showing the benefits of relying on biodiversity to stabilize system performances, we highlight a potential trade-off between performance level and stability but also possible solutions to overcome and make bearable it. Finally, we discuss the short-term criticism of anthropic input-based strategy, which are performing but time- and resource-consuming. We present the potential interest of systems balancing both ecosystem services and anthropic inputs that offer a strategy to both fill the yield gap and reach resilience.

Effects of farming practices and subsidies on the stability of food production and farm income in a variable climate

Caroline Harkness[1]; Francisco Areal[2]; Mikhail Semenov[3]; Nimai Senapati[3]; Ian Shield[3]; Jacob Bishop[1]

[1] University of Reading, United Kingdom; [2] Newcastle University, United Kingdom;
[3] Rothamsted Research, United Kingdom

Climate variability and weather extremes threaten agricultural production and the ability to maintain a stable food supply. Such production shocks can also affect the stability of farm income, representing a significant challenge for farm management and the design of public policies. The stability of food production and farm income are also affected by farm characteristics (e.g. size), farming practices (e.g. agricultural diversity and input intensity) and government subsidies, which are important to consider alongside climatic impacts. However, such quantitative assessments at the farm level, and across different farm types, remain rare.

We analyse the relative effects of climate variability, subsidies and farming practices on the temporal variability (inverse of stability) of food production and farm income. We use data for 929 cereal, general cropping and mixed farms in England and Wales between 2005 and 2017, and link farms to historic climate data at a sub-regional scale. We estimate Bayesian multilevel models and fit separate models for different farm types to provide targeted recommendations for farmers.

Our results show that variability in temperature and rainfall affects the stability of both farm income and food production, however, the importance of these effects vary between farm types. Greater agricultural diversity (i.e. lower degree of specialisation in individual crop and livestock activities) has a large relative effect, compared to other farming practices and climate conditions, on the stability of both food production and farm incomes. For general cropping farms, increasing specialisation by 1 standard deviation (we use standardised coefficients) increases the variability of income by 13% and the variability of calories by 5%, on average. For cereal farms, specialisation also has a large relative effect, increasing the variability of income by 5% and the variability of calories by 10%. The impact of input intensity is, however, more complex. Spending more on chemical inputs is associated with greater stability in calories produced at the farm level, but increased input use is also associated with more variable income. Government subsidies are also found to affect the stability of food production and farm income, however the sizes of these effects are smaller. Agri-environment schemes are found to improve stability of both farm income and food production for general cropping and mixed farms, whereas cereal farms do not see the same benefits from these schemes.

Greater agricultural diversity and more precise and controlled use of chemicals can help improve ecological functions and reduce negative impacts of farming on the environment. Our results indicate these farming practices may also improve stability, at the farm level. The relative effects of agricultural diversity and input intensity were similar in size, and in some instances larger, that the effect of climate on the stability of food production and farm income. Our results therefore highlight the importance of considering both farming practices and climate conditions when examining stability of farm performance. Recommendations and practices to improve stability also vary between farm types, therefore future agricultural policy should be flexible and adaptable to benefit different types of production.

Multi-species grasslands open pathways for improving productivity and resilience under intensive management

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Keywords: Multi-species mixture, crop-grassland rotation, ecological intensification

Multi-species grasslands mixtures offer an opportunity to increase sustainable production from intensively managed European grasslands. However, more extreme weather event such as summer drought are to be expected due to climatic changes. We investigate the effects of mixing species and functional groups with the aim of improving forage yield, nitrogen use efficiency and resistance to drought of intensively managed crop-livestock systems.

A simplex design including six species monocultures and 13 mixtures was sown in 2017 in a field experiment in the south-east of Ireland. Three functional groups were represented: grasses (Lolium perenne L., Phleum pratens L.); legumes (Trifolium repens L., Trifolium pratense L.) and herbs (Cichorium intybus L., Plantago lanceolata L.) and combined to create monocultures of all six species, as well as 2-, 4-, 5- and 6-species mixtures within 1, 2, and 3 functional groups respectively. All experimental plots received 150 kg ha-1 of nitrogen fertiliser per annum and a Lolium perenne monoculture with 300 kg ha-1 of nitrogen was included as a comparison, representing standard Irish management.

Each plot was split in two halves. A 2-month experimental drought wass applied to one randomly chosen half, using a rainout shelter. The other half acted as a rainfed control. Aboveground biomass was harvested following a simulated grazing protocol. We measured dry matter yield and nitrogen content of the exported biomass.

After a three-year grassland phase, all plots were reseeded with a Loliul multiflorum monoculture crop and fertilised with 40 kg ha-1 of nitrogen fertiliser in two splits. Again, dry matter and nitrogen yields were recorded. All plots and subplots being treated the same, we could then disentangle the long term effect of grassland's plant diversity and the occurrence of summer drought on the following crop.

The total annual aboveground and nitrogen yields were compared between each plant community and climatic treatments for each phase of the rotation. We also gathered results over the full rotation for a general view of the effects of plant diversity as a management tool for improving productivity and sustainability of temperate intensive agricultural systems over a changing environment.

The annual production resilience indicator and effective diversity of agricultural systems at the national, regional and global levels

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European Commission

Crop production resilience is an important prerequisite for sustainable development, especially in face of global changes such as global warming. This study evaluates the effects of crop diversity on the production resilience in relationships to common stressors such as climate variability, environmental constraints and social instabilities. The analysis is mainly based on FAOSTAT crop production data and open-source software to evaluate the annual production resilience at national, regional and global levels. The software is also discussed in details in a dedicated masterclass of the conference ("Emerging climate services tools for sustainable resilient agricultural systems"). The analysis confirms that diversity is a major constituent of resilience and points to the usefulness of the proposed data-driven indicator. Results show how agricultural systems in developing countries tend to be more diversified than those in developed countries, an aspect that may contribute in a sustainable and resilient increase in productivity. Crop diversification should clearly be consistent with the changes in crop suitability, such as the poleward migration of agro-climatic zones that we estimated for Europe. Finally, local and global food demands should also be consistently oriented.

Poster

Integrated assessment of resilience of crop-livestock systems: An operational approach based on the MAELIA platform

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The volatility of food and financial markets and accelerating climate change are increasingly threatening current farming systems. Diversified and integrated crop-livestock (ICLS) systems, at farm- and local level, are seen as a promising for a viable agroecological transition. However, it is necessary to assess the capability of these systems to maintain their environmental, social and economic performances when dealing with external perturbations. In this study, we show the usefulness of MAELIA, an Integrated Assessment and Modelling platform, to assess the resilience of scenarios of exchanges between seven neighbouring arable and livestock farms in western France (Vendée department). This agent-based platform integrates simple, spatially explicit, robust pattern-based models to finely represent: (i) the spatiotemporal variability given by the edaphic-climatic characteristics of each studied farm and associated agro-ecological processes (e.g. crop growth, as well as water, carbon and nitrogen cycles) and (ii) the farming strategies of each production situation.

Using MAELIA, we assess the resilience of the current (baseline) situation and a self-sufficiency-based ICLS under nine scenarios combining: (i) three representative concentration pathways (RCP2.6, RCP4.5 and RCP8.5) for climate change and (ii) three economic scenarios with increasing levels of fluctuation and uncertainty. Seven functions were considered to be maintained in the face of hazards: food provision, economic viability, ecosystem services to farmer and society, environmental integrity, social acceptability and self-sufficiency. The resilience of each of these functions was evaluated through 13 corresponding performances attributes (PA), that include energy yield, gross margin, nitrogen provision, carbon storage, greenhouse gases and farmer workload. In addition, four criteria (level, trend, variability and resistance) were used to describe the PA's dynamics over time.

Our results show the value of ICLS, based on the spatio-temporal complementarity between specialized farms, to achieve both autonomy and resilience to climatic and economic hazards. Trade-offs and synergies between PA dynamics were analyzed. This study also demonstrates the interest of MAELIA to perform an integrated resilience assessment of (i) a wide range of performances representing the multifunctionality of agriculture, while considering both (ii) the key biotechnical processes and interactions from field and farm to farm group levels and (iii) a range of long-term climatic and economic exogenous disturbances.

Landscape Complexity and U.S. Crop Production

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Agricultural expansion and intensification have simplified Earth's landscapes, with negative consequences for the biodiversity and ecosystems services that support agricultural production. Field-scale research suggests that increased landcover complexity can improve crop productivity; yet, less is known about how complexity and crop productivity interact at broader landscape scales. This study evaluates the relationship between landscape complexity and crop yields for counties in the conterminous U.S. from 2008 to 2018. Our results suggest that what is on the landscape has a stronger influence on yields than how things are arranged on the landscape. Specifically, increased landcover diversity is associated with yield increases for corn and wheat of more than 10%; an effect strength similar to the impact of seasonal precipitation and soil suitability. Notably, landscape configurations that are both moderately complex and also highly diverse are associated with yield increases of more than 20% for corn and wheat.

Valuing the diversity of farms interactions to design sustainable agricultural systems at landscape level

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Keywords: Crop-livestock integration, Pastoral systems, Sustainability assessment, modelling

In the Mediterranean region, the specialization of farms has decoupled crops and livestock at the farm level, but new dynamics of crop-livestock integration beyond the farm level are emerging (Asai et al., 2018). These new dynamics are based on a diversity of interactions between crop and livestock farming systems and seem to be relevant levers for improving the ability of farms to mitigate the impacts associated with disturbances. However, if diversity in crop and livestock activities in a farm has been shown to reduce vulnerability, at a higher scale, the growth of diversity and its benefits remain unclear (Garett et al., 2020). The objective of the work was to analyze how the diversity of livestock and crop activities affects sustainability performance at the farm and territorial levels (Lurette et al., 2020). We developed a scenario evaluation approach using biotechnical models of existing farms within the territory of the Vallées de Duyes in the South of France. From an initial territorial configuration, i.e. a set of interacting farms, two contrasting configurations were simulated: a configuration involving only specialised farms (livestock or crop), a configuration involving only mixed farms. For these two territorial configurations, we tested two levels of intensity of interactions between farms illustrated by exchanges of straw, manure or feed. The intrinsic diversity of individual farms impacts their performance and reveals that the resistance to economic shock varies according to the dependence on inputs and the use of rangelands. If mixed farms exhibit high values of diversity indicators for both land use and product provision, they also present high values for the majority of sustainable properties. At a higher scale, the specialized configuration shows the highest resistance to economic shock, but economic performances are lower than the referenced and specialized configurations. Interactions between farms make it possible to make better use of territorial resources but do not reduce the dependence of the farms concerned on inputs or premiums. However, if guarantees of the durability of these interactions, in terms of quantities or price constancy, can lead to the strengthening of the resistance of the territories to economic hazards. Depending on the specialized or the mixed farms configuration, it is the combination of both the diversity of activities and the intensity of their interactions that prove to be relevant levers for the development of sustainable agricultural territories.

References:

Asai, M., Moraine, M., Ryschawy, J., de Wit, J., Hoshide, A. K., Martin, G. (2018). Critical factors for crop-livestock integration beyond the farm level: A cross analysis of worldwide case studies. Land Use Pol. 73, 184–194. https://doi.org/10.1016/j.landusepol.2017.12.010

Garrett, R. D., Ryschawy, J., Bell, L. W. et al. (2020). Drivers of decoupling and recoupling of crop and livestock systems at farm and territorial scales. Ecology and Society 25(1):24. https://doi.org/10.5751/ES-11412-250124

Biomass and grain productivity of suitable herbaceous cover crops for use in conservation agriculture in northern Benin

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Keywords: Biomass production, food system, ecosystem services, legume cover crops, resilient agriculture, West Africa

Conservation agriculture is perceived as an environmentally friendly production means which is based on the complete soil cover using cover crops. Due to the low productivity of soils in northern Benin, this technique seems promising to boost farmers' yield and alleviate poverty. In order to evaluate the best adapted cover crops species growth and productivity for their use in conservation agriculture, we conducted a trial in two villages from two agroecological zones of northern Benin (Okpara and Angaradébou, respectively in the municipalities of Parakou and Kandi). The set-up was a randomized complete block design with six replicates per treatment. Each plot unit size were 15 m x 4 m. The cover crops were installed in a continuous row (no row spacing) with 0.50 m spacing amid row. Ten species in Okpara (Brachiaria ruziziensis, Crotalaria juncea, Crotalaria retusa, Stylosanthes guianensis, Crotalaria ochrolenca, Centrosema pubescens, Cajanus cajan, Mucuna pruriens, Sesbania rostrata and Crotalaria spectabilis) and three species in Angaradébou (Brachiaria ruziziensis, Crotalaria juncea and Crotalaria retusa) were used. Data collection was done every 15 days after planting and included density, plant height, biomass and grain productivity at harvest. The results showed that plant development varied strongly ($p < 0.001$) from one species to the other with a great variability between sites. Biomass and grain productivity obtained were generally higher at Okpara than Angaradebou. Grain yield and biomass production were also affected by the cover crop at both sites ($p < 0.01$). The highest grain yields were obtained with C. cajan (87 t DM/ha), M. pruriens (68 t DM/ha) and C. juncea (51 t DM/ha), while the highest above ground biomass (leaves + twigs + stem) was observed for C. cajan (219 t DM/ha), M. pruriens (218 t DM/ha) and C. juncea (108 t DM/ha). In terms of yield components, M. pruriens produced more pods per plant (44 2 pods/plant) followed by C. cajan (42 2 pods/plant), C. juncea (38 2 pods/plant) and S. rostrata (37 2 pods/plant). Likewise, C. ochrolenca produced 88 3 seeds/pod and C. juncea (76 3 number of seeds/pod) perform better in terms of number of seeds per pod, while M. pruriens (5.36 1 g/pod) and C. cajan (4.16 1 g/pod) have the highest unit pod weights. Overall, we conclude that the herbaceous cover crops assessed in the present study have great agronomic potential to substantially increase biomass availability and grain yields for seed-bank purposes. However, the use of multipurpose cover crops and their combination in cropping systems would facilitate the success of conservation agriculture, diversification, eco-systemic services and resilient agriculture. Further studies are welcome to evaluate and identify the best combinations in this regard.

Assessing the potential delivery of ecosystem services by farmlands under contrasting management intensities

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Agricultural management can contribute differently to the delivery of bundles of ecosystem services (ES). Low intensity farming systems such as High Nature Value farmlands (HNVf) are expected to deliver a wider range of ES, whereas agricultural landscapes under more intensive management are expected to deliver mainly provisioning services. Identifying management practices contributing to desirable outcomes in terms of biodiversity and ES, entails understanding the key drivers underlying the delivery of ES in agricultural landscapes.

We analysed the links between the delivery of ES bundles associated with farmlands, and their socio-ecological drivers, using a region in northern Portugal as a case study. Based on available data on ecosystems services and drivers, we analysed ES associations and their multifunctional potential, and investigated their relationship with drivers of ES operating at the regional level.

Results suggested a spatial trade-off between landscapes delivering provisioning services of high economic value, and others delivering multiple services. Bundle analysis allowed the identification of an association between multifunctionality of landscapes and higher values of landscape complexity, higher number of farmers and farm sizes. Results reflect the complexity of social and ecological factors operating at the landscape level, while pinpointing landscapes with higher multifunctionality and disclosing the conditions underlying their occurrence. The results also highlight the importance of low-intensity farming systems, such as occur on High Nature Value farmlands, since they provide a wider range of ES delivery within those landscapes.

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SESSION 2:

FARMING SYSTEMS

2.4 Farm economy of cropping diversification

Convenor:

Heikki Lehtonen, Natural Resources Institute Finland (Luke), Finland

Farm level profitability is one of the pivotal elements in the development of diversified cropping systems. It is relevant to evaluate to what extent the costs may be covered by the benefits of diversification in the short and long run. Otherwise there is little economic incentive for farmers to diversify, especially when they are historically linked to specialised agri-food value chains.

Farmers and their close stakeholders need understanding how and why they might reach economic break-even – a situation where costs of diversification are covered by the monetary benefits. There is a need for studies showing concretely how cropping diversifications may or may not produce positive economic outcome or prove more profitable than less diversified cropping.

The purpose of this session is to introduce different approaches in studying farm level economic effects of cropping diversification while showing also results based on empirical material of the costs and benefits, e.g. profitability of diversified cropping compared to less diversified farming, or how diversification can be proven economically viable. It is recognised here that the mere economic profitability is often not the sole objective for farmers. Diversification may provide farmers utility gains, reduced risks, or avoided costs in the long run. Hence this session encourages papers showing clearly where the costs and benefits come from and if various benefits may outweigh the costs of diversification and provide improved avenues for farming.

The second slot of this session will have a focus on "decision making and barriers".

Orals

Crop rotation and low input practices adoption in intensive farming systems. A Gross Margin impact evaluation in tomato-cereals specialized farm

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Promoting practices that increase the capacity of agricultural systems to produce food and other ecosystem services is outlined worldwide by international agenda (SDGs), in Europe proposed by CAP reform documents. Agents potentially involved to achieve these goals are various, many of them will be play a role to support farmers to plan their activities looking at sustainable intensification principles (Struik and Kuyper, 2017).

This transition is analysed in some studies aimed to evaluate whether the introduction of agro-ecological practices could produce environmental benefits without compromising the profitability of farmers. However, the great heterogeneity of agricultural production systems and proposed practices makes it difficult to obtain meaningful comparisons about tradeoffs potentially gained between environmental performance and profitability improvements at farm level (Rosa-Schleich et al., 2019). Moreover, these analyses often analyse impact on revenues and costs related to agroecological practices adoption by small and medium-sized farms characterized by family work and connected to local value chain (Van der Ploeg et al., 2019) while there are few studies that investigate on intensive production systems where specialized farmers meet the agro-industrial supply needs.

In this context this study aims to evaluate the economics feasibility of sustainable practices introduced by multiyear and multi crop cultivation contracts in professional farms specialized in commodities production.

Among DIVERFARMING project case studies, 3 farms specialized in irrigated arable land cultivation from north Italy have been involved. A hypothetical multi-years & multi-product contract was defined by a co-design process that have involved researcher, farmer, and agro-industry officers and applied to 15 ha of arable land for two agrarian-years: 2017–2018 and 2018–2019.

The arable land was divided into three plots of about 5 hectares each to test a three-year rotation that include legumes (Pisum sativum) and second harvest tomato. The experimental scheme (DIV) allows to test effects on GM related to the adoption of: low input management practices (reduced tillage on soil preparation for wheat; organic fertilizer); risk management tools (for peas and tomato); durum wheat quality premium price. The baseline cropping system reference (BAS) have considered assuming most common crop-rotation scheme (tomato-tomato-durum wheat), cultivated in a common way in the area.

Gross margin (GM) assessment was done using data collected directly from plots during the two agrarian years to allow a comparison between BAS and DIV scheme of production. The revenues include values related to subsides, premium price gained by contract agreement as well as insurance contributions; costs are related to input, mechanization, labor, external services, insurance and other explicit fee related to crops management on the plots.

In all cases, the transition from BAS to DIV system led to an improvement in the average profitability of one hectare of arable land. The co-defined diversifications options have mitigated the effect of climatic and market instability on GMs compared to current management.

Results confirms that positive outcomes can be obtained in specialized farms when diversification options are agreed between supply chain and technicians operators and specific tools to distribute risks among value chain operators are provided.

Financial feasibility of intercropping. The case of irrigated mandarin (se Spain)

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Monocrop is the predominant farming system among irrigated crops along Europe. Despite the high yield achieved, monocropping systems may provide many negative environmental impacts (erosion and soil loss, greenhouse and gases emissions, soil and water pollution, etc.) which could even compromise the long-term sustainability. Diversified farming system seems to be a feasible alternative to overcome many of these environmental challenges maintaining farm profitability, since it takes into account the maintenance of ecosystem services that provide relevant inputs to agriculture. Within these systems, intercropping practices are one of the main alternatives for woody crops. Intercropping consist of growing more than one crop at the same time in the same plot. Regarding to monocropping systems, intercropping improve soil characteristics, reduce pest risk, and improve sustainability in the long-term.

However, although the environmental benefits of intercropping over monocropping have been extensively studied, there is a lack of studies on the financial side, especially in the case of woody crops, such irrigated citrus. According to literature, in perennial woody crops, the implementation of alley crops in intercropping should not affect negatively to the main crop yields. However, transitioning from monocrop to intercropping practices could imply high start-up costs and a rise of many production costs that could compromise the farm financial performance, being a barrier for farmers adoption.

In this context, this study aims to evaluate the financial feasibility of implementing intercropping in a mandarin orchard. To this end, two intercropping systems are evaluated together with conventional irrigated mandarin monocrop. Diversification 1 (D1) consist of mandarin intercropped with multiple cropping of vetch/barley (Vicia sativa/Hordeum vulgare) for feed and fava bean (Vicia faba) for food, during 2018, 2019 and 2020. Diversification 2 (D2) consists of mandarin intercropped with a rotation of vetch/barley and fava bean during 2018, purslane (Portulaca oleracea) during 2019, and a rotation of vetch/barley and cowpea (Vigna unguiculata) during 2020. Data have been obtained from a field experiment located in the Region of Murcia (SE Spain). Revenues, costs and gross margins for both diversifications and monocrop during 2018, 2019 and 2020 have been estimate at field scale and differences between financial indicators have been checked.

Results show that intercropping practices in mandarin orchard could imply significant costs increases that does not necessary involved significant changes in gross margins and, consequently, in the farm profitability. Intercropping raises, therefore, as a feasible alternative to monocrop in the case of citrus orchards. Furthermore, in spite of the financial analysis results, intercropping in mandarin orchards could lead associated farm benefits that improve the financial performance in the long term, such as environmental and biodiversity benefits, and risk mitigation by a higher resilience and price volatility.

Improving dynamic farm level modeling through coupling pre-crop values with crop rotation optimization

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Keywords: Crop modeling, dynamic optimization, land use, agricultural economics

There is a consensus that pre-crop effects, i.e. the effects of preceding crops on yield, do exist but the magnitudes of the effects are neither well known nor utilized by decision making. However, recent empirical estimations on the pre-crop effects (Peltonen-Sainio et al., 2019) enable their integration into agricultural models and crop rotation optimization. Using pre-crop values may lead to more realistic and valuable results in farmers' decision making.

Prior, optimal crop rotation analyses have utilized assumed pre-crop effects on crop yields based on expert estimates. For example, some experts may reasonably assume that monocultures cause some yield losses, while others may avoid such yield losses if cultivating different crops in a sequence. While such assumptions might be plausible, the pre-crop effects are still uncertain. Furthermore, without sound empirical basis for the pre-crop effects there might be a need to add additional constraints to prevent unrealistic or infeasible solutions. Using empirically estimated pre-crop values takes the inter-temporal crop dynamics explicitly into account and eliminates the more-or-less subjective expert estimates of pre-crop values or additional constraints.

In this paper, we extend an earlier published farm model (Purola and Lehtonen, 2020) with empirically estimated pre-crop values (Peltonen-Sainio et al., 2019). The model simulates farm management of a 10-parcel farm located in Southwestern Finland. We optimize crop rotations with 6 possible crops and their related input use, as well as options for setting the parcel aside or as nature managed field, and maximize net present value with 6% interest rate over 30 years. We analyze three cases:

- no pre-crop values with minimal land-use constraints
- no pre-crop values with extensive land-use constraints
- pre-crop values with minimal land-use constraints

We show that with no pre-crop values and minimal land-use constraints, where only constraints related to agricultural subsidy is active, the farm is nearly malting barley monoculture, and thus does not represent farms in the region the model is based on. If we extend the model with the more extensive land-use constraints (cf. Purola and Lehtonen 2020), we obtain more diverse and realistic crop rotations. However, these land-use constraints may limit the applicability of the model to wider issues. Applying the same model with pre-crop values and with minimal land-use constraints, we obtain similar crop rotation diversity typical to the region as with extensive land-use constraints.

However, since we are not using assumed pre-crop effects or additional land-use constraints, our results show how farmers could attain more value by utilizing the pre-crop effects in their farm management and decision making.

This approach in crop rotation optimization is novel, and will enable the study of more diverse situations, including climate change and novel crops, and their effect on optimal crop rotation and farm economics.

References:

Peltonen-Sainio, P. et al. (2019). Pre-crop values from satellite images for various previous and subsequent crop combinations. Frontiers in plant science 10.

Purola, T. and Lehtonen, H. (2020). Evaluating profitability of soil-renovation investments under crop rotation constraints in Finland. Agricultural Systems 180.

Costs and benefits of measures to diversify cropping systems

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Keywords: Biodiversity, sustainable agricultural farming systems, cost-benefit analysis

Protecting and promoting biodiversity is an important societal issue as species loss is one of the greatest ecological challenges worldwide besides climate change. Agricultural landscapes play an important role due to the high share of agricultural land use. Crop production systems need to be adapted according to these requirements through appropriate agricultural measures and strategies. In particular, those that also support functional biodiversity can help to improve ecosystem services such as pollination or pest control and thus support crop production at the same time.

Such measures or strategies include combinations of structural elements within the agricultural landscape, specific cultivation methods, or diversity of species and varieties of crops. These measures are, however, associated with both positive and negative effects, or costs and benefits, for farms and society.

Within the H2020-project EcoStack, such farming strategies based on functional biodiversity are developed, tested and evaluated, including a cost-benefit analysis of the implementation of measures and strategies in different European pedo-climatic zones, socio-economic regions and agricultural production systems with their different demands.

EcoStack measures are environmentally friendly cropping methods at different spatial scales. At the landscape or off-crop level, we examine structural elements such as flower strips, grassy field margins, and hedgerows. At the field or in-crop level, we study biodiversity enhancement through variety mixtures, undersowing, or organic mulching. At the micro- or plant-level, we investigate the introduction of beneficial microorganisms and the use of biopesticides. EcoStack measures are individual measures that will be combined or “stacked” to EcoStack strategies with the intention of achieving synergy effects.

Our research focuses on the question, which measures and strategies are best suited to promote biodiversity in agricultural landscapes under different regional conditions? Where do socio-economic costs and benefits arise and how can we measure them?

In order to approach the rather complex aspects of costs and benefits, we first systematize and describe all expected positive and negative effects of the measures at farm and societal level in a qualitative and – as far as possible – quantitative way. Based on this inventory of data and information, we conduct expert consultations for a more detailed evaluation of the expected effects and for selecting the most promising measures for further investigation.

We present first examples for selected measures, where we consider additional costs such as inputs of seed, labor, machinery, as well as transaction and opportunity costs for foregone yield. These costs are compared to the expected benefits such as higher yields, savings in pesticides and their application, improved pollination and pest control by beneficials. We also point out knowledge and data gaps, and ways to address them.

Finally, we provide an outlook on how results will be linked through modeling at the landscape level and how the modeling results will be incorporated into the cost-benefit analysis.

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Farmers' action space to adopt sustainable practices: a study of arable farming in Saxony

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Keywords: Agriculture, agri-environmental policy, behavioural studies, sustainability

The urgency to address climate change, biodiversity loss and natural resource degradation makes major changes in agricultural practices necessary. Agricultural policy in the European Union and in Germany has so far failed to generate such changes (Pe'er et al., 2019); meanwhile, public demands for new regulations are met by widespread protests and opposition from farmers. Against this background, an improved understanding of the factors influencing farmers' uptake of sustainable agricultural practices is necessary. This study introduces the concept of farmers' action space, which aims to analyze the role of barriers to change which lie beyond farmers' perceived immediate control. This conceptual framework is applied to the case of diversified crop rotations in the German federal state of Saxony. We combine semi-structured interviews and a survey to identify key barriers to change and their relative weights. We find that farmers feel rather strongly restricted in their action space to implement diversified crop rotations. The most important barriers pertain to the market environment, which severely limits the feasibility of many crops due to limited willingness to pay for sustainable products, market power in processing and retail, and underdeveloped regional infrastructure for processing and marketing of additional crops. Furthermore, limited regulatory predictability as well as regulatory incoherence and limited flexibility are perceived by farmers as restricting their action space. The role of resource availability within the farm businesses as well as availability and accessibility of knowledge is ambiguous between interview and survey results. The analysis of interactions indicates that multiple barriers form a self-reinforcing system in which farmers perceive to have little leeway to implement sustainable practices. These results emphasize the need to create an enabling market and regulatory environment in which sustainable practices pay off.

References:

Pe'er, G., Zinngrebe, Y., Moreira, F., Sirami, C., Schindler, S., Müller, R., Bontzorlos, V., Clough, D., Bezák, P., Bonn, A., Hansjürgens, B., Lomba, A., Möckel, S., Passoni, G., Schleyer, C., Schmidt, J., Lakner, S. (2019). A greener path for the EU Common Agricultural Policy. Science 365, 449–451. https://doi.org/10.1126/science.aax3146

Farmers' adoption of crop diversity – an explanation using the theory of planned behavior

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Keywords: Farmer decision-making, crop diversification, sustainability, theory of planned behavior

While various studies have examined the adoption of agri-environmental schemes and sustainable farming methods in general (Dessart et al., 2019), less research has been conducted on the voluntary adoption of specific practices. Our research, in contrast, specifically addresses the decision to grow a wide variety of crops and the factors that influence this decision.

Agricultural diversification has been proposed as one important measure for more sustainable agriculture. In the last years, crop diversification has also been part of agri-environmental schemes aimed at improving farm-level biodiversity in several German regions, but its adoption has been far from universal. In this paper, we analyze the intention to adopt a diversified farming practice, as defined by simultaneously cultivating at least five different types of main-crops, using the theory of planned behavior. This approach has been used to analyze a wide range of farming decisions (Sok et al., 2020). Our data comes from a quantitative survey, based on a convenience sample in the Rheinische Revier region in North Rhine-Westphalia.

Highly productive agricultural soils and a large share of grain production shape the region. At the same time, as part of the coal phase-out, the region is undergoing rapid structural change and following the objective of becoming a model region for a sustainable bioeconomy. On the one hand, farmers are envisioned to provide resources for both regional foods and material uses. On the other hand, different methods and technologies to increase farm-level sustainability are proposed as part of the transition. In this context, we argue that sustainable production methods that improve upon ecological aspects with as little negative impact on yields as possible are central. As such, diversification of cultivated crops from the currently prevailing cultivation of wheat, beet and potato could play an important role.

We thus examine the role of a number of behavioral, normative and control beliefs on the intention to adopt a variety of at least five main crops. We consider the role of beliefs with regard to marginal profit contributions and receiving financial support as well as non-financial motives as factors of influence. Understanding the importance of these factors for decision-making provides valuable information for facilitating further crop diversification as part of the transition towards a sustainable bioeconomy.

Furthermore, we examine the role of general environmental attitudes and structural variables as background factors. We aim to define different farmer types based on these personal factors and to show differences in beliefs with regard to using a wide variety of crops.

References:

Dessart, F. J., Barreiro-Hurlé, J., van Bavel, R. (2019). Behavioural factors affecting the adoption of sustainable farming practices: a policy-oriented review. European Review of Agricultural Economics 46, 417–471. https://doi.org/10.1093/erae/jbz019

Sok, J., Borges, J. R., Schmidt, P., Ajzen, I. (2020). Farmer Behaviour as Reasoned Action: A Critical Review of Research with the Theory of Planned Behaviour. J Agric Econ. https://doi.org/10.1111/1477-9552.12408

Making smart choices – Behavioural traits and resilience to environmental shocks among farming households in Thailand

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Keywords: Resilience, Household decision-making, Environmental shocks, Behavioural traits

Climate change, in the form of intensified environmental shocks, adds significantly to the existing challenges of small-scale farming households in emerging economies. Households can adopt various response strategies, based on their resilience capacity, to mitigate the impact of shocks on their overall welfare. These can be categorized as absorptive, adaptive or transformative, depending on the intensity of change that they entail. Absorptive strategies aim at persistence and reducing the direct impact of a shock (Béné et al., 2016). Adaptive strategies imply incremental changes, while transformative strategies lead to deeper transformational responses and address structural causes of vulnerability (ibid). Furthermore, the chosen strategies cannot always be considered as positive and could impact the household's welfare outcomes negatively in the long run. Therefore, the decisions pertaining the household's choice of response strategies demands more attention. Literature identifies household financial capital as an important determinant of its resilience capacity and hence response strategy (Béné, 2020). However, evidence on the role of human capital, especially behavioural traits, is scarce. Additionally, most findings on behavioural traits and resilience are based on data from developed countries and may not hold in the context of emerging economies. Therefore, the aim of this paper is to investigate the role of behavioural traits in the household's choice of response strategies to environmental shocks in rural Thailand. In particular, we examine how behavioural traits influence the decision of households to adopt (i) absorptive, adaptive or transformative and (ii) positive or negative response strategies.

We use primary household level data on around 2000 households from the Thailand Vietnam Socio Economic Panel from 2017 and 2019, in combination with spatial data on rainfall and temperature to obtain causal effects. We consider a set of response strategies such as diversification of crop patterns, use of child labour, migration, and selling of productive assets to capture the diverse nature of responses adopted by the households. These are categorized as absorptive, adaptive or transformative, and positive or negative. Seven measures of behavioural traits, namely, openness, conscientiousness, extraversion, agreeableness, and neuroticism (the Big Five Model) as well as risk preference, and patience are included in the analysis. Seemingly Unrelated Probit regressions are used to estimate the two research questions. We expect our results to show a bigger role for behavioural traits, especially openness, risk and patience. A better understanding of this decision-making process can aid in designing policies and developing programmes that encourage the choice of smart response strategies among households and promote agricultural resilience.

References:

Béné, C. (2020). Resilience of local food systems and links to food security – A review of some important concepts in the context of COVID-19 and other shocks. Food Security, 12(4), 805–822.

Béné, C., Headey, D., Haddad, L. and von Grebmer, K. (2016). Is resilience a useful concept in the context of food security and nutrition programmes? Some conceptual and practical considerations. Food Security, 8(1), 123–138.

Crop diversification in steep slope viticulture with perennial herbs

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The EU-funded project DIVERFARMING (Horizon 2020 no 728003) aims to develop and deploy innovative farming and agribusiness models based on crop diversification. Germany is involved with a broad-based study in organic steep slope viticulture in Wawern (Saar Valley/Mosel Wine Region). The investigated Eutric Skeletic Regosol (Aric, Humic) is characterised by an extreme soil climatic regime.

A fundamental issue of steep slope viticulture is related to vegetation management below the vines. In order to overcome problems of soil erosion and soil organic matter depletion, an increasing number of winemakers is establishing cover crops such as grasses and legumes in driving lanes. On the contrary, the area underneath the vines is typically kept free of vegetation to avoid fungal diseases and competition on water. As cover crops do not benefit to the value chain and may compete with vines on water or have other adverse effects on vine performance, an alternative strategy for vegetation management underneath vines in steep slope viticulture is required.

Therefore, intercropping vines with perennial herbs like Thyme and Oregano growing underneath is a promising cropping practice to address the abovementioned issues. Both herbs are economically valuable and originate from dry and warm environments, which are typical for most viticultural areas. Furthermore, their relatively low need for water and flat-growing habitus is assumed to be suitable to cover the soil underneath the vines in order to protect against erosion and suppress weeds without having adverse effects on vine growth and -health. In addition, they can be marketed directly or indirectly as extracts for cosmetics, perfumes, dietary supplements, food and plant fortification.

In this presentation, we will inform about the status of 3 project years, especially about establishment, growth and manageability of the herbs (Thymus vulgaris and Origanum vulgare). Furthermore, measurable effects on vine (Vitis vinifera L. cv. 'Riesling') and soil, water demand and further use of the herbs as well as their effects on biodiversity and soil erosion will be presented.

SESSION 3

LANDSCAPE MANAGEMENT SYSTEMS

SESSION 3:
LANDSCAPE MANAGEMENT SYSTEMS

3.1 Pathways for a Sustainability Transformation of agricultural Landscapes in Europe

Convenors:

Christian Levers, VU Amsterdam, The Netherlands

Matthias Bürgi, Swiss Federal Research Institute WSL, Switzerland

Tobias Plieninger, Georg-August-Universität Göttingen, Germany

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Agricultural systems in Europe face a multitude of complex sustainability challenges. Ongoing and accelerating mega-trends such as farm-size enlargement, ageing of farmers, dietary change, and not the least climate change will increase the pressure on these systems and will likely require fundamental changes to meet sustainability goals.

The ongoing mechanization, specialization, and intensification of agriculture, often argued as means to improve productivity, economic growth, and societal wellbeing, triggered a homogenization of agricultural landscapes across Europe. However, increasing diversity on farms and in landscapes has been linked to positive outcomes for people and environment and provides a clear sustainability pathway for resilient agro-ecosystems, more diverse diets, and improved health. Yet, benefits and costs of diversified agricultural systems are largely unclear, as well as trade-offs and synergies on sustainability outcomes such as biodiversity, human health, and farmer livelihoods.

This session will offer new insights into transition pathways of European agricultural landscapes towards sustainability with a particular focus on diversified agro-ecosystems by welcoming contributions in form of papers/presentations from all world regions addressing questions such as:

- How can the sustainability of different pathways for European agricultural landscapes be evaluated?
- How is diversity on farm- and landscape-level linked to sustainability outcomes?
- How do mega-trends, markets, and policies influence agricultural diversity patterns?
- How does farmers' risk perception influence their decision making towards more sustainable and diverse systems?

Orals

Disentangling the effects of farming intensity and semi-natural habitats at different spatial scales on vascular plants and arthropod communities involved in pest regulation and pollination services

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In Europe, agriculture intensification has been pointed out a major driver of the decline of biodiversity and of the alteration of ecosystem services. Restoring biodiversity and associated services is crucial to allow the development of more sustainable farming systems and agricultural landscapes. Several strategies have been proposed to counteract this decline in agricultural landscapes. Among them, some rely on the extensification of management practices through the diminution of pesticide use, or on the maintenance/restoration of semi-natural elements in the close vicinity of fields i.e., planting hedgerows. The effects of these strategies are well documented for many biodiversity taxa, but they remain poorly understood from a multifunctional point of view. Here, we investigated the contribution of farming type (organic vs. conventional) and hedgerows at both local and landscape scale to the diversity of vascular plants and arthropod communities involved in pest regulation and pollination services. We selected 40 crop fields, 20 under organic farming and 20 under conventional farming. Fields were distributed along two orthogonal gradients, one of proportion of semi-natural elements and one of proportion of organic farming measured in a 1 km radius centred on each field in the Zone Atelier Armorique, north-western France. Vascular plant species and Arthropods (carabids, spiders, beetle larvae, staphylinds, domestic and solitary bees, bumblebees, syrphids) are monitored along two transects, one located in the center of each field, another located along the hedgerow bordering each field, from May to July 2020. The hierarchical, pseudo-experimental design will allow to disentangle the effects of factors acting at different spatial scales (from local to landscape scale) on arthropod communities. Our study will thus arise critical issues regarding which strategies are relevant for enhancing the conservation of biodiversity, as well as pest regulation and pollination services and thus multifunctionality in agricultural landscapes.

GenRes Bridge: Identification of genetically diverse landscapes for conservation and use of plant, animal, and forest genetic resources

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Conserving and using genetic resources is essential for the sustainability of our food and forest systems. The Convention on Biological Diversity and the UN's Sustainable Development Goals call for the maintenance of genetic diversity, with an emphasis on domesticated plants and crop wild relatives, animal breeds and forest trees. Furthermore, the most recent IPBES Global Assessment Report on Biodiversity and Ecosystem Services, highlights the loss of genetic diversity in these domains and advocates for integrated landscape planning and management to support more effectively the conservation and sustainable use of genetic resources.

To address these overarching objectives, the EU Horizon 2020 GenRes Bridge project aims to strengthen and improve the integration of conservation and sustainable use of genetic resources in the plant, animal and forest domains in Europe and neighbouring countries. The identification of Genetically Diverse Landscapes (GDL) composed of agricultural plants, livestock breeds and forest trees, is key to efficient conservation and sustainable use. We define GDL as geographic regions where a particularly high level of local and locally adapted genetic diversity is found within a disparate array of plant, animal, and forest species. We report the location of three GDL studied as demonstration cases to illustrate their value and integrated conservation, as well as a means of raising awareness of the value of genetic resources.

The three demonstration cases: Aurland (Norway) which is the most northernly of the sites harbouring unique genetic diversity across all domains; the Alps with three cases from east to west which are important as glacial refugia- Triglav National Park (Slovenia), Paneveggio Pale San Martino Natural Park Dolomites (Italy), and Mont Ventoux (France); and Ehden Nature Reserve (Lebanon), which is important due to its location within the Fertile Crescent, a centre of origin and domestication for many crops and livestock.

These demonstration cases provide evidence-based support for the benefits of adopting a GDL approach to integrated genetic resource conservation and management. Such an approach fosters landscape resilience and production system sustainability, collectively and within each genetic resource domain. Furthermore, the demonstration cases illustrate that diverse landscapes ranging from low to high (mountain) elevation are a perquisite associated with GDL, as they provide diverse sub-sites for evolutionary differentiation and complementary production systems, often showing a fine patchwork of agricultural land intermingled with wider biodiversity. Therefore, to effectively conserve and use genetic resources and underpin global food security, the management of geomorphological and ecogeographically diverse landscapes is fundamental, as well as the establishment of partnerships between local genetic resource, biodiversity, ecosystem services, heritage and cultural stakeholders.

Diversified agricultural landscape nitrogen management for environmental and nature protection

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Recently, the European Commission initiated the development of both farmer and policy maker guidance on how to implement environmental measures to obtain a more sustainable agricultural production with combined water, air, nature and climate benefits, including a review of land use and landscape management measures (Dalgaard and Butterbach-Bahl, 2019).

The present paper draws on these results, in particular in relation to the extensive challenges related to the implementation of future EU Policies and compliance with the EU WaterFramework- and Habitats Directives. It points to potentials for landscape-based solutions, including more Mixed Farming Systems (www.MIXED-project.eu) and the development of more NatureBased Solutions for sustainable cultural landscapes under Global Change (www.Sustainscapes.org). This will be illustrated for the case of Denmark where the government promotes a paradigm shift towards a more targeted regulation to supplement the existing general regulation of nitrogen use and management (Dalgaard et al., 2014).

As a result of an expert workshop in Brussels, a series of relevant landscape measures have been identified (Dalgaard and Butterbach-Bahl, 2019), including the following general types of measures whose potential implementation in the concrete landscapes is suggested to be assessed in sequence with the aim to establish local targets for reduction of N losses:

1. Changed crops and crop rotations dependent on landscape properties.
2. Better distribution of livestock manure and fodder production and assessment of the potential for more mixed farming and agroforestry systems.
3. Hot spot management of livestock facilities.
4. Introduction of new biotopes for reduced pollution from agriculture in the landscape (buffer strips, hedgerows, wetlands, mini-wetlands, afforestation and set-aside land).

Geographically targeted landscape management has been discussed for many years. However, this aspect has gained greatly in importance with the development of new digital mapping and modelling techniques, and example of which will be given. Moreover, in countries like Denmark, the low hanging fruits from more general types of measures introduced to reduce N pollution have been plucked and implemented to a degree where further implementation will be very costly (Dalgaard et al., 2014). Additional measures are therefore urgently needed to meet the enhanced policy targets of reduced pollution, not only for water but also regarding air, climate and biodiversity impacts. Moreover, such an approach provides opportunities for a continued development of more environmental friendly food production systems.

References:

Dalgaard, T. and Butterbach-Bahl, K. (2019). Land use and landscape management. www.clrtap-tfrn.org

Dalgaard, T. et al. (2014). Policies for agricultural nitrogen management … Environ. Res. Lett. 9, 115002.

Evaluating impacts of crop diversity and land consolidation shifts: a case study from California

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Meeting growing challenges to maintain food production and rural livelihoods, while minimizing land degradation, will require significant changes in the way global farming landscapes are managed. In California's Central Valley, a major agricultural production hotspot in the United States, these challenges are compounded by dynamics of land-ownership consolidation, shifting dietary trends and crop demand, and the impacts of climate change. In this context, an evaluation of the sustainability impacts and potential trade-offs or synergies associated with different agricultural systems, is crucial to inform the development of future farm management and land-use governance solutions. Here we investigate relationships between changes in crop distribution and diversity, land-ownership consolidation dynamics, and sustainability outcomes in Kern County, California for the period from 2002 to 2018. Our study region consists of a diverse farming landscape which produces over 120 different crop commodities on 700,000 ha; the region has undergone a recent agricultural land-use transition from annual to perennial cropping systems. Our analysis draws on parcel-level data documenting changes in land ownership and in the spatial distribution and land-use footprints of individual crops. We integrate this data with ecosystem pressures and service indicators maps (including water-use, soil erosion, profit and carbon sequestration). We then assess trade-offs and synergies at parcel-level and landscape levels, and discuss our findings in the context of developing mega-trends in the region.

Conflicts and co-benefits between agricultural ecosystem services: sensitivity to scale and unit of analysis for the case of Brandenburg, Germany

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Keywords: Agricultural landscapes, conflicts and co-benefits, scale sensitivity, IACS data

Research on the measurement, analysis and interpretation of spatial patterns and their relationship with ecosystem services (ESS) increased over the past years. Habitat provision and quality for various animal and plant species in agricultural landscapes can be influenced by, for example, the mosaic of crops and uncultivated patches such as woodlots and hedgerows. Ongoing trends of intensification of agricultural land management come along with adverse environmental effects, including decreasing soil and water quality, biodiversity losses, and reduced landscape heterogeneity and lower eco-functionality. Several studies suggest that landscape heterogeneity has been linked to positive outcomes for the environment and people. Spatial heterogeneity, however, is known to be sensitive to scale and units of analysis (UoA) and has been investigated particularly for single ESS. Yet, little is known about the scale sensitivity of relationships between ESS. The aim of this study is to analyze 1) the spatial patterns and 2) scale and UoA sensitivity of conflicts and co-benefits between two exemplary ESS, agricultural production and habitat provision, using bivariate maps. We incorporate fine-scale plot-based data (Integrated Administration Control System; IACS) and remote sensing data (land cover data derived from Sentinel 2) to identify ESS indicators and their spatial patterns. We compare a set of different UoA (i.e. farm-level, hexagonal grids and administrative units) across different spatial (landscape) scales (i.e. spatial resolution). Habitat provision is indicated through the mean nearest distance to green infrastructures, i.e. ‘high vegetation’ in the earth observation data. To evaluate agricultural production structure for farm-level analysis, we calculated the share of the three largest maize plots of total agricultural farm area, while on landscape level agricultural production structure is represented by the mean area-weighted maize plot density. We performed a systematic scale and UoA sensitivity analysis by the computation of indicator variances (data differentiation) and Spearman correlation coefficients between them (data consistency). Furthermore, we compared the spatial distribution of conflicts and co-benefits across UoA and scales. We find high frequencies of conflict classes (~40%) and low frequency of co-benefits (~5%) across all landscape UoA and scales. Our analysis also revealed the importance of choice of scale: a single farm can be homogeneous (e.g. in terms of habitat diversity) but the landscape can still be heterogeneous when homogenous but differently producing farms smartly combine at the landscape scale with diverse spatial patterns. At the same time, landscapes can be homogenous, despite heterogenous production structures at the farm scale. Data differentiation (indicator variances) and correlation between ESS decrease with increasing scale across UoA. Given landscapes’ important regulating features, we conjecture that the landscape scale should be more in view of policy to support smartly tailored environmental and agricultural policies to regional and local characteristics aiming for the development of multifunctional agricultural landscapes.

Farmer attitudes towards ecosystem service delivery: Drivers of sustainable permanent grassland management in Europe

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Permanent grassland (PG) is an important agricultural land use for the delivery of multiple ecosystem services (ES), including habitat provision, carbon sequestration, water quality protection, food production, and cultural activities. However, PG environments are threatened by intensification, cultivation or abandonment. At the same time sub-optimal management can limit ES provision. The behaviour of key decision-makers, including farmers and land managers, is crucial to the facilitation and maintenance of sustainable practices that balance the delivery of ES with productivity. Pathways towards sustainability for PG systems require understanding of the motivating factors and attitudes that lead to the decisions that farmers make about their livelihoods and farm businesses, particularly in light of barriers associated with wider political, economic and cultural contexts.

This study applies the Theory of Planned Behaviour and the Protection Motivation Theory to understand the intentions of farmers regarding the management of PG, particularly in relation to the delivery of ES. The results of structured interviews with 375 farmers, undertaken between October 2020 and April 2021 across five European countries (UK, Spain, Sweden, Czech Republic and Switzerland), which represent five biogeographic regions, with three types of farming system (high input, low input and organic) are presented. The attitudes, preferences and priorities of farmers are assessed in relation to their decisions around PG management on their farms, contextualised by their livestock systems, farming practices, personal values, opinions of the market and policy conditions, and perceived risks and challenges, as well as knowledge of, and attitudes to, management systems and technologies. The results are discussed with regard to opportunities and risks for ES provision, and the role of innovative practices, technological adoption, and diversification in addressing risks and providing opportunities for change. The results offer an understanding of the drivers of, and barriers to, sustainability in PG systems.

From empirical findings to a formalized model: An agent-based approach to represent farmer decision-making on agri-environmental schemes

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Model-based analyses can effectively contribute to investigate leverage points for sustainability transformations in agriculture. They allow for a systematic assessment of policies under changing environmental, economic, or institutional conditions and can be used to evaluate the efficiency of different policy designs. This makes them an important tool for critically evaluating agricultural policies and shaping them appropriately to achieve the desired effect. For analyzing agricultural systems, agent-based modeling is particularly useful as it allows to represent individual farmers – the crucial actors at the landscape level. This approach can explicitly incorporate farmer behavior to map, for example, the conditions for adopting sustainable practices that lead to more diverse agroecosystems.

In order to provide policy makers with an effective tool, an adequate representation of farmers' decision-making is crucial. However, formalizing empirically observed farmer behavior in model rules is difficult because, as in all models describing human behavior, complex decision-making must be simplified into clear cause-effect relationships. Following established behavioral theories, on the other hand, also entails difficulties: First, theories often consider only certain aspects of decision-making and fall short when it comes to incorporating the multiple influences that farmers face. In addition, a rather low degree of formalization of theories as well as limited data availability for model parameterization are problematic. As a consequence, many ABMs remain rather stylized, reducing the external validity of the emerging results and leading to limited potential to help policy makers identify suitable measures for a sustainable transformation of agriculture.

We aim to address this gap with a methodological contribution by developing an empirically driven decision framework for the adoption of agri-environmental schemes (AES). To capture the most important processes of the decision-making in this context, we first collected possible influence factors in an extensive literature search. Based on this overview, we derived a semi-structured interview protocol covering open questions and a standardized questionnaire that provided the basis for an interview campaign in five case study regions across Europe (Czech Republic, Germany, Serbia, Spain and United Kingdom). With the help of local case study experts, we were able to derive key factors for farmer decision-making on AES adoption from the obtained qualitative and quantitative data. We condensed these observations in a formalized conceptual framework that covers a three-step decision process. It incorporates (1) whether farmers are in general open toward the adoption of specific AES, (2) which of their fields are suitable for AES adoption and (3) the final deliberation whether farmers adopt specific AES that is not only driven by economic factors but also includes ecological and social aspects as well as whether an AES fits to the established farm practice. To parameterize the framework and capture regional differences more specifically, we plan to conduct a discrete choice experiment with which the influence factors can be further quantified. We conclude with illustrating examples of research questions that can be addressed using this framework.

Comparing agricultural development to development desired by societal visions

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There is broad agreement that European agriculture has to become more sustainable in order to provide enough healthy food at minimal environmental and social costs. But what is “more sustainable”? More often than not, different stakeholders have opposing opinions on what a more sustainable future should look like. In this contribution, we present a novel approach to assess the sustainability of agricultural development based on societal visions. We illustrate the approach in a Swiss case study area by linking observed changes in agricultural land use intensity with desired change according to three contrasting visions. The three visions, from a liberal think-tank, the Swiss Farmer Association, and the agroecological movement, cover a wide spectrum of sociopolitical interest groups. The observed developments aligned most closely with desired developments of the liberal think-tank. Farmer interviews revealed that farms increased in size (+ 57%), became more specialized, and more productive (+ 223%) over the past 20 years. In addition, interpretation of aerial photographs indicated that farming became more rationalized at the landscape level, with increasing field sizes (+ 34%) and removal of solitary field trees (-18%). The case study example highlights the potential of referring to societal visions as yardsticks to assess changes in land use intensity and outcomes in various sustainability dimensions. The approach accommodates multiple stakeholder goals, while explicitly addressing their narratives and respective systems of values and norms, thus being more informative to the wider public. Furthermore, visions can be exchanged, depending on the study goal. In a next step, we plan to scale up the approach and compare agricultural development to pan-European visions in 14 case study landscapes covering a broad range of European agricultural contexts, from olive orchards in Greece to intensive livestock production in the Netherlands.

Scaling up sustainability experiments in agricultural landscapes: insights into enabling and constraining conditions

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The role of experiments, pilot projects or living labs in promoting sustainable agricultural landscapes and practices, has increasingly received attention from policy makers and academics. These might entail initiatives aimed at regenerative agriculture, nature conservations and improvements of farmer livelihoods. Experiments could facilitate processes of (social-, policy-, and technical) learning and co-creation, as they provide a real-life platform in which participants could (temporarily) experiment with new practices or conduct interventions on a small geographical scale and within institutional boundaries. In order for these experiments to become consolidated and have a wider impact, they need to be further scaled up.

However, while experiments are often successful in generating and testing innovative practices and facilitate learning, they commonly function in isolation and in general face difficulties in the process of scaling up. This difficulty is also represented in the phrase that ‘pilots never fail, they (also) never scale’ (Dagerskog et al. as cited in Van Buuren et al., 2018, p. 151). This could partly be explained by the existence of a so-called ‘pilot paradox’, meaning that the conditions that facilitate a successful experiment, function as a barrier for the further scaling up of the experiment (Van Buuren et al., 2018). This raises the question which factors are disabling or enabling to the upscaling of innovative, sustainable agricultural practices.

To answer this research question the paper presents a review of the main literature on the upscaling of experiments. Different strands of literature have aimed to understand and describe patterns and processes of upscaling. These include the literatures on science & technology studies, innovation studies, environmental policy, planning- and geography, urban studies, and transition studies and perspectives such as socio-technical transitions, multi-level perspective, strategic-niche management, and transition management. The study will bring together insights from these strands of literature to conceptualize processes of upscaling and to shed light on which success- and failure conditions play a role in the upscaling-stages of sustainability experiments.

It will be shown that (1) scaling up of sustainability experiments has been conceptualized in different ways, (2) still little is known about which success- and failure conditions contribute to or constrain the scaling up of sustainability experiments and how they vary across different contexts, and (3) which of these enabling or constraining conditions are important in which stage of the process of the scaling up of sustainability experiments, taking place in agricultural landscapes?

References:

Van Buuren, A., Vreugdenhil, H., Van Popering-Verkerk, J., Ellen, G. J., Van Leeuwen, C. and Breman, B. (2018). The Pilot Paradox: Exploring Tensions between Internal and External Success Factors in Dutch Climate Adaptation Projects. In. B. Turnheim., P. Kivimaa and F. Berkhout (Eds.), Innovating Climate Governance: Moving Beyond Experiments (pp. 145–165). Cambridge: Cambridge University Press.

Is abandonment in less favorable land management systems inevitable? Different responses to mega-trends on the islands of Lesvos and Lemnos, Greece

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Agricultural systems in marginal or less favored areas of Europe have faced a multitude of challenges as a response to so-called “mega-trends”, such as intensification, specialization, farm-size enlargement, ageing of farmers, and social factors that render farming unfavorable as a livelihood. A typical response has been land abandonment. The focus of this paper is on the land use systems of the islands of Lesvos and Limnos. These islands are geographically very similar but differ greatly in their land use systems, resulting in different responses to the same megatrends: the olive plantations of Lesvos have faced more serious abandonment issues, while on the contrary, on Lemnos abandonment was less important and diverse responses have been recorded, including specialization towards animal and dairy products. We performed land cover analysis and interviews with farmers in both areas, in two complementing rounds: one more quantitative that recorded recent changes and farmer rationales and a more qualitative one that investigated longer term trends and decision making patterns. The different events and processes that have led to the current state are listed for each island, including land ownership differences, land uses and their changes, mapped at the landscape level and described by farmers. The analysis revealed that, among others, land ownership and inheritance patterns matter in both areas in different ways, leading to diverse trajectories. In Lemnos, as part of the traditional mixed-farming system (Mandra), land leasing is dominant, separating land users and land owners. Even as ownership increased, the differences are manifested when compared to private and small scale olive plantation ownership on Lesvos. Interviews also reveal the different symbolic capital, as olives are considered as a family asset and not just a land use, something that cannot be said of the rented grazing lands on Lemnos. Nevertheless, land abandonment is far more widespread on Lesvos and indeed farming is still much more active on Lemnos. The market value of the different products surely are important, but the different trajectories also demonstrate how the rationales behind the responses to mega trends can guide which trajectories will be dominant in the area.

The role of co-production in ecosystem services governance: a multilevel approach

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Keywords: Co-production, ecosystem services governance, document analysis, policy analysis

People's quality of life is underpinned by a wide range of ecosystem services (ES). These are created by an interplay of both natural and anthropogenic capitals (i.e. human, social, physical, and financial capitals), a phenomenon known as ES co-production. Governance of these capitals affects the provision, use, and distribution of ES. Here, governance of ES co-production is executed on different yet interlinked administrative, spatial, and temporal scales. Although ES governance has been investigated thoroughly, making emphasis on the role of formal governance and institutions like legal frameworks or ordinances, their influence on the interlinked management of natural and anthropogenic capitals and their stake in ES co-production has rarely been acknowledged. We address this research gap by uncovering how policies across different administrative scales consider natural and anthropogenic capitals in relation to ES management.

In doing so, we conducted policy document analyses of those policies implemented in the sectors of forestry, agriculture, and biodiversity conservation at the EU level as well as at the national, regional and local administrative levels in Germany. The local case studies are those of three Biodiversity Exploratories: the Biosphere Reserve Schorfheide-Chorin, the Hainich-Dün National Park, and the Biosphere Reserve Schwäbische Alb. To assess ES governance, we employed the classification proposed by Primmer et al. (2015), which includes hierarchical, scientific-technical, adaptive-collaborative governance, and the governing of strategic behaviour.

Our preliminary results show that natural and anthropogenic capitals are represented broadly in the reviewed documents and policies mainly refer to hierarchical governance in the context of ES co-production. Based on our further analysis, we will discuss how the interplay of anthropogenic and natural capitals could be further integrated into policies and what this may imply for the sustainable management of ES.

Is or is not a transformation? 18 key components to analyse transformation processes in Landscape Laboratories in Germany

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Agriculture is one of the main drivers of biodiversity loss. Several studies concluded that minor changes within the current framework conditions would not be enough to solve the problem (IPBES, 2019). A transformation of the system including the socio-economic as well as technological framework is needed to develop more sustainable land-use systems and enhance biodiversity in the long-term. Transformation means deep, fundamental, and systemic changes in the way people think, act, and organize themselves to produce necessary outputs for nature and human wellbeing, such as food, feed, fuel, fiber, water, clean air, etc. In this context, several projects, initiatives, and innovative research strategies are being developed to transform agriculture systems. The term “transformation” has become popular and widely used on political discourse, civil society, and researcher’s narrative, but how do we know when a project or initiative qualifies as a transformation? How to demonstrate (for reporting) and analyse (for learning) if a research project can contribute to a transformative change? Based on these research questions and societal demands to conserve biodiversity, we developed a concept to analyse transformation processes within a case study (the FInAL project) that aims to enhance insect biodiversity in three Agroecosystem Living Laboratories. The concept for analysing Transformation Processes (TP) is based on the three dimensions of transformative change: changes in the way of thinking, acting, and organizing. These three dimensions of change in a transformation processes represent technological innovations, governance models, and societal values, respectively. A comprehensive review of theoretical framework and examples of transformations in diverse sectors (energy, urban, and agriculture) were used to identify and summarize a set of 18 structural and functional key components of Transformation. These components are access to natural resources, spatial explicitness, use of technological innovation, dynamic (speed, acceleration, trajectories), flexibility, efficiency, durability (timeframe), social inclusion, breadth (system definition), traceability, effective communication, repeatability, use of diverse pathways and knowledge, depth, relevance, future visions (scenarios), reasonable (easy to understand), and robustness towards opposition and disturbance. Each component is described and monitored through various indicators at the landscape and project level, using multi-methods approach to collect data and analyse progress of change. Methods include social network analysis, storytelling, and mapping mental models for identifying values, perception, and beliefs in actors and stakeholders to address the dimension of “thinking”; meanwhile Geographic Information Systems (GIS) are useful to established and monitoring changes in the dimensions of “acting” and “organizing”, reflecting physical changes on landscape structure and composition, access and use of natural resources, and efficiency of measures in terms of provision of habitats and resources for insects. Our concept seeks to provide a methodology to facilitate the understanding and evaluation of transformation processes in agricultural landscapes that pursue specific environmental objectives (biodiversity protection) within complex contexts (agri-food systems) in the frame of institutional projects.

Co-creating variants of circular agriculture to support a sustainability transition in Dutch rural landscapes

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Keywords: Agroecology, sustainable intensification, spatial planning, discourses, archetypes

A sustainability transition of the Dutch agriculture is being accelerated by the increasing public demand for and a policy vision on creating less impactful, healthier and fairer food systems. Agriculture in the Netherlands is highly productive, but agricultural systems often operate at the expense of key ecosystem services (ES), generating social and environmental externalities. At the same time, the increasing demand for land and related ES, along with climate change, pose a challenge on how to accommodate all these competing claims for space. To address all this, Circular Agriculture (CA) has emerged as a “new” umbrella concept to promote more efficient use of resources and inputs, and reduce negative externalities while closing cycles in agricultural production depending on the spatial scale and configuration. Given its broad definition, CA has been embraced by multiple actors with diverse and sometimes conflicting perceptions and goals for the future of the Dutch rural landscapes, creating uncertainties on the meaning of CA and its implementation. The aim of this research is to make explicit this diversity of understandings by conceptualizing with stakeholders potential CA variants to enable its implementation in a province with high land use pressure in the Netherlands. A workshop and interviews were conducted with stakeholders to assess their definition and goals for CA in the province of North Brabant, and to describe main variants to implement CA based on their potential economic, social and environmental impacts, and spatial configuration. Despite a general agreement on the need to transition to more sustainable agriculture among stakeholders, there are major differences in their goals and implementation strategies. Based on existing stakeholder discourses, circular variants were translated in three major potential archetypes based on: nature (e.g. nature inclusive agriculture, agroecology), land and technology (e.g. precision farming), and technology (e.g. agroparks, vertical farming). Each of these archetypes was exemplified by innovative farmers and agribusiness across the study area, illustrating the potential implementation of distinct CA pathways. This study confirmed that the diversity of perceptions and goals among farmers and other local actors should be identified and included to adapt CA to local conditions and needs. The co-creation of CA variants with stakeholders also confirmed the potential challenges of combining them in space to ensure their feasibility and sustainability. Leverage points have to be identified and targeted to include the different CA variants, especially those that are currently underrepresented (i.e. agroecology), enabling fair and positive system changes. This study concludes that spatial planning is essential to embrace the diversity of CA variants, ensuring and accelerating the overall sustainability transition of the Dutch agriculture.

Rethinking the future of the socioecological systems underlying high nature value farmlands

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Farmlands represent the largest terrestrial ecosystems in the Anthropocene. When managed under low-input farming systems, farmlands are associated with diverse cultural and natural heritage around the world. Known as high nature value farmlands (HNV farmlands) in Europe, these farmlands and their underlying farming systems evolved as tightly coupled socioecological systems, and are essential to biodiversity conservation and the delivery of ecosystem services to society. However, HNV farmlands are vulnerable to socioeconomic changes, leading to either agricultural intensification or land abandonment. Here, we use scenarios to envision alternative plausible futures for HNV farmlands and discuss the related management options and expected socioecological outcomes.

Departing from an overview of the socioecological pillars underlying the value of HNV farmlands and their delivery of multiple ecosystem services to wider society, examples of high nature value farmlands worldwide are presented. Then scenarios are used to envision alternative plausible futures for HNV farmlands and discuss their implications for land management and expected socioecological outcomes.

Finally, focusing on a future where HNV farmlands are embraced as promising ‘Seeds of a Good Anthropocene’, requirements to guide a paradigm shift towards socially, economically and ecologically viable HNV farmlands are presented and discussed. This research was funded by FEDER Funds through the Operational Competitiveness Factors Program – COMPETE and by National Funds through FCT – Foundation for Science and Technology within the scope of FARSYD project – 'FARming SYstems as tool to support policies for effective conservation and management of high nature value farmlanDs' (PTDC/AGR-REC/5007/2014 – POCI-01-0145-FEDER-016664).

Multifunctionality as a potential solution for increased sustainability?

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Keywords: Multifunctionality, ecosystem services, landscapes, Europe

The management and use of cultural landscapes in Europe has intensified during the last century. So-called multifunctional landscapes (i.e. those providing a diverse set of ecosystem functions and services) gradually transformed into more specialized and uniform landscapes (i.e. providing fewer ecosystem functions and services). Since the loss of ecosystem services can seriously affect human well-being, scientists and intergovernmental organizations (e.g. EU, IPBES, WTO, OECD) increasingly call for the restoration of multifunctionality at the landscape scale. Here, we would like to present results of different studies from local to European scale in order to discuss pathways for sustainable agriculture and the potential role of the multifunctionality concept. As one example, we conducted spatial analyses to understand how multifunctionality at the landscape scale varies across Europe and across different land system archetypes. Our results clearly confirmed findings of local-scale studies that low-intensity management systems support higher ecosystem multifunctionality. While these landscapes are considered more sustainable, we showed that landscapes managed to maximise a narrower set of ecosystem services often make important contributions to regional multifunctionality by providing unique ecosystem services. Land management options to increase ecosystem multifunctionality seem to be evident. However, due to inherent limits to multifunctionality in some areas (e.g. trade-offs, biophysical constraints, ecosystem service demand), maximising ecosystem service supplies is not possible or reasonable everywhere. In order to find viable solutions, researchers have to derive more place-specific management recommendations, take into account stakeholder perspectives on multifunctionality to support decision-making processes and to ultimately achieve more sustainable management systems.

Poster

Understanding local actors' demands for grasslands ecosystem service: a case study in County Meath, Ireland

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Keywords: Functional land management, Q Methodology, Ecosystem services, Multifunctional landscape

There is a growing demand for multifunctional landscapes, which simultaneously produce food and provide other ecosystem services (ES). This is the case of Ireland, where landscapes are shaped by pasture-based ruminant production and are expected to deliver a wide range of ES. However, specific demands for ES may differ between actors in a given region. Moreover, the demand for ES is driven by actors other than those who deliver these ES through land management. The identification of different demands and the potential tensions between demands and supply of ES can help in the design of desired multifunctional landscapes. The aim of this study was therefore to understand the diversity of local demands for ES in an agricultural region in Ireland.

The Functional Land Management (FLM) framework proposes to assess multifunctionality of land by its capacity to provide five soil functions, i.e. primary productivity, water regulation and purification, carbon regulation, habitat for biodiversity and recycling of nutrients. The FLM framework was combined with the Q methodology and Geographic Information System to assess and map the demand for the five soil functions by 21 actors. The study was carried out in County Meath, Ireland, characterized by undulating orography, grasslands and ruminant production. A range of actors were identified, including farmers, advisors, associations, local government, farm input suppliers and market representatives. Actors were of several ages, locations and gender, and they were selected by researchers' network and snowball sampling. In an interview, using a Q set of 25 statements, actors ranked their demands for the five soil functions in different locally relevant landscape units. Landscape units were defined by differences in soil drainage, topography and soils organic matter content. These landscape aspects were then used as geomorphological indicators for mapping the spatial variation in demand.

The Q Methodology revealed three clusters of actors. Meat production from landscapes was the most divergent feature among clusters. Each cluster had a preference for a soil function, i.e. preservation of biodiversity (cluster one), meat production (cluster two) or carbon regulation and water purification (cluster three). Clusters converged on low demand for nutrient cycling. Also, demand for biodiversity preservation and carbon regulation was never considered low. Mapping clusters' demands disclosed heterogenous spatial distribution of the demands per landscape units that may reveal where they diverge and converge the most. For instance, riverbanks are the most demanded area for different ES and the three clusters consent to highest demand for biodiversity in land with high soil organic carbon content.

Our findings showed that local actors differ in their demands for soil functions in multifunctional landscapes, with contrasting expectations for land type. To promote land multifunctionality, it is crucial to recognize the diversity of local demands, unravel the potential tensions and convergences, for then develop tailored land(scape) management strategies.

Value below the surface: a discrete choice experiment into preferences for soil-based ecosystem services

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Keywords: Agricultural soils, discrete choice experiment, economic valuation, ecosystem services

Soils, including agricultural soils, are a highly important natural capital asset, and they contribute to the provision of many ecosystem services (Paul et al., 2020). Their multifunctional management implies trade-offs, which can be illuminated by information about public preferences, e.g. from economic valuation studies. However, economic valuation of soil-based ecosystem services has been neglected and there is a paucity of information about preferences towards agricultural soils, as most of the few existing studies so far used cost-based valuation methods (Bartkowski et al., 2020). In this paper, we present a web-based discrete choice experiment aiming to elicit preferences among the German public for a subset of soil-based ecosystem services (food provision through biomass production; flood protection through water storage; clean freshwater through water filtration and nutrient cycling; climate regulation through carbon sequestration). To facilitate the understanding of the valuation scenarios by the respondents, we express changes in soil-based ecosystem services relative to the soil's potential to provide them (Vogel et al., 2019), rather than in terms of absolute units. This novel approach puts realistic, biophysically informed bounds to the range of ecosystem service realizations for which preferences are expressed. Furthermore, we investigate the spatial heterogeneity in preferences, which we expect to vary along the urban-rural gradient and between federal states/regions of Germany as well as in dependence of the availability of substitutes (e.g. the proximity to undisturbed groundwater reservoirs in protected areas).

References:

Bartkowski, B., Bartke, S., Helming, K., Paul, C., Techen, A.-K., Hansjürgens, B. (2020). Potential of the economic valuation of soil-based ecosystem services to inform sustainable soil management and policy. PeerJ 8, e8749. https://doi.org/10.7717/peerj.8749

Paul, C., Kuhn, K., Steinhoff-Knopp, B., Weißhuhn, P., Helming, K. (2020). Towards a standardisation of soil-related ecosystem service assessments. Eur. J. Soil Sci. n/a. https://doi.org/10.1111/ejss.13022

Vogel, H.-J., Eberhardt, E., Franko, U., Lang, B., Ließ, M., Weller, U., Wiesmeier, M., Wollschläger, U. (2019). Quantitative Evaluation of Soil Functions: Potential and State. Front. Environ. Sci. 7. https://doi.org/10.3389/fenvs.2019.00164

Polarization of agricultural land use across Europe? An analysis of changing land use intensity in 14 case study sites

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Keywords: Land use change, intensification, disintensification, agricultural pathways

In the last twenty years, agriculture has been under high pressure from different sides. On the one hand, food demand increases, which calls for an intensification and higher agricultural production on the same area. On the other hand, marginal lands, where cultivation is no longer profitable, are managed more extensively or even abandoned. Under a complex interplay of constraining factors, farms tend to develop either towards more intensive or extensive managements, respectively.

In this study we analyzed the change of land use and landscape complexity between 2000 and 2020 in 14 study sites in 12 European countries, each 5x5km^2. We hypothesized to see polarization, i.e. that intensive areas are increasingly intensified, while extensive areas are abandoned, reforested and/or fragmented. Further, we expected to see polarization not only between but also within the individual sites.

Using GIS we digitized two georeferenced orthophotos from around 2000 and 2020 for each study site. We measured changes in land use as well as field size and agricultural landscape elements like trees or hedgerows.

Preliminary results of nine out of 14 study sites show that polarization is visible. Characteristics of intensification include that more land is used for crops or intensive grasslands, less landscape elements are encountered and the average field sizes increase. The classification of the land uses allowed to compare changes statistically and disentangle the most important trends. However, the initial contexts and pathways are really site-specific. By the time of the conference we hope to have finished the analysis and reveal important insights in the dynamics of European agriculture and associated landscapes. Understanding the dynamics of land use change and its drivers is required to manage the limited land resources in a sustainable and productive way.

Direct payments and on-farm employment: evidence from a spatial regression discontinuity design

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Direct payments are found to slow down the structural change in the agricultural sector (Breustedt and Glauben, 2007; Key and Roberts, 2006), a finding for which they are often criticized. However, direct payments may also safeguard on-farm employment as these payments reward the provision of public goods and serve as income support for lower paid jobs in the agricultural sector (Federal Assembly Switzerland, 2021). E.g., in Switzerland the median labour income of a farm family worker amounts to about 60000 Swiss francs (valley region) while in the second and third sector the median salary is about 15000 Swiss francs higher (FOAG, 2020). Since the argument of a decent agricultural entrepreneurial income is furthermore relevant for the security of supply of food and the development of rural areas (Finger and El Benni, 2021; Wuepper et al., 2021), policymakers frequently use it to defend public expenditure for farming (European Commission, 2017).

Strengthening employment outside of urban regions is especially important in predominantly rural countries like Switzerland in which commuting to larger towns with better job opportunities is often time-consuming. From an international perspective, Switzerland is also one of those countries that highly subsidizes the agricultural sector (OECD, 2015). Thus, the question arises if government expenditure can truly enhance employment prospects.

In this article, we exploit the implementation of the Swiss direct payments system and apply a spatial regression discontinuity (RD) design that needs weak identifying assumptions (e.g., Imbens and Lemieux, 2008; Lee and Lemieux, 2010). Our analysis focuses on dairy farms as a labor-intense farm type of which each year about two percent abandon farming and about one percent changes to the more labor-extensive suckler cow husbandry (Zorn and Zimmert, 2020). In contrast to prior studies, we use detailed farm-level data instead of data sources from some more aggregated administrative unit.

Our findings show that direct payments have the potential to increase on-farm employment. While the number of male family workers is not affected, we find that additional 1000 Swiss francs increase the number of female family workers by about 0.025 corresponding to an annual salary of about 40000 Swiss francs per additional female employee. We conclude that direct payments safeguard traditional family farming by enabling women to support their spouse on the farm.

Sustainability assessment of biodiversity sensitive farming systems: a critical review of methodological frameworks

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Keywords: Socio-ecological modelling, ecosystem services, natural capital, life cycle assessment

Farmland covers around 48% of the European Union's (EU) terrestrial area. Intensive farming is responsible for just over 10% of the EU's greenhouse gases emissions and is a major contributor to biodiversity loss. Consequently, there is a growing interest in the development and implementation of biodiversity sensitive farming systems that enhance biodiversity and environmental performance and provide economic and social co-benefits. Future biodiversity sensitive farming systems could take advantage of the more than 170 sustainability assessment frameworks already developed for the agricultural sector. They offer a great number of alternatives that differ on their specific interests with respect to i) sustainability dimensions, ii) targeted social actors, iii) complexity of the approaches, iv) type of quantification, v), spatio-temporal levels; and vi) targeted products or systems. Despite the wide variety of frameworks available, few consider a natural capital (or an ecosystem services) assessment approach explicitly. Frameworks that do include a natural capital approach do not combine it with a life cycle thinking approach to understand impacts throughout the supply-chain futhermore natural capital approaches have thus far failed to integrate biodiversity assessment as an intrinsic component. This prevents a better understanding of how farming practices impact on ecosystem conditions, and how it propagates into the supply of ecosystem services and social and economic benefits to people (i.e., public goods) at farm, landscape and at regional levels connected through the supply chains. In this paper, we critically review a selection of current sustainability assessment frameworks that are suitable for the development of a sustainability assessment framework for biodiversity sensitive farming, which interrelates biodiversity, natural capital and life cycle assessments. We have reviewed frameworks of different complexity defined as set of indicators, simple models (e.g., process-based, statistical), socio-ecological modelling tools and integrated models. Based on the 58 sub-topics defined in the Sustainability Assessment of Food and Agriculture systems (SAFA) guidelines of FAO, we have analysed the sustainability completeness of the frameworks. We have identified quantitative indicators and metrics that could suit our biodiversity sensitive framework based on their relevance, clearness, credibility, cost-effectiveness of data collection, robustness, monitorability, previous use in international projects, and sensitiveness to farming practices. As a main result of the critical review, we have defined a sustainability assessment framework for biodiversity sensitive farming at a conceptual level. The framework is based on a core set of sustainability indicators covering environmental, economic and social dimensions that will feed socio-ecological models and ultimately will inform changes in natural capital accounting of farming systems.

Scenarios for recultivation of agricultural abandoned lands in Bucharest urban region

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In many urban regions across the world, rapid urbanization leads to abandonment of farming activities and of agricultural land. Abandonment occurs despite lands being fertile and not marginal (i.e., compared to abandonment in remote areas). Urban regions in the Mediterranean area and Central and Eastern Europe are most affected, with abandonment covering between 9% to 20% of all available farmland in urban regions. As concerns about food security are growing, debates about the future of these abandoned lands are timely.

The aim of this research is to assess the potential for recultivation of abandoned lands. A literature review was conducted to identify drivers of recultivation (e.g., urban development, spatial planning, policies, natural site conditions). Drivers were incorporated into a spatially explicit Ordinary Least Square model to determine how much land could potentially be recultivated. The model was applied to Bucharest urban region. Three recultivation scenarios, representing three intensification situations, were developed to account for uncertainty in the most important drivers. Crop diversity was accounted for in the recultivation scenarios.

Findings show that up to 13% of all available agricultural land in the urban region was affected by land abandonment. Recultivation could take place between 19% and 70% of the abandoned land surface, with recultivation being mainly driven by spatial development strategies and farmers involvement in local action groups.

A Bayesian Network for analysing the relationships between agricultural land and groundwater management under climate change in the Seewinkel region

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Keywords: Bayesian Network, trade-off analysis, land management, groundwater management

Competing demands for land and groundwater are particularly prevalent in semi-arid regions and may even increase under climate change. The semi-arid Seewinkel region in Austria is confronted by excessive use of groundwater for agricultural irrigation. However, the existing saltine lakes require high groundwater levels to ensure the capillary uptake of salts what protects them from siltation. This is especially important as the saltine lakes are unique, biodiversity-rich biotopes (e.g. important breeding habitat for many bird species) and about 75% were lost within the last 150 years. The Seewinkel belongs to a single groundwater body with typical annual variations, i.e. high in spring and low in summer. However, more frequent and more intense climate change-induced dry spells and droughts combined with increasing temperatures might impede the renewal and increase the pressure on the groundwater body. The conflicting demands for groundwater use call for comprehensive analyses, as balancing agricultural and environmental interests is key for sustainable land and groundwater management under climate change. We aim at analysing causal relationships, i.e. synergies and trade-offs, between agricultural land and groundwater management, land and groundwater policies, the ecological state of saltine lakes, and climatic conditions. However, combining data, methods and theories from related disciplines is a major challenge. Therefore, we use a Bayesian Network (BN) which is a probabilistic graphical model that can be used to display and explore causal relationships between a set of variables and to study the conditional dependencies between these variables, i.e. to which extent a change in one variable affects the probability of the other variables being in a certain state. A BN is an alternative approach to deterministic models if environmental or socio-economic processes are not fully understood, data gaps are evident, or other uncertainties are prevalent. Moreover, a BN suits our research interests well, because information and data from different sources (i.e. qualitative, e.g. expert knowledge; quantitative, e.g. modelling results, empirical data) at different spatial and temporal resolutions can be integrated. We combine empirical data from previous research in the Seewinkel region, such as modelling results, bio-physical and land use data as well as expert knowledge. The development of a BN, i.e. identifying the most relevant variables, determining discrete levels for each variable and determining the conditional probabilities between these variables, is an iterative process. Results indicate that potential groundwater policies, such as an upper threshold for groundwater extraction and a groundwater price, significantly influence the probabilities in farmers' decision for a certain land use type, i.e. the probability for cropland decreases in both cases. However, the effect of both policy options, i.e. the effect on the probability that other variables are in a certain state, varies depending on the assumption of future climatic conditions. The BN can serve as a decision support tool for policy makers and can be used to support agricultural land and groundwater management.

References:

Blaschke, A. P. and Gschöpf, C. (2011). https://wasser.bgld.gv.at/fileadmin/user_upload/news/Kurzfassung_Bericht_GWM.pdf

Karner, K. et al. (2019). Journal of Environmental Management 249. https://doi.org/10.1016/j.jenvman.2019.109431

Mitter, H. and Schmid, E. (2021). Ecological Economics 180. https://doi.org/10.1016/j.ecolecon.2020.106908

Working with or against multifunctional landscapes? A case study of local knowledge of forest-grassland transition zones in north-eastern Germany

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Current agricultural policies aim at the maintenance or restoration of multifunctional landscapes that have the potential to provide a broad array of services to local and global stakeholders. Especially, land-use transition zones for instance between grasslands and forests have a high potential to fulfil multiple purposes due to their special ecological characteristics that support the needs of a diverse number of species. However, local land users shape the characteristics of landscapes and land-use transition zones and therefore determine fundamental ecological processes that build the base for service provision. Local knowledge of land users could give important insights into complex interactions between human and environmental issues driving land users decisions that cannot be captured by scientists. Therefore, we explored how land users' local knowledge might contribute to the establishment of multifunctional landscapes. We did so by conducting 21 semi-structured qualitative interviews with livestock farmers and local experts for agriculture and nature conservation using grassland-forest transition zones as a specific example for components of multifunctional landscapes. We found that local knowledge of the interviewed farmers can contribute to the establishment of multifunctional landscapes in several ways: it contributes to ecological research on ecosystem functions, enables land users to use landscape function-production synergies, and provides insight into the negative and positive contributions of forests on grasslands. Forests' negative contributions to grassland production were a major decision driver for farmers' management decisions. Context-specific scientific knowledge could increase farmers motivation to maintain or restore multifunctional landscapes by making positive contributions more visible to farmers. In this sense, scientific and local knowledge complement each other in several ways by looking at similar interrelations from varying perspectives. Finally, we concluded that the successful synthesis of scientific and local knowledge can produce actionable knowledge that supports farmers' decisions in favour of multifunctional landscapes.

Optimizing conservation biocontrol in arable farming

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As the largest land user in Germany, agriculture offers habitats for many species that are often reliant on the agroecosystem. Intensive agriculture, with its cleared-out landscapes and through its use of pesticides, has put these species under pressure. With the decline in biodiversity comes a loss of ecosystem services, including those arthropod-provided services that are essential to farming itself, such as pollination and natural pest control. The deterioration of natural pest control services reinforces the dependency on insecticides, thus creating a negative spiral. Studies in the UK and the Netherlands have shown that it is possible to reverse this spiral of insecticide dependency: By using selected flower strip compositions, informed by decades of research, it is possible to specifically promote those beneficial arthropods that provide biological pest control while also supporting pollinators and biodiversity in general. This minimizes pest pressure and thus reduces the use of insecticides. The demonstrated drop in pesticide use in turn, has an important positive effect on local insects and the ecosystem services they provide. This results in a positive spiral that not only increases biodiversity but can also increase yields. This novel approach shows that nature conservation and agricultural productivity do not need to be in conflict but can rather support each other.

In our current collaborative project "Gezielte Insektenförderung für die Landwirtschaft” (Targeted Insect Conservation for Productive Agriculture) as part of the Bundesprogramm Biologische Vielfalt (Federal Programme for Biological Diversity), we adapt this approach to German regional conditions. For this purpose, we develop specific plant mixtures for perennial flowering strips. Once established, we assess their effectiveness in terms of pest regulation and crop yield in sugar beet, potato and winter wheat on commercial farms, with sugar beets being investigated for the first time. We evaluate the short- and long-term effects of the flowering strips on the abundance of pests and beneficial arthropods as well as on biodiversity in general. The focus is on the cropping period and on arthropod overwintering success.

The aim of the overall project is to develop functional perennial landscape structures for the agricultural landscape, which provide food, habitat and overwintering sites, especially for natural enemies of agricultural pests. In doing so, these structures may contribute to a reduction in insecticide use, which represents an important further benefit to the wider ecosystem. Through the concrete implementation of these solutions, we make them tangible to stakeholders and show how a win-win for agriculture and nature can be achieved. This concept also shows how the interests of nature, agriculture and politics can be aligned.

Terroir as an Ecosystem Service in Vineyard Landscapes: A Social Media Approach

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Keywords: Vineyard, Terroir, Cultural ecosystem services, Social media

A transition from production to consumption is happening in rural areas worldwide. As a result of this transition, some of these rural areas are serving amenity functions and, thus, are becoming destinations for different types of users. This introduces complexities in such socio-ecological contexts, particularly when decision making around rural development. Such landscape include emerging grape and wine production landscapes, including vineyards in Annapolis Valley, Nova Scotia (NS) and more established ones in Niagara, Ontario (ON). Our study uses textual and image-based representations of viniculture regions posted on Instagram by the vineyards' stakeholders, including visitors and owners/marketers. Content analysis was performed with a hybrid of inductive-deductive coding using 200 posts gathered by hashtags (#nswine and #niagarawine). For textual coding, cultural ecosystem services (CESs) were used, which are non-material benefits individuals gain from ecosystem services (MEA, 2005). Additionally, statistical multiple correspondence analysis (MCA) was used with the content analysis result to understand the variables' associations.

The result of content analysis implies that: 1) the motifs captured by stakeholders were quite similar in both regions (e.g. linear vines, sky, trees, grassland/fields, and people) with some exceptions characteristic of particular geographies and vineyards, 2) four CESs, including recreation and ecotourism, sense of place, aesthetic values, and social relations, respectively are the most important values associated with vineyards' landscapes, and 3) a conceptual gap exists in the Ecosystem Services (ESs) Framework in the concept of terroir. Terroir refers to a unique characteristic of food originating from a place because of the interactions between the physical and biological environment of the place as well as human factors (Van Leeuwen and Seguin, 2006). Our results cause us to conceptualize terroir as inhabiting an intersection of provisioning, cultural, and relational services. Our Instagram results suggest that terroir consumption and production remain much more important for those who are producing and marketing vineyards than those visiting them. Instagram data is a powerful yet relatively untapped tool for understanding interactions with and marketing of landscape.

Assessing impacts of land use trajectories on ecosystem services through social values

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Rural agricultural areas have been recognized as a source of essential ecosystem services (ES) in all categories (provisioning, regulating and cultural). The complexity of the relationships that exist in these socio-ecological systems requires approaches that are also complex, through which horizontal knowledge can be achieved. The social demand for ES (i.e. the subjective perception, assessment and prioritisation of ES by stakeholders) should be included in the assessment of landscapes, especially in rural agricultural areas close to a highly absorbing urban core as is the case in this research. However, techniques to include the sociocultural perspective in rural agricultural areas are not formalized. This study aims to analyze the discourse of the local population regarding different land use trajectories and their impact on ecosystem service supply in recent decades. More specifically, we first characterized and mapped the trajectories of land use change for the time period 1990–2018, secondly, we explored the social perceptions for and against the promotion of specific of specific land uses; third, we analyzed the social perception regarding the impacts of land use trajectories on ecosystem services, and finally, we explored the social importance and perceived vulnerability of ecosystem services. We found that most of the land use change trajectories occurred between 1990 and 2000. We showed three predominant trajectories in the study area: agricultural land, followed by aggregates industry and agricultural intensification. The respondents clearly perceived rural abandonment with a negative impact on food from agriculture, soil fertility, and maintenance of the gene pool through local varieties. We believe that the methodology used has allowed linkage the time scale of the biophysical analysis, and the perceptions of local participatory surveys. Therefore, this paper aims to answer the question of how to include transdisciplinary methodologies to assess the sustainability of the different pathways of European agricultural landscapes.

SESSION 3:
LANDSCAPE MANAGEMENT SYSTEMS

3.2 Biodiversity in future landscapes: Integrative modelling approaches of land use and green infrastructure

Convenors:

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Best benefits for farmers, society, and biodiversity build on the idea of an “optimal” landscape, where diversification of crops, landscape features and species play a key role. However, current approaches are rather theoretical or disciplinarily focused e.g. on biodiversity, on agriculture management or farm profitability. Moreover, there is typically a scale mismatch of disciplinary models. While bio-physical models often focus on management practices at plot level, bio-economic models focus on farm level approaches, while biodiversity models profit of landscape level analysis valuing ecological networks and diversified landscape mosaics. Therefore, the focus of this session is to present examples of the spatial integration of current biodiversity and bio-economic models and their application on existing landscapes in a scenario context. This should also include studies of the interactions between farm management and landscape biodiversity to safeguard important diversity of landscape elements (and ecosystem services) to facilitate future decision-making.

We invite contributions from a multidisciplinary background that aim at such objectives and that highlight methodological landscape approaches. The session will provide a platform for (worldwide) exchange on how to model diversified landscapes in interdisciplinary approaches with different scales and different levels of data availability.

Orals

Accounting for biodiversity in agricultural landscape assessments: A review

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Agricultural landscapes provide several services and functions besides food production, such as climate regulation, erosion control, or biodiversity [1,2]. Agricultural policy increasingly acknowledges the need to not only focus on efficient food production but to optimally manage such landscapes and the various trade-offs and synergies between the different functions. We undertook a systematic literature review to explore, which landscape functions are commonly considered in agricultural landscape models and further focused on how specifically biodiversity and agricultural production are accounted for, as well as the extent to which the respective models are loosely coupled or fully integrated [3]. Following a Web of Science search based on five selection criteria, we identified ~105 publications presenting (1) spatially explicit models, where (2) the spatial unit of analysis was at least the landscape level and (3) agricultural production was assessed as one landscape function. Furthermore, (4) at least one additional ecosystem service had to be assessed and (5) the presented approaches supported policy making. Our preliminary results show that biodiversity was, in addition to agricultural production, considered in half of the reviewed publications, making it the third most frequently analysed landscape function. While there was little consideration of livestock production in these publications, we found various modelling types for crop production. Proxy based, empirical, and process-based models were represented equally often to compute output variables such as yield (79%) or area (21%). The reviewed publications displayed furthermore a variety of approaches to assess biodiversity: 80% of the studies addressing biodiversity used habitat or biotic diversity indicators, whereas 20% considered both aspects. Studies focusing on habitats computed mainly habitat suitability and quality (44%), or habitat connectivity indicators (40%) based on driving factors like land use and land structure parameters. Studies focusing on biotic diversity indicators, calculated species richness (33%), diversity (24%), abundance (19%), or distribution (14%) indicators through proxies or empirical models. The reviewed publications relied mainly on loosely coupled biodiversity and agricultural production models, with each model having their own set of drivers and only a subset of drivers being shared or linked from one model to the other. Land use and land structure parameters were used as shared driving factors in 60% and 36% of the cases. Management factors as well as soil features, and climatic factors, were often used solely by crop production models, while habitat maps and species distributions were specific to the computation of biodiversity indicators. In summary, although biodiversity was one of the most frequently assessed landscape functions, it was neglected in half of the agricultural landscape assessments. Additionally, no uniform evaluation approach could be identified, and while the assessment of biodiversity and agricultural production is partly based on the same drivers, approaches mostly relied on loosely coupled models, often omitting the impact of biodiversity on agricultural production.

References:

[1] Fry, G. (2001). Multifuncional landscapes – towards transdisciplinary research. Landscape and Urban Planning, vol. 57, 3–4, pp. 159–168, 2001.

[2] Stürck, J. and Verburg, P. H. (2017). Multifunctionality at waht scale? A landscape multifunctionality assessment fort he European Union under conditions of land use change. Landscape Ecology, vol. 32, no. 3, pp. 481–500, 2017.

[3] Antle, J. M., Capalbo, S. M., Elliott, E. T., Hunt, H. W., Mooney, S. and Paustian, K. H. (2001). "Research Needs for Understanding and Predicting the Behavior of Managed Ecosystems: Lessons from the Study of Agroecosystems." Ecosystems 4(8):723–735.

Application of Bayesian Belief Network models in simulating the effect of agricultural practices and management on ecosystem services

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Food production often leads to environmental degradation. Consequently, insights into ecosystem functioning in relation to exploitation are needed as a basis for socioeconomically acceptable mitigation of these impacts. A Bayesian Belief Network (BBN) model is developed to link three major ecosystem services (ES), i.e. food production, water provision and ecotourism, and determine the effect of local agricultural practices and management on the ES in the Guayas Basin (Ecuador). Several data sources were integrated into the BBN model, including processed spatial data from primary and secondary sources, sampling and survey data, and expert knowledge. The model output suggests that banana and sugar cane generate the highest yield but provide low ecotourism benefits. In contrast, cacao produces the lowest yields but contributes to better water quality. Scenario analyses suggest that environmental gains are possible by optimising the land use (LU) based on the edaphoclimatic requirements of crops. Moreover, the integration of LU optimisation with upscaling and farming intensification can allow for additional advantages in water provision and ecotourism while mitigating productivity losses. The BBN models provide probabilistic assessment of the trade-offs between ecosystem services as a result of changing agricultural practices and management.

Sustainable agricultural landscapes – benefits and challenges of spatial optimization analyses for the case of Brandenburg, Germany

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Landscape management is often characterized by balancing trade-offs between different goals. Agricultural landscapes are often optimized for food and feed production, which results in declines of biodiversity and non-provisioning ecosystem functions and services. While several approaches exist to analyse trade-offs between functions in agricultural systems, still the question of where to allocate certain land uses to minimize the trade-offs is an important challenge. Multi-objective optimization in combination with simulation models can help solving complex land use allocation problems by considering the multiple, often competing demands on landscapes of biodiversity and agricultural production. The search for optimal land use allocations has to result in feasible solutions satisfying constraints given by the already existing environment. There are many studies concerning multi-objective land use optimization, which can be roughly split in two categories: The first category are studies that rely on metaheuristics, which cover only small study areas. These algorithms can explore a complex decision space but are not well suited for optimisation problems with large sets of decision variables. The other category are exact methods like Linear Integer Programming, which has been proven successful for land use optimization problems with many decision variables. While being efficient at large scales, it is not possible to account for non-linearity.

The aim of this contribution is to present a spatial optimization framework based on linear integer programming, which can handle a large study area and optimize multiple objective functions. We assess trade-offs between biodiversity and agricultural production based on different policy scenarios for the case of Brandenburg, Germany. We modelled biodiversity as an indicator based on the relative abundance of bird species whereas agricultural production is characterized by a model, which takes into account the total area of cropland and other bio-climatic variables. We use this framework to assess how future land-use zoning could minimize trade-offs between biodiversity, and agricultural production. This enables us to explore the space of possible options to reach these objectives. Finally, we critically discuss benefits and challenges of spatial optimization models as a step forward toward to support decision-making for sustainable agricultural landscapes.

Integrated model-based investigation of farm management options and measures to improve biodiversity in agricultural landscapes in north-western Switzerland

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Keywords: Agricultural landscapes, biodiversity, farm managements, ecological-economic modelling

Multifunctional landscapes are assumed to not only provide benefits for farmers (economic) and society (cultural), but also safeguard biodiversity and natural resources in order to secure long term ecosystem service provision. Current research emphasised that biodiversity-rich landscapes have a positive effect on agricultural yields, while monocultures and landscape homogenisation reduce long-term benefits. Yet, biodiversity losses are omnipresent. Monitoring data showed e.g. a decline of bird populations in European farmland; corn bunting, lapwing, and skylark birds declined by 50% over the last 30 years. Landscape composition was mentioned as one key factor.

Although managing landscapes to satisfy these mentioned demands requires an understanding of landscapes and their processes under specific agricultural managements, current research approaches are focusing either on agricultural production at the field level or on biodiversity assessment at the landscape level. Exploring the linkage is even more important considering potential changes due to long term climate change and short term socio-economic changes. Thus, our aim was to integrate available biodiversity and bio-economic farm models, apply these at the landscape level and study the interaction between farming practices and green infrastructure with regard to biodiversity to safeguard essential landscape elements and facilitate future decision-making. The inputs from local stakeholders played an important role in the modelling process to validate our approach.

Our research took place in Schwarzbubenland, in north-western Switzerland. The region is known for traditional fruit orchards in addition to a mosaic of grasslands and arable land. Within the 50 km2 case study, we gathered individual farm and agriculture management information, documented biophysical data (soil, climate, etc.), mapped habitats and landscapes structures, and collected bird and butterfly data on transect walks.

For economic analysis, the MODAM model, a multi-objective decision support tool for agroecosystem management, was used to simulate land-use changes under farmers´ rational behaviour considering a set of management options as well as biophysical conditions. We clustered the 78 existing farms into five types using the K-means method according to farm size and production type. For an analysis of species diversity, the SALCA-Biodiversity model, which was developed on life-cycle methodologies, was applied to evaluate different farming practices and spatially simulated land-use changes. We then integrated both models and built an innovative land use change model. This model enabled us to assess the effect of land use changes under farm management options and policies, taking both ecological and economic performances into account.

The study revealed biodiversity values and the reaction of essential habitats to biodiversity measures, providing information on how farms cost-effectively perform under different management settings. We concluded that the integration of ecological-economic models is a useful approach to account for the process of land use changes and resulting effects on agricultural biodiversity.

What is the effect of increasing field size on landscape structure elements?

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Keywords: Land consolidation, field size, farmland biodiversity

Agricultural systems in Europe are undergoing rapid change and face a great number of sustainability challenges. Trends such as growing competition on the agricultural market, mechanization pressure, farmland intensification and farm-size enlargement put an increasing pressure on these systems. While technological progress combined with larger field sizes increases farm productivity and efficiency, the accompanying loss of landscape elements is a driver of biodiversity decline on farmland. In the long term, agricultural systems are required to implement more sustainable approaches in their farm management in order to become more environmentally friendly and resilient.

This study presents a comparative analysis of the relationship between agricultural field size and a selection of landscape elements based on 14 case study sites across Europe over an investigation period of 20 years. The first objective of this study is to examine if landscapes with smaller field sizes contain more landscape elements. Secondly, we analyse whether field sizes increased more in study regions, which previously had smaller agricultural fields. The third goal is to investigate if an increase in field size correlates with a loss of landscape elements. This land use and landscape analysis is based on a visual image interpretation of orthorectified aerial photographs by the use of GIS from two points in time, namely 2000 and 2020. In each study area of 5x5km^2 mapping involved the digitalization of major land use types (e.g. intensive and extensive grassland, crops, shrub plantations) and a selection of landscape elements (e.g. tree lines, hedgerows, small and big field trees). This was followed up by an indicator analysis, computing the mean field size of the major land use types, the total length of linear landscape elements, the number of tree signatures as well as their respective proportion in each land use type.

Despite a high variety in land use, farming types, landscape compositions and operating agricultural policies, results from six out of 14 analysed study sites show that mean field size increased significantly from +22 to +158% in five of the six sites, while it decreased slightly in one other. With regard to linear elements, the results show that the total length of treelines and hedgerows declined substantially from -22 to -54% in three study areas, whereas an increase between +5 to +34% could be noticed in the others. In view of field trees, the majority of the study sites showed a decline which ranged between -8 to -27%. Two study sites revealed an increase in field trees with +33% and +97% each. Looking into the development of small and big trees, there is a clear tendency showing a decline of big field trees by majority. The number of small field trees accumulated at a high rate, ranging from +2 up to 755%.

The results over the past 20 years show that European agricultural systems continue to be simplified in many regions. This implies that farmland biodiversity is likely to continue to decline despite growing awareness of its importance for ecosystem functioning.

Drivers of land change and the role of traditional communities on forest conservation

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Besides being an important biodiversity hotspot, the Brazilian Atlantic Forest also has unique historical and cultural characteristics, which are still currently preserved by indigenous and traditional peoples. Traditional communities (TC) are defined as culturally differentiated groups of people, which use natural resources as a condition for their cultural, social, religious, ancestral and economic systems. Our study aimed to understand the role of the TC on the most dominant process of land-change in the Northern Coast of São Paulo State (NC) from 1985 to 2000 and from 2000 to 2015. Since the late 20th century, the NC region is characterized by fast urban expansion encroaching into the natural and cultural landscapes. We used a Partial Least Squares – Path Modelling to model the relation between main drivers of landscape change and the most frequently observed type of land use dynamics in NC (forest persistence, deforestation and urban/peri-urban increase). The land use and environmental policies, distances to the main transportation infrastructure, and the presence of steep slopes in Serra do Mar influenced forest persistence and were also determinants for urban settlement distribution. This complex combination of drivers has led to fast urban expansion (162.4% from 1985 to 2015), rural depopulation and decrease in small-scale agricultural uses (from 20.5% to 13.9% of the NC territory), reducing the diversity and functionality of the studied landscape. Although the TC were not the most important drivers in our models, distances from TCs were negatively correlated with forest persistence and positively correlated with peri-urban use increase, which suggests that these communities can be considered an important driver of forest persistence and do not contribute to increases in built-up areas. The importance of TCs to drive landscape multifunctionality and increase the variety of ecosystems services and its resilience, and to improve local food security, has been discussed not only for tropical regions but for other biomes. The history of land change in the NC has resulted in several land use conflicts in the present, especially when considering fast urban growth versus a very large proportion of areas where no human settlement is permitted. In this current scenario of urban expansion, these communities are the remnants of agricultural use in the region, and they can minimize the impact generated by urbanization and consequently, contribute for the effectiveness of protected areas. Further, the TCs collaborates with local food production to meet part of the urban demand, they maintain the diversity of the landscape and improve food security regionally with the application of agroecological practices. There is an urgent need to develop public policies to ensure the rights of the Northern Coast TC and to protect their land uses and territories.

Spatio-temporal meta-modelling for pest-predator dynamics in complex heterogeneous agricultrual landscapes

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Landscape heterogeneity affects population dynamics determining species persistence, diversity and interactions. Configuration and composition of crops and semi-natural habitats have the potential to promote a bundle of desired ecosystem services thanks to their influence on the ecological community at multiple spatio-temporal scales. Semi-natural habitats can support more diverse and abundant natural pest enemy populations than simple landscapes, thus leading to positive outcomes on pest regulation. However, the nexus of semi-natural habitat proportion and organization with pest suppression is not trivial. Therefore, it is crucial to understand how pest and auxiliary species behavior, the underlying landscape structure, and their interaction may influence conservation biological control at different spatial scales. These relationships can be represented by advanced spatially-explicit models (SEMs), which allow for high spatio-temporal resolution and detailed numerical outputs. However, these approaches are often characterised by high amount of computing and memory requirements for data output, and outputs may be difficult to analyse due to their high dimensionality. It is possible to deal with this complexity by aggregating outputs over time and space. A drawback of this solution is that interesting information may be lost, such as local spatio-temporal relationships or patterns. We propose to pursue the alternative solution of meta-models and meta-analysis, where simplified mathematical relationships are derived to sum up the complex dynamics among inputs and outputs. Here, we aim to present an original approach to analyse SEM output. We develop a generative stochastic landscape model to simulate realistic agricultural landscape compositions and configurations by considering both patches as fields and linear elements as hedges. Generated landscapes are used as spatial support, over which we simulate a spatially explicit predator-prey dynamic model to model pest control by natural enemies. Following a meta-modelling approach based on spatio-temporal point processes (STPP), we characterize spatio-temporal population dynamics and landscape heterogeneity relationships in an agricultural context. Spatio-temporally explicit outputs are simplified to point patterns of key events of population dynamics such as as pest introductions, outbreaks and pesticide treatments. Then, we develop and estimate regression equations to explain and predict patterns in multi-type STPPs of event occurrence intensity and magnitude through a set of predictor variables. At landscape scale, we find that semi-natural habitats boost predator population, but this alone is not sufficient to provide an efficient pest regulation by auxiliaries. Indeed, predator movement from hedges to fields is fundamental for decreasing pest density and pesticide treatments. By moving to a local scale through the STPP analysis, we are able to gain insights on local spatio-temporal dynamics of pest-predator systems. Moreover, we differentiate the contribution of different driver categories (i.e, spatio-temporal, spatial and population dynamic drivers). We also highlight how the effect on occurrence intensity and magnitude may change when considering drivers at global or local scale. This approach leads to results relevant in agroecological contexts, where the organisation of cultivated fields and semi-natural elements have been shown to be crucial for pest regulation. This approach has strong potential to set guidelines for improving biological control strategies at global and local scale.

Winners and losers of land use change: a conceptual model linking agricultural management and population development of the world´s crane species (gruidae)

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What does conservation science tell us about how an "optimal" landscape for biodiversity protection should look like? We reviewed 215 scientific publications on the interactions between agriculture and the world´s 15 crane species (gruidae). All cranes are protected species. Their diurnal movement from wetland night roosts to daytime foraging areas aswell as their seasonal migration from breeding to wintering areas necessitates management at multiple scales. Eleven crane species are classified as endangered, seven of them further decreasing in numbers. In contrast, the population of common cranes (grus grus) and sandhill cranes (grus canadensis) increased more than three fold in the last 40 years. As a consequence, incidences of cranes foraging on newly sown seeds with high economic costs to farmers have become frequent. To analyse differences in the extent to which crane species depend on agricultural area as foraging source, we present quantitative information on diet composition for seven crane species. They display great inter- and intra-specific variation ranging from 0–100% agricultural crops in their diet. The most frequently used crops by cranes are corn (zea mays), wheat (triticum aestivum) and sorghum (sorghum sp.). Moreover we identified 20 main interactions between cranes and agriculture: e.g. cranes provide ecosystem services such as pest control and nutrient effects but also disservices such as crop damage. Our conceptual model synthesizes the impact of agriculture on crane species in two main pathways: 1) habitat destruction with negative effects on specialist crane species and 2) provision of superabundant food levels in terms of high energy cereal grains that are beneficial for species showing high behavioural plasticity. Whereas the effect of habitat destruction on biodiversity is comparably well understood, we highlight the importance of research on ecosystem effects of agricultural foraging sources. We found that most publications on cranes are written from a single disciplinary background. A shift to research that integrates the perspective of species conservation and agricultural productivity could benefit both objectives: Planning measures for crop protection against crane at landscape scale is likely to be more efficient than current practices at field scale, that intervene after damage has incurred. At the same time conservation management would benefit from knowledge on the impact of changing agricultural management on forage availability for cranes.

Quantification of landscape composition on airborne diseases using a dynamic model, application to Pseudocercospora fijiensis in Martinique

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Quantifying the effect of landscape composition on disease dynamics remains challenging because it depends on many factors: disease epidemiological traits, climatic effect, cultural practices used to control diseases and landscape features. With usual ecology modelling, it is difficult to quantify and disentangle these factors. The objective of our study was to separate landscape effect from all these other factors. To this end, we have developed a dynamic disease model that integrates disease development, climate and fungicides effects. This model was applied to the case of banana leaf streak disease (BLSD) caused by Pseudocersospora fijiensis in Martinique. This disease is one of the main biotic constraint of banana production all over the world. Each process of our model was calibrated on a dataset including 83 plots producing Cavendish banana located all over Martinique. For each plot, between 2015 and 2019 the stage of evolution of the disease (SED, represents the dynamic of fungal infection on young leaves), the types of fungicide treatment applied, and the Piche evaporation were measured weekly. The model was used in two steps. First, we ran the model for each week based on measures of previous week. Then, we established a GLM of the residues of the model as a response to the weeks after the beginning of the epidemic, the week of the year, and the Piche evaporation. This GLM aimed at taking account the effects of i) the increase of the disease pressure over the island (constantly growing since its first detection in 2011), ii) the seasonality of the disease, and iii) the inoculum potential, respectively. We then subtracted the prediction of this GLM to the simulated SED, leading to a corrected predicted SED (SEDc). We hypothesized that SEDc to be related to the landscape effect on the disease, development and sporulation because all other factors were extracted. Finally, we correlated the SEDc with landscape composition variables calculated in buffers around each plot (200, 500, 800, 1000 m). We quantified the proportion of semi-natural areas (forests), host and non-host cultivated plots, and the area of hedgerows in the 200 m buffer. Interestingly, our results show that the length of hedgerows in a 200 m buffer were negatively correlated to SEDc, i.e. it acted as constraint against BLSD spreading and development. There was also a negative effect of the proportion of cultivated banana in the landscape on SEDc (significant for all buffers), probably due to the mass effect of fungicide treatments. Surprisingly, the proportion of forest was positively correlated with the SEDc (significant for all buffers). We hypothesize that this positive effect might be the result of wild banana plants that acted as sinks of BLSD propagules in the landscape.

Poster

A preliminary evaluation of tree-crop systems on some hilly landscapes of southern Ghana

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Population increases in many hilly landscape locations of southern Ghana has increased the encroachment of the natural forests for cropping. Such developments threaten the stability of the ecosystem and diminish the environmental services offered by trees. In this study, we assessed land use changes that have occurred over a 5-year period (2010 to 2015) along some farming zones of hilly landscapes of the Akwapin-Togo ranges that stretches from southwest to northeast of Ghana (320 km; 460 m asl.). In particular, we analyzed the vegetation changes at Kpeve, a farming zone of the South Dayi District in the Volta Region of Ghana. In addition, we conducted a rapid farmer survey at 3 farming communities (Kpeve, Have and Santrokofi) all located along the hilly landscapes. Satellite imagery comprising Landast ETM+ 2010 image and Landsat 8 OLIS 2015 image (both 30 m resolution) showed that the total forest cover along the hills at Kpeve was 79315 ha compared with 114642 ha crop plus fallow land in 2010. By 2015, the forest cover decreased by 26775 ha to 52539 ha. Crop and fallow lands also showed a slight decrease of 5365 ha. Changes in forest cover are conspicuous to the eye with many patches of croplands randomly scattered across the hillslopes. Satellite images showing changes in forest cover between 2010 and 2015 at Kepve (middle and right). The analysis of the farmer survey indicated that farmers at Kpeve who were mostly males cultivated the upper and middle slope positions of the landscape. Slash and burn was the dominant land preparation method. Maize yields were relatively high (1200 kg/ha compared with the national average of 1500 kg/ha). Almost all farmers observed severe forest loss on the landscape and attributed this more to logging activities for fuelwood and charcoal production and bush fires than farming. Though the majority of the farmers recognize the importance and role of tress in ecosystem stabilization, none planted trees because of the lack of support. Farmers at Have (less than 10 km from Kpeve) expressed similar observations except that forest loss was rated as moderate rather than severe. Also, the majority of the farmers cultivated the mid-slope positions and maize yields were somewhat low (800 kg/ha). Farmers at Santrokofi (64 km from Kpeve) were largely females that mostly cropped downslope positions. Land preparation was by slash and application of weedicides. More than 80% of the farmers did not observe any deforestation and more than 50% did not consider the role of trees in the ecosystem as important. It is our view that the complexity of the tree-crop systems on hilly landscapes require more detailed information (e.g., use of UAVs) and simulation modelling tools to investigate a range of management practices to optimize the system. To date, there is no tree-crop modelling activity in Ghana. In this paper, we present a modeling framework for the tree-crop systems which needs further development and validation. These remain challenges for research but are also of practical interest for agriculture-forests decision.

Possible pathways to implement agricultural and forestry innovations – A transdisciplinary system dynamics modelling approach

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Keywords: Sustainability innovations, participatory modelling, future scenarios

Innovations in agriculture and forestry represent more sustainable alternatives to intensive cultivation and management. They counter consequences such as natural degradation and existential fear for small-scale farmers and foresters. Questions remain on how to implement these innovations, i. e. what social-ecological prerequisites in the landscape are required to foster innovations and to avoid trade-offs between different sectors depending on the same resources.

Thus, a holistic and interdisciplinary approach is needed which not only considers the complex social-ecological system in which the innovations are embedded but which also includes a long-term and a landscape scale perspective. In the past, research in this field concentrated on generating theoretic knowledge including various frameworks on how to integrate agricultural innovations into agri-food systems. However, an application of this knowledge in practise is still lacking.

This conference contribution introduces a model for describing and analysing geo-referenced scenarios for a sustainable future land use. Scenarios depict alternative system states in the future and assume that sustainability innovations cover considerably larger areas of land than today. The main aim of the spatial and temporal modelling approach is to visualise and evaluate different scenarios, which include combinations of innovations in the context of regional supply systems. The innovations, which stem from online and scientific literature searches conducted beforehand, encompass small-scale farming approaches with mixed cultivation and regional distributions as well as forest managements with a focus on climate resilience and the provision of ecosystem services. A system dynamics (SD) approach was chosen for the quantitative modelling as this approach can deal with different levels of data availability as well as different qualities of the data. Additionally, SD modelling allows for a whole systems perspective and helps to identify feedback mechanisms which can reveal trade-offs. Parts of the model include ecological, economic and social components derived from literature searches as well as expert and innovator interviews in order to ensure the usability and relevance of the model. Finally, the scenarios are visualised using geographic information systems (GIS).

So far, the model introduced in this conference contribution is a prototype which will be applied and tested in a real-world context. It was developed in the course of a transdisciplinary research project on transformative landscape management in Lower Saxony, Germany. Therefore, a first application of the model will be conducted in the project's case study area which is characterised by high animal densities resulting in high nitrate values in the ground water as well as monoculture farming resulting in declining biodiversity. The outcomes of the model contribute to defining pathways to a more sustainable landscape management.

Integrated modelling of biodiversity and ecosystem services for sustainable land use

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Sustainable use of the landscape is only possible with sufficient landscape diversity. This is directly reflected in the ability and quality of performance of individual ecosystem functions and services, as well as in the internal mechanisms of ecological stability and self-regulation. A well-functioning landscape is a prerequisite for ensuring almost all human needs, from economic use to recreational or social activities. However, biodiversity is too complex a phenomenon to be expressed by a single indicator (method, value, model). It is therefore necessary to adopt an integrated approach and an appropriate spatial scale. In our view, an integrated approach is the analysis and calculation of several indicators in one environment, from the same data sources and with the same knowledge. The IMALBES integrated tool currently includes the use of 12 specific models dealing with biodiversity in the landscape in a habitat detail with a scale of 1: 10,000, which reflects the heterogeneity of the Czech landscape. Each included model has its own knowledge base, i.e. a set of coefficients and expert values, and the simultaneous calculation thus enables the assessment of the state and vulnerability of biodiversity and the provision of ecosystem functions and services.

IMALBES uses methods and data from landscape ecology and nature conservation (determination of natural losses, occurrence of rare species; data from Natura2000 mapping) as well as from agricultural practice (data on LPIS agricultural areas, rainfall-runoff model, erosion risk assessment) or forestry areas (growth models). In several steps, the integrated models also use satellite data (in particular Sentinel-2), thanks to which they work with the current state of the area and are able to capture, according to the concept of precision agriculture, the spatial and temporal variability of individual vegetation stages depending on their growth phase, fitness, water availability, etc. The landscape evolution sub-model is also in the development phase. All outputs of the model are at a scale of 1: 10,000, which is the basic scale for spatial planning documentation in the Czech Republic and the outputs can be applied directly. The model also has a national/regional scale, i.e. data and a corresponding knowledge base for a scale of 1: 100,000 based on the data of Corine LC, which also offers the possibility to analyze the time series of landscape development.

The application of the model will assess the state of the landscape, identify stable (hot-spot) and risky (cold-spot) sites for the fulfilment of ecosystem functions (production, evapotranspiration, water runoff, erosion control) and for the maintenance of biodiversity and ecological stability of the area. The results obtained (detailed maps with uniform visualisation) can be used in a comprehensive assessment of the area of interest and serve as one of the important documents for the design of adaptation measures for sustainable agricultural and forestry management. The proposals will be formulated in a joint discussion with the end users (farmers) as well as with the ""managers"" of the area (representatives of the local administration, representatives of the nature conservation authorities).

Spatial heterogeneity and the economic value of grassland ecosystem services

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Grasslands cover a major share of the world's agricultural area and their management influences ecosystem services and biodiversity in agricultural landscapes. Spatially targeted policy instruments can increase the total provision of grassland ecosystem services and contribute to more sustainable food production. However, policy instruments still focus on farm individual incentives. We here assess the economic value of grassland ecosystem services (i.e., forage yield, carbon storage) and biodiversity and its variability in a region when managed at the regional and farm scale, respectively. Our bioeconomic simulation approach combines information on biophysical and economic values of grassland ecosystem services from two recent meta-studies and allows to go beyond the representation of biodiversity values as opportunity costs of alternative management. We find that gains of spatial targeting on a regional scale are rather small compared to farm scale and that the heterogeneity in opportunity costs at the farm scale are much higher than the spatial heterogeneity in values in our case study region. Our approach provides basic information for the implementation of incentive mechanisms, ready to cope with the nexus of food production and ecosystem service provision in grasslands.

The structure and composition of land-use mosaics affect the trade-offs between services provided by arable weeds

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Inrae – UMR Agroecologie, France

The need for multifunctional agricultural landscapes which combine the delivery of production services and that of other ecosystem services is now widely recognised. Arable weeds are an interesting component of agricultural landscapes as they can be potentially harmful to crop production but also provide floral and seed resources that support organisms delivering pest control and pollination services. Weed communities delivering limited harmfulness and high level of services, both at a stable level across years, would represent an interesting trade-off (Petit et al., 2015). Here, we assessed the dual contribution of some 700 weed communities recorded within a small arable landscape in Burgundy through the estimation of nine (dis)service proxies. We found that crop management strategies (number and type of crops in rotation and associated practices) strongly affected the trade-off between harmfulness and services; our results also highlighted that weed communities located at the edge of fields (area between the perennial field margin and the first row of crop) delivered higher levels of services than those located in the core of arable fields (Yvoz et al., 2020). Modifying the relative proportional cover of different cropping strategies (composition) and the length of field edges (structure) within a landscape could thus represent an interesting lever to achieve optimal trade-offs between harmfulness and services provided by weeds. To evaluate this statement, we developed from the current land-mosaics 72000 scenarios combining one of three landscape structures (large, medium and small field size) and crop management strategies composition (one to eight coexisting strategies, with varying relative proportional cover). Using Pareto frontier analyses, we identified the landscape scenarios that delivered the most interesting trade-offs. We found that land-use mosaics composed of many cropping strategies equally represented fared better than more simple landscapes, suggesting the existence of complementarities between strategies. Conversely, increasing the length of field edges in the landscape only had a limited impact on trade-offs, although it often improved the temporal stability of services. These results highlight the positive effects of landscape diversification on the functioning of agroecosystems.

References:

Petit, S, Munier-Jolain, N., Bretagnolle, V., Bockstaller, C., Gaba, S., Cordeau, S., Lechenet, M., Mézière, D., Colbach, N. (2015). Ecological intensification through pesticide reduction: weed control, weed biodiversity and sustainability in arable farming. Environmental Management 56, 1078–1090.

Yvoz, S., Cordeau, S., Zuccolo, C., Petit, S. (2020). Crop type and within-field location as sources of intraspecific variations in the phenology and the production of floral and fruit resources by weeds. Agriculture, Ecosystems & Environment 302, 107082.

SESSION 3:

LANDSCAPE MANAGEMENT SYSTEMS

3.3 Diverse, evolving and adaptive African landscapes

Convenors:

Mariana Rufino, Lancaster University, United Kingdom

Cheikh Mbow, Director of Future Africa, University of Pretoria, South Africa

African landscapes are continuously evolving and adapting to multiple drivers. Whereas many regions of Africa are undergoing fast development, others face the consequences of land degradation. Degradation is associated with stagnation in food production and therefore must be resolved to secure future food while simultaneously avoiding biodiversity and carbon losses. In many parts of Africa, the risk of land degradation is high calling for a combination of sound landscape management and restoration to improve food production. There are however major uncertainties about how land restoration initiatives can be implemented and quantitative studies that show how restoration can succeed are lacking, especially in Africa.

Evidence shows that high livestock grazing pressures alter land productivity and diversity and that grazing can degrade soil fertility. Further, landscapes with high livestock densities are exposed to erosion, have greater emissions of greenhouse gases and increased risk of ecosystem degradation. In these situations, restoration approaches need to take into account interactions between grazing lands, croplands and adjacent forests. This session will present evidence of 1) how to harness the potential of biodiversity to improve livestock production in African farming systems and to restore degraded landscapes; and 2) how to improve landscape resilience through increased landscape diversity underpinned by an understanding of livestock-mediated landscape interactions.

Orals

Systemic review of the perception and adaptation strategies of women livestock breeders in the face of climate change

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Climate change is a major problem that negatively impacts the development of livestock activities. The analysis was built on the premise that livestock production offers substantial opportunities for food security and sustainable development if adaptation to climate change is appropriate. This study evaluated 45 publications published in English and French between 2007 and 2020 on the impact of climate change and adaptation of women livestock producers.

The climatic parameters most perceived by women farmers are temperature and rainfall. Women farmers are trying to adapt to them based on endogenous knowledge that has been passed on from generation to generation. The adaptation strategies adopted by women are: diversification of activities (27%); diversification of livestock (23%), crop residues (14%), reduction of herd size (13%); integration of agriculture and livestock (13%) and animal mobility (10%). These strategies will be more effective if they are carried out in a decision-making process in which all stakeholders participate. It is important to strengthen the capacities of women livestock breeders to better cope with climatic disturbances and to develop systems to support them. The participation of women in the development of new methods ensures that they will be responsive, appropriate and sustainable.

How to break landscape-level vicious circles of land use competition and food insecurity? An agent-based modelling approach

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In many regions of the world, as land use patterns change and population grows, competition over land is becoming more prominent. One driver of such change is the adoption of new livelihood strategies that compete with traditional strategies. For example, the expansion of crop farming into areas where formerly pastoralism was the primary livelihood may contribute to fragmentation of rangelands and loss of key grazing areas, resulting in unforeseen impacts on the livelihoods of pastoralists and accelerating landscape degradation.

One example is the Borana Zone in Southern Ethiopia, where the expansion of crop cultivation into communal pastureland is undermining traditional livestock-based livelihoods. Droughts are a recurring feature of this area and have repeatedly led to livestock losses, which is one reason that households adopt crop cultivation. Rainfall, however, is low and highly variable, and as a result crop harvests are only rarely successful. On the other hand, several studies have revealed that the drivers that impel households to adopt crop cultivation are manifold, including food insecurity, the desire to diversify income, and the desire to lay claim to a piece of land. Thus, the trend of pastureland conversion continues, leading to further shortage of grazing resources and increasing the likelihood of households to lose their livestock and being forced to adopt crop cultivation. This trend has the potential to result in a vicious circle that contributes to landscape degradation and an erosion of resilience. The mechanisms that drive the emergence of such a vicious circle, however, are still poorly understood.

This contribution analyzes key dynamics of land use competition using an agent-based simulation model. The model takes a social-ecological systems perspective by considering the dynamic interactions between pastoralist livestock production, cropland expansion and household livelihoods in a stylized dryland system based on Borana Zone.

Using the model, we analyze whether and how conversion of pastureland into cropland affects the food security of smallholder households. We specifically take a long-term perspective to assess possible unsustainable side effects of cropland expansion and rangeland fragmentation that may outweigh short-term benefits. For this, we compare different scenarios of household density, cultivation restrictions and environmental conditions. This allows us to identify conditions that lead to the emergence of a vicious circle.

Our main findings are that, on a system level, crop cultivation provides an immediate benefit by reducing the overall number of food insecure households in most cases. However, on the household level, more households undergo shorter periods of food insecurity, and, in the long-term, those that remain food insecure experience larger consumption deficits. This leads to a higher inequality in food security across households, indicating that cropland expansion can indeed set a vicious circle in motion.

These results lay the ground for identifying policy and management options that would allow for some level of conversion of pastureland to farmland in a way that mitigates the impact on grazing systems. This can promote the coexistence of livestock grazing and crop cultivation while at the same time preventing a further degradation of the environment.

Combining drought-tolerant varieties and fertilizer micro-dosing enhances maize productivity and profitability in the Sub-humid region of Benin

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In sub-Saharan Africa, smallholder farming systems continue to record very low yields despite the availability of appropriate crop management technologies. A two-years field experiment was conducted in 2018 and 2019 at the Agricultural Research Station of Northern Benin to evaluate the response of growth, grain yield and components and resource use efficiency of different drought-tolerant (DT) maize varieties (TZEE-W POP STR QPM, TZE-Y POP STR, 2008Syn EE-W DT STR, 2000Syn EE-W of 80–90 days cycle) compared to DMR ESR W, a drought-susceptible (DS) variety of 90 days cycle) under different fertilizer options [no fertilizer control, micro-dosing options 1 (MD1, 25 kg N ha−1 , 4 kg P ha−1) option 2 (MD2, 25 kg N ha−1 , 8 kg P ha−1), option 3 (MD3, 35 kg N ha−1 , 8 kg P ha−1) and broadcast fertilizer at recommended rate (RR, 76 kg N ha−1 , 13 kg P ha−1). Generally, combining micro-dosing with DT varieties shown very good performance by increasing leaf area and biomass by 71% and 85% at anthesis compared to conventional practice. Micro-dosing increase grain and stover yields by 171% and 98% compared to unfertilized control with generally no difference between MD3 and RR treatments. Also, the DT varieties obtained the best yields (+19%) with the highest observed with the TZE Y variety. However, no significant interaction was found between varieties and fertilization for grain yield in opposite to stover yield which exhibited a significant interaction. Microdose fertilization and DT varieties showed high efficiencies of nutrients and rainwater use. Likewise, DT varieties and micro-dosing fertilization show a high economics performance and are revealed to be an excellent mean to increase smallholder farmer's income. The results of the current study demonstrated that there is considerable potential for smallholder farmers of northern Benin to improve maize productivity by means of DT varieties and fertilizer micro-dosing. However, it is important to evaluate the stability of the yields under these management options in farmer's fields by taking into account climatic, soil and soci-economic conditions.

Saffron as a sustainable crop for anti-atlas marginal areas: An efficiency analysis

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The saffron is a low input cop characterized by specific agronomical and biological traits, which converted it to a sustainable farming system with very low requirements in fertilizer and high adaptation to poor soil (Gresta el al., 2008).

The Green Morocco Policy (PMV) promotes the increase of the production of more climate-adaptive and sustainable crops. The saffron sector is considered in the core of this policy as a viable alternative crop for anti-atlas marginal areas where the increased scarcity of rainfall and low water accessibility critically limits the cultivation of traditional crops (e.g. cereals). Through this policy, the cultivated area increases and reaches 1800 hectares in 2019 (MAPA, 2020) putting Morocco as the world's fourth producer of saffron. However, the productivity stills very low comparing to other countries (3.6kg/ha compared to 5kg/ha or 8.4kg/ha in Iran and Italy respectively).

The objective of this study is the analysis of the production and efficiency of the Moroccan saffron farms. In doing so, we provide policy makers with relevant information on the improvement of saffron productivity, efficiency and recommendations for its adoption as an adequate sustainable farming system to the climatic and edaphic conditions of the Anti-atlas area.

To achieve our goal, we conduct a 130 household survey on farms production and socio-economic aspects in the production area of Taliouine and Taznakht using stratified sampling method. We estimate a Stochastic Frontier Production function using the method of maximum likelihood (Lambarraa et al., 2007).

The results of the statistical tests show that the null hypothesis of the absence of inefficiency effects is rejected which indicate that saffron farms suffer from inefficiencies and that the technical inefficiency effects explain output variability. The hypothesis of the presence of constant returns to scale is accepted making an increase in the saffron farms size unattractive. This result is confirmed with the measured production elasticities. Results derived from estimated model show that first-order parameters are all positive and statistically significant indicating that production is increasing in all inputs. The saffron bulbs plantation, labor and land are the most important factors in explaining the saffron production. The predicted technical efficiencies take an average value of 51%. The results of technical efficiency model proves that the adoption of technology, management skills and younger age of the farmers improve the productive efficiency. However, the off-farm activity and the near to the urban center affect negatively the efficiency.

In the light of these results, we suggest the need to implement strategies inside the PMV oriented towards improving the saffron farms efficiency. The PMV needs to be oriented to younger farmers, as they are more prone to introduce changes in crop management techniques and through the dissemination of training and tools that helps them to improve managerial skills and technical conduct and facilitate their access to the technology. More regulation is needed regarding the access to the market, which helps to convert this activity to the main source of income for the farmers and increase farms specialization and its full commitment to this activity.

Species distribution modelling for mapping tree diversity in Sahelian agroforestry farming systems: A case study of Faidherbia albida parkland in Senegal

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Keywords: Landscape ecology, Tree species, Biodiversity, Agroforestry systems

The paramount importance of agroforestry systems (AFS) for African smallholder farmers and the myriad of ecosystem services provided are no longer to be demonstrated in a context of climate change. Used for centuries by farmers that have contributed to shape Sahelian AFS, studies reported that trees are one of the drivers for improving people's resilience to future changes while contributing to biodiversity conservation. Thus, the characterization and monitoring of tree species diversity are important for sustainable management of AFS. At the landscape scale, geospatial techniques are widely used for the characterization of parklands structures, but they still do not allow to correctly identify the different species. In particular, authors used the species distribution models (SDM) for mapping tree species (Franklin, 2010).

Beyond the prediction of species distribution using SDM, this study aimed to map tree diversity through different diversity indices while subsequently analyzing the relationship between tree diversity and the human impacts on the environment. The study area is located in the Senegalese Peanut Basin. It is characterized by a tree-based farming system dominated by Faidherbia albida. A robust and representative dataset of 9258 trees encompassing 63 different species (see Ndao et al., 2021) was used. The predictors were derived from various sources of geospatial data including 33 environmental variables related to different categories (e.g. climate, vegetation, landform, human habitats). For each of the main tree species, six SDM algorithms were tested through four scenario of modelling approaches in order to achieve the best prediction performance. Subsequently, knowing that probability of occurrence of a species is closely related to its environmental conditions, we assumed that between two species, if the probability of presence is higher for one, the environmental conditions are more favorable for it and therefore its abundance should be relatively higher. Thus, the probabilities of occurrence resulting from the SDM predictions were translated into relative species abundances in order to calculate diversity indices (e.g. richness, Shannon). A Kruskal-Wallis test and a Focused Principal Component Analysis were used to analyze relationship between tree species diversity indices and the distance to village used as a proxy of the human impacts on the environment.

The results showed that there is no single 'best' SDM algorithm or modelling approach for all species. Combining climatic variables with non-climatic environmental variables and anthropogenic variables leads to the best performance in most cases. The resulting tree species diversity indices are significantly correlated with the anthropisation of the environment.

In contrast to what is reported in forest ecosystems, the results showed that in Sahelian AFS, tree diversity is sustained by anthropisation, i.e. the closer one gets to the village, the greater the tree diversity. Diachronic mapping of tree diversity could be used for monitoring its spatiotemporal dynamics to support management plan and conservation measures. In perspective, the relationships between tree diversity and crop yields will also be analyzed to appreciate the contribution of tree diversity to AFS productivity.

References:

Franklin, J. (2010). https://doi.org/10.1017/CBO9780511810602

Ndao, B. et al. (2021). https://doi.org/10.1016/j.ecolind.2021.107481

Why Smallholders Stop Engaging in Forest Activities – The Role of Migration in Livelihood Transitions in Southwest Ethiopia

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Every year, around 13 million ha of forests are lost worldwide, fueling carbon emission and contributing to biodiversity loss. Furthermore, forest decline and degradation poses a risk to those who depend on forest resources such as wood, medicine or food, which are often the rural poor in the tropics. In-migration of smallholders to forest frontiers is often considered one underlying cause for tropical deforestation and forest degradation, mainly because of the migrants needs for wood and agricultural land. Depending on institutional, social, political and economic framing conditions, migration can fuel transitions of the land and resource use in receiving system. So far, scholars usually focus on the resource use of migrants; however, the influence of migration on the livelihoods and resource use of the hosts is rarely studied.

This study aims to investigate the impact of migration on forest-dependent host communities. We chose the Bench Maji district in Ethiopia’s remote southwest as a case study, which is a hotspot of in-migration and forest loss in Ethiopia. In this region, scholars have observed a transition from traditional forest-based to cereal-based livelihoods over the past two decades, attributing it to planned and unplanned in-migration of smallholder farmers from the northern and southern drought-prone and degraded Ethiopian highlands and the expansion of agricultural land. We employed a quantitative, multisite approach, by integrating 224 household surveys from three different villages. We applied a random forest regression tree procedure to understand how and why livelihoods, in particular forest activities, of local (forest-based livelihoods) and migrant (agriculture-based livelihoods) population groups changed since a major resettlement program was launched in 2003. We complemented our findings with insights from group discussions, interviews with key informants and regional experts to assess the role of migration in livelihood transitions in the study region.

We found that due to in-migration of smallholders from agricultural-based systems, but also due to an expansion of commercial agriculture for the production of cash crops, the cultivated area in our study region expanded at the expense of the forest, which hampered forest activities, especially the collection of non-timber forest products for the forest-based local communities. In addition, participatory forest management was introduced and access to the forest was restricted for all population groups to protect the remaining forests. Our findings show that the decline in forest area, but also restricted possibilities for participation in the newly established forest management groups, made it increasingly difficult for the local people to continue their forest-based livelihoods. Rather, local people gradually adopted the migrants' agricultural practices. Moreover, agricultural policies, which promoted land-intensive farming practices and the production of cash crops for national and international markets, further encouraged an uptake of agricultural activities. Our findings suggest linkages between migration, resource use and livelihood transitions are mediated by land tenure security, resource access and road and market connections.

Farming with trees: Agroforestry options for the design and re-design of sustainable farming landscapes in Africa

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Parkland agroforestry has been promoted as a precious option in adaptation against climate change, food and nutritional security, soil and water conservation, energy self-sufficiency, and improvements in the overall livelihoods of smallholder farmers in Eastern and Southern Africa (ESA). Yet, empirical evidence and our experiences hint inconsistencies vis-à-vis the effect of parkland agroforestry on crop yields. We present here the insights of agriculturalists with extensive experience on agroforestry systems from ESA. First, we show that agroforestry in the region is ubiquitous, and particularly so for small farms. Second, we demonstrate that farmers keep trees for a variety of products (including fuelwood) often ‘by default’ (e.g., energy poverty) and that the species farmers use are often not those promoted by agroforestry interventions. Third, we highlight the fact that – except for rare systems that constitute an exception rather than a rule (e.g., Faidherbia albida parkland) – trade-offs between crops and trees are conspicuous. Forth, we demonstrate that these trade-offs can be reduced through crop management (including selection of germplasms, and adjustment of fertilization and tillage). Fifth, we point to the fact that trade-offs at plot-scale and on the short-term may turn into synergies at landscape scale and on the longer term. We conclude by asserting that scattered trees buffer crops against climate change, improve water availability and nutrient use efficiencies in crops, although trade-offs are conspicuous. Utilization of these facilitative effects of scattered trees by minimizing tree-crop trade-offs necessitates a pragmatic approach. Thus, ‘process-based’ rather than ‘technology-based’ approaches are required when promoting scattered trees.

FarmImpact – Integration of tree shelterbelts into vineyards and fruit orchards for climate-smart agricultural systems in the Western Cape, South Africa

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Water scarcity is one of the biggest challenges in South Africa, alongside the effects of climate change, human vulnerability, and the loss of biodiversity and ecosystem functions. Agriculture, in particular, is threatened by pronounced dry seasons and water scarcity. As the center of wine and fruit cultivation, the Western Cape has great national importance for the export of agricultural products. The integration of windbreaks and agroforestry systems as part of climate-smart landscapes has a great potential to reduce wind speed and evapotranspiration and enhancing the resilience to climate changes. A better understanding of the tree-crop interactions is important to increase the ecological and economical values of shelterbelts for production in agriculture. In a multidisciplinary project, the implication of agroforestry systems and shelterbelts are studied in two commercial fruit orchards and vineyards near Stellenbosch in the Western Cape. The FarmImpact project introduces modern scientific approaches such as numerical modeling of near-ground wind fields and crop evapotranspiration, microclimatic and ecophysiological measurements of tree crop performance, remote sensing with modern plant-sensors technology, and soil and hydrological models to determine the exact water needs of farm crops. Already detailed measurements of meteorological parameters relevant for the computation of reference and crop-specific evapotranspiration following the FAO 56 approaches have shown the beneficial effect of an existing hedgerow consisting. In the vineyard, the mean wind speed in a position of about 18 m from the hedgerow at the canopy level was reduced by 27.6% over the entire year and by 39.2% over the growing season. This effect leads to a parallel reduction of reference evapotranspiration of 15.5% during the whole year and 18.4% over the growing season. The changes in the orchard and vineyards microclimate are higher relative humidity, higher daytime air, and soil temperature, and reduced rates of evapotranspiration, which should result in lower stress in the plant. Trees grown in the wind-protected area of the orchard are expected to have better leaf development and growth, and an increase in fruit quality is observed. The results from the external quality analysis will give producers an indication of their percentage pack-out which is directly correlated with the economic return. By the combination of an integrated agroforestry design tool and by integrating current weather forecasts, measurement data from the soil moisture sensors installed in the zones and, the forecasting tool can precisely specify the actual irrigation requirement for the different growing zones. The beneficial effects of scientifically designed modifications of crop canopy microclimate are expected to increase crop productivity while irrigation water demand could be reduced. For the bigger project, the agronomic results will be included in a full economic cost-benefit analysis which will give farmers a better understanding of the investment potential of considering the introduction of windbreaks again.

Poster

Evaluation of the sheltering effect of an agroforestry system on wind erosion in South Africa

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Keywords: Soil erosion, dust emission, agroforestry, terrestrial laser scan

Sediment transport by wind is causing serious ecological problems and is threatening agricultural productivity and sustainability worldwide. According to a report by the United Nations Environment Program, wind erosion is responsible for more than 46% of global soil degradation in arid regions. Montanarella et al. (2016) identify erosion as the greatest threat to African soils.

The integration of vegetative windbreaks around field edges is a traditional approach to tackle wind erosion. For this, the reduction of wind speed, effects on soil properties and the microclimate, in the immediate vicinity, are well reported (Sheppard et al., 2020).

In February 2020, during the fallow, a two-week long measurement campaign was carried out to evaluate the effects of a vegetative shelterbelt on a wheat farm in the Overberg region, South Africa. The study site is characterized by sandy soils, low average rainfall and high wind speeds up to 20 m/s. A row of Eucalyptus trees, with varying heights and densities, is situated vertically to the main wind direction. To characterize the vertical and horizontal dust emission dynamics, 20 Modified Wilson and Cook (MWAC) dust samplers were used on the lee- and windward side, with seven as input and 13 as output respectively. High resolution, compact All-In-One weather stations measured wind speeds and climatic variables in front and behind the windbreak. Additional supersonic anemometers, in different heights, provided information about the vertical wind profile. Hand anemometers were installed on top of the MWACs, for daytime field values and identification of obstacle induced variation of airflow on the plot. Soil samples were taken for texture classification and further analysis. Terrestrial laser scanning (TLS) was carried out to provide the individual height and density of the Eucalyptus trees and will be implemented in a recently developed 3D modelling approach of quantifying tree shading effects at high temporal and spatial resolution (Bohn Reckziegel et al., 2021). All acquired datasets will be integrated in a GIS for accurately calculating spatially and temporally varying effects of the windbreak, during the vulnerable state of fallow.

References:

Bohn Reckziegel, R., Larysch, E., Sheppard, J. P., Kahle, H.-P., Morhart, C. (2021). Modelling and Comparing Shading Effects of 3D Tree Structures with Virtual Leaves. Remote Sensing 2021, 13, 532.

Montanarella, L., Pennock, D. J., McKenzie, N. J., Badraoui, M., Chude, V., Baptista, I., Mamo, T., Yemefack, M., Singh Aulakh, M., Yagi, K. et al. (2016). World's soils are under threat, SOIL 2016, 2, p. 79–82.

Sheppard, J. P., Bohn Reckziegel, R., Borras, L., Chriwa, P. W., Cuaranhua, C. J., Hassler, S. K., Hoffmeister, S., Kestel, F., Maier, R. et al. (2020). Agroferestry: An Appropriate And Sustainable Response to a Changing Climate in Southern Africa?, Sustainability. 2020, 12, 6796.

Spatial patterns of argan-tree influence on soil quality of intertree areas in open woodlands of South Morocco

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The endemic argan tree (Argania spinosa) in Morocco forms open-canopy forests that are highly degraded due to overgrazing, illegal cutting of firewood and the expanding intensive agriculture, but is also the source of the valuable argan oil. Fruit collection to produce the oil leads to little regrowth which cannot establish itself because of the high grazing pressure. Reforestation measures are often unsuccessful and the bare areas between the isolated trees are expanding. We could already show in a previous study that these intertree areas are more prone to erosion and more degraded than the areas under the trees.

The spatial extent of argan-tree influence on soil quality from the trunk to the intertree area is so far unknown. Hypothetically, spatial differences in soil characteristics of the intertree area should result from the transport of litter and soil particles downhill (by runoff and erosion) and towards the east (by wind drift). Shade in the hot midday and afternoon sun should have positive influences on soil moisture in northern or northeastern directions. To test this hypothesis, we took 403 soil samples around 31 argan trees in four directions: uphill, downhill and in both directions along the contour lines. Samples along these transects were taken near the trunk, inside and outside the tree drip line and in the intertree area in the middle between two trees. The soil samples were analysed for various soil parameters (C/N, percolation stability, electrical conductivity, pH, soil moisture). To determine the unsaturated hydraulic conductivities along the tree drip line, tension-disc infiltrometer experiments were performed.

The results show that the influence of the trees is mostly limited to the crown-covered area with a decrease of values from trunk to tree drip line. However, trends of a spatial pattern around the trees can be found for specific directions (east due to wind drift, north due to shade and downslope due to slope runoff). The unsaturated hydraulic conductivities differed significantly at the tree drip line between canopy-covered and uncovered areas, suggesting limited infiltration and a potential for higher erosion and further degradation. Understanding argan-tree influence on their surrounding intertree areas would enable structured reforestation measures in tree shelters with higher soil quality and a better microclimate and thus with a higher chance of successful rejuvenation of the argan forest.

SESSION 3:

LANDSCAPE MANAGEMENT SYSTEMS

3.4 The role of wildlife management for agricultural production

Convenors:

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Karoline Hemminger, Leibniz Centre for Agricultural Landscape Research (ZALF) and Humboldt-Universität zu Berlin, Germany

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When aiming to promote sustainable development of agricultural landscapes, making trade-offs between the objectives of wildlife conservation and agricultural production is one of the biggest challenges. Limited availability of natural habitat increases the likelihood of negative impact on agricultural production caused by wildlife and the resulting conflicts over management objectives have become a topic of global interest.

Many studies have been conducted to monitor the populations and movement of wildlife species as well as assess their impact on agricultural management. Land use and wildlife species interact bilaterally, both in terms of wildlife population development and selection of habitat: e.g. the high population growths of wild boar (Sus scrofa), common crane (Grus grus) and several species of wild geese (Anser and Branta spp) have been related to high availability of agricultural forage.

This session aims to discuss how to integrate the perspective of concerned actors, such as farmers, wildlife managers and research disciplines, such as wildlife ecology and agricultural science, to develop sustainable and diverse agricultural landscapes fulfilling the multiple objectives of agricultural production and species- and habitat conservation. Moreover, management solutions to human-wildlife interactions will be discussed: How can we mitigate ecosystem disservices (EDS) and enhance ecosystem services (ES) provided by wildlife both at the level of cropping and grassland systems and at landscape level? In the first part of the session, we will invite four presenters to share their experience and ideas on these topics. The latter part of the session will be open for discussion among all participants.

Orals

The wild boar – domestic pig interface: A quantitative overview of the interaction risk at the European scale

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The wild-domestic interface is a crucial component of the shared human-animal landscape. At this interface, different exchange processes can take places, among which disease transmission is the most feared one. With the recent expansion of the African Swine Fever disease in Europe, a disease threathening the suids group only, the wild boar – domestic pig interface provide a great example of such a feared interface. However, our knowledge on the interactions between wild boar and their domestic relatives is still relatively scarce and mostly based on occasional observations or qualitative approaches. We proposed here to investigate in a more quantitative way this relation by using wild boar movement data at the European level (using Euroboar platform) and pig farm locations. By using a point-to-point distance method, we specifically analyse i) the spatio-temporal patterns in wild-domestic pig interactions and ii) the landscape conditions favouring those interactions. This analysis will provide more accurate and detailed insights on the relative risk of wild boar-domestic pig interactions in different environmental and pig production settings, allowing us to better inform the risk of diseases (ASF but not only) spillover.

Managing 'landscape of fear' in depopulated rural communities: perspectives from behavioral research

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Human presence is a major threat for wild animals, modifying and constraining their behavioral and ecological traits. Human activities can increase vigilances in wild animals and induce their spatio-temporal avoidances from humans. This is substantially consistent to the behavioral-mediated risk effects (or 'landscape of fear') between mammalian predator and prey. Indeed, intense human activities in agricultural landscapes can modify diel activity patters in wild mammals (e.g., shift to being nocturnal) and prevent their intrusions into human residential areas, consequently declining agricultural, forestry or property damages by them.

Currently, however, rural communities are facing depopulations owing to social (i.e., migration to urban areas) and/or natural attritions (i.e., residents' aging and low birth rates) in some Asian and European countries. For example, in Japan, elderly households (65 yrs old <) make up 50% < of rural communities in mountainous hamlets. In those rural communities, farming activities declined and croplands were abandoned, enabled wild animals to intrude into the areas and make conflicts with the residents. Depopulated rural communities are predicted to increase and expand across Japan in the next decades, indicating declines of anthropogenic pressures to wild animals in rural areas. It needs to consider cost-effective measures to manage human-wildlife conflicts in depopulated communities.

I discussed managing 'landscape of fear' by human activities as applicable management tools in depopulated rural communities. The key concept is rural areas managed as 'risky spaces' for wild animals. Under predation risk, habitat selections by prey animals are often constrained by tradeoff between fear for death and food acquisition probabilities. Declining accessibilities to agricultural crops as well as availabilities of other resources (e.g., harvest residues) results in increasing relative risks for wild animals, provoking spatial avoidances from rural areas. Behavioral responses to predation risks often appear at fine spatial scale (i.e., resource patch). Moreover, habitat structures can change intensity of risk effects; for example, some wild ungulates are more vigilant in structured/closed habitats (with lower visibility) than in opened spaces (with higher visibility), owing to interferences of their risk recognitions and escapes. Rural landscapes should be re-organized with spatial gradients of risk effects by human presence. Fencing may play as visual and/or mobile barrier for animals, provoking their vigilances or spatial avoidances. In regions with drive hunting (with dogs or beaters), 'pseudo-hunting activities' that non-hunter walks with dogs or using game call may also help as increasing risk effects. According to current studies, however, it also needs to consider that personality in wild animals, e.g., their boldness or sensitivity to anthropogenic disturbances, may also affect the behavioral responses.

Emergent conservation outcomes of shared risk perception in human-wildlife systems

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Human perception of risks related to economic damages caused by nearby wildlife can be transmitted through social networks. Understanding how sharing risk information within a human community alters the spatial dynamics of human-wildlife interactions has important implications for the design and implementation of effective conservation actions. We developed an agent-based model that simulates farmer livelihood decisions and activities in an agricultural landscape shared with a population of a generic wildlife species (wildlife-human interactions in shared landscapes [WHISL]). In the model, based on risk perception and economic information, farmers decide how much labor to allocate to farming and whether and where to exclude wildlife from their farms (e.g., through fencing, trenches, or vegetation thinning). In scenarios where the risk perception of farmers was strongly influenced by other farmers, exclusion of wildlife was widespread, resulting in decreased quality of wildlife habitat and frequency of wildlife damages across the landscape. When economic losses from encounters with wildlife were high, perception of risk increased and led to highly synchronous behaviors by farmers in space and time. Interactions between wildlife and farmers sometimes led to a spillover effect of wildlife damage displaced from socially and spatially connected communities to less connected neighboring farms. The WHISL model is a useful conservation-planning tool because it provides a test bed for theories and predictions about human-wildlife dynamics across a range of different agricultural landscapes.

Virtual impact assessment of human-wildlife interactions: a transboundary wildlife management case

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Keywords: Human-Wildlife coexistence, Stakeholder participation, Conservation and management

In the first half of the 20th century, two iconic herbivores; the European bison (Bison bonasus) and moose (Alces alces) have been driven to extinction in many countries on the European continent. However, as a result of conservation efforts, these species have returned to Northern and Eastern parts of Europe. Poland is one of the countries with an increasing number of wild bison, of which about ~300 animals are located near the German border. Moose sightings in the northeast part of Germany have also increased in the past decades. These facts indicate the possibility of even larger numbers of these species crossing the border and re-establishing habitats in Germany. While the return of the large herbivores enriches biodiversity, contributes to the cultural identity of the region and economic incentives for tourism, it also has a high potential for conflict. Main conflict areas may appear between human land use activities and returning species – as agricultural landscapes have greatly been altered and fragmented, during the absence of these species.

The EU InterReg project LosBonasus-Crossing! aims to support transboundary wildlife management using impact assessment to explore adequate management options and envisage possible trade-offs that may occur between different stakeholder interests. Project partners from Poland and Germany are working on early and proactive involvement of stakeholder to improve conservation efforts, increase acceptance and for early identification of potential areas of conflict.

The application of an elaborate set of stakeholder analysis, participation and impact assessment methods was planned to develop a sustainable management approach for the two herbivore species in Germany. However, due to the ongoing COVID-19 pandemic situation, the interactive activities of participatory methods needed to be redesigned into online formats. We present a new design of an online impact assessment format and its implementation for the case of transboundary management for the first time. The outline of this study is based on the Framework for Participatory Impact Assessment (FoPIA) to conduct an ex-ante assessment of four alternative scenarios concerning the future management of European bison and moose. To assess their impact and sustainability, the scenarios are rated by experts in the field using a set of sustainability criteria and indicators, based on Land Use Functions (LUFs) separated into the three fields of ecology, society and economy. Experts are asked during interviews to weigh the criteria on a qualitative scale with regards to their estimated importance for management approaches. This is followed by an online workshop where representatives of key stakeholder groups (agriculture, forestry, conservation, tourism; administration) will come together to share their perspective on the scenarios. This presentation will share the results of the online format as well as highlight its strengths and challenges from the development stage. We believe that the findings of this study will greatly contribute to addressing human-wildlife conflicts around the globe in pandemic times and beyond, especially for large-scale or multinational wildlife management efforts where face to face meetings would only be possible at great resource expense.

Handling large grazing birds in the agricultural landscape – a local perspective

Anders Hallengren

County Administrative Board Skåne, Sweden

From the mid 1990: s there has been a massive increase in the populations of large grazing birds (i.e., swans, geese and common cranes) in Skåne, Southern Sweden.. Five things were identified as cause of the increase in large bird populations in Skåne, besides the overall increase in numbers in Europe. These five things were- climate change, increased effort in restoration of wetlands, new agricultural methods, decrease in predation pressure and decrease in hunting pressure

During the increase in the late 1990: s farmers contacted the County Administrative Board (CAB) of Skåne and raised the issues about the big problems that these large grazing birds caused on the farmers' fields. The farmers also felt alone in dealing with the increasing problem.

To meet the farmers frustration CAB Skåne started a discussion group in 1997 with inspiration from Lake Hornborgasjön in Sweden and the Rügen-Bock Area in Germany. The management group consists, besides CAB Skåne, of Landowners, farmers, NGO: s, scare consultants, damage control consultants, Swedish University of Agricultural Science and Kristianstad University.The discussion group transformed over the years into a large grazing bird management group. Topics discussed within the group is summarization of damage prevention, reports on survey results, economy reports of compensations for crop damage and subsidies to prevent crop damage, preventive actions and what information that should be sent out to the farmers.

The benefits with the group are better and more clear information and advice and guidelines have been made available for the farmers. More knowledge has led to an increase in responsibility from the farmer to take own actions, evaluation of damages made by geese has progressed and expert knowledges has been acquired, resource persons working with the farmers are highly appreciated,and funds for preventive work are more effectively spente- Moreover, this have increased the collaboration with external partners like the food industry and maybe the most important result is that the farmers feel that we take them seriously and we care.

With the big increase in the large grazing bird population we now face new problems in the large grazing bird management. We deal with a new species, the protected barnacle geese and it's not just a farmer problem anymore, but also a nature conservation management problem. This has forced us to increase the prevention work, allocate more funds for compensation of crop damage and invent new scaring and deterrent methods.

SESSION 3:

LANDSCAPE MANAGEMENT SYSTEMS

3.5 Scaling up landscape interventions based on sustainable intensification and diversification approaches for improving rural livelihoods in South Asia and sub-Saharan Africa

Convenors:

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Kaushal K Garg, International Crops Research Institute for the Semi Arid Tropics (ICRISAT), India

Jennie Barron, Swedish University of Agricultural Sciences (SLU)

Amare Haileselassie, International Water Management Institute (IWMI), Ethiopia

Cofie Olufunke, International Water Management Institute (IWMI), Ghana

Sustainable intensification and diversification is needed for improving rural livelihood system while balancing ecosystem services within and beyond designated agricultural landscapes.

Landscape based approaches use holistic approaches for addressing rural poverty while simultaneously restoring degraded soils that support livelihoods. These approaches use integrated packages of interventions including diversification of crops and animal to build system level resilience and support sustainable intensification. Realizing and operationalizing this potential now receives more than two billion USD/year by various development agencies in Asia and Africa (Mandal et al., 2020). However, there is scope to strengthen the planning, designing and execution of such interventions through science led approaches aligned with local innovations. In addition, there is a need to strengthen the capacity of and partnerships between different actors, to ensure more equal opportunities and sharing of benefits and costs.

The CGIAR Collaborative Research Program on Water Land and Ecosystems (WLE) and partners have more than 40 years of experience in science-based landscape management approaches. ICRISAT, IWMI in collaboration with state governments and other partners in India and Ethiopia have implemented initiatives from pilot scale in micro catchments to the scale of river basins, which addressed water availability, land degradation, to diversify livelihood opportunities whilst strengthening ecosystem services. In this session, we will share some of our lessons learned to catalyse upscaling of landscape diversification approaches. The session invites contributions that provide new understanding and novel science findings on how diversified landscapes can contribute to system resilience, ecosystem regeneration, optimizing trade-offs, impacts on livelihoods etc. as well as their application with various stakeholders for co-design and effective implementation. It also aims to highlight lessons learned in building essential and effective partnerships for scaling, to share both costs of implementation and the benefits attained.

Orals

Scaling up best management practices towards achieving sustainable intensification in fragile drylands of Asia and Africa

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Drylands are facing number of challenges such as water scarcity, land degradation and poor crop and livestock productivity. These areas are also hotspots of poverty and malnutrition. Due to poor resource availability, dryland regions are characterized with low crop intensification and system diversification. However, there is increasing evidence that dryland areas could be turned from fragile status to productive landscape through a range of landscape and field scale interventions. This study highlights the benefits generated by integrating landscape and field scale interventions in selected benchmark sites of India and Ethiopia. Knowledge generating institutions in respective countries have identified and piloted a range of landscape based interventions and created evidence since past two decades. These sites are also intensively monitored for understanding biophysical, hydrological, socio-economic parameters at micro and meso-scale watersheds ranging from 500 to 5000 ha scale.

Best management interventions facilitated to harvest a fraction of surface runoff at uplands and improved groundwater recharge by 50–100% compared to baseline status. Increased shallow groundwater availability helped to provide life saving irrigation both in monsoon and post-monsoon seasons and reduced the risk of crop failure from intermittent dry spells. Up to 15–20% of fallow lands brought into productive agriculture also helped to intensify crop production. With increased resource availability, farmers have diversified their crop portfolio towards high value vegetables and also allocated their lands for agroforestry system and high density orchards (~5–10%). Moreover, green and dry fodder availability increased with crop intensification in these benchmark sites. These sites show improved provisioning ecosystem services whilst indicating improved regulatory and supporting ecosystem services through improved baseflow availability (additional by 30–90 days) and reduced soil loss (50–80%). The paper further discusses on various ecosystem trade-offs during dry-normal and wet years and the new knowledge needed to support to take informed decisions by stakeholders for more productive dryland systems.

Landcape effects on biodiversity, ecosystem services and nutritional security on Malawian smallholder farms

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Landscape simplification due to agricultural intensification is a major driver of biodiversity loss. Paradoxically, agriculture depends on biodiversity to provide essential ecosystem services, such as pollination and pest control, for productivity. Particularly for smallholder farmers in the global south, this loss of ecosystem services could be highly impactful and increase food insecurity and social disparities. There are strong indications that the decrease of biodiversity in agricultural landscapes can be mitigated through the implementation of various agro-ecological practices, both on a local (field & farm) scale and on a landscape scale, whilst also providing increased food and nutritional security for smallholder farmers. In sub-Saharan Africa particularly, some of these agro-ecological practices, such as intercropping with legumes, are part of traditional smallholder agricultural practice. In our study area in Malawi, the principal livelihood of the majority of people is smallholder agriculture. In addition, Malawi experiences a steady decline in semi-natural habitats across its landscape, which are important habitats for the biodiversity that provides ecosystem services. For these reasons, Malawi illustrates many of the challenges facing the global south, and particularly challenges in the context of sub-Saharan Africa.

In our farmer-participatory project in northern Malawi, we selected 60 fields in 24 villages which varied in their implementation of agro-ecological practices and semi-natural habitat in the surrounding landscape. We performed surveys of bird, insect and soil microbiome biodiversity as well as assessed ecosystem services, such as pest control, pollination and yield. Additionally, we surveyed over 200 smallholder farmers in the participating villages about their implementation of agro-ecological practices as well as multiple social outcomes, such as nutritional security. Our study aims to answer the following: (1) does local and landscape-scale uptake of agro-ecological practices benefit biodiversity both in simple (little semi-natural habitat) and more complex (high semi-natural habitat) landscapes? (2) Does increasing agro-ecological practices and biodiversity improve ecosystem service provision? (3) Do farms with a higher uptake of agro-ecological practices have better nutritional security outcomes? And, finally (4) Does the uptake of agro-ecological practices result in a win-win scenario that benefits both biodiversity and smallholder farmers?

Towards integrated modelling of the multi-functionality of African savanna landscapes under alternative climate and policy scenarios

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Quantitative assessment of how multiple ecosystem services and functions are affected by alternative management, policy interventions and climate change is challenging. Particularly in African savanna regions, highly integrated land-use activities have created a landscape mosaic with flows of multiple resources between the different land use types. An integrated modelling framework is needed that quantifies the effects of climate change, management and policy interventions on ecosystem services that are most relevant for rural communities, such as provision of food, feed, carbon sequestration, nutrient cycling and natural pest control. In spite of progress made in ecosystem modelling, data availability and stakeholder interactions, these elements have neither been brought together in an integrated framework, nor evaluated in the context of real-world problems. Here, we propose and outline such framework as developed by a multi-disciplinary research network, the Southern African Limpopo Landscapes network. Components of the framework such as the crop model APSIM and the vegetation model aDGVM2 had already been parameterized and evaluated using data sets from savanna regions of eastern, western and southern Africa, and were fine-tuned using novel data sets from Limpopo. A prototype agent-based farm model was developed using comprehensive farm survey information from the Limpopo Province of South Africa. First tests of the functionality of the integrated framework has been performed for alternative policy interventions on smallholder crop-livestock and maize-based systems. In this paper we demonstrate and discuss the versatile applicability of the framework, with a focus on smallholder landscapes in the savanna regions of southern Africa that are considered hotspots of impacts of climate change and other global change processes.

Scaling-up sustainable intensification and adaptation to climate change in mixed crop livestock systems in Zimbabwe: a co-design approach

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Mixed crop-livestock systems are vital to provide food, nutrition, income and cultural spaces for large parts of the African landscapes. However, in areas like semi-arid Zimbabwe, they are threatened by amplifying magnitudes of climate change, mingled with socio-economic pressures. Low resource productivity with often depleted soils and water shortages, undermine their potential to contribute to food production and preservation of the natural environment. This study illustrates how integrated simulation modeling of specific farming systems, combined with agro-ecological similarity at landscape scale, can guide policy decisions for sustainable intensification, today and in preparation for futures with climate change. We applied the Regional Integrated Assessment approach developed within AgMIP to co-design systems that improve synergies and reduce trade-offs from sustainable intensification at farm and landscape levels. Experts were consulted in determining and refining inputs to simulation and remote-sensing applications, and discussing relevance of results for influencing policy decisions towards improved sustainability, resilience and resource use efficiency. The approach used principles of co-design and feedback at three scales of analysis.

1. Local-level intensification pathways: Through ex-ante integrated impact assessment, considering climate, multiple crops and livestock, and economic components, we assessed possible impacts of diversification and intensification, for current and future socio-economic conditions. In semi-arid areas, shifting towards climate smart crop and livestock production improved farm net returns substantially. However, many farmers were likely to remain poor, if not supported through a small herd of productive livestock. Allocating more land to produce high-quality biomass, e.g. fodder crops such as mucuna pruriens or leucaena leucoephala, supporting organic soil amendment and locally sourced feed, was economically more viable than commercial options. Through better feeding, farmers could improve offtake rates and focus on livestock market functions.
2. Landscape-level agro-ecological similarities: To widen the applicability of lessons from local pathway analysis, we engaged national experts in discussions about remote-sensing observations that describe agricultural production patterns in Zimbabwe. A range of locally relevant GIS layers (soils, temperatures, rainfall, dry spells, cropping calendar) illustrates the distribution of similar agro-ecological conditions and responses to climate change. As such, we determined landscapes where similarly improved management and adaptation strategies might apply, and key drivers that might shift the systems in future.
3. National-level consistency analyses: To better understand the gaps between what is technically feasible and what may materialize in reality, we used the simulation results to interrogate national priorities and local level implementation. National level sustainability scenarios by 2030 provided the framework for future transition pathways, and informed the redesign of simulated systems.

Creating synergies between sustainable intensification efforts and climate change adaptation ensures that the gains from such investment are not lost under a future with climate change. This type of research feeds directly into the demand by national policy and decision makers. To fulfil their country's vision for 2030 and international commitments, they need research to bring forward targeted information to improve farm management under local conditions, backed-up by vulnerability and adaptation analyses to prepare for uncertainty imposed by climate change.

Common lands in India: Spatial distribution and overlay with socioeconomic and environmental indicators

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Commons (or common pool resources), including forests, wetlands, groundwater, grasslands, and pastures, are natural resources that are shared among community members, and provide important socioeconomic and ecological benefits for local communities and beyond. There is growing literature and interest in how commons can provide livelihood and other benefits and contribute to SDGs. Globally, an estimated 2.5–3 billion people around the world depend on commons for their livelihoods and also to fulfill recreational or spiritual needs; nearly a quarter of the Earth's lands and waters are owned or managed by indigenous groups and under community management. Knowledge on the extent of commons, the primary uses and users, and how commons overlap with areas of high conservation values thus holds a critical key to the solutions to the sustainability challenges countries are faced with. This study aims to examine these questions by evaluating the case of India.

In India, common lands constitute around a quarter of the country's landmass, help meet the critical subsistence and livelihood needs of more than 350 million rural population, and are of social and cultural significance to rural communities. Despite these vital contributions, policymakers tend to perceive the commons as "wastelands" because the true extent and value of commons is not known. India's commons face widespread degradation, registering a decline of around 31–55% in the last 50 years. Expansion of economic development, human encroachment, and land conversions, along with environmental pollutions, have led the loss, degradation, and fragmentation of common lands. Weak community rights over commons and eroding local institutions governing commons aided the degradations. Yet, India's rural poor are affected by the loss and degradation of commons the most, which in turn further exacerbates poverty and conflict.

The essential role of commons in supporting the economic, social, and environmental wellbeing of rural communities as well as in providing ecosystem services that benefit the wider society needs to be urgently documented and recognized. This study starts laying some of the first stepstones toward improved understanding of the magnitude and vitality of commons for rural communities and the society, focusing on land-based commons in India. We provide a first of its kind national assessment of the spatial extent and usage of common lands across districts, using 2011 Census of India data and Household Census data. To illuminate the importance of common lands to rural communities, we assess key demographic and socioeconomic characteristics of districts as well as indicators that capture some of the tangible benefits derived from common lands. We examine the spatial overlap between common lands and officially recognized protected areas to shine light on the possible locations where sustainable management or restoration of common lands can potentially add value to conservation, in addition to benefiting local communities. The study compiled and assessed a range of publicly available spatial datasets, allowing for the identification of spatial patterns and intersections.

SESSION 4

PUBLIC AND PRIVATE GOVERNANCE SYSTEMS

SESSION 4:
PUBLIC AND PRIVATE GOVERNANCE SYSTEMS

4.1 Pesticide policies for a sustainable and resilient agriculture

Convenors:
Niklas Möhring, CEBC-CNRS, France
Karin Ingold, University Bern, Switzerland
Ashley Larsen, UC Santa Barbara, United States of America
Robert Finger, ETH Zürich, Switzerland

The reduction of environmental and health risks from pesticide use is a central challenge for agriculture. Sustainable pest management should maintain crop yields for a growing global population, while reducing adverse effects of current strategies. A number of countries have introduced National Action Plans "to reduce environmental and health risks from pesticide use". Despite substantial efforts, pesticide policies have failed to reach reduction goals. Research on effective and efficient pesticide policies for a sustainable pest management is therefore needed.

In this session we will present cutting-edge research on pesticide risk reduction for effective and efficient pesticide policies.

This session aims to bring together ongoing research on policies to reduce pesticide risks, taking an interdisciplinary approach, which integrates theories, concepts and methods from agricultural economics, policy research, agronomy and ecology. Farmers' behaviour shall play an important role in this session for the understanding of pesticide use decisions and the design of policies. Finally, the session aims to show how effective and efficient pesticide policies can be designed. For example, shedding light on policy perspectives beyond the level of individual farms and accounting for the diversity of actors' land use and management decisions at the landscape level.

Orals

Pesticide policies for a sustainable and resilient agriculture

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Keywords: Sustainable pest management, pesticide policies

The reduction of environmental and health risks from pesticide use is a central challenge for agriculture. Embedded in a bigger framework of food policies, sustainable pest management should maintain crop yields for a growing global population, while reducing adverse effects of current strategies, especially arising from pesticide use.

To this end, numerous policies for pesticide risk reduction have been introduced recently – but only with limited success. We here outline a holistic framework for effective and efficient pesticide policies. We then present pathways for advancing pesticide policies, taking an interdisciplinary point of view (Möhring et al., 2020).

In our presentation, we highlight that successful pesticide policies need to account for all actors of the food-value chains. Especially farmer behaviour and spatial interactions of farmers and the ecosystem are key for pesticide risk reduction.

In this context, we discuss recent research findings on landscape-level drivers of pesticide use that highlight the importance of farmer behaviour and farmer coordination and respective policies for these landscape level approaches (Larsen and Noack, 2020).

Finally, we outline future avenues for research and highlight the key role of interdisciplinary approaches for advancing research and policies in the field.

References:

Larsen, A. E. and Noack, F. (2020). Impact of local and landscape complexity on the stability of field-level pest control. Nature Sustainability, 1–9.

Möhring, N., Ingold, K., Kudsk, P., Martin-Laurent, F., Niggli, U., Siegrist, M., Studer, B., Walter, A. and Finger, R. (2020). Pathways for advancing pesticide policies. Nature food, 1(9), 535–540.

Identifying and characterizing pesticide use on 9,000 fields of organic agriculture

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Organic agriculture is an oft suggested means to improving the sustainability of agricultural production. Notwithstanding popular perception, many of the environmental impacts of organic agriculture are poorly understood and debated. Fueling the impasse is the general lack of data on the location of and input use on comparable organic and conventional agricultural fields. Here we identify the spatial location of about 9,000 organic fields from 2013 to 2019 using unique field-level crop and pesticide use data, along with state certification data, for Kern County, CA, one of the US' most valuable crop producing counties. Using log-normal hurdle models and careful accounting of farmer and crop characteristics, we parse apart how being organic relative to conventional affects decisions to spray pesticides and, if spraying, how much to spray. We find the expected probability of spraying any pesticides is reduced by about 30 percentage points for organic relative to conventional fields, across different metrics of pesticide use. However, we report little difference, on average, in pesticide use for organic and conventional fields that do spray. While only one metric of sustainability, pesticide use is highly relevant for organic consumers and is an area with surprisingly limited quantification. Our results suggest organic agriculture is more likely to be "pesticide-free", but organic fields that are sprayed tend to receive similar levels of pesticides as their conventional neighbors.

Austrian farmers' intended weed management behavior after a potential national glyphosate ban

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Keywords: Crop protection, glyphosate-based herbicides, qualitative content analysis

Globally, glyphosate-based herbicides are widely applied in agricultural weed management. Their use has increased sharply in the last decades mostly because of their high effectiveness, ease of handling, and low cost. Conflicting evaluations of the active ingredient glyphosate generated controversial discussions among farmers, citizens and policy makers. The Austrian parliament responded with a national glyphosate ban which has not yet become effective. Still, farmers are exposed to legal uncertainties and the societal pressure to decrease the use of glyphosate-based herbicides. While research has focused on potential economic effects resulting from a glyphosate ban, much less is known about farmers' intended behavior after a potential national glyphosate ban. Such knowledge would, however, be useful to inform policy design and policy acceptance. We aim to explore Austrian farmers' intended weed management behavior after a potential national glyphosate ban.

We have conducted 41 semi-structured interviews with farmers across Austria. Farmers were selected based on the criterion of maximum variation in order to integrate a broad range of perceptions and intended behaviors. The transcribed interviews were analyzed with a content-structuring qualitative content analysis, followed by a type building approach. Drawing on the Theory of Planned Behavior, the three socio-psychological constructs attitude, subjective norm and perceived behavioral control toward a planned behavior informed the empirical analysis.

Farmers intend to apply mechanical or chemical alternatives, either individually or combined with cultivation practices, such as changes in crop mixes. What interviewed farmers have in common, is, that they perceive major challenges regarding their weed management behavior, because of rapid changes in pesticide approvals and a lack of effective alternatives to glyphosate-based herbicides. They also agree on a perceived low societal acceptance of chemical measures, which is particularly true for glyphosate-based herbicides (i.e. injunctive norm).

Furthermore, based on our interview data, we identified four types of farmers who differ in their intended weed management behavior after a potential national glyphosate ban. These farmer types diverge regarding their attitude, descriptive norms and their perceived behavioral control toward their intended weed management behavior. For instance, farmers who expect negative on-farm (e.g. higher costs, lower yields, soil degradation) and off-farm outcomes (increase of CO_2 emissions) express a negative attitude toward the intended weed management behavior. Perceived behavioral control differs mainly with regard to farmers' experiences of and know-how about weed management alternatives and their on-farm resources (e.g. machinery).

Our results suggest that policy designs aiming for a decrease in the use of glyphosate-based herbicides should take into account perceived on-farm and off-farm outcomes and control beliefs. The interviewed farmers would appreciate more factual than emotional societal discussions and favor a European instead of a national glyphosate ban. Finally, they ask for weed management alternatives with similar effectiveness and costs as glyphosate-based herbicides.

References:

Matousek, T., Mitter, H., Kropf, B., Larcher, M., Schmid, E. (2019). Wahrnehmung zur Verwendung von glyphosathaltigen Herbiziden in der Land- und Forstwirtschaft, in: Nationale Machbarkeitsstudie Zum Glyphosatausstieg. Endbericht Zum Forschungsprojekt Nummer 101347. Wien, pp. 121–149.

Adoption of pesticide-free production practices depends on farmers' perception of pesticides environmental and human health effects

Robert Finger[1]; Niklas Möhring[2]

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The reduction of environmental and health risks from pesticide use is a key challenge for agriculture (Möhring et al., 2020, Nature Food). The sustainable intensification of agriculture requires the adoption of new practices and production systems on a large scale. Recent literature has shown that farmer behaviour will be central for this challenge (Larsen and Noack, 2020, Nature Sustainability). However, the design of effective and efficient tools and policies requires insights in the mechanisms of farmer behaviour driving the adoption and use of sustainable production practices.

In our analysis, we focus on a novel pesticide-free but non-organic wheat production standard in Switzerland, where farmers substitute pesticide use with a combination of resistant varieties, mechanical weed control, crop rotations and other agronomic measures. Contrary to organic farming, the program neither restricts the use of artificial fertilizer, nor does it restrict pesticide use in the rest of the crop rotation (see also Böcker et al., 2019, Agricultural Systems, for further details). The program envisions that until 2023 more than 20% of Swiss wheat production will be under this pesticide-free production scheme. Such a large-scale pesticide-free production program is unique and is the first of its kind.

Farmers' participation in the program is incentivized by a combination of governmental direct payments and price premia paid by the industry. We here aim to show that not only monetary incentives matter, but farmer perception of risks is central for the up-take of pesticide-free production practices. The main focus of our analysis is on how farmers' uptake of pesticide-free production is associated with their perception of positive effects of switching to pesticide-free wheat production on i) the environment and ii) health of farmers and consumers.

For our analysis, we conducted an online-survey on program participation with the complete population of potential participants in Switzerland, i.e. farmers which currently participate in a low-input production program in the producer organization IP Suisse (Böcker et al., 2019). We surveyed in total 4749 farms in 2019/2020 and received 1105 complete answers (response rate of 23.3%). We identified if farmers participate in the pesticide-free production or whether they intend (or not) to join the program in following cropping seasons. We find that 156 (14%) producers participate in the program.

Our results show that adoption of pesticide free production is positively and significantly correlated with a more positive perception of environmental and health effects for farmers and consumers. These findings are robust to the inclusion of a large set of control variables in regression analyses. We show that farmers' perception of positive environmental effects was more important in explaining adoption than perception of positive human health effects from removing pesticides.

Our finding emphasizes the importance of non-monetary incentives for the adoption of sustainable production practices. Providing specific information, such as "green nudges" can be an effective complement to other policy measures. It further underlines the importance of research on farm-level environmental and health effects of agricultural practices and their communication to farmers.

What makes the difference? An interdisciplinary approach to match behavioral insights with policy design to regulate individual pesticide use

Ruth Wiedemann; Jennifer Inauen

University of Bern, Switzerland

Farmers use agricultural pesticides to enhance productivity and meet consumer demands. While pesticides not only contribute to agricultural productivity, they also pose a threat to environmental ecosystems and to human health. This is particularly alarming in the Global South, where pesticide use is often excessive, unsafe, and unsustainable. This is why targeted policies are needed to protect humans and the environment from the negative effects of pesticides without compromising agricultural growth. However, for a policy to achieve this goal, it must be effective, or in other words, it must have the potential to provoke a change in farmers' pesticide usage. Yet, public policies often fail to reach their goals, as the intended behavioral change does not occur. More recent literature stresses that the individual and his/her behavior have to be considered to align policy instruments with behavioral determinants and to avoid policy failure. In this vein, what is needed in the study and analysis of policy formulation, design and implementation processes is a better, more systematic and empirically robust and supportable linkage of the expected behaviour of policy targets to the full range of policy tools available.

Pesticide related problems are driven by individual behavior, and typically by farmers' and farm workers' practices. Effective pesticide control and regulation therefore needs to directly address these target groups to shift their behavior towards sustainable use of pesticides in agriculture. This is why we ask: 'What social{psychological factors determine farmers' pesticide use behavior in the Global South? And, based on behavioral insights, which public policies are most suitable to steer farmers' behavior towards sustainable pesticide use?

To achieve this, we create an inventory of socio-psychological determinants triggering pesticide use of individual farmers. A systematic literature review of existing research on pesticide use behavior is conducted to identify the most important behavioral factors. The data (i.e. on the effect of different behavioral factors on farmers' pesticide use) extracted from the body of literature are grouped according to a theory-based model borrowed from health psychology, the Behavioral Change Wheel. According to this model, individual behavior is the result of three interdependent components – motivation, opportunity and capability – and several sub-components. This grouping enables us to prioritize the (sub)components as determinants of pesticide use and use this knowledge to deduce effective policy interventions and instruments within the same Behavioral Change Wheel. The final output is a list and the discussion of public policies and policy instruments with the potential to change farmers' behavior towards sustainable pesticide use.

Through a novel combination of tools from applied social psychology and policy analysis, we generate insights, that inform decision-makers regarding effective policy options. We benefit from the synergies between policy studies and applied social psychology (i.e. the goal of changing individual/target group behavior) and contribute to the literature by enriching our understanding of effective pesticide regulation in the Global South through an interdisciplinary perspective.

SESSION 4:
PUBLIC AND PRIVATE GOVERNANCE SYSTEMS

4.2 Farmer typologies for agri-environmental policy analysis and design: Methods, uses and insights

Convenors:

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Bartosz Bartkowski, Helmholtz Centre for Environmental Research – UFZ, Germany

Robert Huber, ETH Zürich, Switzerland

To foster transformation towards sustainable and resilient agriculture in Europe and beyond and to put the right incentives for farmers it is important to understand factors driving farmers' behaviour. Effective policy interventions should take into account farmers' heterogeneous decision-making. In this context, empirical research emerged that tries to classify farmers' decision-making into typologies or archetypes. The idea is to find patterns of decision-making that simplify the representation of famers' behaviour in scientific analyses.

The spatial focus of this conference – the landscape scale – evokes the question, how and to what extent individual characteristics of farmers can be aggregated to a type or a group that exhibit a different behaviour than another type/group for landscape scale analysis.

For this session we invite contributions to bring together knowledge from different disciplines, e.g. earth system sciences, rural sociology, human geography, modelling and economics related to the concept of farmer typologies. We encourage submissions that provide insights from different data sources (e.g., surveys, census, big data) and research approaches (e.g., machine learning, meta-analysis, modelling). The discussions are aimed to offer new perspectives on how to consider the heterogeneity in farmers' decision-making for the analysis of landscape scale policy options that contribute to a more sustainable and resilient agriculture in different regions in the world.

Orals

Farmer typologies in Europe: A review of state of the art and the detection of next steps needed

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Understanding farmers' behaviour and their different responses to environmental change, institutional change and policy interventions is highly policy-relevant and can inform the design of targeted instruments to support transformation towards sustainable agriculture.

Identification of behavioural types can be very useful in facilitating the transferability of findings between contexts, while also pointing out limits to generalization of behavioural patterns detected in individual studies. However, empirically derived typologies on farmers in Europe are quite scattered geographically, among contexts and disciplines, and a synthesis of these studies is needed. With this contribution we aim to present results from a literature review on empirically derived farmer typologies in Europe on the basis of 36 academic studies. We investigated and compared amongst others the underlying methodology for determining the types, the objectives of the typologies (including the relevance for policy design) and whether there recur similar farmer types in different contexts and locations.

Our results show the following: (i) the different typologies have been developed for various purposes: from theory-driven work, such as testing of different (social science) theories to grouping farmers with respect to their environmental awareness, their adoption of specific practises and partly to target policy instruments for these groups. Typologies have also been used to deliver the basis for representing farmers' heterogeneity in agent-based models. (ii) Typologies are based on factors from six categories: farm characteristics, social-psychological factors, socio-demographic factors, technological factors, business characteristics, and knowledge. Mostly, factors from only 1–2 categories were considered in a typology. (iii) Our qualitative clustering of recurring types revealed that similar farmer types occur repeatedly within different typologies partly under different names, such as the innovator, the productivist, the environmentalist and the conservative.

Two limitations were identified methodwise: First, there is a wide variety of how research processes are documented in the articles, considering data collection processes, response rates, definition and operationalisation of relevant variables and methods used for analyses. The given information on such details of the research process are partly insufficient. Secondly, references to previous work on the development of typologies are quite rare and selective, indicating that research on farmer typologies is being carried out somehow scattered.

Finally, we present next steps needed with respect to better aligning empirical research on farmer types in Europe and therewith for fostering synergies. These advancements would support transferability of insights on farmer behaviour for different contexts and spatial locations. In addition, such better informed and embedded typologies can also be a still more useful basis for modelling (e.g. agent-based models) that would allow to investigate (and potentially generalize) the many empirical findings on farmers' behaviour and to analyse the feedback between farmers' behaviour and the agroecological system in time.

Environmental issues in farmers´ objectives and their acceptance of agri-environmental measures – a qualitative analysis

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Keywords: Germany, non-pecuniary objectives, high input farming

Understanding factors that influence a farmer's decision for or against the implementation of agri-environmental measures is essential for developing effective programs and consultancy.

When considering the acceptance of agri-environmental measures, specific factors and designs are often referred to as relevant whereas general attitudes towards environmental and nature protection as factors for decision making are often considered less differentiated.

We conducted guided-interviews with 44 farmers in ten German regions mostly characterized by intensive agricultural production. Based on the interviews we developed a typology of farmers in order to link attitude and action (as participation in measures). Related to qualitative content analysis and empirically grounded construction of types, the interviews were first coded inductively. On the basis of the subcategories formed, we identified the relevant characteristics for the typology as the comparative attributes a) environmental issues that farmers consider in their farm management, b) their general ratings of measures that promote biodiversity and c) the implementation of biodiversity measures with different funding sources on their farm. Subsequently, the cases could be grouped by means of these characteristics and their defined dimensions.

Through this analysis we identified six types of farmers with common characteristics: the enthusiastic, the ambitious realistic, the positive neutral, the extrinsically motivated, the amenable and the uninvolved. The enthusiastic deals intensively with the topic of biodiversity and implements extensive self-financed measures while the ambitious realistic is well informed about agri-environmental schemes and implements several biodiversity measures with different funding sources. The positive neutral implements individual measures without greater ambitions while the extrinsically motivated implements only measures with attractive payments or positive externalities. The amenable does not implement any funded biodiversity measures but is not averse to in principle while for the uninvolved there is simply no need to implement measures (at his farm).

There are clear differences in all of the three comparative dimensions (a, b and c) between the groups. For example, the uninvolved name as environmental issues only the protection of resources like soil and water protection. Thus, the only implication for the implementation of measures for this group – without influencing their objectives in general – can actually be natural resources as a factor of production or compliance with the applicable regulations (e.g. distance regulations with buffer strips next to a watercourse). The enthusiastic name diversity of species and individual species groups as environmental issues, so there are many implications for the implementation of measures. For this group it could be important to provide information on the requirements of species and accompanying advice on the implementation of measures to maximise the effect of measures.

With the different environmental issues considered for farm management, the analysis shows various implications for the implementation of measures, which can be taken up e.g. by adapted consultancy concepts and thus foster the willingness to participate in biodiversity measures.

Patterns in farmers' responses towards a pro-environmental policy design of the Common Agricultural Policy

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The recent interest in farm typologies to explain and improve farmers' adoption of pro-environmental practices in general and of agri-environmental measures in particular has been part of a broader interest in a more detailed understanding and harnessing of behavioral factors as mechanisms for policy interventions. The most influential approach is rooted in social psychological theories that distinguish various types of cognitive and normative beliefs as drivers of the behavior and decisions of farmers (Dessart et al., 2019). This paper follows a different approach. It takes the attitudes of farmers towards alternative policy options and their ensuing reasoning as a starting point to inductively identify distinguishable types of farmers with distinct responses to specific policy interventions.

The data source is a telephone survey with 54 farmers in Germany, representing opinion leaders, on alternative options to improve the incentives for the implementation of sustainable farming methods in the Common Agricultural Policy (CAP) of the European Union (EU). We assessed the farmers' evaluation of the CAP for the funding period 2014 to 2020 and their main concerns with regard to the further development of the CAP. A hierarchical cluster analysis was conducted to identify patterns in farmers' responses based on their attitudes towards options for a pro-environmental policy design of the CAP, accompanied by farm characteristics. On this basis, an inductive frame analysis was used to identify the underlying argumentative patterns employed by the farmers grouped in each cluster.

The analysis generated three distinct clusters (types) of farmers. The clusters differ not only with regard to their attitudes towards particular policy design options, they also use different argumentative frames. Farmers grouped in the first cluster tend to be skeptical of a pro-environmental design of the CAP, but would be most likely to support a continuation of the existing policy design. The second cluster shares a rather skeptical attitude towards an environmentally-oriented CAP, but prefers a move away from government payments to market-oriented instruments to foster environmental, climate and nature conservation. Farmers in the third cluster show the highest support for a pro-environmental design of the CAP and agree that all CAP payments should be linked to environmental performance. We further identified six different frames: productivism, market competition, feasibility, fairness, entrepreneurship and environmentalist frame. By using different frames, the farmers grouped in the clusters each accentuate certain aspects of the complex agricultural reality and downplay others when it comes to evaluating and expecting the CAP.

Building on the results, we discuss how this farmers' typology can inform future policy design of the CAP. We argue for a broad portfolio of instruments that take into account the various groups of farmers in a differentiated manner. This requires a stronger differentiation of the CAP along different sets of challenges – also within the member states, down to landscape level. Effective agri-environmental policy options should be designed to address the spatial specificities of farmers and their particular farming realities.

Combining the best of two methodological worlds? Integrating Q methodology-based farmer archetypes in a quantitative model of agri-environmental scheme uptake

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Increasing farmers' acceptance and adoption of environmentally beneficial farming practices is essential for mitigating negative impacts of agriculture. To support adoption through policy, it is necessary to understand which types of farms or farmers do or do not (yet) apply such practices. However, farmers are not a homogeneous group and their behavior is subject to a complex array of structural, socioeconomic, and socio-psychological influences. Reducing this complexity, farmer typologies or archetypes are useful tools for understanding differing motivations for the uptake of sustainable farming practices.

Many existing investigations of the role of farmer archetypes in the adoption of such practices rely on either purely qualitative or purely quantitative methods in data collection, typology creation, and hypothesis testing. Our study combines both approaches by classifying survey respondents into farmer types based on a previous Q methodological study. We then use these types in a two-part regression model that aims to explain participation in agri-environmental schemes (AES) and the level of scheme participation. To control for farm structural factors, we additionally link our questionnaire data to secondary data from the farm accountancy data network.

Results indicate that in Austria, AES are attractive to all types of farmers, but the level of participation (AES income per hectare) in these schemes differs between archetypes: Profitability-oriented farmers participate less, and nature-oriented farmers participate more than other types. This suggests that monetary compensation for sustainable farming practices is not perceived as sufficient by certain groups of farmers, and policy makers need to consider additional kinds of incentives.

Stakeholder perspectives towards agri-environmental contract design – A Q-methodology approach

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Agriculture has large impacts on the environment, and agri-environmental schemes are considered a promising mechanism to achieve environmental policy goals. Different stakeholders are important players in developing and implementing these agri-environmental schemes. Their attitudes largely determine the institutional design of policies and drive farmers' uptake of these measures. Hence, in this paper we analyse subjective viewpoints of relevant stakeholders on the institutional design of agri-environmental schemes as important framework conditions to avoid policy mismatches. We apply Q-methodology with 25 individuals from Brandenburg, Germany, from the domains of farmers, policy administrators and intermediaries. We identify three distinct attitudinal profiles, not corresponding to the individual stakeholder groups. Instead, each profile matches a social perspective, spanning across different stakeholder groups. Results give evidence that general differences in viewpoints of policy designer and implementer of the one hand and farmers on the other hand are not source of policy mismatches. Rather, the attitudinal profiles can be used to develop different, adapted policy programmes with lightly different rationality behind. Policymakers should be aware of the different tailor-made options for the institutional design of agri-environmental programs and, where appropriate, implement different agri-environmental (sub-) programs in parallel. Our research strengthens the argument that stakeholders should be incorporated in the policy design, as each individual may incorporate personal arguments that may favor overarching social perspectives and thus strengthen these.

Smallholder livelihood typologies in pigeon pea-based farming systems: an application to rural Uganda

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Smallholders produce over 30percent of the food supply, and operate 24 percent of the global gross agricultural area, yet are minimally recognized as critical entities for contributing to food security globally. Worldwide, smallholders are diverse and produce food within their resource-constrained environments that are heterogeneous. Legume-based cropping systems have been for long a part of the smallholder ecosystem. Pigeon pea is an orphan legume crop grown in the semi-arid tropics in Africa and Asia. Against this backdrop, this study sought to classify smallholder and determine distinguishing characteristics between clusters. We gathered data through an interdisciplinary approach with 257 smallholder households in northern Uganda, in addition to group discussions to develop hypothesis about this farming system. Using multivariate analysis (Principal Component Analysis (PCA) and Hierarchical Cluster Analysis (HCA)), we constructed typologies using thirteen structural and functional variables. We constructed six distinct smallholder clusters with 56, 45, 30, 65, 35 and 24 members respectively. There are differences between clusters in terms of land, livestock and farm asset ownership, farming experience and access to and use of farm remedies. Typology construction proves relevant to policy and program makers since it provides the structural and functional traits according to smallholder farming system heterogeneity. The varying characteristics between clusters is evident for targeted programs and policies by governments and funders.

Empirically based farmer types in the context of climate change adaptation in Austria

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Climate change directly and indirectly affects the agriculture and food sector. Previous assessments suggest that farm resilience can be strengthened through timely and effective climate change adaptation. Farmers decide on the implementation of adaptation measures and can be supported by tailored outreach programs, agricultural and climate policies (Mitter et al., 2018). Currently, there is only limited knowledge on the diversity of farmers' beliefs in anthropogenic climate change, perceptions of climate change, related risks and opportunities, knowledge and appraisal of adaptation measures, and adaptation intentions. Accordingly, extension activities and policy design rarely consider farmers' perceptual and behavioral diversity. An increased understanding of farmers' perceptions on climate change and their intended adaptation behavior is crucial to adopt public adaptation incentives to farmers' needs. Hence, we aim to develop empirically based farmer types with heterogeneous perceptions of climate change and adaptation intentions. We adopt a two-phase procedure, i.e. a qualitative research phase is followed by a quantitative research phase. In the first, qualitative research phase, we have conducted 41 semi-structured interviews with farmers in three different landscapes in Austria. The Model of Private Proactive Adaptation to Climate Change has been used as a theoretical basis because it explicitly considers socio-environmental context factors related to personal, farm and landscape characteristics (Grothmann and Patt, 2005). Based on the qualitative data material, we have identified four farmer types. They are characterized by high internal homogeneity with respect to the attributes belief in anthropogenic climate change, appraisal of climate change as risk or opportunity, awareness of adaptation measures, perceived self-efficacy, perceived adaptation costs, and socio-environmental context factors. The qualitative data material reveals that three types of farmers already adapt to climate change and plan to do so in the future, whereas one type does not form adaptation intentions (Mitter et al., 2019). The qualitative data material has been further analyzed and condensed to derive items for a standardized, quantitative survey. In the second, quantitative research phase, the standardized survey is sent to about 2,000 Austrian farmers. The collected data are used to verify and revise the farmer types identified in the qualitative research phase by running multivariate analysis including factor analysis and Latent Class Analysis. The resulting farmer types are characterized verbally and validated in a face validation process. These results may serve as a starting point for follow-up activities at extension service and policy level to increase resilience on farms and related up- and downstream sectors. At extension service level, the empirically based farmer types may inform the development and design of information and communication strategies, and training programs. At policy level, farmer type specific activities may be encouraged through adaptation plans and tailored incentives, which may then contribute to timely adaptation.

References:

Grothmann, T. and Patt, A. (2005). GEC 15, 199–213. https://doi.org/10.1016/j.gloenvcha.2005.01.002

Mitter, H. et al. (2018). JEM 209, 286–300. https://doi.org/10.1016/j.jenvman.2017.12.063

Mitter, H. et al. (2019). EM 63, 804–821. https://doi.org/10.1007/s00267-019-01158-7

A farmer typology for intentions towards adoption of ecological approaches in European agriculture

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Targets for net zero carbon and biodiversity requires food production to sit alongside approaches which exploit co-benefits. Increasing activity in these areas is explicit in numerous policies aimed at meeting both food security and climate goals. We explore the intentions to increase ecological approaches within a survey of 1,200 European farmers to understand the heterogeneity of farmers operating these practices. We employ a latent class approach and the concept of path dependency to explore how current behaviours may lock farmers into a particular trajectory.

We estimate covariates behind our types using multinomial regression and find that factors such as age, the level of agricultural diversification and risk seeking perceptions were significant in influencing adoption of ecological approaches. However, the strongest predictor for intended increases was past engagement in these practices. This tends to confirm that lock-in effects are limiting wider participation in these activities within the farming population. As Governments are seeking to promote transition within the industry we argue for clear policy intent in payment regimes and regulations, as well as holistic approaches to institutional structures to target particular classes of farmers for real behavioural change.

SECLAND – farmers' decision-making from a socio-ecological perspective

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Keywords: Agent-based modelling, SWAT, farmer's decision-making, land-use change

Farmers in Europe make decisions within several constraining principles, such as guidelines set by agricultural programs, market demands, economical situations, and biophysical features of the land. However, farming is not only a business, but farmers are also social actors with a specific family or traditional structure and with individual lifestyle preferences, factors that are often underrepresented in the modelling of farmer behavior (Huber et al., 2018). In SECLAND, we developed a socioecological land-use model based upon an agent-based model (ABM) (programmed in Netlogo) that aims to fill this gap by including intrinsic behavioral traits that impact farmers' decision-making. The agents in SECLAND are not solely guided by profit maximization but also follow a well-being/work-life-balance approach by acting within the thresholds of a maximum workload and a minimum income. Alongside farming types, the model integrates the concept of farming styles (Schmitzberger et al., 2005), which represent the intrinsic motivation (world view) of farmers as an essential criterion for their decision-making process.

The SECLAND model integrates the combined use of quantitative and qualitative data analysis. The socio-economic initialization of the model depends strongly on the quantitative analysis of agroeconomic statistics (IACS, regional agricultural). This is accompanied by a qualitative process consisting of semi-structured interviews with regional farmers and experts. The interviews are an essential part for the selection of relevant farming styles and the parametrization of the option space (set of relevant actions) for the decision-making processes. The dual analysis is a key element for the adaptation of the model to different research questions and study regions.

In several future scenarios that integrate farming changes due to the climate (e.g. yield decreases or increases) and due to socio-economic factors (e.g. subsidies, prices, workload, preferences), we investigate how these changes in the framework conditions impact the decision-making of farmers. In the latest project, we apply the model to the Enns valley (Austria) to explore land-use patterns between 2015–2050 for three different future scenarios. Besides aggregated agro-economic data, the model generates spatially explicit land-use maps that depict annual land cover and cropping intensity changes at the field level for the entire modelling period.

The land use maps serve as the interface between SECLAND and an eco-hydrological model. Through the annual land-use maps in each of the three scenarios, we link the ABM in SECLAND with the SWAT model to investigate the impact of changes in agricultural land use patterns on surface water quality. The combination of both models allows a holistic analysis of the impacts of future land-use patterns considering the changes among land use types, as well as cropping intensity gradients and surface water quality.

With the loose coupling of SECLAND and SWAT, we deepen current knowledge in the field of sustainable cropping systems for the future, mainly by adding the human decision-making component of a land use model, to derive socio-ecological options for agricultural change and to determine farmers practices that reduce nutrient losses to surface water while maintaining or improving crop yields.

Farmer typology and implications for policy design – an unsupervised machine learning approach

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Within the European Union, there is currently a vivid debate about the European Farm to Fork Strategy and the related future design of the Common Agricultural Policy post 2020. Recent large-scale protests of farmers within EU countries as a response to the implementation of a new fertilizer ordinance is just one example of how differentiated and targeted policy design and implementation is often not or just partly achieved. In addition, critics of various stakeholders come up questioning if the high agricultural budget is spent wisely and sustainably.

For creating accurate, target-group oriented policy measures, a crucial pre-requisite is to understand the structure of farmers in a comprehensive and objective way. To classify farmers and farm structures from only one or few dimensions (e.g. farm size, farmers' age), does not reach far enough, as the conception of the farmer nowadays for instance gives more and more way to entrepreneurial-focused activities. Thus, a multidimensional perspective incorporating many factors describing the farmer, their farm and its context on the basis of hard facts is needed.

For the vast majority of existing studies analyzing farmer typologies, the underlying data is narrowed merely to selected aspects and furthermore, picking selected regions. As a result, the explanatory power and generalizability of these typologies is rather limited and the resulting clusters cannot provide a comprehensive typology of farmers, which is independent of the respondents' opinions or the researchers' bias towards a specific topic. Hence, their applicability to support policy design and communication is often restricted.

To address this research gap, we conduct a cluster analysis on the basis of a comprehensive farmer survey, which comprises a wide range of quantitative variables and "hard facts" about their farms, their entrepreneurial activities and socio-demographic data of themselves. Moreover, we correct for potential researchers' bias towards specific topics by using an unsupervised machine learning approach with Partitioning Around Medoids (PAM) for the clustering of farmers. Compared with the popular k-means clustering method which can only analyze continual variables, PAM takes into account mixed data.

According to the results, German farmers can be clustered into three different groups. The conventional growers are the oldest group of farmers and characterized by a focus on traditional and politically subsidized activities. The versatile youngsters are rather young in age and the majority of them have completed a higher education. Their business profile is diverse. The third group of family-based farmers has the highest shares of family support within their farming business and consists of the majority of dairy farmers. Policy and communication design needs to consider all these different profiles. Especially new and innovative programs could be developed and tested together with the versatile youngsters. Furthermore, aspects ensuring an effective and economically rewarding production of agricultural goods should be taken into account to offer a perspective for the conventional growers and for food security. Moreover, the family-based farmers constitute a promising target group for rural development programs.

These results were recently published in Land Use Policy: Graskemper, Yu and Feil (2021).

From farm type to farming strategy – for better policy evaluation

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Keywords: Machine learning, structural change, agri-environmental objectives

The classification of farms into farm types is of high policy relevance. For instance, farm typology is used to identify structural change within the agricultural sector, to assess the competitiveness of a specific market such as dairy production or to compare incomes within and between farm types. Even though, farm types are often used as a unit for policy evaluations, there is hardly any discussion on how farm types are defined and whether the definition of farm type affect evaluation results or policy conclusions.

Farm structures and agricultural policies have become increasingly complex over time (Finger and El Benni, 2021), resulting in very heterogeneous farm structures and production technologies used (Renner et al., 2021). These developments can not only be attributed to market price signals, but also to agri-environmental policies that incentivize certain behaviors of farmers and farm households such as the provision of ecosystem services (Plieninger et al., 2012). Environmental objectives of agricultural policies, however, are not reflected in the current criteria used to define farm types. Thus, farm types as they are defined today hardly allow any conclusions to be drawn about the the achievement of environmental objectives of agricultural policy and its structural consequences.

In this contribution, we use Swiss farm-level agricultural census data of dairy and cattle producers of the year 2018 and apply two unsupervised machine learnings approaches, k-means and fuzzy-c-means clustering to identify farm types using six different criteria: the share of dairy cows, the share of grassland area on total agricultural area, stocking density, share of biodiversity area on grassland area, agricultural area in ha, number of livestock units. The results of the identified farm clusters are compared between ML approaches used and with the current farm type clusters as defined in Switzerland.

The results show a distinct picture with four main farm type clusters by both ML methods applied: 1 - big intensive crop & dairy with biodiversity, 2 - specialized grassland-based extensive dairy, 3 - grassland-based extensive dairy and cattle, 4 - specialized grassland-based intensive dairy.

Using unsupervised ML approaches and considering environmental variables allowed us to detect formerly unobserved farm types that are currently mainly declared as being dairy or combined dairy and crop farms. Given that agricultural policies of today mainly work with incentive-based measures, the current definition of farm type should be reconsidered. Based on our results, we argue that we should observe the existence of management strategies rather than farm types in the future to evaluate (structural) effects of agricultural policies.

References:

Finger, R., El Benni, N. (2021). Farm income in European agriculture: new perspectives on measurement and implications for policy evaluation, European Review of Agricultural Economics 48(2), 253–265.

Plieninger, T., Schleyer, C., Schaich, H., Ohnesorge, B., Gerdes, H., Hernández-Morcillo, M., Bieling, C. (2012). Mainstreaming ecosystem services through reformed European agricultural policies, Conservation Letters 5, 281–288.

Renner, S., Sauer, J., El Benni, N. (2021). Why considering technological heterogeneity is important for evaluating farm performance. European Review of Agricultural Economics, 415–445.

SESSION 4:

PUBLIC AND PRIVATE GOVERNANCE SYSTEMS

4.3 Collective action for diverse agricultural landscapes – new approaches for agri-environmental contracts

Convenors:

Bettina Matzdorf, Leibniz Centre for Agricultural Landscape Research (ZALF), Germany

Katrin Prager, University of Aberdeen, United Kingdom

Francis Turkelboom, Research Institute Nature and Forest (INBO), Belgium

A diverse and resilient agricultural landscape requires a variety of environmental friendly land uses. An important approach to promote appropriate land use is the use of financial incentive instruments such as agri-environmental measures. These are designed to influence the behaviour of farmers and other land users in a targeted manner. Currently, separate contracts with individual farmers predominate.. Active management of entire landscapes is thus often not effectively possible, although this is essential for many environmental goals. New approaches and innovative contract design are therefore needed to achieve the necessary effects at landscape scale. However, collaborative agri-environmental schemes to improve spatial coordination and targeting of agri-environmental measures need to be carefully designed to motivate farmers.

In this session we would like to present research results that investigate new forms of contract design supporting cooperative approaches, perhaps combined with result-oriented approaches. The focus will be on empirical results on the institutional setting for promoting cooperation at the landscape level and the impact of different contracts design features on the behaviour of actors. In this session, the research results will be discussed by practitioners, policy makers and researchers against the background of their relevance for the concrete design of financial incentive instruments.

Orals

Practitioners' perceptions from about collective and result-based agro-environmental contracts

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Collective and result-based agro-environmental contracts are often proposed as promising and effective alternatives for activity-based individual contracts. While the possible advantages and disadvantages are often discussed in research papers, there have been so far few evaluations of these contract approaches from practitioners' perspectives. In the framework of Horizon 2020 project Contracts2.0, practitioners were asked to share their opinions via a SWOT exercise during participatory workshops. The SWOT workshops took place between January 2020 and March 2020, and a total of 235 people from 9 participating European countries were involved. Recurring themes and subthemes were identified that appeared along the different SWOT reports.

On one hand, collective approaches were perceived to need trust and collaboration among farmers, as well as farmer motivation to uptake agri-environment-climate measures. At the same time, collective contract types were perceived to motivate, empower and increase engagement of the farming sector to conduct environmental and sustainable practices. These kinds of measures were related with agri-environmental outcomes that require large areas. Collective approaches were perceived to reduce the administrative burden on government level, but increased among farmers' management.

On the other hand, result-based contracts approaches were perceived as flexible in payments towards farmers, being able to customize the measures with farmer's management; but to do it effectively it is important to define long-term contract duration in order to be able to affect the landscape dynamics and impact the biodiversity and ecosystem services state. At the same time, result-based contracts could represent a financial risk for farmers. From the administrative and political perspective, result-based contracts have a suitable fit with the new CAP; however, this approach was perceived to have an increased administrative burden on government level.

Overall we found a high interest in these new contract approaches among farmers and stakeholders, indicating that there is a potential role for them in the future provision of environmental public goods from farming. A general challenge for agri-environmental contract development from practitioners' perspective is their time frame: On the one hand the importance of long term visions (+/- 10 years) and continuation taking into account landscape dynamics are stressed, on the other hand social dynamics (turnover of transhumance, political changes...) make such long term visions and continuation very difficult. Another general outcome of the SWOT analysis which can be used when developing innovative contracts is the suggestion to combine contract approaches. On the other hand, contract development becomes increasingly complex when combining different contract approaches.

Should agri-environmental schemes aim at coordinating farmers' pro-environmental practices? A review of the literature

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The James Hutton Institute, United Kingdom

Agri-Environmental Schemes (AESs) traditionally offer payments to individual farmers who voluntarily accept to adopt pro-environmental land management practices, independently of other farmers' land-management choices. Recent literature has thus focussed on the best way to achieve coordination of farmers' pro-environmental actions to provide landscape-level benefits. By re-viewing the economics, social and ecological literature assessing the performance of AESs, we question whether a move from independent individual contracts to schemes favouring coordinated action would actually induce more sustainable farming.

The complexity of AES evaluation and the newness of the attempts to promote coordination limit the number of studies available. Many of the works analysed discuss coordination issues qualitatively or present the results of economic experiments or economic and ecological models. Most studies focus on EU and other developed countries; however, the developing countries literature provides interesting indications.

AESs adopted at a scale larger than the single farm may deliver multiple environmental benefits, namely meadow bird protection; habitats for natural enemies; forest and biodiversity protection; and collaborative pest management. However, the evidence on the effectiveness of coordination strategies is mixed.

Producers' perception of being a 'good farmer' is still associated to conventional practices. Farmers highly value independence, prefer to avoid the 'reliant cooperation' promoted by conditional payments, and see collective payments negatively because they can favour free-riders. Another barrier is the lack of inter-peer communication on agri-environmental practices. Facilitating institutions and advisory services may help build trust and reduce transaction costs. However, this re-quires long-term practice, as the successful Dutch environmental cooperatives shows, and is not replicable everywhere.

The strategies for achieving farmer coordination are diverse, including regulatory interventions; the creation of facilitating institutions; nudging; and economic incentives such as agglomeration bonusses or minimum participation rules. In general, farmers prefer simple, local-based efforts to complex, centrally defined actions. Interventions should be tailored to local farming systems to avoid negative impacts at local level. Facilitating institutions and the involvement of specific per-sons trusted by local stakeholders may enable successful AES negotiation and coordinated action.

This review provides useful indications for EU and national policymakers interested in promoting the coordinated uptake of AESs. Complementing economic incentives with the creation of facilitating institutions, nudges (e.g. provision of information on social norms) or labels seem a promising strategy. Discriminatory payments based on group-level bids may help achieve cost-effectiveness and prevent crowding-out.

In general, farmers prefer 'handshake' approaches and small-scale, tailored practices to top-down menus of interventions. It is thus important to facilitate information exchange and lower transaction costs to favour coordinated uptake.

Further research is needed to assess the impact of existing (or potential) AES designs. In particular, there is a lack of field experiments implemented among farmers in developed countries. This could be a feasible alternative to costly and time-demanding randomised control trials.

Learning about collective agri-environmental contracts from co-designed public goods games with farmers in Germany

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In the "Dutch model" of agri-environmental schemes, farmers exclusively receive support under group contracts. Approximately 40 regionally organized environmental farmer cooperatives are currently active in the Netherlands. Major goals are to achieve better environmental outcomes at landscape scales and to lower administrative costs compared to individual support schemes. In spite of great interest in this model from other member states, little is known about factors influencing farmers' willingness to cooperate. We use public goods games to study farmers' willingness to cooperate in Germany. In a workshop with stakeholders, four treatments were co-designed, addressing the role of (1) heterogeneous endowments, (2) leading-by-example, (3) social norms, and (4) pinpointing the socially optimal solution. Initial results from a sample of approximately 350 farmers indicate that contributions in the game exceed those typically found in laboratory studies. In addition to treatment effects, our presentation will also discuss expert predictions of the experiment.

Promoting farmer cooperation at the landscape scale: Institutional trade-offs in agri-environment schemes

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Adopting a landscape-scale approach to agri-environment schemes (AES) is seen as a promising way to increase the effectiveness of conservation measures. The Countryside Stewardship Facilitation Fund (CSFF) is dedicated to supporting landscape-scale implementation of AES in England, by establishing farmer groups. CSFF provides funding for facilitators to develop cooperation amongst a new or existing group of land managers and agree the agri-environmental management priorities that they plan to take forward across their holdings. Since 2015, over 130 groups have been established. With this extent of 'group working', what is the progress towards implementation of landscape-scale AES?

This paper unpacks the common assumption in policy and academic literature, that landscape-scale AES and farmer cooperation are synergistic. However, farmers cooperate in different ways and for different purposes, with agri-environmental collaboration representing a different, more unique, case in relation to cooperation. This paper argues that farmers' openness to engage in agri-environmental cooperation cannot be overlaid onto pre-existing examples of cooperative farming relations, nor should farmers' general willingness to cooperate be conflated with collaboration under the demands and constraints of a landscape-scale AES.

Based on data from semi-structured interviews with farmers and facilitators from 6 groups in Cumbria and East Anglia, we found a varied understanding of what the group and its purpose is, differing levels of group cohesion, and limited evidence of farmers undertaking collaborative agri-environmental activities. In areas without a prior history of farmers working together, the CSFF helped farmers to get to know each other, start building trust and explore members' interest in environmental and biodiversity objectives. In areas with pre-existing groups, the CSFF made it possible to expand the group's reach and members' knowledge, trigger interest and even 'friendly competition' around achieving farm biodiversity outcomes. We conclude that the CSFF struggled to create functioning, self-sustaining groups of farmers collaborating on agri-environmental management, but it supported steps to increase the capacity of individuals (and in some cases groups) to deliver agri-environmental outcomes. A state-funded scheme is limited by inherent trade-offs between achieving social outcomes such as farmer cooperation and the environmental outcomes associated with landscape-scale management.

Social networks of regional governance structures in the Dutch agri-environmental scheme

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Keywords: Collaborative governance, agri-environmental programmes, Social Network Analysis, Net Map tool

In this study, we explore the network structure of two farmer organisations, called farmer collectives, in the context of the national Dutch agri-environmental scheme. To participate in this scheme, it is now mandatory for farmers to be member in one out of 40 farmer collectives. They contract individual farmers and coordinate environmental measures so that a collective contract with regional authorities on the landscape scale can be met. Since the farmer collectives have a high flexibility to organise themselves and have different stages of experience as an organisation, looking into the network structure of involved actors can provide useful insights into their inner organization. This is important, because to date, only little is known about the individual pathways of the farmer collectives to carry out the scheme successfully.

To address this knowledge gap, we use Social Network Analysis (SNA) to explore the pathways of two farmer collectives. Therefore we chose two contrasting examples, which differ in their size and in their experience. While one farmer collective was top-down initiated and has been founded only 6 years ago, the other was founded bottom-up and already exists for 17 years. With SNA, we take stock of all relevant actors in the networks and also analyse how they formally and informally interact with each other. Data is collected by applying a participatory interview technique, the Net-Map tool. By this, we are able to directly involve the actors in reflecting upon their roles and influences on decision-making.

Our results show how both farmer collectives established successful yet different ways to carry out the scheme. For both examples we show the specifics in regard to the types of involved actors, their formal and informal linkages, their motivations for being involved, their influence on decision making and their obtained benefits. In the discussion we highlight on the differences between the two cases as a possible consequence of their contrasting features and development pathways. In particular, we discuss which evolved structures offer an advantage in terms of promoting social capital.

Innovative ways for environmental friendly agricultural land use – Diverse forms of collective organization of joint land ownership and its contract design

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We are presenting an overview of a diversity of new forms of collective land ownership, that do currently experience a growth in Europe and in Germany. These forms of collective land ownership represent joint and community-supported land governance arrangements.

The institutional shift of private (individual) to collective property rights to land has long been asserted as a way of improving incentives to use land in a more societally desirable and sustainable way (Bromley and Hodge, 1990). We will show this unique development for Germany with a large diversity of numerous legal forms and a range of 1–68 partner farms each. We investigate key characteristics of these organizational forms, which could potentially lead to more sustainable and resilient agriculture systems. Although not being agri-environmental measures in the CAP context, these organizations offer and experiment with new forms of contract design among supporters, land owners and tenants. Common to all is to a large part their not-for-profit orientation and their self-initiated ecological and often also social value added (Bahner, 2015).

Each individual legal form of governing such community-supported organization allows for different styles and formal arrangements of environmental friendly agricultural land use. With a scoping study conducted in 2020, we discovered 56 organizations and propose a typology to systematize them.

We could show promising opportunities that environmentally friendly land use can be reached with these new forms of collective land ownership, upon the conditions set (Theesfeld and Curtiss, forthcoming 2021). Promising in this regard means, there is a contract design that gives a good indication about the shift of the agricultural production towards environmental friendly land use by certain conditions farmers need to agree in exchange for receiving the option to lease land plots from or to access land through partnership with these community-supported organizations that acts as the steward.

We will answer the core question on how to secure long-term stability of these sustainability objectives with the help of two purposive selected cases which represent expansive influential organizational types: a foundation and a registered cooperative. While the goals of a foundation are permanently anchored by the law, in the case of a cooperative they are subject to the amendable statutes. Thus, a cooperative has to ensure enforceability of the conditions on land use by defining more specifically each individual rental contract with the farmers managing individually or in partnership the leased land. We will exemplify how partner farms, who are supported by such new organizations of land ownership through long-term rental relationship and rental rates often below market rates, have to follow various ecological guidelines, ranging from broad aims of environmental friendly farming to directly specifying production procedures.

References:

Bahner, T. (2015). Bürger investieren. Ökologie & Landbau, 01/09/15, 2015.

Bromley, D., Hodge, I. (1990). Private Property Rights and Presumptive Policy Entitlements: Reconsidering the Premises of Rural Policy. European Review of Agricultural Economics 17(2): 197–214.

Theesfeld, I., Curtiss, I. (forthcoming 2021). New Types of Land Ownership to Sustain Life on Land. In: Beckmann, V. ed. Transitioning to Life on Land. Basel, Switzerland: MDPI.

Poster

Contribution of social cohesion in water conservation: a case of Iranian farmers

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While water is an important factor in human activities, including agriculture, water scarcity is a growing problem in many regions of the world, including Iran, resulting in food insecurity and socio-economic losses to farmers. Against this background, the question emerges how we can help farmers to adapt to the effects of water scarcity by adopting appropriate measures. Rural households in developing countries adapt individually and collectively to the risks of water scarcity. Research shows that existence of social cohesion is critical to resilience and strengthening adaptation to environmental stresses including water scarcity. The concept of social cohesion emphasizes several factors that are not new but are often overlooked in the context of water conservation. Social cohesion defined by the level of (1) resilient social relations, (2) Connectedness, and (3) common good. In this study we focus on two first dimension. Social relations including horizontal relationships of individuals, and comprises intact social networks, trust in people and acceptance of diversity. However, Connectedness emphasizes the vertical relations between individuals and institutions, and consists of identification, trust in institutions and a perception of fairness. In particular, we examine effects of social cohesion components including trust in people (public trust), formal and informal networks and network size from first dimension and trust in water associations and trust in government organizations from second on water conservation behavior. In addition, we added subjective norms as a predictor of the implementation of water conservation behaviors among farmers in Bushehr, southern Iran. A random face-to-face survey with 180 samples was performed in Bushehr, then structural equation modeling was performed using AMOS software to identify the components affecting water conservation behavior. The reliability and convergent validity of constructs using confirmatory factor analysis were confirmed by meeting the criteria above 0.7 and 0.5 for the two indices of CR and AVE. The structural model has a good fit (relative chi square= 2.004, CFI= 0.984, IFI= 0.904, RMSEA= 0.075). The results showed that the informal network between farmers ($\beta = 0.82$), subjective norm ($\beta = 0.22$) and network size ($\beta = 0.21$) were predictors of water conservation behavior such as the cultivate of drought-resistant crops. Informal networks refer to farmers 'relationships with neighboring farmers and friends, and the subjective norm refers to the expectations of friends, family, and other important people for farmers' regarding water conservation. Accordingly, networks communications from social relations is a critical element contributing to adoption of water conservation behaviors. In whole, informal network, subjective norms and networks size predict 36% of changes in the acceptance of water conservation behaviors. Thus, bringing together farmers to enhance their degree of connectedness is recommended as one measure to teach on and foster water conservation. The findings can help design policies based on collective activities to improve and implement adaptation and water conservation policies in Iran, as well as improving existing knowledge.

Outcome-based assessment of the payment for mountain agriculture: a community-based approach to countering land abandonment in Japan

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Agricultural land accounts for 37% of the world's terrestrial area, and its multiple functions are of great importance for sustainable land use and management. To ensure that multifunctionality, payment for ecosystem services (PES) schemes have been developed for heterogeneous agrosystems. However, the effects of the schemes have not been fully measured because, in most cases, they have been implemented as action-oriented programs rather than outcome-based payments. This study examines the effect of a community-based PES (CB-PES) program on the prevention of farmland abandonment to assess the agricultural outcomes of PES implementation in hilly and mountainous areas in Japan. We interviewed farmers in enrolled communities, mapped the distribution of enrolled plots, and analyzed agricultural census data on the socioeconomic characteristics and farmland management conditions of 12,261 farmers in 960 agricultural communities in a typical hilly and mountainous area of Noto Peninsula in northern Japan. The results confirm that direct payments are effective in enhancing community management in these areas and in preventing additional farmland abandonment. In addition, we found that several socioeconomic and environmental factors at both the community and farmer levels—including geographical conditions, collective management activities, absence of successors, farm scale, and off-farm income dependency—simultaneously affected the farmland abandonment process. Specifically, collective practices within and between communities is a significant factor in preventing farmland abandonment more than collaboration with outsiders. Considering the depopulation and aging of rural communities throughout Japan, intercommunity enrollment could improve the effectiveness of CB-PES by upscaling the current payment scheme to maintain community functions.

Selling the system: Engaging agriculture in multi-scalar scale environmental mitigation

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Keywords: Agri-environmentalism, social-ecological systems, landscape scale, ecosystem services

Agriculture is a promising site for environmental mitigation interventions, but this potential is fraught because, in many jurisdictions each farm is independently owned and managed, limiting its potential for environmental mitigation to the farm scale which is frequently only in the tens or at most hundreds of hectares. Furthermore, the limitations on agriculture's potential for environmental mitigation are magnified by the business nature of the farms, where management decisions are primarily focused on the welfare of the farmers and their dependents, minimising the farms' productive output in terms of ecosystem services provision and directing it toward the farmers' livelihood. At the same time, contemporary neoliberalism demands continually increasing productive output while reducing the economic value of the farms' products. This cost-price squeeze consequently reduces any amount of residual environmental benefit by forcing the farm's entire land base into economic production, removing it even from incidental ecosystem services production.

While agriculture's economic output is widely understood to be embedded in the broader social economic system that supplies diverse resources to the larger community (Thomas et al., 2011), the farms' economic obligations to the farmers disembeds the land base from the wider social-ecological systems. This effect is especially evident in ecological systems and functions that are fundamentally place-dependent, such as water filtration, soil development and biodiversity enhancement. Consequently, a shift in environmental management focus from farm scale to geographic/ecosystems scales in terms of functional features such as watersheds rather than social-economic structures will provide significant synergistic benefits, increasing the environmental mitigation effects beyond what can be achieved by individual farm efforts alone.

This presentation examines the literature addressing the ecosystem services benefits to be had by increasing the scope of social-ecological systems management to the ecosystem scale, demonstrates the value of this approach through a case study of the West of the Hudson Watershed which provides drinking water for New York City without the aid of filtration plants, and closes by discussing contemporary barriers to the implementation of this kind of social-ecological systems management, alongside the implications of adoption of such scalar shifts.

SESSION 4:

PUBLIC AND PRIVATE GOVERNANCE SYSTEMS

4.4 Digital rural landscape monitoring in the context of the agricultural and environmental policies

Convenors:

Marijn van der Velde, European Commission – Joint Research Centre

Maria Luisa Paracchini, European Commission – Joint Research Centre

Raphael d'Andrimont, European Commission – Joint Research Centre

Philippe Loudjani, European Commission – Joint Research Centre

A twin digital and ecological transition is needed to achieve global sustainability ambitions. Transformations are needed in the way we produce food, preserve biodiversity and landscapes, and address climate change. Agricultural and environmental policies play a key role in preserving and restoring diversified agricultural landscapes and biodiversity while achieving climate neutrality by 2050.

The session focuses on the use of new imaging technologies, data capturing methods, and analytics (e.g. artificial intelligence) for policy design and implementation. In-situ and remote sensing based approaches underpinned by e.g. Galileo and Copernicus provide new mechanisms to foster sustainable land management (e.g. ensuring good agricultural practices) but also provide new tools to track progress towards targets by monitoring indicators for ecosystems, landscape organization, and biodiversity, combining insights from smartphones, farm sensors, street level cameras, and satellite sensors. These developments are feeding in policy development around the world, including the Common Agricultural Policy of the European Union.

Examples include the use of deep learning to extract information from pictures on land related aspects (land cover and use, landscape elements, phenology), ways how biodiversity monitoring (plants, insects) can be improved by citizen science apps, and how such in-situ data can inform Earth Observation at different scales for better managing e.g. green infrastructure. We warmly invite presentations and posters illustrating such digital and policy relevant applications from around the world.

Orals

Digital rural landscape monitoring in the context of the CAP and European Green Deal

Marijn van der Velde[1]; Maria Luisa Paracchini[2]; Raphael d'Andrimont[1]; Philippe Loudjani[1]

[1] European Commission – Joint Research Center; [2] European Commission, JRC

A twin digital and ecological transition is needed to achieve the ambitions of the European Green Deal. Transformations are needed in the way we produce food, preserve biodiversity and landscapes, and address climate change. European policies such as the Common Agricultural Policy (CAP) and the Habitat and Birds directives play a key role in preserving and restoring diversified agricultural landscapes and biodiversity while achieving climate neutrality by 2050.

This introductory talk focuses on new imaging technologies, data capturing methods, and analytics (e.g. artificial intelligence) for policy design and implementation. In-situ and remote sensing based approaches underpinned by e.g. Galileo and Copernicus provide new mechanisms to foster sustainable land management (e.g. ensuring good agricultural practices) but also provide tools to track progress towards targets by monitoring indicators for ecosystems, land use and land cover characterization (e.g. crop diversity), and biodiversity, combining insights from smartphones, farm sensors, street level cameras, and satellite sensors.

Implications of using remote sensing to support agri-environmental policy

Melf-Hinrich Ehlers; Robert Huber; Robert Finger

ETH Zürich, Switzerland

Current agricultural policy often fails to achieve its goals, as its instruments lack effectiveness, especially with respect to environmental goals. However, digital technologies are increasingly considered to make agricultural policy more effective and efficient. Among them, remote sensing using satellite imagery is exceptionally prominent to monitor compliance with agri-environmental policy measures and to generate data for policy evaluation and identifying policy needs. However, these opportunities for agricultural policy making are largely unused. There remains a lack of systematic analysis of the scope, limitations and prospects of satellited based remote sensing applications for agri-environmental policy. In particular, clarity is needed 1) on the extent remote sensing can be used to support agri-environmental policy and 2) on how the use of remote sensing changes selection of targets and designs of agri-environmental policy measures.

Addressing this gap, we provide a policy perspective on the use of satellite-based remote sensing of agri-environmental relations relevant to Europe. With help of a systematic review, we investigate the scope and limitations of remote sensing using satellites in supporting formation, implementation and evaluation of agri-environmental policy. The review provides foundations to derive implications for future policy targets and design of agri-environmental policy measures. Our approach is informed by economic and policy analysis concepts. It draws on a systematic analysis of policy documents, project reports and research articles on satellite-based remote sensing applications for agri-environmental policy.

Generally, the literature provides insights into technological options and policy demands arising with satellite-based remote sensing of agri-environmental issues. However, technological progress and adoption of imaging technologies to generate and use remotely sensed data to monitor agri-environmental policy varies substantially. Remote sensing of outcomes of policy measures would, for example, be particularly attractive for results-based policy measures that are increasingly demanded. Yet, satellite-based applications often remain limited to the monitoring of more or less close proxies of desired outcomes. Moreover, not all currently targeted impacts of farming and outcomes of agri-environmental policy measures can be remotely sensed. Remote sensing can also lack precision.

Our systematic analysis of reported applications of remote sensing to support agri-environmental policy shows 1) how satellite-based remote sensing can fit in existing (and future) agri-environmental policy instruments, and 2) how satellite-based remote sensing performs on different agri-environmental attributes with respect to policy indicators. Our analysis is restricted to agri-environmental policy but goes beyond subsidised agri-environmental measures. It uncovers that many publications derive policy needs from remotely sensed agri-environmental issues. However, our analysis goes further than this. It establishes where satellite-based remote sensing facilitates agri-environmental policy and where limits arise to support agri-environmental policy goals. In particular, satellite-based remote sensing can imply greater use of proxies for policy outcomes and compliance requirements that are unambiguously captured with remote sensing. Policy issues that can be monitored more efficiently with remote sensing could become preferential targets. Our findings suggest a need of further research on technological constraints of remote sensing applications for agri-environmental policy and a need to generate more evidence on effects on agri-environmental policy.

Pl@ntNet: Contribution of Pl@ntNet citizen science platform to rural biodiversity monitoring

Pierre Bonnet[1]; Alexis Joly[2]

[1] CIRAD, UMR AMAP; [2] Inria, Zenith team

Pl@ntNet is a citizen science platform developed more than ten years ago, whose initial objective was to facilitate the identification and the collection of a large volume of plant observations. The implementation of a virtuous loop facilitating the production of large volumes of visual biodiversity data, the development of increasingly high-performance recognition algorithms, and the mobilization of wide human networks, has led to major progress since its launch. By relying on a highly diversified network of expertise, involving researchers and engineers in computer science, ecology, citizens, local authorities and businesses, Pl@ntNet has enabled millions of people to participate in the monitoring of plant biodiversity at a very fine spatial and temporal scale, with up to several hundreds of thousands of observations daily produced. The image-based automated plant species identification service, used in Pl@ntNet, which relies on deep learning technologies since 2015, now allows fast, easy and reliable identification of a large number of plants. Widely known for its web platform and mobile applications, Pl@ntNet also contributes to the development of new forms of IT tools for the management of rural ecosystems, particularly in agricultural contexts. In the framework of this intervention, we propose to illustrate different case studies highlighting the diversity of contexts to which it contributes, via the expertise developed at the frontier between machine learning, participatory science and agro-ecology. These case studies, conducted at different geographical scales, will thus enable a better understanding of the ways in which Pl@ntNet partners use the services that the platform offers (via its ""my.plantnet"" API in particular), and to discuss the obstacles that need to be surpassed to strengthen the current mechanisms for preserving and restoring biodiversity.

References:

Affouard, A. et al. (2017). Pl@ntnet app in the era of deep learning. In ICLR: International Conference on Learning Representations.

Champ, J. et al. (2020). Instance segmentation for the fine detection of crop and weed plants by precision agricultural robots. Applications in plant sciences 8.7: e11373.

Joly, A. et al. (2016). A look inside the Pl@ntNet experience. Multimedia Systems 22.6: 751–766.

Computer vision for automated surveying of flowering plants

Neija Elvekjær; Laura Martinez-Sanchez; Maria Luisa Paracchini; Marijn van der Velde

European Commission – Joint Research Centre

Large scale biodiversity monitoring is essential for assessing biodiversity trends and the effect of human activities on ecosystems (IPBES). Evaluating current policies and the effectiveness of conservation efforts requires biodiversity data across larger scales. However, traditional surveying methods such as vegetation relevees are both costly and have limits in the scale that can be represented.

Recent technological developments have led to computer vision-based plant species identification tools. Applications such as Pl@ntNet allow users to determine the species of a plant from a picture (Affouard, 2017). Currently, these tools are mostly used in citizen science projects and by the general public. However, increasing accuracy of such methods present an opportunity of integrating automated species recognition into larger monitoring schemes – thus expanding their capacity and providing the essential knowledge for future conservation strategies.

The LUCAS Grassland module survey was carried out across the European Union (EU) in 2018, to investigate the state of grassland ecosystems throughout the EU (Sutcliffe, 2019). Several photos were collected from each site as part of the surveying protocol. This dataset provides us with the opportunity to evaluate if computer vision-based methods can achieve similar accuracies in recognition of individual plants compared to surveyors and expert botanists in a large-scale biodiversity monitoring scheme. These developments are also important in the context of automating ground-based evidence provision related to agri-environmental support schemes (e.g. flower strips, field margins).

With image recognition algorithms we produce proxies for abundance and diversity of flowering plants in European grasslands. We train a Mask-RCNN model (He, 2017) to detect and extract flowers in photos. We estimate flower density, and we use Pl@ntnet to identify the individual flowers and determine the presence of key species. By comparing our results with the surveyor data, we evaluate the accuracy of computer vision based monitoring of grasslands. We discuss the limitations of this methodology and provide recommendations on how to better integrate computer vision-based tools in large scale biodiversity monitoring of grassland flowering plants.

References:

Affouard, A., Goëau, H., Bonnet, P., Lombardo, J., Affouard, A., Goëau, H., Bonnet, P., Lombardo, J., Joly, A., Lombardo, J. and Joly, A. (2017). Pl@ntNet app in the era of deep learning.

He, K., Gkioxari, G., Dollár, P. and Girshick, R. (2017). Mask R-CNN. http://arxiv.org/abs/1703.06870

Sutcliffe, L. M. E., Schraml, A., Eiselt, B. and Oppermann, R. (2019). The LUCAS Grassland Module Pilot – qualitative monitoring of grassland in Europe. Palearctic Grasslands, 40, 27–31. https://edgg.org/sites/default/files/page/Sutcliffe_et_al_PG40_27_31.pdf

Satellite Image Time Series to detect and monitor agricultural large-scale land acquisitions (LSLAs): Senegal case study

Yasmine Ngadi[1]; Valentine Lebourgeois[2]; Mohamadou Dieye[3]; Jeremy Bourgoin[2]; Agnès Bégué[2]; Anne-Elisabeth Laques[4]

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Keywords: Land use mapping, MODIS NDVI, BFAST

Large scale land acquisitions (LSLAs), often referred as “land grabbing”, refer to the control of larger than locally-typical amounts of land by any physical/moral person for agricultural purposes, logging, tourism, conservation, mining, urban expansion or large infrastructural works. LSLAs are highly dynamic and complex land use systems, that are rapidly transforming ecosystems and societies in many low-income countries of the world, bringing on one hand sustainability challenges and, on the other hand, undermining the right of peoples to self-determination over natural resources. Consequently, monitoring of those large-scale agricultural expansions has appeared to be of paramount importance. International initiatives such as the Land Matrix relying on publicly available sources, have emerged in response to that need. However, because information on those acquisitions is opaque and scarce, systems allowing near real-time LSLAs detection, characterization and monitoring are needed (1).

With the increasing availability of global satellite data products, technological development in cloud computing, image and data mining analysis, remote sensing has appeared to be an interesting tool for the detection and characterization of such land use systems. Their repetitive coverage at short intervals and consistent image quality, combined with the free-of-cost availability of dense temporal series of satellite images, have explained their wide use in land use and land cover change detection. While LSLAs are not directly observable from remote sensing images (no one-to-one relation between land cover and functionality), they may be inferred from observable land cover, structural elements in the landscape and spatio-temporal characteristics at different scales (2).

This study deals with the detection of agricultural LSLAs (~80% of LSLAs) across Senegal. Its strong north-south gradient of rainfall, makes of Senegal an interesting study case for the detection of LSLAs under different environmental conditions. The approach relies on change detection algorithms (here BFAST, for Breaks For Additive Season and Trend (3)) applied on 2000–2020 MODIS Vegetation Index (NDVI) time series. Because the country knows an overall low but highly variable precipitation, rainfall-induced changes were accounted for separately in order to minimize their contribution. Results consist of date-of-change maps, that were subsequently clustered to extract areas potentially related to agricultural LSLAs. Those areas were characterized (e.g. year of change, spatial expansion) and evaluated against field data compiled by the Senegalese Institute of Agricultural Research (ISRA, with ~800 deals recorded) and high spatial resolution spatial imagery (Landsat/Sentinel-2).

References:

Bégué, A., Arvor, D., Lelong, C. Vintrou, E. and Simoes, M. (2015). Agricultural Systems Studies using Remote Sensing. https://doi.org/10.1201/b19355-66

Giger, M., Nolte, K., Anseeuw, W., Breu, T., Chamberlain, W., Messerli, P., ... and Haller, T. (2019). 13 Impacts of large-scale land acquisitions on common-pool resources. The Commons in a Glocal World: Global Connections and Local Responses, 257.

Verbesselt, J., Hyndman, R., Newnham, G. and Culvenor, D. (2010). Detecting trend and seasonal changes in satellite image time series. Remote sensing of Environment, 114(1), 106–115. https://doi.org/10.1016/j.rse.2009.08.014

Poster

Application of landscape capacity assessment to verify spatial development plans of protected rural landscapes

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The spatial development potential of communities in Poland is determined in a document called a study of conditions and directions of spatial development. Unfortunately, the current legislation does not take into account the need to analyse the changes that will occur in the landscape as a result of the implementation of spatial development plans. No tools are used in this area to objectively identify the most sensitive landscapes that should be protected. Therefore, the main goal of the research was to develop the method for assessing landscape capacity defined as ability of the landscape for absorption of changes in spatial structure without losing its visual quality. This method is based on the assessment of landscape features such as topography, height of buildings and vegetation, composition of buildings and vegetation and visibility from viewpoints and main roads. These are the criteria recognized as the most affective for ability to hide land use changes in the landscape. The application of this method is presented on the example of a case study of one of the villages in the Ślężański Landscape Park located in south-western Poland.

SESSION 5

FOOD SYSTEMS

SESSION 5:
FOOD SYSTEMS

5.1 Supply-chain governance as an enabler of landscape sustainability: Prospects for sector-wide changes

Convenors:

Mairon G. Bastos Lima, Stockholm Environment Institute (SEI), Sweden

Toby Gardner, Stockholm Environment Institute (SEI), Sweden

A handful of agricultural commodities drive most landscape transformations. Both conservation and food system sustainability crucially require addressing forest-risk commodities (e.g., soy, palm oil, cocoa). Trade in these commodities has witnessed an unprecedented level of attention, but piecemeal action by individual actors has fallen far short of the scale of sector-wide change needed. Recent improvements in satellite monitoring, supply chain transparency, and agricultural commodity traceability have offered new opportunities to identify barriers and assess progress. Yet, understanding how agri-food governance may capitalize on these developments remains a challenge.

This section will explore novel ways governance innovations can benefit from agricultural supply-chain data and transparency. It will focus particularly on demand-side measures by food-importing players that can support change towards more diverse and sustainable landscapes. Questions will include: What are the most actionable indicators for measuring commodity-driven deforestation? How can markets and consumer governments effectively promote landscape biodiversity in producer countries? Which instruments are the most promising to deliver change at scale? And what are some of the hard truths we need to face? We welcome macro analyses as well as in-depth case examinations for a discussion of how evidence-based supply-chain intelligence can support governance innovations.

Orals

Virtual trade of cropland area and its impact on the loss of species habitats worldwide

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Keywords: Agricultural trade, Telecoupling, Consumption-based accounting, Biodiversity-loss

Agricultural expansion and intensification are threatening biodiversity worldwide. However, the most severe impacts in recent years were reported in tropical and sub-tropical forest regions. Models that predict the future expansion of agricultural land indicate that this trend will continue.

Part of this increased need for agricultural land is due to a growth in domestic population (for example in Sub-saharan Africa), but in some countries, especially in South America and South-East Asia, agricultural expansion is mainly caused by an increased production for export. The production of such “cash-crops” is often done under an immense economic pressure (“cheap food paradigm”) and causes additional environmental impacts, such as an increased input of fertilizer and pesticides.

National and international assessments that are designed to track the impact of agriculture on biodiversity, often only record production side impacts. They are not designed to take consumption-side aspects, like for example an increased demand due to a shift in diets, into account. They thus fall short in guiding supply-chain interventions.

Here we show, how we used global trade data, provided by the Food and Agriculture Organisation of the United Nations (FAO,) and a national biodiversity indicator, the Species Habitat Index (SHI), to quantity consumption-based impacts of agricultural trade. We construct consumption-based indicators of global species habitat loss and identify potential impacts of supply and demand-side actions.

Our analyses show that especially countries in Western Europe, North America, and the Middle East create a large part of their biodiversity footprint outside their own country borders. Their imports in agricultural produce have, on average, a higher biodiversity footprint than their domestic production. By also taking into account how much these countries depend on imports, we can identify countries where consumption-based interventions might have the most effect on the protection of global biodiversity (Western Europe, Middle-East, Japan, China). All in all, the data shows the clear divide between countries that suffer from environmental degradation due to agricultural expansion, and countries that benefit from it.

Analyses like the one presented in this study are needed for future sustainability assessments. By taking into account both sides of agricultural trade and production, they can help guiding bi- and multi-lateral agreements on biodiversity protection.

Distinguishing deforestation drivers and deforestation risk for supply chain governance: options and challenges

Vivian Ribeiro; Toby Gardner; Michael Lathuillière

Stockholm Environment Institute (SEI), Sweden

Trase is an initiative focused on increasing transparency around the dynamics and sustainability of agricultural commodity supply chains. Central to this work is assessing the link between commodity production and trade and deforestation in two complementary ways – the deforestation associated with buyers of a given harvest (deforestation risk) and the deforestation associated with land-use conversion to a given commodity. To estimate the deforestation embedded in commodity supply chains we calculate the commodity deforestation risk, which is a measure of the exposure of buyers (traders or downstream buyers) to recent deforestation in their sourcing areas. This measure compares regions of commodity production (and harvest for export) each year with prior deforestation in the same regions. It is a measure of risk exposure as it is limited to jurisdictional sourcing. Deforestation risk is shared among buyers in proportion to how much they source from each region (as a proportion of total production). By contrast, commodity deforestation estimates how much land is deforested each year due to the expansion of a given commodity. The key difference in linking commodity production and deforestation in these two measures is the starting point and direction of how they are calculated. For deforestation risk, we start from the perspective of the commodity, which is then associated with deforestation that occurred in the past. By contrast, commodity deforestation starts from a measure of annual deforestation which is then classified according to the real or estimated subsequent conversion to commodity use. We rely on multiple assumptions and parameters to calculate both measures, but particularly the allocation periods – the time between the initial deforestation of an area of land and the production of the commodity for which the land was cleared. This is the period in which shared responsibility for deforestation can be most clearly linked to a buyer of that commodity. Estimating this period, therefore, has a significant impact on the levels of responsibility – and therefore action – that may be assumed by buyers exposed to risk, as well as one the significance with which the expansion of a commodity is seen as a deforestation driver. Here we measure how the variation in the allocation period can impact estimates of both deforestation risk and commodity deforestation for different commodities. In the case of soy, we calculated both deforestation measures using one, three, and five years of allocation period for each of the Amazon and Cerrado biomes in Brazil, 2011 as our year of interest. Preliminary results for soy in Amazon and Cerrado show a marked increase in both commodity deforestation and deforestation risk when using a longer allocation period (1y: 33424, 3y: 121928, and 5y: 182779 ha for deforestation and 1y: 104096, 3y: 78609, and 5y: 101306 ha for risk, respectively), clearly demonstrating that using a short allocation period reduces considerably the responsibility attributed to soy sector – in this case – with concomitant impacts on the stance of key stakeholders and design of interventions to curb deforestation.

Data availability and transparency are key to tackling EU-driven deforestation

Christopher West[1]; Margot Wood[2]; Fanny Gauttier[2]; Helen Bellfield[3]; Rosa Indenbaum[4]

[1] University of York, United Kingdom; [2] Conservation International; [3] Global Canopy, United Kingdom;
[4] Stockholm Environment Institute (SEI), Sweden

The world's forests are highly threatened, with an estimated 1.3 million square kilometres lost between 1990 and 2016. Many companies, financial institutions, and governments have made voluntary commitments to address deforestation embodied in their supply chains and financing. However, little to no progress has been made in reducing commodity-driven deforestation.

Considering the relative failure of voluntary commitments, consuming countries are taking a more proactive role in addressing their 'imported deforestation' but whilst most have yet to take concrete policy steps the European Union (EU) recently initiated a process to address deforestation in its supply chains, with proposed regulation forthcoming. Mandatory due diligence, in particular, is considered an important tool by a wide range of stakeholders (e.g. Bager et al., 2020). However, the effective implementation of such a regulation is predicated on the availability and quality of data – and associated institutional capacities – to identify and assess supply chain risks and to inform adequate mitigation measures. It is widely recognized, including by companies and the European Commission, that information gaps are a barrier for successful due diligence.

In this paper, we summarize how key parts of a due diligence regulation – risk identification and assessment – would require the existence of, and access to, specific data to be successfully implemented. We assess and review the current supporting data landscape, current data providers, and the constraints and limitations associated with these data. We provide a series of considerations and recommendations for overcoming these constraints:

To improve baseline data to support due diligence, we recommend prioritizing access to sub-national level data, improving remotely sensed commodity maps, and prioritizing government investment in public data platforms to increase access to, and integration of, data. To improve availability of country-of-origin information for downstream companies, we recommend future regulations place the burden of proof on the companies bringing the product to market. To balance flexibility and complexity, we recommend reviewing and regularly updating the commodities covered by the scope of a regulation based on the latest trends, projections, shifting production patterns, and shifting crop suitability in the face of climate change. We also provide commentary on sufficient data needs to allow for mitigation measures and to prevent negative externalities such as deforestation leakage and the disengagement from risky landscapes resulting in loss of smallholder livelihoods.

Finally, we recommend that additional measures be put in place to enable the implementation of the regulation, such as financial and technical support for developing countries and producers (in particular smallholders), which should also improve the success of the regulation and plus improve the availability and quality of data (e.g. Lambin et al., 2018).

We conclude that a due diligence regulation is achievable, though simultaneous investments in availability and quality of data are needed. A well designed and successfully enforced due diligence regulation could minimize deforestation in producer countries, improve transparency (Gardner et al., 2019) and traceability of agricultural supply chains, and pave the way for other major markets to initiate similar policies.

Multi-stakeholder research needs to tackle sustainability challenges in complex commodity chains: Application to Latin American soybean landscapes

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Keywords: Land use change, Life Cycle Assessment, Carbon footprint

Companies have made ambitious commitments to source agricultural commodities more sustainably in order to reduce detrimental landscape transformation. However, identifying effective solutions to meet these commitments is particularly challenging in complex globalised supply chains. Despite rapid advances in the availability of tools and methods that can convert complex data into useful information about environmental concerns, the implementation of this knowledge into decision-making is lagging behind (Guerry et al., 2015). There is an urgent need to find out how science and its application could be improved to accelerate progress towards more sustainable landscapes in producing countries (Gardner et al., 2019).

Here, we first explore how different stakeholders involved in shaping decision-making within globalised supply chains themselves see limitations in knowledge and barriers to progress in the specific context of ‘forest-risk’ commodities. We present results drawn from 22 interviews and focus group discussion data of companies, NGOs and data providers. Stakeholders mentioned a need for more research and guidance on how to identify and manage trade-offs and unintended consequences across different dimensions of sustainability and between different producing landscapes.

In response, the second part of this paper considers land use change and other environmental concerns in landscapes that neighbour those currently in focus due to their connection to deforestation (e.g. see Escobar et al., 2020). We use supply chain transparency data to link soy importing companies and countries to producing landscapes to derive spatially-explicit footprints of greenhouse gas emissions, biodiversity, soil erosion and water scarcity. This multi-indicator analyses, when applied to powerful sub-national supply chain models helps to identify trade-offs between different dimensions of sustainability within and between landscapes, and particularly those environmental concerns that need to be identified in order to provide solutions for the sustainable management of producing-country landscapes in the long-term.

References:

Escobar, N., Tizado, E. J., zu Ermgassen, E. K. H. J. et al. (2020). Spatially-explicit footprints of agricultural commodities: Mapping carbon emissions embodied in Brazil's soy exports. Global Environmental Change, 62, 102067.

Gardner, T. A., Benzie, M., Börner, J. et al. (2019). Transparency and sustainability in global commodity supply chains. World development, 121, 163–177.

Guerry, A. D., Polasky, S., Lubchenco, J. et al. (2015). Natural capital and ecosystem services informing decisions: From promise to practice. Proceedings of the National Academy of Sciences of the United States of America, 112(24), 7348–7355.

Landscape approaches are key to cleaning up commodity supply chains

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Commodities are moved around the world via complex supply chains. Despite a surge in sustainability commitments by companies, these supply chains continue to be mired by sustainability issues, including (illegal) deforestation, child labor, and forced labor. In this context, commodity traders are key actors in the supply chain for sustainable products. Commodity markets are strongly consolidated; a small number of trading companies handle product procurement in the country of origin and act as a bridge between producers and upstream actors.

The degree to which traders exert control over the origination of their sourcing is unquantified. From a supply chain management perspective, there is a key difference between the products sourced 'directly' from producers, vs 'indirectly' via other intermediaries (e.g. brokers, aggregators, cooperatives) in multi-tier supply chains in the country of production.

This presentation makes four contributions.

First, we provide a unified definition of 'direct' and 'indirect' sourcing in supply chains. Second, we merge a wide range of data on supply chains to report the prevalence of indirect sourcing across four contexts, responsible for a large share of global deforestation (Goldman et al., 2020). These are the export of live cattle from Brazil, soy from Latin America, oil palm from Indonesia, and cocoa from Côte d'Ivoire. Third, we use these data to make three observations. That traders' [i] direct sourcing from producers is the exception rather than the norm; [ii] trading companies have been slower to engage with and report on their indirect suppliers than their direct suppliers, and [iii] that indirect sourcing poses a threat to the effectiveness of sustainable sourcing commitments. Finally, we reflect on the prospects for achieving sustainable commodity sourcing, given the reality that large parts of the supply chain are and will continue to be indirectly sourced. We contend that landscape approaches are key to cleaning up commodity supply chains.

References:

Goldman, E. D., Weisse, M., Harris, N., Schneider, M. (2020). Estimating the Role of Seven Commodities in Agriculture-Linked Deforestation: Oil Palm, Soy, Cattle, Wood Fiber, Cocoa, Coffee, and Rubber. Glob. For. Watch. https://doi.org/10.46830/writn.na.00001

SESSION 5:
FOOD SYSTEMS

5.2 Smallholder Agriculture and Covid-19 Pandemic: Diversification for Resilience Building

Convenors:

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While COVID-19 has had a great impact globally, the pandemic has hit the livelihood capitals of smallholder farmers in the developing world particularly hard. This includes effects on smallholders' financial, market, social, human, and information and technology capitals. The multi-dimensional impacts of the pandemic have also interacted with climate stress, which is affecting natural capital, and magnified the economic, food and nutrition security impacts.

This session focuses on these inter-related impacts of COVID-19 on farm systems and related diversification strategies to strengthen resilience at food system level. Diversification at various levels, including diversification in farm systems, diversification of income and diversification of social and economic systems will be discussed as possible strategies in the frame of the "building-back better" initiative. The session introduces and discusses experiences from different countries and continents, including Ghana, Iran, Kenya, Nepal, Senegal, in order to identify potential pathways for future pandemic management and improved food security in crisis situations. Participants of various backgrounds are invited to join and contribute during discussions for a fruitful and enriching session. Contributions focusing on resilience and diversification strategies in Asia, Africa, Latin America and the Middle East are particularly welcome.

Orals

Resilient versus vulnerable households during the Covid-19 pandemic: What made a difference?

Muzna Alvi[1]; Prapti Barooah[1]; Elizabeth Bryan[2]; Shweta Gupta[1]; Claudia Ringler[2]

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The agriculture sector of LMICs has had a crucial buffer function during the Covid-19 crisis, absorbing millions of returnee migrants and providing food security for urban and rural populations that were hit by both income and mobility shocks. However, while there is agreement that the impacts of the crisis were larger in urban areas—particularly among those employed in the informal sector, including food services that largely collapsed early on in the crisis—rural households also suffered from dramatic income losses and were less likely to be reached by support measures.

Rural household members' level of exposure and sensitivity to the pandemic, their resilience capacities, their decision-making authority, and the set of response options that they had at their disposal and selected either increased or reduced their vulnerability to the adverse impacts from the pandemic. All of these dimensions of resilience are gendered and it is expected that, overall, women had fewer resilience capacities and response options to choose from. This paper examines the resilience capacities and response options of rural women and men in several African and South Asian countries based on a wave of 3–5 phone surveys of rural women and men. Key resilience elements that will be examined include the Water Supply, Sanitation and Hygiene (WASH) environment which helps fight the Covid-19 pandemic, the capacity to make decisions over spending and a diverse set of income sources, as well as access to transfers and other support provided by the government in response to the crisis. The effect of having access to these resilience elements will be assessed on a series of shorter- medium- and longer-term outcomes, including food security and dietary diversity, assets and children's education. The paper concludes with recommendations on resilience capacities and elements that need to be strengthened to reduce adverse effects on key human development outcomes.

Impact of COVID-19 on Climate Smart Agriculture pathways: Evidence from coastal Bangladesh

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Climate smart agriculture (CSA) strategies of smallholder farmers include intensification, diversification, alteration of farming practices, transformation to other enterprises, mitigation of greenhouse gases and temporary or permanent migration. The strategies increase aggregate production and income levels while building resilience to climatic stresses and reducing emissions. The CSA strategies in turn depends on livelihood 'capitals' namely physical, natural, human, social and financial as well as information and technology capitals of smallholder farmers. COVID-19 pandemic affected physical, human, social, financial as well as information and technology capitals and in turn causing shifts in CSA strategies. The paper reports a conceptual frame linking CSA strategies and COVID-19 pandemic and quantitative results of an ongoing study in coastal Bangladesh, which is one of the most climate vulnerable areas in the entire world. The study collects indicators of CSA and analyze how the CSA strategies differed in 2020 compared to 2019 to understand COVID-19 impacts. The CSA shifts are captured by indicators such as change in fertilizer, pesticide and irrigation use for intensification; modification in sowing or transplanting dates and change of varieties in case of alteration of practices, shift to new enterprises or reducing existing enterprises to enhance or reduce diversification, migration decision of farmers to diversify income sources. The study develops a composite indicator of these changes in CSA strategies and links them to indicators of human capital (labour availability in the household, education, skills, farm experience), physical capital (irrigation source, road access, ownership of land, machinery, mobile phone, type of house), financial capital (livestock units, farm and off farm income, credit, remittance), social capital (family cooperation, coordination with neighbouring farmers, social media use for farm information, membership in associations), natural capital (size of farm, water quality, presence of earthworms, fallows, use of non-chemical methods of pest control, organic fertilizer use) and information capital (media source, extension contacts, weather information) through quantitative regression models. The overall aim of the paper is to present a conceptual and methodological frame to understand the COVID-19 impact on CSA and present quantitative evidence on how the livelihood capitals influence these impacts.

COVID-19 lockdown & maize farmers in Nepal: How the crisis impacted agriculture production, incomes, and farmers' coping strategies

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International food policy research institute

The nationwide COVID-19 induced lockdown had severely impacted all sectors in Nepal. Agriculture, which forms the backbone of the economy providing employment to 65% population, faced challenges due to the restrictions and closure of input and output markets and international borders. We studied the immediate and gradual impacts of COVID-19 induced lockdown on access to agriculture markets, extension, and inputs; and impacts on income and livelihoods for 2300 maize-growing farmers in Dang district of Province 5 in midwestern Nepal through a two-round phone survey. Dang falls in the terai (plains) region where much of the population relies on agriculture as a livelihood source. Our sample comprised of maize-growing farmers from over 134 villages across four municipalities (Lamahi, Shantinagar, Rapti, and Dangisharan) in the district. The first round of the phone survey commenced in late May, two months after the lockdown in March. This round followed the harvest season of wheat and tried to capture the post-lockdown conditions in agriculture markets. The second round was carried out between late-August and early-September, coinciding with maize harvest. Around 71% of respondents in the study were women who reported to be agricultural decision-makers in the household; women were the primary agriculture decision-maker in 38% households.

Nepal announced a country-wide lockdown from March 24, 2020. While agriculture was among the first few sectors to be exempted from the lockdown to ensure constant food supply (MoALD, 2020), lack of clarity on the ground constrained farmers from being able to access markets to sell their harvest. Although there was a dedicated time window for farmers to access markets during the day, they continued to face a variety of issues, including lack of transport. Transportation bottlenecks not only limited farmers' access and movement to markets but also hindered a regular flow of inputs to them. This was followed by increased prices of vegetables and lowering prices of poultry in the study area as farmers could not sell their vegetable produce. The region also faced labor shortage, affecting wheat harvest operations (MoALD & WFP, 2020).

We observe prolonged effects of the lockdown on the incomes of the farmers, as 9% of our respondents reported zero income, even four months after the lockdown. Farmers continued facing issues with accessing agriculture extension and inputs, especially fertilizers, during the monsoon cropping season. The lockdown intensified the inequalities in agriculture as we find heterogeneous effects, with Dalits more likely to reduce their food consumption to cope up with the pandemic-induced hardships. Institutional support reached poorer households, however, by the second round, fewer households reported receiving such support. Farmers gradually resorted to looking for extra work and using their savings to cope up with the income losses. The income shocks have been the highest for migrant households as they struggle to support returned migrants and deal with income losses. The redressal of these negative impacts would require both short-term strategies to bring farmers to their pre-pandemic conditions, and long-term strategies that aim to build their resilience to minimize the impact of future shocks.

The impacts of COVID-19 shock on the well-being of smallholder farmers in Iran

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COVID-19 pandemic has caused unexpected and unprecedented shocks in agricultural chains and food supply around the world. Smallholder farmers are the backbone of food production in developing countries. They have already faced challenges such as water scarcity, climate change, and pests and diseases, which have become more vulnerable with the outbreak of the COVID-19 pandemic and restrictions. Due to the mutation of the virus and the lack of definitive treatment, adaptation to the disease is the only way to cope with it. Farmers' adaptive behaviors can reduce the impacts of the COVID-19 shock. Therefore, an assessment of adaptation strategies and the factors affecting them is required in order to minimize the shock impacts of COVID-19. The aim of this study is (1) to determine the factors affecting the adaptation behavior of farmers against COVID-19 shock and (2) to investigate the impacts of the adaptation strategies on the farmers' well-being. For this purpose, a cross-sectional study was conducted in July 2020 in Dashtestan County, in Bushehr province, in southern Iran. A total of 377 farmers were selected using the convenience sampling method and a structured questionnaire used. The results show that following health and safety measures at work , bringing to work home-cooked meals, maintaining good relations with the government and cooperating with them in preventing the further spread of the COVID-19, reducing the number of daily wage workers by increasing the use of family labor, as well as collaborating and sharing information and equipment with other farmers were the most important adaptation strategies by smallholder farmers to coping with the shock of the COVID-19 pandemic. The results of structural equation modeling show that components of government support, collective effectiveness, stress, and threat predicted 26% of the variance of farmers' adaptive behavior to COVID-19 shock, respectively. The results also show that the components of adaptation behavior and self-efficacy explained 32% of the variance of farmers' well-being. The most powerful component to predict farmers' adaptation behavior to the COVID-19 shock was government support. The results of this study not only provide more empirical evidence on adaptation behavior to COVID-19 to foster subjective well-being but also provides useful insights and information for policymakers and service providers to design and implement the health and social programs and policies needed in the agricultural sector. It is suggested that government policies and adaptation strategies be to support farmers and their collective effectiveness in coping with the COVID-19. While our results indicated that government support is the strongest predictor of adaptation so the government can play an important role in supporting farmers 'needs and improving farmers' adaptation to the shock by providing food subsidies, targeted subsidy supports, and forgiving late payments and facilities. Therefore the results provide solutions to how to reduce the risks to farmers' activities in the context of the COVID-19 pandemic.

Impact of COVID-19 on Agricultural terrace systems and community response in Central Peru

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Keywords: COVID-19, agricultural terraces, traditional ecological knowledge, community resilience

This presentation looks at the role of agricultural terraces in contributing to food security and sovereignty, crisis management, and community resilience in the face of the COVID-19 pandemic. This presentation draws from on-going online participatory research being carried out in the Nor-Yauyos-Cochas Landscape Reserve and the Potato Park in Peru. This research explores local community perspectives and adds to the limited body of literature on terraced landscapes in Peru and their environmental, dietary, economic, social, and cultural significance. This research has been carried out entirely during the COVID-19 pandemic and showcases innovative strategies for conducting participatory research online and in remote settings. Methods include semi-structured interviews, mapping, and photovoice. This research is being undertaken for Sampoorna Bhattacharya's Master of Science thesis for the Rural Planning and Development program at the University of Guelph and is supported by Asociacion ANDES and the International Potato Center (CIP).

The Andes region is home to over 60 native crop species, including Andean roots, tubers, and cereals, and is considered a biodiversity hotspot. Terraced agriculture is one of the most significant traditional practices in the Andes region and inherently embodies many agroecological and organic farm practices. The terraces are also a cultural symbol of the country, abundantly spread throughout the Peruvian Andes and deeply embodied within local folklore.

Disruption due to the COVID-19 pandemic over the last year has resulted in significant reverse out-migration in many parts of rural Peru. As youth and families return to communities, they are reconnecting with cultural practices and recognizing the fiscal, environmental, and emotional value of cultivating crops in the terraces. Entrepreneurial and community led initiatives act as an additional source of resilience and have allowed communities to secure food for the families, ensure healthy and nutritious diets, and diversify activities to new and niche markets (i.e., consumers in cities who can pay for organic products, eco-tourism and immersive experiences, crops unique to the Andes, delivery of processed products). This has significant implications for the preservation of traditional ecological knowledge, the management of agrobiodiversity, and strengthening community resilience. Preliminary results of this research indicate that terraces are vital structures with great capacity for encouraging resilience and risk management in the communities in which they are situated. Terraces offer a host of unique agricultural and ecosystem services, including climate control and water management but also cultural, historical, and spiritual value, and are protected through generationally transferred local and traditional knowledge. Communities in the high Andes are extremely resilient and have been adapting their practices for decades in response to a variety of stressors including imbalances in water supply, climate change, insufficient service provision, poor infrastructure, and now the impacts of COVID-19. This past year has resulted in disrupted harvesting and processing, closed roads, low prices for crops, and wastage left in the fields. This session will highlight diverse community responses and provide community-suggested best practices for continuing to improve resilience.

References:

Tittonell, P., Fernandez, M., El Mujtar, V. E., Preiss, P. V., Sarapura, S., Laborda, L., Mendonça, M. A., Alvarez, V. E., Fernandes, G. B., Petersen, P., Cardoso, I. M. (2021). Emerging responses to the COVID-19 crisis from family farming and the agroecology movement in Latin America – A rediscovery of food, farmers and collective action, Agricultural Systems 190. https://doi.org/10.1016/j.agsy.2021.103098

Poster

Smallholder Agriculture, Climate and Covid-19: An Overview Analysis of North Region of Brazil During 2020

Rodrigo Rudge Ramos Ribeiro

Getulio vargas Foundation (FGV)

This article examines the impacts and potential repercussions of the Sar-CoV-2 pandemic crisis in small-scale agriculture in northeaster region of Brazil during 2020. The methodology was based on qualitative data regarding smallholder agriculture using the regional context as a reference. Information was obtain through interviews with representatives of family farming and indicators published by national institutions. The study area is the Chapada Diamantina landscape region, located in the center of the Bahia state, in the north region of Brazil. For the climate aspect for the region, the year of 2020 with good volume of rain (like in the station of Lençóis that registered with 1.600mm) and well distributed, resulting in a not extreme year for the fire occurrence. The results regarding the Sar-CoV-2 indicate, against a backdrop of many restrictions and circulation controls, the local fairs of family farmers have had numerous negative effects, especially the suspension of local street markets. As a solution of the crisis, electronic commerce using whatsapp group list with the products and local producer contacts, even in small villages, was used to sell the products. As a lot of family's were eating at home, they start to look for organic products; what´s make increase the sales and direct connection with local rural producers. The conclusions of the analysis point out that the pandemic resulted in economic loss and new kind of actions to sell the farm products. This innovation was supported by regional universities and local institutes. Finnaly, the main transformation resulting from the pandemic in relation to smallholder agriculture is the increase in virtual commerce.

An integrated indicator-based assessment on COVID-19 related stress of agricultural households at different diversification levels: A study from Bangladesh

Mehrab Bakhtiar[1]; T.S Amjath-Babu[2]; Akhter Ahmed[1]; Shahidur Rashid[1]

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Though the COVID-19 posed similar set of constraints to multiple farm enterprises, the economic impact varied depend of perishability, storage availability, resilience of the market linkages, ability of farmer to respond to the constraints. In case of developing countries like Bangladesh, where integrated farming dominates, the varied impact on pandemic on field crops, vegetables and fruits, diary, flower and fish production and marketing requisites an integrated assessment. The study constructs multiple stress indicators and see how the indicators vary spatially and temporally among different kinds of integrated farms. The indicators developed are production stress indicator (production decline compared to previous season), output market stress indicator (limited buyers, transportation issues, price decline). Input market stress (fertilizer, seed, machinery, labour related stress) and income stress (income loss from multiple enterprises). Understanding these stress indicators and dynamics for farmers with different land sizes (small, medium, large) and ownership types (owned/rented land) and diversification levels (rice-fish, vegetable-fruits, vegetable-livestock, flowers, rice-vegetables-livestock etc.) are analyzed using a large data set collected through telephone surveys in Bangladesh by IFPRI. The ongoing work explores the stress indicators and their correlations with various co-factors and endowments at farm level. The work also analyzes whether women headed households were disproportionately affected by COVID-19 pandemic stress. The interplay of gender, enterprise diversity and resilience capacity of farmers and markets is evident in the results of the study will be presented here.

Does diversified income sources protect from secondary impacts of COVID-19 impact: Lessons from Nepal

T.S Amjath-Babu; Timothy J. Krupnik; Anne-Laurie Pilat

International Maize and Wheat Improvement Centre (CiMMYT)

The income sources of Nepalese farmers i.e. farm and off-farm income and remittances are impacted by COVID-19 pandemic in a differentiated manner due to varied impacts on crops (rice, wheat, maize vegetables) and diary enterprises, level of dependence on off farm income and remittances. The secondary impacts of these income changes on nutrient food consumption, education of children, health costs, migration decisions and women workloads at households are explored in the study. The study reports the results of survey among 1250 farmers in Terai and mountainous regions of Nepal. The work analyzes various secondary impacts of COVID stress and link them to farming types and livelihood resources. Among the survey respondents, 53% reported a loss of farm and off-farm income while, among those receiving remittance from abroad, 13% reported a a decrease of 25–50% in money remitted. The income shifts forced 34% of the farmers to reduce their expenditure The main reduction around 20% in consumption was reported for fruits, chicken and fish followed by eggs (-11%), vegetable (-10%), Milk (-6%), wheat-grains (-3%) and red-meat (-2%). 41% of farmers reported to be unable to pay school fee once schools open. Additionally, 43% indicated a reduce access to health services due to lack of money to spend on hospital fee (28%), fear of the virus (25%), hospital not functioning (11%) and limited transport facility (12%). The study develops secondary impacts of COVID on human development potential including indicators of food consumption, nutrition, education and health expenditure and link them to farm types identified using cluster analysis. The results highlight how the farm types with different levels of income diversification is linked to secondary impacts of COVID-19 stress.

SESSION 5:

FOOD SYSTEMS

5.4 Transition towards a sustainable food system

Convenors:

Björn Moller, Fraunhofer Institute for Systems and Innovation Research ISI, Germany

Ariane Voglhuber-Slavinsky, Fraunhofer Institute for Systems and Innovation Research ISI, Germany

Ewa Dönitz, Fraunhofer Institute for Systems and Innovation Research ISI, Germany

The Food sector is facing many challenges in the years to come. Mega trends like climate change will have big impacts on the productivity of agricultural land, a growing world population has to have access to save and nutritious food, and damages to ecosystems and biodiversity exercise negative impacts on agricultural production. In addition, trends in food and agriculture as well as changes in societal behaviour will shake up today's food sector, like consumer demands for alternative proteins and an increasing request for environmentally friendly produced food. The growing awareness around the need to transition towards sustainability is now evidenced in a number of policy initiatives around the world. Sustainable food production, ensuring food security, reducing food losses and waste and many other aspects are essential to reach a fair, healthy and environmentally friendly food system.

In this session, the impact of the diverse trends as well as possibilities and measures how to tackle these challenges along the whole food value chain will be presents and discussed. This includes new production methods like urban farming and aquaponics, innovative packaging like edible or biodegradable foils but also aspects like artificial intelligence in logistics and retail e.g. for predictive stock management. The question "Who is driving the actions for sustainability most?" will be discussed when possible pathways towards a more sustainable food sector in 2035 will be sketched.

Orals

Rethinking the food paradigm for integrated policies to build resilient agri-food systems: a methodological proposal combining community-led agri-food initiatives, agroecology, and the foodshed approach

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The new Common Agricultural Policy (CAP) of the European Union (EU) is currently under discussion and each Member State must decide which eco-schemes will be fostered. However, changes in the agricultural production must be accompanied with further changes in the food supply networks and shifts in consumption patterns, e.g. towards more regional and environmental- and socially-friendly diets. In other words, in order to exploit its potential, the CAP must be in line with other strategies of the EU (e.g. Farm to Fork, Biodiversity, and Climate Change Adaptation). However, the current situation is very far from achieving this situation. Currently rural landscapes are dominated by the influence of the conventional agricultural system, fostering the cultivation of monocrops, leading to a reduction of biodiversity, and the narrow framing of food as a “commodity”. This is very critical, since for most people, especially those living in urban areas, food has become the last element connecting them to the natural system.

In this context, agroecology has emerged – or “rescued” – as a suitable framework linking sustainable production and consumption. It fosters soil organic management improvement and crop diversification in agriculture, and enables citizen engagement in urban areas and livelihoods preservation of rural communities. A combination of different community-led agri-food initiatives (e.g. community-supported agriculture in food production and food hubs in distribution) becomes a promising instrument in order to increase the diversity of regional food production, shorten food-supply chains, or increase the awareness of people living in urban areas about the real impacts of the food system. Nevertheless, and in order to assess the feasibility of the implementation of agroecology and community-led agri-food initiatives, the spatial context has to be considered. Here, the foodshed becomes an appropriate and useful concept. A foodshed is understood as the geographical area between where food is produced and where that food is consumed.

In this contribution we show how community-led agri-food initiatives, and in particular a food hub in Berlin, can contribute to the transition to sustainable agri-food systems in urban areas and how the foodshed assessment (Vicente-Vicente et al., 2021), carried out with the Metropolitan Foodshed and Self-sufficiency Scenario (MFSS) model developed at ZALF (Zasada et al., 2019) can serve as the starting point for delimiting the spatial limits of a more sustainable and resilient agrif-food system and to considering the key role of urban-rural permeability. Agroecology is seen as a transverse axis of every assessment or initiative implemented, since a transition towards a sustainable food system must be carried out by scaling agroecology in the city region, meaning scaling out, scaling up and scaling deep (Nicol, 2020).

Community-supported agriculture: a viable innovation for sustainable food production?

Lukas Egli; Emily Ehrlich; Daria Ernst; Isabel Lindemann; Till Newiger-Dous; Judith Rüschhoff; Rebecca Thoma; Janine Voge; Emilia Wilhelm; Jörg Priess

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Keywords: Agroecology, community-supported agriculture, food loss, food waste

In the light of climate change, biodiversity loss and increasing demand for agricultural products, innovative approaches to simultaneously foster the sustainability, resilience and productivity of food systems are urgently needed (Pigford et al., 2018). Community-supported agriculture (CSA) is increasingly recognized as a promising concept to address these challenges (Haack et al., 2020). CSA directly links farmers and consumers and aims at sustainable regional production. Diversified and labor-intensive smallholder structures are fostered through the long-term commitment of CSA members sharing the risks related to farming (Paech et al., 2019). In return, members benefit from regional and transparent food production and supply, social participation, as well as practical and organizational skills related to CSA management. Therefore, CSA offers opportunities for holistic approaches providing synergies between ecological, economic and social aspects that could contribute to a transformation towards sustainable food systems. While CSA initiatives in Germany and elsewhere have increased rapidly in recent years, they still remain a niche. Consequently, scientific evidence on CSA performance regarding their contributions to a more sustainable food system remains scarce. In an ongoing project, we aim at addressing some of these knowledge gaps. In particular, we regularly assess yields, land use, as well as the drivers and dimensions of food losses and waste from producers to consumers in several CSA initiatives in Central Germany. Moreover, we use qualitative approaches to better understand the motivations and strategies of CSA farmers and members. In this talk we will present initial results of this project and draw first conclusions about the potential of CSA as a role model to simultaneously address multiple challenges of the food system.

References:

Haack, M., Engelhardt, H., Gascoigne, C., Schrode, A., Fienitz, M. and Meyer-Ohlendorf, L. (2020). Nischen des Ernährungssystems: Bewertung des Nachhaltigkeits- und Transformationspotenzials innovativer Nischen des Ernährungssystems in Deutschland (Dessau-Roßlau).

Paech, N., Rommel, M. and Sperling, C. (2019). Transformatives Größenmanagement – Wie lassen sich transformative Wirtschaftsformen wirtschaftlich und sozial stabilisieren? Transformative Unternehmen und die Wende in der Ernährungswirtschaft (Marburg: Metropolis Verlag) pp 129–58.

Pigford, A. A. E., Hickey, G. M. and Klerkx, L. (2018). Beyond agricultural innovation systems? Exploring an agricultural innovation ecosystems approach for niche design and development in sustainability transitions Agric. Syst. 164 116–21.

Developing sustainable business models for extensive cattle grazing systems that contribute to increase biodiversity and preserve cultural landscapes

Michaela Haack; Josephine Lauterbach; Anna Maria Häring

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Regionally and sustainably produced food is becoming increasingly important to both consumers and policy makers. Extensive cattle grazing systems linked to biodiverse grassland meet consumer demands for animal welfare and provide a number of ecosystem services. In the Federal State of Brandenburg, suckler cow husbandry is of particular importance due to the low yielding soils and the high proportion of grassland areas. Grazing of lower quality grassland with cattle can increase biodiversity and preserve the cultural landscape. Since the offspring of suckler cows is mostly sold to supra-regional fattening farms, the valorisation of grassland has yet to take place within the region. The reasons for the transfer of added value are manifold and range from a lack of regional structures for slaughtering, processing and logistics to a lack of market opportunities and low profit margins. In order to increase the regional added value of beef from pasture-based farming, business models need to be developed that distribute risks and benefits along the value chain, and correspond to consumers who are willing to contribute to sustainability efforts.

Using the approach of a living lab, the R+D project ""WertWeideVerbund"" aims to develop and test models of cooperation and coordination between stakeholders in the beef value chain in Brandenburg.

The present paper aims to illustrate the basic requirements and expectations of the different stakeholder groups along the value chain of beef for the development of regional value-based cooperation. Interviews and focus groups with farmers, slaughtering, processing, potential bulk purchasers (canteen kitchens, food retailers and butchers) and interest groups (farmers, landscape conservation) will be conducted by August 2021. Furthermore, a panel study with 1000 participants will identify consumers’ priorities for beef consumption.

Preliminary results show that, in addition to organisational-legal requirements, the definition of a common value basis is of particular importance for the development of cooperation. For this purpose, the stakeholders along the value chain defined minimum requirements as well as requirements for a premium quality standard for high animal welfare husbandry of cattle. The discussed quality requirements include aspects such as suckler cow husbandry, minimum grazing period (at least during the vegetation period), fattening (e.g. dry bedding options, outdoor access) and feeding (minimum share of farm-produced feed, GMO, origin of soya-based feed, etc.). With regard to animal welfare, other relevant criteria involve animal health (use of antibiotics), transport time and stress-free slaughtering. Furthermore, aspects such as transparency along the value chain (regionality), participation in a quality assurance system (e.g. Participatory Guarantee Systems, animal welfare officers) and fair remuneration of the producers are also considered as basic prerequisites in order to successfully establish a value-based cooperation

Starting in September 2021, potential business models, based on the discussed quality requirements, will be developed in cooperation with interested stakeholders and tested and evaluated in an iterative process.

Exploring consumer trust in community-supported agriculture in Germany

Felix Zoll; Rosemarie Siebert

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Due to increasing awareness for negative environmental impacts of intensive agricultural practices, the modern food sector is confronted with distrust by consumers. Consequently, many critical consumers try to reconnect with producers in alternative food provision models such as community-supported agriculture (CSA). CSA is often perceived as a more sustainable, localized mode of food production as it provides aspects such as transparent production or social interaction between consumers and producers. This enables consumers to observe where their food is coming from and therefore CSA is considered as suitable to build trust in food production. However, there are mainly qualitative studies that explore trust-building aspects in CSA, but it is unclear which factors have the strongest contribution. To determine the influence of different trust-building factors when compared to each other, we conducted a quantitative study among CSA consumers in Germany (n=780) and applied a structural equation model. The data reveals that personal trust in CSA and the associated farmer is generally high, even though social interactions on the farms play a rather subordinate role. In comparison to the personal trust level, institutional trust in organic certification is lower. We conclude that producers' willingness to open their farms and display their production methods already signals trustworthiness to CSA consumers. In order to restore agriculture's integrity a transition towards a value-based food system seems promising.

Poster

Bogotá Agricultural Landscapes: A case study of conservation opportunities and landscape management interfacing

Clara Lucia Matallana Tobón[1]; Fabio Lozano[2]; Diego José Rubiano[2]; Diana Cristina Moreno Vargas[3]; Silvana Espinosa[3]; Ana María Vargas[3]; Pedro Camargo[3]; Carolina Avella[3]

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Stakeholders in private institutions, public institutions, and communities in Colombia are concern about the management and transition processes to the sustainability of agricultural landscapes. The Study summarized the interface measurement between the landscape conservation index and the socio-economic viability index of agriculture landscapes in the Tunjuelo River sub-basin.

We collected data from 167 farms, 15 connectivity and conservation routes, and 81 structured producer surveys. A case study is illustrated and developed in three matrices of the rural landscape in the study area.

From information on the ecology, production mechanisms, and establishment dynamics of the native plant and bird species that survive in the study area, we designed the Landscape Management Tools for conservation and sustainable use.

Based on the results obtained, we identified and prioritized the farms with agricultural and livestock activities according to the punctuation in the scale of socio-economic viability. The farms with the highest scores were select for the establishment of conservation and productive reconversion actions.

The socio-economic issues of agricultural systems and their relationship with the landscape biodiversity sampling allowed the measurement and definition of the conservation opportunities.

We identified the landscape elements and their conservation value for each property.

Sixty-one farms comprising seven areas associated with aqueducts were in three conservation matrices, then we design the Landscape Management Tools in this area.

The results showed the integration of Landscape Management Tools for conservation with complementary tools for sustainable production to strengthen conservation and connectivity routes.

Finally, we proposed actions leading by stakeholders in the community that allowed the gradual recovery of the landscape and the encouragement of sustainable forms of production systems.

SESSION 6

CROSS SCALE SYSTEMS

SESSION 6:
CROSS SCALE SYSTEMS

6.1 Digital tools for site specific and diversified field arrangements to increase ecosystem services and biodiversity

Convenors:

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Ioanna Mouratiadou, Leibniz Centre for Agricultural Landscape Research (ZALF), Germany

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Agricultural landscapes are required to simultaneously fulfil various tasks: increase or stabilize crop production, maintain soil fertility, provide clean groundwater, sequester carbon, increase/promote biodiversity etc. Those goals are sometimes contradicting each other. One way to harmonize them is the approach of spatial diversification of land use systems by segregating fields according to site-specific requirements into smaller and more homogenous patches and conducting different spatially adapted management practices from point to patch to field scale. This session aims to address the following associated challenges:

- How to identify the potential of fields and landscapes for enhanced ecosystem service and biodiversity provision though diversified field arrangements,
- How to improve and implement novel management practices based on new field arrangements at the field and farm scale,
- How to solve the technical mechanization challenges related to smaller field arrangements and how to include field robotics for implementing diversified field arrangements.

Digital technologies, including sensing, monitoring, robotics as well as decision support tools are essential to tackle those challenges. The session will focus on the field scale, but will relate the field arrangements to the farm level as well as evaluate the effect of diversified field arrangements at the landscape scale.

The session is open to contributions from all interested participants across world regions. Newest findings from the projects DAKIS, patchCROP and others will provide insights to the challenges which diversified field arrangements face.

Orals

Digital tools and their requirements for practical use of Spot Farming concept

Jens Karl Wegener; Dieter von Hörsten; Daniel Herrmann

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Spot Farming is an experimental idea for the implementation of sustainable intensification of plant production. It is a „fitness program" to make plant production more resilient against climate change. Aim of Spot Farming is to lower the input while increasing yield and resistance against extreme weather events under strict consideration of social and environmental aspects.

Focus of Spot Farming are three different levels: single plant level, field level and landscape level. Within these different levels Spot Farming tries to optimize on four different core topics:

- Optimized allocation of plants to locations
- Optimized management concerning time and space
- More efficient use of agrochemicals
- Fortification of functional elements in landscapes

For the optimization of plants to site characteristics different digital information (e.g. soil type, yield, height profile, geografic orientation, shading by surrounding structures, potential of field erosion etc.) are combined together in order to identify spots with homogeneous characteristics to a large extent. In contrast to today´s side specific treatment of plants where only management measures are adopted Spot Farming focusses on different types of use of subareas first. Speaking in extreme words: high productive areas are used for increasing yield whereas low productive areas are used for increasing environmental or social benefits. In reality there are differentiated use cases between the extrema serving different aims in context with surrounding landscape.

An example for the optimized management of space on field level is triangular seeding. With this special seeding matrix yield can be kept or even raised while halving number of seeds per square meter at same time. Actual field experiments at Julius Kühn Institute are analysing in addition which characteristics of plant varieties are advantageous for triangular seeding, whether there are possible savings concerning the use of plant protection products or which positive impacts there are towards water efficiency and stress tolerance of cultivated plants.

The more efficient use of agrochemicals is aiming on management practices on plant specific fertilizing and plant protection as well as the establishment of technical solution for precise deposition in relation to temporal and local properties.

Fortification of functional elements is dealing with the existence and distribution of hedges, ditches, wildflower strips and fringe structures in context to surrounding landscape. These functional elements not only offering divers habitats, connecting these and support biodiversity, but they also protecting cultural plants against wind and soil erosion and drain the farm land in case of extreme weather conditions.

Today´s big machinery in agriculture is not applicable for Spot Farming, since Spot Farming happens on much smaller field sizes and amorphous field structures. For this reason autonomous field robots are of special interest, because they can offer also small scale solutions being economical feasible.

For realization of Spot Farming digital tools, e.g. for the identification of spots, for optimal allocation of plants to spots, for holistic interpretation of land use considering dissenting aims, are developed. Furthermore, digital instruments for the utilization of field robots for triangular seeding and single plant treatment.

DAKIS: Digital Agricultural Knowledge and Information System for a diversified landscape

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Keywords: Diversification, decision support tool, biodiversity, ecosystem services

With the endorsement of the Sustainable Development Goals (SDGs, UNEP 2017), society formulated important, yet complex and interrelated, requirements. The complexity and conflicts among different goals are particularly evident in the case of agricultural systems. Apart from satisfying increasing demand for food and bio-based raw materials, they have to make efficient use of resources, adjust to cater for climate change, provide ecosystem performance, minimise risks to health, observe ethical guidelines and form closer ties with value chain networks (DFG, 2014). Conflicting objectives often cannot be achieved in single fields or spots, but can be attained at a larger landscape scale. Our vision is that agricultural systems of the future will be spatially and functionally diversified while accommodating different, and potentially conflicting, environmental and socio-economic objectives in a landscape context.

To verify this hypothesis, we started the project "Digital Agricultural Knowledge and Information System" (DAKIS) in the frame of the call "Agricultural systems of the future" by the Federal Ministry of Education and Research in 2019. The aim of the project is to create a decision support system that allows designing multifunctional agricultural systems that simultaneously address the production of sufficient food, feed and fibre, the provision of ecosystem services, the protection and enhancement of biodiversity and the improvement of resource efficiency. The interdisciplinary study is pursued in a spatiotemporally nested approach, since no single scale fits to all approaches.

As a first step we analysed indicators on productivity, erosion, and biodiversity in two case study areas in Germany: Brandenburg and Bavaria. To unite and connect different scales, the concept of a „landscape window" was introduced as the overlapping point where smaller as well as bigger scales can be linked. Two landscape windows of 5km by 5km were established in each of the two regions. The analysis of spatial heterogeneity and segregation was conducted at field level within the landscape windows. Intensive monitoring of specific land use systems (e.g. arable, grassland, agroforestry) was conducted within and outside the landscape windows. Besides the potential for ecosystem service supply a survey on ecosystem service demand was conducted at a regional scale surrounding the landscape windows.

We successfully created an integrated concept of the decision support system to create a holistic and comprehensive decision-making approach that is relevant for farmers as well as for society. At field and farm scale, the menu of measures varies according to resource and machinery endowments, product profitability and socio-economic benefits of improving ecosystem services and biodiversity. In a landscape context, measures may vary even more dynamically according to the potential of the surrounding environment and ecosystem service demand. The DAKIS provides the possibility to concretely suggest improvement measures and at the same time provides a basis for discussion on how agricultural landscapes of the future should be developed.

References:

DFG (2014). J. f Kulturpflanzen, 66. 225–236.

UNEP (2017). SDG Index and Dashboards Report 2017. New York: SDSN.

Digitalizing farmer's multiple cropping activities for better understanding the intensification and diversification of agricultural land systems

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Keywords: Agricultural intensification, Multiple cropping system, Agricultural land systems, Remote sensing

Agricultural land systems operate at the intersection of human and natural systems, which mainly aim to provide food for society through using natural resources for farming. As a result, the distribution of natural resources as well as human's farming activities will shape the pattern and function of agricultural land systems at multiple spatial and temporal scales. Multi-cropping is a common practice of agricultural intensification, which enables multiple crops harvested on a given land parcel each year. Yet it is difficult to capture the spatial-temporal characteristics of multiple cropping and therefore to understand the consequences of multi-cropping toward the crop production function and ecosystem services provided by agricultural land systems. In this study, we apply remote sensing as a tool to digitalize farmer's multi-cropping activities to illustrate how multi-cropping system (MCS) exists across multiple spatial and temporal scales. Specifically, we aim to understand how different cropping and fallow decisions are adopted and how these human land use intensification strategies make agricultural land systems spatially diversified. Selecting a typical agricultural region (Poyang Lake Plain, Jiangxi Province, China), we propose four classes (from constant single-cropping to mixed cropping and further to constant double-cropping) for characterizing the MCSs and develop a spatially explicit MCSs map from 2001 to 2018 based on the remote sensing observation and a set of decision rules parameterized by agronomic principles and empirical evidence. We find that nearly 40% of cropland show mixed practices of multiple cropping (i.e. 3 crops in 2 years, and 5 crops in 3 years), which substantially enriched the spatial diversification of local agricultural land systems. Supposing the variation of biophysical conditions is limited as the case study area is not big, such a great disparity in MCS implies that local farmer's management decisions are largely diversified. As different farming strategies will result in different consequences on crop production and ecosystem services, our study further indicates the potential benefits on understanding the trade-offs and synergies for optimizing the spatially adapted practices in agricultural land systems.

References:

Waha, K., Dietrich, J. P., Portmann, F. T., Siebert, S., Thornton, P. K., Bondeau, A., Herrero, M. (2020). Multiple cropping systems of the world and the potential for increasing cropping intensity. Global Change Biol. 2020, 64, 10213.

Wu, W., Yu, Q., Peter, V. H., You, L., Yang, P., Tang, H. (2012). How could agricultural land systems contribute to raise food production under global change? J. Integr. Agric. 2014, 13, 1432–1442.

Zabel, F., Delzeit, R., Schneider, J. M., Seppelt, R., Mauser, W., Václavík, T. (2019). Global impacts of future cropland expansion and intensification on agricultural markets and biodiversity. Nat. Commun. 2019,10(1), 1–10.

Using remotely sensed land-use time series to identify current field arrangements linked to collective rainfed crop rotations in a Tunisian Mediterranean landscape

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The spatiotemporal distribution of crops at the landscape level results from famers' rules for allocating crops to fields. These rules drive both the annual distributions of crops among farmlands and the successions of crops over several years. Characterizing these rules and their determinants is a prerequisite for the development of acceptable alternative agricultural land use scenarios, including field arrangements. Most studies consider that these rules are defined at the field and farm levels. However, in some regions of the world, the crop rotations are collectively defined within adjacent fields belonging to different farms. To construct acceptable land-use scenarios in these regions, it is important to distinguish the respective impact of individual and collective rotations on the observed patterns of crop distribution. The use of remotely sensed land-use time series, combined with the use of a spatial statistical test, makes it possible to assess these respective impacts.

The studied case concerns a rainfed agricultural landscape (67.7 km²) located within the Cap Bon Peninsula in north-eastern Tunisia. The observed collective rotations address common constraints linked to the farmland fragmentation. The spatial distribution of crop successions was characterized from remotely sensed land use time series at field resolution. It was described through the sizes of clusters of adjacent fields having the same type of crop sequence in three successive years (2016, 2017 and 2018). We assumed that a cluster of fields with the same type of crop sequence was the result of a collective rotation if its size, expressed in number of fields, could not be explained by individual rules for locating crop sequence. The individual rules were related to the characteristics of the fields and their neighborhoods and were defined statistically. A spatial statistical test was developed to distinguish clusters resulting from individual rules from those resulting from collective rotations. The test was implemented for the two types of sequences most represented in the study area: biennial sequences (wheat sown alternately with legumes, spices or forage crops) and forage-dominant sequences.

The results show that collective rotations are mainly biennial sequences. These sequences are synchronized between adjacent fields based on the wheat crop: wheat is sown in all adjacent fields in the same year. Collective rotations are secondarily fodder-dominant sequences. Biennial and forage-dominant collective rotations have a significant impact on the distribution of crops in the landscape. They involve approximately 40% of the fields and their total area in the study area. These fields belong to clusters including two to 96 adjacent fields

The developed approach includes the possibility a graphical presentation of the results (GIS-based maps). It is a tool for considering the issue of collective rotations and constraints they address for the definition of sustainable diversified field arrangements at the landscape level.

Digitizing crop rotation system based on remote sensing technology for enhanced ecosystem services and biodiversity

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Keywords: Crop mapping, Google Earth Engine, Sustainable agriculture, Agricultural landscapes

Crop rotation is a consequence of human's farming activities and field arrangements, which leads to regular alteration of cropland surface and causes huge impacts on crop yield, soil fertility, and carbon sequestration. The spatial-temporal crop rotation information provides implications for understanding the prospective of management optimization for enhanced ecosystem services and biodiversity [1]. Yet current knowledge about it is mostly field-scale derived from field experiment, spatially explicit crop rotation data is seriously limited, hindering verifying the potential of crop rotation cross scales. In the presented case study, we aim to reconcile farmer's crop rotation decisions with crop signals captured by remotely-sensed images, and further provide a scheme for making crop rotation maps on complex agricultural landscapes. Focusing on Guangdong province in Southern China where the agricultural landscapes are largely fragmented, we propose a classification of crop rotation system consisting of three main distinctive systems (paddy, vegetable and orchard system) and seven subsystems (double rice, single rice, high-diversity vegetables, low-diversity vegetables, mixed vegetables and fruits, short-term orchard and long-term orchard), with reference to crop coverage and management locally. According to the classification, we produced 10-m crop rotation system maps in Guangdong in 2020, using remote sensing and the Google Earth Engine (GEE) cloud computing platform. Paddy system was first mapped combining Sentinel-1 and Sentinel-2 time series images with phenology-based algorithm. Then, vegetable and orchard system were separated through Random Forest classifier fed with optimized spectral, temporal, and textural features. Afterwards, we generated subsystems maps in view of their intrinsic characteristics on the basis of several indexes, among which phenological difference index can recognize temporal crop diversity. The pattern of crop rotation system varies significantly across Guangdong. Northern region with higher percentage of paddy system likely exhibits better soil quality and carbon sequestration ability, because of lower chemical inputs, tillage intensity, and paddy-upland rotation, whereas places with higher percentage of vegetable system are quite the reverse [2]. More spatially diversified landscapes, like central Huizhou County, have rather balanced crop rotation system composition, and more temporally diversified landscapes are composed of larger proportion of high-diversity vegetables. Our classification and mapping method suggests a digital tool to systematically monitor crop rotation and can be used for reference in other similar regions. The produced maps firstly provide detailed landscape pattern of crop rotation, which will clearly display spatial variation of field management with differing effects on the agricultural environment. Thus, diverse spatially adapted farming practices are viable. Moreover, crop rotation distribution data permits identifying the implications of crop rotation management from the field to landscape scale, combined with precise point or field scale crop rotation knowledge.

References:

[1] Barbieri, P., Pellerin, S., Seufert, V. et al. (2019). Changes in crop rotations would impact food production in an organically farmed world[J]. Nature Sustainability, 2019, 2(5): 378–385.

[2] Wang, X., Dou, Z., Shi, X. et al. (2021). Innovative management programme reduces environmental impacts in Chinese vegetable production[J]. Nat Food, 2021, 2, 47–53.

Using agroecosystem models to optimize spatial and temporal crop diversification in new field arrangements in heterogeneous landscapes

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Germany has a strong agricultural sector, with more than four million hectares dedicated to the production of major cereals. Despite the high productivity of these intensified systems, the practice has also led to a series of environmental concerns due to the pollution of water bodies resulting from nutrient leaching, increased N2O greenhouse gas emissions to the atmosphere and loss of biodiversity, raising the need to switch to multifunctional agricultural systems that better contribute to the provision and regulation of ecosystem services and additionally improve cropping systems resilience to the changing climate. Crop diversification offers multiple benefits to the agroecosystem on improving resource use efficiency, yield/yield stability, reducing pest incidence, and reduction of yield risk. Additionally, with the development of smaller agricultural robots in the future, it may be possible to redefine large field arrangements in the agricultural landscape with smaller field sizes (e.g. patches) adapted by considering physical and chemical spatial soil heterogeneities. Combining spatial and temporal crop diversification with new field arrangements considering field heterogeneities can be an alternative to improve resource use efficiency and the provision and regulation of ecosystem services. Agroecosystem models are a meaningful tool to explore crop and ecosystem dynamics, with the flexibility to explore a wide range of environments and management practices and they can be used as a complementary tool to experimentation of diversified field arrangements. Our aim is to apply and further develop dynamic agro-ecosystem models to explore how different spatial crop arrangements adapted to spatial soil heterogeneities affect the multifunctional response of agroecosystems and how they can contribute to a more sustainable and resilient agriculture. By applying agroecosystem models, we are aiming to explore the following questions: i) Can we improve resource use efficiency and ecosystem services within heterogeneous landscapes through new spatial arrangements of crops (spatio-temporal crop diversification)? ii) Can we use remote sensing or other sensing technologies, for model calibration, validation and improvement? iii) What are the possible implications of upscaling this practice from the landscape to regional scale? Here we present the results for the first stage of model application on exploring the impacts of spatial and temporal diversification on crop yields and resource use efficiency and their interaction with patch sizes. The expected outcomes of this research is to gain mechanistic insights into scale-dependent effects of crop diversification on agroecosystem performance and to demonstrate and evaluate the possibilities of new digital technologies combined with crop modelling to implement and manage diversified new field arrangements in a sustainable manner.

A novel LoRa based soil sensor network for real-time monitoring of soil moisture in the landscape laboratory patchCROP

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Keywords: Distributed sensor network, soil moisture, LoRa WAN

Sustainable agricultural systems of the future should be driven by an optimized use of resources, including water and soil. The landscape laboratory patchCROP aims at achieving this through diversified agricultural landscapes in space and time by reducing the field size and by introducing site-specific, diverse crop rotations that are adapted to heterogeneous soil conditions. It offers the opportunity to assess the functioning of innovative field technologies and monitoring networks combined with multiple scientific measurements of sustainability. As monitoring and automation play an increasingly important role in agriculture, a wide set of data is continuously collected and connected to an Internet Of Underground Things (IOUT) by using, for example Long-Range-Wide-Area Network (LoRa WAN).

The objective of this study was to investigate the real-time dynamics of soil water content at four different depths under differing soil texture and crop regimes using LoRa WAN. The experiment was conducted in newly designed field arrangements within a 70 ha large field whereas experimental units comprise 30 patches with a size of 0.5 ha each, following two different yield potential zones with varying soil conditions and site-specific five-year crop rotations.

Sensors were installed at 7 cm, 30 cm, 60 cm, and 90 cm depth in each patch to monitor the volumetric water content, soil temperature and soil electrical conductivity every 20 minutes. The user-friendly online visualization tool developed by the technology partner of patchCROP enables real-time monitoring of raw and processed data. Using LoRa WAN offers further advantages for field monitoring, such as low power consumption and high communication distances under adaptive data rate. Since the experimental set-up of patchCROP is implemented on-farm, routine field traffic and activities like reduced tillage or mechanical weed control are conducted constantly. This demands technical data collection solutions which do not disturb normal field traffic. All components of the underground soil sensor network are deployed wireless and are equipped with batteries with approximately one year lifetime. The LoRa network in patchCROP was additionally equipped with two weather stations and mobile sensors measuring soil moisture in the top soil.

By September 2021, the results will consist of a yearlong time series of water content, soil temperature and electrical conductivity data. The high temporal resolution provides an excellent basis for comprehending the behavior of soil moisture under different local conditions within the field. The high spatial resolution will enable the predication of drought stress for different crops in different growth stages at the specific sites. In this way, findings on the impact of differences in soil characteristics and resulting plant water stress on yield can be obtained. Furthermore, when coupled to climate data and vegetation cover, the measurements of soil moisture at different depths will allow new insights in the percolation behavior of soil water at the field scale. This large set of objectives shows how the use of LoRa technology can support to optimize crop production schemes and the management of resources as well as strengthen drought risk management at the agricultural landscape level.

Optimization of soil pH and crop yield based on a precision liming strategy guided by proximal soil sensing: Results of three on-farm field trails

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Soil acidity is a key factor for soil fertility as it simultaneously influences several yield-relevant soil properties and thus the productivity of agricultural soils. Besides natural pedogenetic processes, on agricultural land, soil acidification is amplified by the removal of the harvested biomass as well as by the application of acidifying fertilizers. Therefore, regular lime application on agricultural fields is inevitable to sustain soil quality and productivity. In Germany, the standard method for defining the lime requirement of a soil is the VDLUFA framework of the German Advisory Board for Agricultural Analytics. The VDLUFA method uses look-up tables that define the lime requirement according to soil texture, soil pH (CaCl2) and soil organic matter (SOM) content (LVLF et al., 2008). To determine these lime-relevant parameters, fields should be subdivided into subunits of 3 to 5 ha. Within a subunit, one mixed sample from 15 to 20 samples should form a composite sample for further reference lab analysis. However, a uniform lime requirement determined for subunits of 3 to 5 ha is often in contrast to the real soil variability observed in the field (Kling et al., 2019). In order to reflect the within-field soil variability, a few studies have demonstrated the use of high-resolution proximal soil sensing (PSS) data as tools for variable rate (VR) lime application (Bönecke et al., 2020; Pätzold et al., 2020). However, there is a lack of studies that evaluate the feasibility and benefit of VR methods in on-farm field trails. Therefore, the aim of this study is to compare the performance of site-specific liming based on PSS to optimize soil pH and crop yield with that of commonly applied standard liming methods in Germany. To determine the effect and practicability of the VRA method, a multi-site-multi-year experiment was conducted between 2017 and 2020 on three sites in Brandenburg, Germany. The trial compared the effects on soil pH and crop yield of three lime management practices: variable-rate liming based on PSS data (VR-PS), uniform liming rate based on the VDLUFA standard method (UR), and no liming (ZR). Soil texture and soil pH were assessed with two mobile sensor platforms: the Geophilus system measuring apparent electrical resistivity (ERa) and Gamma-radiation and the Veris pH Manager (Veris Technologies Inc., Salina, KS, USA). Crop yields were obtained from revenue recordings of combine harvesters. Lime prescription maps were generated with an adapted and stepless VDLUFA algorithm, allowing a continuous CaO recommendation (Bönecke et al., 2020). Based on these maps, management zones were delineated to perform lime spreading with state-of-the-art technique. In this study, we outline the conceptual framework of the VR liming approach and present first results from the on-farm field trials to verify the VR approach for an optimized soil acidity management as well as consider whether the higher economic revenue can compensate for added costs for mapping services and spreading technologies.

Poster

A Roadmap: Deep Learning Remote Sensing Analysis to Monitor and Predict the Spatiotemporal Dynamics of Agronomic Variables at a Landscape Scale

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Keywords: Deep Learning, Explainable Artificial Intelligence, Remote Sensing, Agricultural Landscape

Deep learning image analysis is a powerful predictive tool in agricultural science. While previous studies suggest the promising potential for a wide range of applications, most of them focus only on one or two variables and at a field scale or smaller. Therefore, there is a need to develop a study framework that can evaluate the comprehensive aspects of agricultural science at a landscape scale. In this poster presentation, we show a study framework we are currently developing. In particular, we consider it is inevitable to predict multiple domain specific agronomic variables, such as soil moisture and degradation, pH, vegetation index, leaf area index, canopy density, biodiversity status and their role in an agricultural landscape. Understanding how they affect crop yield, productivity, and stability can be of key interest for future agriculture systems. The complex and spatiotemporal characteristics of the variables could be captured by deep learning architectures. We investigate a combined system approach of convolutional and recurrent neural networks. Convolutional neural networks readily express spatial components, whereas recurrent neural networks aresuited to capture the temporal mechanics. Automatic feature learning is a benefit of using deep learning and of central importance. As a case study, we plan to analyze data acquired from some intensive field campaigns held in Germany (e.g., patchCROP and DAKIS projects) so as to test our approach. For that, in the first experiments, we develop a deep learning workflow to effectively use remote sensing data obtained at multiple spatial scales from centimeters to kilometers. Our model allows to derive agronomic variables from multi-spectral data as primary or secondary variables. Having that, in future experiments we quantitatively assess the effect of such variables on productivity or stability related variables such as crop yield. To improve trust in intrinsic black box deep learning models we propose to study the effect's underlying temporal and spatial configuration using explainable artificial intelligence techniques. We either offer explanations for the model's decisions using model agnostic approaches like LIME or interpretations using techniques like network dissection to illuminate the models internal feature maps and thus show the reasoning behind the model. We anticipate that estimating multiple agronomic variables across multiple spatial scales using remote sensing data can be a valuable source for decision making for agriculture and landscape planning.

Off-site impacts of water erosion – Identification of hotspots on arable land for small scaled land use conversions

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Keywords: Ecosystem services, erosion control, InVEST, precision agriculture

Introduction: The future common agricultural policy of Europe aims for a performance-based remuneration of agricultural measures and there impacts on ecosystem services (Europäische Kommission, 2011). Thus, there is urgent need to quantify these services precisely. Erosion control was identified as one pivotal ecosystem service strongly impacted by agricultural land use changes (Smith et al., 2017). Previously, on-site erosion was calculated based on the universal soil loss equation which quantifies soil relocation within areas. However, less information is available on both the amount of soil removed from a field and the final destination of eroded soil and relating impacts on surrounding ecosystems. Small-scaled, highly concentrated erosion such as rill and gully erosion can occur within arable fields. These hotspots are caused by specific relief characteristics, especially in the connecting lines between the lowest points of all cross profiles in the longitudinal direction of a terrain. Using precision agriculture (PA), a targeted conversion of land use in these hotspots can effectively reduce soil loss and related negative on-site and off-site effects while economic losses are minimized.

Objectives: This study aims to i) quantify the net soil export from delimited arable fields as a value for on-site soil degradation ii) quantify soil input into water bodies as an off-site impact value for aquatic ecosystems and iii) identify small scaled erosion hotspots within arable fields.

Material and Methods: The study area was a 5 km² landscape section in the tertiary hill country of Bavaria, Germany. The soil export was calculated based on one meter resolution relief data, soil and climate data and the current crop rotations based on administrative data (InVeKos). A map of waterbodies was included to the model to calculate the soil export into aquatic ecosystems. The input data were processed using the open source software InVEST SDR (The Natural Capital Project, version 3.9). The resulting raster data set was further processed by GIS tools to identify small scaled erosion hotspots for PA conservation measures.

Results und Discussion: Identified hotspots were visualized in a map with graduated colors reflecting the soil import to aquatic ecosystems in t ha-1 a-1. The results were confirmed by overlapping soil degradation visible on areal images. The map can be used by PA technologies to realize small scaled conversion measures. The resulting reduction of erosion quantified in t ha-1 a-1 is a suitable reference value for performance-based remunerations in accordance with current political objectives.

References:

Europäische Kommission (2011). Die Biodiversitätsstrategie der EU bis 2020. Luxemburg: Amt für Veröff. der Europ. Union.

Smith, A. C., Harrison, P. A., Pérez Soba, M., Archaux, F., Blicharska, M., Egoh, B. N. et al. (2017). How natural capital delivers ecosystem services: A typology derived from a systematic review. In Ecosystem Services 26.

The Natural Capital Project: InVEST. Sediment Delivery Ratio. http://releases.naturalcapitalproject.org/invest-userguide/latest/sdr.html#the-model. (last accessed 17/02/21)

Participatory Mapping of Demands for Ecosystem Services

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Agricultural landscapes can provide a wide range of public goods, ranging from aesthetic values such as landscape attractiveness to ecosystem services (ES) such as biodiversity, water regulation and carbon sequestration in soil and plants. The management of agricultural and forest land use systems greatly influence the provision or degradation of these public goods and ES. While the decisions of land use and management are taken by few people, the consequences of the management affect a broad public of different stakeholders in the landscape. The demand of various stakeholders on ES is not captured fully yet, while it is essential to plan the provisioning of ES at landscape scale. Thus, , our aim is to investigate the potential of participatory mapping exercises for integrating societal perceptions in land use decisions, and to analyse and minimize trade-offs between ES and actors in land management. The study forms part of the project “DAKIS – Digital Agricultural Knowledge Information Systems”, which follows the goal to optimize cropping systems by integrating ES in decision making processes of farmers and enhancing cooperation between farmers, consumers and society. We assessed the demands of different stakeholder groups for five ES in agricultural landscapes of Brandenburg, Germany. The five ES were yield, biodiversity, water availability, erosion control and carbon sequestration. An online-questionnaire with elements of participatory GIS (PGIS) was used to capture the perception of the current state of the landscape and demands of different stakeholder groups for ES. The software Maptionnaire was employed for the mapping exercise. In an interactive map, it allows participants to indicate areas and spots of interest, and relate these spatial data points to specific questions and attributes. After an introduction to the goal of the survey and to the topic of ecosystem services, participants were able to self-assign to different stakeholder categories. Consequently, the survey was structured by the five ecosystem services assessed. For each ES, participants had the possibility to map up to three areas, and answer questions related to their perceived current supply of the respective ES in the mapped area, and to state their demand. Preliminary findings suggest that the demand for ES exceeds the current perceived level of supply for all services, stated by participants from all stakeholder groups. The gap between perceived supply and state demand is lowest for yield, and highest for erosion control, followed by water availability. No significant differences for demands by stakeholder groups could be identified, dismissing the hypothesis of trade-offs between actors. Our study contributes to the integration of participatory elements in land use research, especially with respect to regulating ES, and allows for integrating potential trade-offs between both actors and ES.

Catchment topography and the distribution of electron donors for denitrification control the nitrate concentration in headwater streams and the denitrification hotspot of the Lake Hachiro watershed, Japan

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Objectives: Understanding catchment denitrification as a self-water purification process of soil functions is needed for sustainable agriculture and water resource usages. Topography and distribution of electron donors for denitrification may control catchment denitrification. Sulfur driven denitrification may also be a key site-specific NO3- removal process in sulfide-rich regions. We examined the linkages between topography and electron donors for denitrification on stream NO3- concentration in headwater catchments and tried to identify the potential denitrification hotspot in patches by a scale down monitoring based on the results of catchment scale monitoring in the Lake Hachiro watershed having marine sedimentary rock, Japan.

Method: In 35 headwater forest catchments (0.07–16.9 km2), we sampled stream water and analyzed water chemistry. Stream sediment was sampled for measurement of denitrification potential (DP), and water-extractable soil organic carbon (WESOC) and easily oxidizable sulfide (EOS) in soils and sediments, which can be considered the potential electron donors for denitrification. The topographical features of each catchment were calculated using a digital elevation model by GIS. In a scale down monitoring, we sampled two adjacent streambank soils in the catchment of relatively lower stream NO3– concentration and higher EOS content in riverbed sediment. Anaerobic incubation experiments using those streambank soils were conducted to evaluate variations of N solutes, N gases, and the bacterial flora. Two treatment solutions containing NO3– (N treatment), and NO3– and S2O32– (N+S treatment) were prepared.

Results and Discussion: Stream NO3- concentrations displayed large spatial variation among catchments, ranging from 0.06 to 0.52 mg N L–1, and were negatively correlated with topographic wetness index (TWI) ($P < 0.01$) and were positively correlated with catchment slope ($P < 0.01$), indicating NO3- concentrations decreased in wetter and gentle slope catchments. Sediment DP and the WESOC content in sediments were positively correlated with TWI, significantly. These results suggested denitrification was likely to occur in higher TWI catchments. EOS content in riverbed sediments also displayed large spatial variations and tended to correlate stream NO3- concentration negatively. Higher soil DP with higher EOS was detected in the stream bank subsoil. In the N+S treatment of the soil incubation, NO3– concentrations decreased by 98%, with increases in the SO42–, NO2–, NO, and N2O concentrations. Some denitrifying sulfur-oxidizing bacteria (Thiobacillus denitrificans and Sulfuricella denitrificans) were detected and the stoichiometric ratio of SO42– production and NO3– depletion rates indicated that denitrification using thiosulfate occurred even without S addition, indicating that inherent S served as an electron donor for denitrification. S addition was significantly decreased NO3– concentrations and increased NO2–, NO, and N2O concentrations, especially in some subsoils with higher sulfide contents. The same denitrifying sulfur-oxidizing bacteria found in the different streambank subsoils, suggesting these bacteria are widespread in sulfide-rich soil layers in the catchment.

Conclusion: We conclude that catchment topography and the distribution of electron donors in riverbed sediment can be important indicators to explain the spatial variation in in-stream NO3– concentration and sediment DP. EOS in riverbed sediments contain site-specific information about denitrification hotspot driven by sulfides.

Potential and challenges of the NatApp to improve biodiversity in agricultural landscapes

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Keywords: Biodiversity, digitisation, agriculture, application, nature conservation measures, CAP

Agricultural intensification and land-use change are seen as major drivers of the significant loss of biodiversity and the decline in traditional landscapes with their underlying functions. Since the 2000s, preservation and protection of biodiversity has become a crucial issue and measures such as the environmental protection measures implemented in the first and second pillar of the European Common Agricultural Policy (CAP) are evaluated as a promising approach to conserve and enhance biodiversity. Especially, small-scale field-integrated conservation sections have demonstrated high efficiency of biodiversity protection (Redwitz et al., 2019). Currently, several considerable obstacles against implementation of these nature protection measures in agriculture still exist. These include fear of sanctions and economic losses on the farmers` side and personnel-demanding and time-consuming procedures on the side of the administration (Long et al., 2016). In parallel, Long et al. (2016) suggest that agriculture is currently undergoing a fourth revolution, marked by the increasing use of information and communication technology in farming practices. Indeed, digital tools may represent a helpful tool for addressing the major challenges of facilitating natural protection measures for farmers while keeping productivity constant. Ideally, this would lead to a broader implementation of nature conservation measures and simplify as well as enhance the transparency of the underlying processes (Bacco et al., 2019). To facilitate the complex application and enable site-specific CAP implementation for farmers as well as administration officers, the digital App “NaturschutzAPP (NatAPP)” was conceptualized. The NatAPP tool, currently in the stage of a prototype, is adaptable to ordinary digital devices of farmers, and suitable for Android as well as iOS system softwares. For farm related information and geographical orientation, it uses already established and broadly used technologies like the digital field catalogue or professional Global Positioning System products. Via an information desk, farmers can choose the most appropriate conservation measure for their property and are guided step by step through the implementation and necessary documentation steps. Regularly interposed questions make sure farmers don´t forget important operations. After recording the conduct of measures, documentations are saved on a central server. From there, public authorities can control whether all regulations have been met by the farmers. Hereby, personal controls in the field become less necessary and the effort for the administration is reduced. Ideally, with the NatApp, participation of farmers in small-scale field integrated conservations sections can be fostered and potential existing barriers and obstacles for farmers as well as the administration diminished. In the current fourth period of the project „Länderübergreifende Umsetzungsstudie zur Anwendung der Naturschutz-App (NatApp) in der landwirtschaftlichen und Verwaltungspraxis“(NatApp 2.0) the applicability and effective facilities of NatAPP in use will be tested and evaluated on about 20 selected pilot farms in the four federal states Bavaria, Brandenburg, North-Rhine Westphalia and Thuringia. In the future, the NatApp is planned as an open source application and a voluntary offer for farmers in all federal states of Germany. Potential and challenges of NatApp will be discussed in this presentation.

Mapping spatial variability of surface soil organic matter composition with a hand-held FTIR spectrometer at field scale

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Soil organic matter (SOM) determines many physical and bio-chemical soil properties. Content and composition of SOM is spatially distributed especially within larger fields but its quantification is a challenge; for example, when trying to optimize between crop yield and environmental risks (leaching, erosion) by improved site-specific management of more homogenous patches within larger heterogeneous fields. SOM can be studied in the lab (mixed samples) and field (remote sensing) using Fourier Transform Infrared (FTIR) spectroscopy. However, for intermediate scales (e.g., patches) and soil surfaces covered by plants, approaches to characterize the spatially distributed SOM are limited. It is hypothesized that a hand-held FTIR is usable to analyze mixed soil samples (0–25cm) as well as the upper soil surface layer under field conditions (on-site), and that the on-site analysis offers a possibility to study the OM composition of soil surfaces covered by plants at an intermediate plot scale allowing to determine the spatial distribution of soil properties (wettability, nutrient storage) in an experimental field.

The objective is to test if hand-held and lab-based FTIR allow to spatially distinguish SOM composition of topsoil samples, and if SOM composition of surface soils determined on-site by a hand-held analysis can be representative for that of mixed samples from topsoil. FTIR spectroscopy is used to characterize OM composition in lab and on-site the patchCrop field experiment.

Both, hand-held und lab-based FTIR, were used to analyze air dried soil samples (0–25 cm). The hand-held FTIR was also used for an on-site analysis of SOM in the upper soil surface layer. The SOM composition was determined as the ratio between the band intensities of hydrophobic (C-H), and hydrophilic (C=O) groups (C-H/C=O ratio) in FTIR spectra as a measure for the potential wettability.

Compared to the lab-based spectra, the hand-held spectra of air dried mixed soil samples show a lower resolution and about 4 times lower C-H/C=O ratios which are even lower for the on-site hand-held spectra of the upper soil surface layer. Both hand-held and lab-based FTIR allow to detect variations in SOM composition: The lowest C-H/C=O ratios were found for the plots with maize and the highest for the plots with lupine. The lower resolution of the hand-held spectra can be explained by technical differences and for the on-site analysis by the higher soil water contents as compared to the air dried mixed samples. Although quantitatively different, the spatial patterns in OM composition are similar for data from hand-held and lab-based FTIR. The on-site analysis did not reflect any larger differences in the OM composition of the near-surface soil of plots with lupine and phacelia; while for the mixed topsoil samples, the lab and hand-held analysis indicated a larger spatial variability between these plots. FTIR (hand-held and lab-based) spectra are applicable to characterize spatial variability of the OM composition at the plot scale such as in the patchCrop field experiment. The mapping of near-surface SOM composition needs to be complemented by SOM depth-functions before the information can be used to improve a site-specific patch-crop management.

Estimating spatio-temporal C sequestration dynamics by combining an advanced robotic chamber system with IoT and remote sensing data: The CarboCrane experimental field

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Improved agricultural practices sequestering additional atmospheric C within the soil are considered as one of the potential solution for mitigating global climate change. However, agricultural used landscapes are complex and their capacity to sequester additional atmospheric C differs substantially in time and space. Hence, accurate and precise information on the complex spatio-temporal CO2 flux pattern and their drivers is needed to upscale and evaluate the effects/benefits of new agricultural practices aiming towards increasing soil organic carbon.

To date, different approaches are used to measure and quantify CO2 flux dynamics and derive the C sequestration of agricultural landscapes in an area (eddy covariance) or point manner (manual and automatic chamber systems). However, all these methods fail to some extend in either accounting for small scale spatial heterogeneity (e.g., eddy covariance and automatic chambers) or short-term temporal variability (e.g., manual chambers), nor do they alone enable an upscaling to represent the heterogeneous agricultural landscapes such as present within inter-alia the widespread hummocky ground moraine landscape of NE-Germany.

We developed a novel robotic chamber system and combined it with an IoT network and remote sensing approaches with the to detect small-scale spatial heterogeneity and short-term temporal variability of CO2 flux dynamics as well as crop and soil conditions for a full factorial experimental setup. The experimental field stretches over a range of three different soil types, and contains two N fertilization forms (2; mineral vs. organic) and two soil manipulation status, representing two different tillage practices. Here, we present the experimental setup and first results for measured CO2 flux dynamics and plant status (RVI, NDVI) for the 36 subplots directly following soil manipulation and N fertilization during summer 2020. Our results show distinct differences between the three measured soil types as well as a clear response of all three soil types to conducted soil manipulation, yielding in significantly lower NDVI and correspondingly ecosystem respiration (Reco) and net ecosystem exchange (NEE) for manipulated vs. non-manipulated subplots. No clear difference, however, was obtained in case of N fertilization.

Water and sediment retention function of agricultural landscapes in upland farming watershed in northeastern Japan

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Keywords: Soil erosion, SWAT, agricultural landscape

Introduction: Accelerated erosion in agricultural land degrades ecosystem services of the land and also aquatic ecosystems in the watershed. Agricultural activities alter soil permeability and vegetation which affect water flowing pathways and sediment retention capability of the land. However, such effects are different in a landscape due to the heterogeneous components of the landscape such as topography and soil [1]. To assess the sediment loss in such heterogeneous landscapes, mathematical modelling which can simulate water and sediment movement processes is known as an effective approach [2]. The objectives of this research are i) to apply Soil and Water Assessment Tool (SWAT), a process-based hydrological model, in Tokoro river watershed (TRW) in northeastern Japan, where intensive crop production took place in areas with various combination of flat and sloped lands, to understand spatial characteristics of surface runoff generation and soil erosion, and ii) to assess the mixed effect of agricultural activity, cropland topography and surface runoff generation on soil erosion in TRW.

Materials and Methods: Water and sediment movements in TRW were simulated in daily time step from 2012 to 2015 using SWAT. TRW was delineated into 17 sub-basins based on the topography and further divided into 764 HRUs which had homogenous combination of slope class, soil type, and land use in each sub-basin. From the calibrated SWAT, outputs were extracted as follows: 1) annual surface runoff in each sub-basin 2) gross sediment yield and erosion rate in each land use, and 3) erosion rate and ratio of sediment loss to surface runoff in each sub-basin. These outputs of sub-basins were visualized in maps and compared with the cropland area and the slope class distribution of croplands in each sub-basin.

Results and Discussions: Cropland which covered 19% of TRW was identified as the primary sediment source contributing to 69% of estimated gross sediment yield of the watershed. From the spatial variation of estimated erosion rate, sub-basins which have higher percentage of sloped croplands were identified to be critical erosion area with erosion rate of 53–65 t/km²/yr compared with average erosion rate of the whole watershed, 33 t/km²/yr. These sub-basins also showed higher ratio of sediment loss to surface runoff (0.39–0.42 g/L) than that of other agricultural sub-basins (0.20–0.27 g/L). It implies that sediment loss from landscapes which have more sloped croplands would sensitively fluctuate affected by the change of the frequency and intensity of surface runoff. Therefore increasing erosion resistance of sloped cropland in these sub-basins is likely to be effective for building a more resilient agricultural landscapes in TRW.

References:

[1] Guerra, C. A. et al. (2014). Mapping soil erosion prevention using an ecosystem service modeling framework for integrated land management and policy. Ecosystems, 17(5).

[2] Baartman, J. E. M. et al. (2020). What do models tell us about water and sediment connectivity? Geomorphology, 367, 107300.

SESSION 6:
CROSS SCALE SYSTEMS

6.2 Mixing crops, livestock and trees in farms and landscapes for people and planet

Convenors:
Tommy Dalgaard, Aarhus University, Denmark
Sara Burbi, Coventry University, United Kingdom
Christine Watson, Scotland's Rural College (SRUC), United Kingdom
Ulrich Schmutz, Coventry University, United Kingdom
Francesco Accatino, INRAE, France

Agricultural systems across the world face challenges in terms of economic, ecological and societal outcomes. There is an urgent need to strengthen the resilience (capacity to cope with challenges), and efficiency (capacity to satisfy food demand with less impact) of these systems. It is assumed that more mixed farming and agroforestry systems can deliver increased resilience and climate adaptation potential, with a more integral coupling of nutrient and carbon cycles, a diversified ecosystem service delivery and a better 3-dimensional use of resources. Research is needed to check these assumptions, quantify the potential of these solutions, and develop strategies for their implementation.

Such mixed and agroforestry systems can operate at many scales embracing diversity at the field, farm and landscape level, as well as in the attached production chains. This session will focus on how these systems can increase production efficiency, while decreasing input use, and minimising negative environmental and social impacts, including greenhouse gas emissions. The session specifically invites participatory co-design approaches to transforming agriculture towards a more mixed pathway for the future.

We welcome contributions from across the globe to highlight the diversity of both land use systems and solutions. This session is co-designed by two new 4-year EU H2020 projects focusing on agroforestry and mixed farming (project acronyms: MIXED and AGROMIX).

Orals

Landscape based metrics to assess livestock carrying capacities associated with selected planetary boundaries

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Dominant discourse discuss livestock as a major environmental threat [1,2]. Yet, livestock plays a central role in agricultural landscape in closing environmental cycles and in the efficient transformation of biomass that cannot directly be used for human consumption such as by-products and grass to high value food protein [3]. Livestock is central to foods systems within the safe operating space when crop-livestock interactions unlock synergies key to the circular economy. This requires balancing livestock-related nutrient flows in a context-specific manner matching with local ecosystem processes and boundaries. In addition, environmental impact from livestock is not the mere unrelated sum of the impacts of individual farms: the optimal combination of farm types or land uses and their related outputs within adequate spatial and temporal boundaries allow to exploit niches in which synergies mitigate potential negative impacts from livestock production. Consequently, only through a landscape approach, sustainability of livestock can be assessed adequately and in a systemic manner.

The objective of this paper is to present a conceptual framework behind the planned enhancement of the SOLm model, a bottom-up mass- and nutrient-flow model of agricultural production and the food sector [4], aiming at computing spatially explicit impacts of livestock. These are derived from selected ecological processes related to planetary boundaries, namely biosphere integrity, freshwater use, biochemical flows, climate change and land use change. Stocks and flows related to livestock production, its integration to crop production are balanced at landscape scale within a wider food system perspective, allowing to derive conditions for landscape-level operations to remain within the local carrying capacities and also to respect the requirements from the planetary boundaries.

At the core of the SOLm enhancement is the development of a spatial allocation algorithm that links the livestock related flows at landscape level to land at pixel level accounting for circularity. This linkage is mainly driven by the feed intake and manure use and can be modelled relying on a range of European and global geographical product [5] enhanced with LCA derived metrics. The enhanced SOLm will allow exploring livestock carrying capacities related to different planetary boundaries, identify the most constraining ones for each European landscape and derive how much livestock can be kept in order to remain within the safe operating space.

References:

[1] Willett, W. et al. (2019). Food in the Anthropocene: the EAT-Lancet Commission on healthy diets from sustainable food systems. The Lancet 393, 447–492 (2019).

[2] Steinfeld, H. et al. (2006). Livestock’s Long Shadow: Environmental Issues and Options. (Food and Agriculture Organization of the United Nations, 2006).

[3] Van Zanten, H. H. E., Van Ittersum, M. K. and De Boer, I. J. M. (2019). The role of farm animals in a circular food system. Glob. Food Secur. 21, 18–22 (2019).

[4] Muller, A. et al. (2017). Strategies for feeding the world more sustainably with organic agriculture. Nat. Commun. 8, 1–13 (2017).

[5] Pfeifer, C. et al. (2020). Designing sustainable pathways for the livestock sector: the example of Atsbi, Ethiopia and Bama, Burkina Faso. Int. J. Agric. Sustain. 0, 1–16 (2020).

Biotechnical and sociotechnical conditions required to engage an agroecological transition: A case-study of organic sheep crop integration in South-western France

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Keywords: Landscape, crop-livestock integration, collective organization, multiuse

The environmental, social and economic impacts of the specialization of farms and landscapes are well documented in the scientific literature. To address these impacts and related ecological issues (habitats, watersheds, erosion), an agroecological transition of agri-food systems is promoted in scientific and political spheres at the farm and landscape levels. Diversification of land use and integration of crop and livestock are core principles of agroecology and seems a promising avenue to achieve sustainability (Lurette et al., 2020). It requires addressing biotechnical challenges at elementary levels (animal, herd, field) as well as organizational challenges at landscape level (Garrett et al., 2020). Understanding how the conditions under which these challenges induce lock-ins or, on the opposite, promote agroecological transitions is critical to achieve impacts at scale.

We analyze a case study of innovative combination of technical and organizational options of crop-livestock integration among crop, livestock and vine farmers in organic farming systems in South-western France. Organized around a cooperative of cereal producers, this initiative aims at making the best use of various resources, diversifying crop rotation and strengthening the presence of livestock farmers in a landscape dominated by vineyards. From a biotechnical perspective, these diversified exchanges depend on the farmers involved. Arable farmers cultivate on bare fields before replanting vines. They integrate fodder legumes into their cropping systems and either let sheep farmers harvest them as hay, or let itinerant pastoralist use them as pasture. Sheep farmers also graze crop residues and vines interalleys in winter dormancy. From a sociotechnical perspective, these exchanges imply a coordination activity provided by the cooperative in terms of linking supply and demand of farmers for different resources. They also imply a variety of bilateral arrangements between farmers over time, according to resources availability, specific needs and constraints.

Finally, we discuss to what extent this innovative initiative constitutes a model of agroecological transition of farming systems at landscape level, through its biotechnical and sociotechnical benefits and limits (Asai et al., 2018). We identify pathways for development and reinforcement of the initiative, among which, the involvement of third-party organizations seems essential: landowners, forest managers, local authorities.

References:

Asai, M., Moraine, M., Ryschawy, J., de Wit, J., Hoshide, A. K., Martin, G. (2018). Critical factors for crop-livestock integration beyond the farm level: A cross analysis of worldwide case studies. Land Use Pol. 73, 184–194. https://doi.org/10.1016/j.landusepol.2017.12.010

Garrett, R. D., Ryschawy, J., Bell, L. W. et al. (2020). Drivers of decoupling and recoupling of crop and livestock systems at farm and territorial scales. Ecology and Society 25(1):24. https://doi.org/10.5751/ES-11412-250124

Lurette, A., Stark, F., Lecomte, L., Lasseur, J., Moulin, C.-H. (2020). A model to explore which diversity is needed to design sustainable agricultural systems at the territorial level. Agron. Sustain. Dev. 40, 32. https://doi.org/10.1007/s13593-020-00634-3

Scaling out Sustainable Land Use Systems in Colombia: Insights and Implications from Two Regional Case Studies

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Keywords: Agroforestry, cocoa sector, Colombia, livestock sector

Nowadays, conventional agricultural practices can reduce the ability of ecosystems to provide goods and services. To enhance environmentally friendly food production and to maximize social and economic benefits, sustainable land use systems (SLUS) are one of the most critical strategies increasingly/strongly promoted by donors organizations, international agencies, and policymakers. This process involves the question of how the scaling of SLUS can be adapted to larger landscape and not merely isolated experiments. In other words, increasing number of people or communities impacted by this kind of strategies involves a complex dynamics and interactions between biophysical, social, economic and institutional factors that could explain how and why SLUS are replicated and spread among more producers. On the other hand, as SLUS are context-specific strategies, diffusion and replication of successful SLUS are not linear processes and require the identification of main factors or critical that facilitate this scaling out process and the anticipation of side effects.

We applied a qualitative case study to investigate the scaling out process of SLUS in cocoa and livestock sector within conflict affected territories in Colombia, specifically, in Cesar and Caquetá region. These two regions are contrasting, but both have a current trend of increasing land degradation and peasants who have suffered from the rural conflict. Presently in Colombia, Caquetá is one of the most deforested departments, and Cesar has some most degraded soils. We conducted 26 semi-structured interviews and 3 group interviews with agroforestry experts in both regions to analyze: (1) what does it mean a sustainable land use system in Cocoa/Livestock, specifically in Caquetá or Cesar and (2) the key elements at the level of the following dimensions: biophysical, economic and profitability, market, social, policy and institutions. To identify, analyze and report patterns (themes), drivers or hinders for scaling out cocoa agroforestry systems (CAFS) and silvopastoral systems (SPS), we coded and analyzed the interviews using MAXQDA.

As the results showed, key themes, among which: premium market, solid regional markets and price stability, water availability and management, generational renewal, land use knowledge and diversification, producer organization and certifications are crucial to understand how the SLUS can have an impact across large-scale landscapes.

Additionally, given that SLUS are context-specific strategies, diffusion and replication of these agricultural innovations require the identification of main factors for scaling out at local level. For example, water management is contrasting for CAFS: whilst in Cesar is necessary to manage the dry season with an irrigation plan, in Caquetá is necessary to manage the high humidity and flood risk. Similarly, on the SPS side, they can prevent deforestation and soil degradation, but for their scaling out need to foster formation of participatory producer associations, particularly in Cesar. Since, such associations can promote and empower cattle ranchers to intensify sustainable production.

The factors mentioned above reveals which key factors might affect SLUS efficiency. However, Scaling out process should consider not only the farm level (adoption process), but also other levels that create a conducive environment for change overall.

Identifying the determinants of farmers' uptake of silvopastoral systems in Caquetá, Colombia

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Deforestation is threatening the existence of the Colombian Amazon forest. Farmers in the region tend to clear forest to establish cattle production farms. The Colombian National Federation (FEDEGAN) has a program that incentivise Colombian farmers to stop deforestation and pursue sustainable production practices. This program seeks to intensity cattle production based on the use of silvopastoral systems (SPS). Based on a sample of 341 farmers in the department of Caquetá, Colombia, we classify farmers' perception of climate change using a latent class approach. We find that there is a gradient of perception and concern towards climate change in this farming community. Utilising a logit model, we also investigate whether climate change perception is one of the drivers behind the uptake of silvopastoral systems in Caquetá, Colombia. We find that farmers that are more concerned about the future consequences of climate change and who have a larger number of cows producing milk are more likely to have a silvopastoral system in place. We also find that distance to the farm is another important driver of uptake: farmers living farther away from their urban centres are more likely to establish a silvopastoral system. These drivers can be exploited by FEDEGAN to design communication and engagement strategies conducive to maximize the uptake of silvopastoral systems as a sustainable intensification strategy in the region.

Impact of intercropping on soil microbial community under a rainfed woody crop in Mediterranean Agroecosystem

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Perennial woody crops such as almond tree (Prunus dulcis) are very important and with a great economic importance in the Mediterranean agroecosystems. Diversification practices such as intercropping in woody cropping systems have been recently proposed as a promising management strategy to simultaneously address global environmental challenges such as soil degradation, climate change mitigation and food security. Particularly, the potential of intercropping in replacing previous soil C losses derived from the conversion of native ecosystems to croplands in Mediterranean environments has been demonstrated. In addition, crop diversification and optimized use of resources can contribute to long-term sustainability of the agroecosystems, where soil microbial community composition and diversity are imperative to maintain the plant and soil biodiversity, soil health and crop productivity.

Within this context, two types of diversifications were implemented in an experimental field of rainfed almond trees located at South East of Spain: i) intercropping with Capparis spinosa and ii) intercropping with Thymus hyemalis in order to evaluate the response of intercropped in soil microbial community structure analysed by 16S sequencing analysis and enzyme activities and the relationship with several soil physico-chemical properties (aggregate stability, pH, soil organic carbon and nitrogen content). A type of intercropping not well studied.

Preliminary results (at the short-term) indicated that bacterial community structure and activity change slightly with diversification respect to the monocrop besides some soil physical-properties changes were observed. It is clear that a longer experimentation period is necessary to observe the effect of intercropping on the microbial community.

Using participatory methods to identify and address the challenges of mixed farming

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Mixed farming and agroforestry systems (MiFAS) integrate crop, livestock and forestry enterprises, resulting in improved nutrient and carbon cycling, increased biodiversity and financial resilience due to multiple income streams. However, MiFAS face a range of challenges that have not yet been fully resolved, such as the need to mitigate and adapt to environmental and climate change, while remaining within technical, agronomic, and socio-economic boundaries.

These challenges for MiFAS are complex, so farmers adopt individual problem perspectives that are not only informed by the information they have received and implemented, but are also framed by their situational interest. This can lead to institutional blind spots in which farmers find an adequate solution and cease to look for ways to improve the resilience and efficiency of their production systems. One way of addressing these farm-level blind spots is to adopt a multi-actor action research approach that follows a reflective learning process to facilitate identification of barriers and lock-ins and to support social learning and co-creation of knowledge. The aim of this contribution is to implement a participatory action research project, which takes place as part of the H2020 MIXED Project, in a range of European contexts.

The reflective learning process implemented in MIXED, which actively engages networks of farmers from across Europe, aims to develop, improve and implement efficient and resilient MiFAS and related agro-feed, energy, food and non-food value chains. Steps in this process include describing the current mixed farming context and challenges, at the regional/national level for case studies from 10 European countries; to identify existing problems (expressed as research questions) in the case studies; to identify past problems in the case studies that have been solved; to provide an interactive forum where solutions are matched to identified problems; to inform the MIXED scientific, supply chain and economic research of the existing problems (expressed as research questions) and finally to identify learning pathways (including co-creation of small scale research projects) for problems that cannot be solved by learning from other contexts and which are outside the scope of pre-defined research in MIXED.

This paper presents the preliminary findings of the context and challenges to MiFAS at the national/regional case study level and the key challenges to MiFAS identified at the farm level and expressed as research questions in 10 European case studies.

Sustainability assessment of olive agroforestry systems in Tunisia

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In the last decades, the market-oriented agricultural intensification has been largely adopted in many North African countries as a response to economic pressure derived from different global changes (e.g. climate change, ongoing demographic expansion). Specialization and intensification resulted in less diverse farming systems, an increase in environmental degradation, loss of ecosystem services and biodiversity. These processes exacerbate the changes in climate and increase the related economic and social inequalities in the region.

Agroforestry is considered the highest diversified farming systems helping in the mitigation of the environmental degradation process (Duru et al., 2015). Olive agroforestry systems (OAS) are widespread in south Mediterranean where olive groves can be associated with annual and other perennial crops. OAS has the potential to enhance ecosystem services and reduce the sensitivity to climate change, which also has positive economic and social impacts on farming communities suchlike the support of food security and the contribution to local development, especially at less favored rural areas.

The transformation over the past decades in many south Mediterranean countries of the OAS into a more intensive system has been accompanied by exploiting natural resources and decreasing the provision of ecosystem services. Consequently, OAS is considered as a natural innovation and a reintroduction of traditional farming in the Southern Mediterranean countries. Therefore, it is necessary to evaluate the contribution of this system to the sustainability and resilience of agriculture in the south Mediterranean regions. Our objectives were to evaluate the environmental, economic and social impacts of OAS by developing a practical methodology based on triple bottom line (TBL) indicators (Janjua et al., 2020). The aim is to assess the sustainability performance of OAS using three-dimensional composite indicators.

In a co-design approach with stakeholders within the BIODIVERSIFY project, we identified indicators for the environmental e.g. nitrogen balance, carbon sequestration and social dimensions e.g. working condition and their subsequent aggregation into composite indicators (Reckling et al., 2016) e.g. indicator of GHG emissions, internal social sustainability. While for the economic evaluation, we analyze the profitability of OAS associated with other annual crops in cereal-legume intercropping and legume supported rotations using a net present value approach (Lambarraa et al., 2016). The reference period of the analysis is 50 years, which represents the life cycle of the olive groves from planting to the end of the productive phase. For empirical application, different sources of primary and secondary data of Tunisian OAS are used. Tunisia is the fourth producer of olive oil in the world, with a vast area of OAS that had been menaced by increasing conversion to intensive system with high use of energy and chemical inputs (BenAbdallah et al., 2021).

With our sustainability assessment of OAS we aim to provide useful insights for farmers, public and private decision-makers. The resulted three-dimensional pillars provide key information elements in supporting agricultural policy aiming the increase of the diversification, sustainability and resilience of the Mediterranean farming systems.

Poster

Land use conflict between Farmers and Herdsmen – implication for agricultural and rural development in Nigeria

Michael Adedotun Oke

Talent Upgrade Global Concept

Keywords: Farmers, Herdsmen, Nigeria, Land, Conflict

Farmers and Herdsmen are having a lot of conflict in areas of land matter. This is due to the inadequacy of grazing resources and the effect of this is noted on the household welfare, loss of material resources, Agricultural produce and reduce income. This presentation study the different conflict suggest ways of ending such, as creating awareness of land use regulations among farmers and herdsmen's, provision of grazing land, extension services to teach farmers and herdsmen on conflict coping mechanisms, educating the farmers and herdsmen's for peaceful co-existence an mutual benefit, viable NGOs on farmers-herdsmen conflict management, especially in areas of awareness, education prevention, support livestock- centered live hoods including cattle herding, and conflict mitigation. Finally conflict management framework is required to curb the danger posed by farmer – herdsmen conflict and Traditional and local leaders should be well involved in finding solutions to farmer herdsmen.

Agroforestry suitability in Caquetá, Colombia: analysis of geo-climate variables, deforestation rate and land use

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Colombia is known for its rich and unique biodiversity, distinct landscapes and high productive and fertile soils. These characteristics allow the production of a wide variety of crops, yet poor land management and demand for livestock products are driving a rapid loss of forest and soil degradation related to extensive tropical cattle farming. This is exacerbating environmental and economic stressors in the agricultural sector, which is already facing the multiple challenges of reducing emissions, deforestation, and maintaining production to meet demand

These challenges are especially relevant in the department of Caquetá, inside the Amazonas boundaries, representing the area in the country most affected by forest loss in recent years. Agroforestry practices, such as Silvopastoral System (SPS) are highlighted as an alternative to conventional cattle farming systems in Colombia, to help tackle many of the issues that farmers in the region are experiencing, namely soil degradation, low productivity and deforestation.

The aim of this study is to research the suitability of implementing agroforestry and SPS practices on farms in Caquetá through the analysis of geo-climate variables, deforestation rate and land use at a landscape scale. This is presented together with a smaller scale analysis including a survey of nearly 200 farmers, to compare their decision making about implementing SPS versus the large-scale drivers and barriers analysed in this research.

First, a parameter was built using 6 geo-climate variables to determinate the potential to implement agroforestry systems in the region, concluding that 83% of Caquetá has a high agroforestry potential (79.000 km2 sq.km), leaving outside mostly the Andes area. In addition, protected areas were considered, leaving a total of 47.000 sq.km available.

However, this is contrasted with the loss of forest in Caquetá with already 30% of its territory affected by it by the year 2000, with an addition of 6,300 sq.km of forest loss in the last 20 years, representing an annual rate of 9%. When the agroforestry potential, the protected areas, and forest cover loss are considered, the real area left is approximately 22% of the total, however most of that area is located in the south west part of the department far away from the nearest farms and agriculture activities, that are much closer to the foothills of the Andes.

This raises the question of what is the agroforestry potential for those areas with high agricultural activity and under rapid forest cover loss? Our results show that 90% of the area of Caquetá with the lowest forest cover (14.000 sq.km) have the highest agroforestry potential. At the same time, there are no areas that have a low forest cover and a low agroforestry potential.

Analysing the year-to-year changes on land use in Caquetá could lead to a better understanding of their agricultural practices and thus be able to predict and quantify the soil use change in the near future. Adding the local farmers perspective into the model, through the use of our survey, could lead to further research on the adoption of SPS in the region.

Montado's erosion emergetic assessment

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Montado is a Unesco protected world heritage multifunctional system and a cultural landscape that has been shaped by man since, approximately, 2000 b.C. It's characterized by three landscape levels: trees, shrubs and pasture. At tree level there are usually two Quercus species, the Q. suber (cork oak) associated with the production of cork for extraction, and the Q. ilex (holm oak) with a major interest as acorn supplier for autochthone animals breeding. Shrub's encroachment is controlled either through grazing or machinery. Pastures are aimed for animal grazing through rotational systems, sometimes complemented with agricultural fields, mainly cereal crop production. Thus, animal integration in this system is essential for the management and preservation of the ecosystem. Although multiple factors influencing grazing can make farmer's decisions harder to maintain a sustainable system for many more years to come.

One of the biggest challenges in the Mediterranean climate for pastures are the seasonal fluctuations influencing biomass diversity and productivity. Coupled to the former, there is an overgrazing problem arising in modern montado management. When animal grazing rotation is not properly managed, there can be several difficulties to tackle such as treading damage, defoliation, juvenile tree breaking, leading to an overall natural regeneration blockage.

In Portugal, 78% of biological production resides in permanent pastures and forage surfaces, becoming the most important organic farming cultivation. In order to maintain these permanent pastures and tackle overgrazing problems there are different feasible measures. For instance, to overvalue natural pasture over sowing a proper mixture of grasses and legumes could hinder seasonal biomass fluctuation and even the bromatological composition of the pasture.

With a suitable procedure, pasture grazing can contribute with several benefits for these agrosilvopastoral systems: carbon dioxide (CO2) sequestration, removing approximately 20% of the CO2 released from global deforestation and land-use changes; nutrient recycling and consequentially soil fertility improvement; fire control through shrubs encroachment, etc. Therefore, it's crucial to develop strategies to strive with its already well-known benefits and avoid its further abandon as a result of its growing erosion and biomass depletion.

A good example of integration of livestock production in these systems is the extensive ovine production. The montado ensures the supply of complete feeding for sheep, that are fully adapted to this ecosystem and are part of it. This is particularly true for the autochthone species such as the Merino. So, grazing systems, including pasture improvement and management, are a means to adapt and mitigate environmental pressures.

SESSION 6:

CROSS SCALE SYSTEMS

6.3 Agroecology as a transition pathway towards diversified, sustainable and resilient farming systems

Convenor:

Heitor Mancini Teixeira, Copernicus Institute of Utrecht University, The Netherlands

Agroecology can be defined as the integration of research, education, practice and movement for the development of sustainable and resilient agri-food systems. The agroecological approach is a response to the dominant industrial model of agriculture towards the integration between scientific and local knowledge for the design of biodiversity-based agroecosystems. Increasing biodiversity can enhance the provision of multiple ecosystem functions and services, and therefore lies at heart of the transition to agroecological systems. Yet, there is no one-size-fits-all solution, and the design of diversified and agroecological systems must be sensitive to local needs and conditions. In addition, scaling the transition towards agroecology requires the creation of new social dynamics at different scales, from household and communities to territories and policy-making.

Despite the broad social and environmental call for agroecology and the increasing number of scientific studies on the topic, there is still limited knowledge on how to successfully implement agroecological transitions as well as its social and ecological impacts. In this session, we invite experts in the field to share their knowledge and advance new coordination strategies to understand and promote agroecological transitions. Submission of papers/posters from different countries and academic disciplines is encouraged to enable an interdisciplinary debate, considering systemic and multi-level approaches to understand the global drivers and impacts of agroecological transitions.

Orals

Innovative agroecological initiatives to inspire the sustainable transition of farming systems in Spain

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Keywords: Agroecological transition, innovation, scale impact, seeds of a good Anthropocene

Agroecology has a transformative character that involves the redesign of the entire agrifood system, analyzing the complex relationships between ecological functioning-human well-being-innovation-governance models and policies. From an integrative perspective, agroecology adopts a socio-ecological vision to understand the relationships between food production, quality of life and the maintenance of agroecosystems (Gliessman et al., 2015). Currently, a determined commitment towards the search for innovative alternatives that deepen agroecology has begun at the international level; there are initiatives (of social, technological, gender, environmental innovation, etc.) called ""seeds of a good Anthropocene"" that, although not abundant, challenge the current system with new ways of understanding and shaping the agrifood model (Bennet et al., 2016). These seeds constitute a relevant object of research, since understanding their characteristics, how they have taken shape, and their transformative character can inspire new models that can be extended to other situations of the agrifood model. This communication has the purpose of showing the results of an identification, compilation, and characterization of innovative agroecological projects emerging in Spain done within SAVIA (SAVIA-Sowing Alternatives for Agro-ecological Innovation) research project. To do so, we analyze more than 70 agroecological initiatives in Spain within the seeds of a good Anthropocene framework (Bennet et al., 2016) examining its positive impact and its transformative effect. The identification of initiatives has been done by digital searching, consultation with experts and reference documents and by a snowball system, then a characterization was done by an online interview. The consultation included information regarding: motivations, goals beyond food production, innovative elements and scaling potential. Following the preliminary results, considering their goals, many of the initiatives went beyond food production dealing with challenges such as social inclusion, education, nature conservation, etc. Most of these inspiring initiatives are transformative in the environmental practices conducted enhancing ecosystem services, economic and organizational model, how they exchange knowledge and its composition. More than 70% of the initiatives considered that they have a very high or high transformative potential in the territory where they are developed. In addition, based on Lam et al. (2020), those initiatives can amplify their impact to foster an agroecological transformation, particularly by scaling deep, scaling up, and scaling out the initiative

References:

Bennett, E. M., Solan, M., Biggs, R. et al. (2016). Bright spots: seeds of a good Anthropocene. Frontiers in Ecology and the Environment 2016, 14, 441–448.

Gliessman, S. (2015). Agroecology: A Growing Field. Agroecology and Sustainable Food Systems 2015, 39, 1–2.

Lam, D., Martín-López, B., Wiek, A., Bennett, E. et al. (2020). Scaling the impact of sustainability initiatives: a typology of amplification processes. Urban Transformations 2020, 2, 3.

Agroecological and conventional farming in South Madrid (Spain): motivations, limitations, and opportunities for an agroecological transition

Sara Palomo-Campesino[1]; Marina García Llorente[2]; José A. González[2]

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The way farmers understand their environment affects their interactions with it and this may influence their decision making process when selecting a certain type of management and the adoption of sustainable practices at their farms. Understanding farmers' perceptions and motivations is a key aspect to consider when developing tailor-made policies to address environmental sustainability. One of the challenges described by the FAO is to promote new ways of research, education, and extension programs that help to understand the specific social-ecological context and multidimensionality of the agri-food systems, facilitating the generation of bottom-up strategies to upscale agroecology. Within this framework, our study aims to define and compare the profiles of agroecological and conventional horticultural farmers in Madrid, and to explore the existing differences between both types of management on: applied practices, products' commercialization, views towards agriculture, relationship with other farmers, and main obstacles to their work in the agricultural sector. In doing so, we conducted semi-structured interviews with 12 agroecological and 10 conventional horticultural farmers of South Madrid. Our goal was to analyse the differences between agroecological and conventional systems and to explore associations between sustainable agricultural practices applied by farmers and farmers' underlying motivations to apply these practices. We found that agroecological farmers applied more sustainable practices and grew more products than conventional farmers, and their motivations were beyond the economic benefits, aiming to preserve or even enhance biodiversity. We found that agroecological farmers generally diversify their agricultural practices towards tourism or environmental education, proving their role in the supply of cultural services. Additionally, we found an improvement in regulating services indicators based on field samplings in their plots (soil erosion control, pollination, and pest control). Most agroecological farmers collaborate and exchange information with other farmers, which is a key aspect for the agroecological transition. The creation of networks by collaboration among farmers results in the generation of collective and horizontal knowledge necessary for creating human capital and empowering farming communities. Additionally, participation and collaboration are inherent to the nature of agroecology and are essential for upscaling since the creation of networks may facilitate the access of farmers to markets, or the generation of bottom-up policies. Agroecology is a necessary transition to ensure the sustainability of socio-ecological systems under the current current context of global change and world hunger. There is no unique guide for this transition, no 'one-fits-all' solution. Instead, context-specific studies should be done to adapt the agroecological transition to the environmental and social peculiarities of the area where this transition is going to be fostered.

Enhancing on-farm diversity. Drivers and constraints in South and Southeast Asia

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Agriculture plays a major role in the transformation of the natural habitat and the consequent biodiversity loss at local and global level. The increase and maintenance of on-farm diversity represent a potential strategy to improve farming systems sustainability, by reducing the pressure on the natural environment, alleviating farmers' risks and vulnerabilities, and increasing farms resilience. Nevertheless, the adoption and implementation of farm diversification strategies are driven or constrained, by several factors and dynamics that vary depending on different environmental, socio-economic and political variables.

We argue that to support diversification strategies, where doing so is beneficial, it is critical to identify the variables that represent these drivers, constraints and contexts at farm scale. Therefore, our study aims to identify and clarify some of the patterns behind the process that lead farmers to adopt farm diversification strategies in order to understand where investments and interventions to support diversification are likely to be appropriate and effective, and how they should be targeted.

We comprehensively review a selection of 97 articles focusing on drivers and constraints of on-farm diversification. We identify 239 drivers/constraints; compared the number of times in which they had a positive, negative or neutral relationship with on-farm diversification; and discuss these results and their implications. Eventually, we test these findings by analysing secondary cross-sectional survey data from a sample of ~9,000 rural households located in nine different South and Southeast Asian countries (Bangladesh, Cambodia, India, Indonesia, Lao DPR, Nepal, Sri Lanka, Thailand, Vietnam). The objectives are to identify (1) if drivers and constraints of farm diversification differ between these countries; (2) which drivers of production diversification remain consistent among farmers with similar characteristics independently from their location; and (3) the comparative benefits for household food and nutrition security of farm diversification and other livelihood strategies.

We found mixed results, with several variables acting as drivers or constraints of on-farm diversification depending on the context or farms' characteristics. Small and subsistence-oriented farms aim to adopt on-farm diversification strategies to satisfy their subsistence needs and adapt to environmental characteristics and risks. Farmers may shift their orientation towards specialisation strategies if the comparative advantage generated by market demand and opportunities, financial capital, technologies and the availability of alternative sources of income displace diversification benefits and its natural insurance effect. The availability of technologies for farm diversification and the access to alternative market options are crucial to stimulate the implementation and maintenance of on-farm diversity in regions with higher income.

These results suggest that further research exploring the existence of non-linear patterns between on-farm diversification strategies and potential drivers/constraints is needed to identify and quantify when, where and under what conditions the shift from diversification to specialisation takes place.

A steep decline in biodiversity with increasing coffee yields along a gradient of management in Arabica coffee's native range

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Keywords: Agroforestry, biodiversity conservation, biodiversity-yield trade-offs, coffee, management intensity gradient, southwestern Ethiopia, species composition, species richness

Tropical agroforestry systems provide farmers with goods, but are also well recognized as refuges for biodiversity. However, there might be a trade-off between yield and biodiversity in these systems. If such a trade-off is present, the potential for synergy will depend partly on the shape of the trade-off, i.e., if the relationship is concave, linear, or convex. We studied the relationship between biodiversity and coffee yield along a gradient of coffee management in southwestern Ethiopia, coffee's native range. We inventoried species richness and community composition of woody plants, herbaceous plants and bryophytes, and measured coffee management related variables at 60 sites in which we also assessed coffee yield for three consecutive years. Species richness of woody plants had a concave relationship with coffee yield, i.e. the tree richness declined fast initially before levelling out at higher yields, whereas there was no relationship between coffee yield and species richness of herbaceous plants or bryophytes. Species composition of woody plants, herbaceous plants and bryophytes all had a concave relationship with coffee yield. The concave relationship between biodiversity components (species richness and composition) and yield suggests that there is a strong conflict between the goals of increasing production and conserving biodiversity. Our results suggest that reconciling biodiversity and livelihoods needs a different approach for the different parts of the landscape. The least managed part of the landscape need to be strictly protected from further intensification to conserve biodiversity and coffee genetic diversity while the other parts of the landscape can be intensively managed to increase yield and improve livelihood. Premium prices for biodiversity friendly coffee management in the more intensively managed parts of the landscape may motivate farmers to grow coffee under diverse shade trees and contribute to biodiversity.

Farmers' thinking about insect biodiversity as prerequisite for an agroecological transformation in landscape labs

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There is an urgent need to cope with the continuing biodiversity loss in agricultural landscapes. Especially, an alarming decrease of insects in number and variety is evident. At the same time insects play a crucial role for the functioning of agroecosystems and provide multiple ecosystems services (e.g., pollination, natural pest control, or decomposition of organic matter). In response to this biodiversity challenge, agroecology is a promising pathway, using ecological guiding principles (e.g. crop diversification) to collaboratively develop and manage sustainable and resilient agroecosystems at landscape scale. In the FInAL project, we adopt agroecological principles to co-design and co-implement insect-friendly measures with farmers and other landscape actors in German landscape labs. However, little is known about farmers' problem awareness of the insect biodiversity loss, their attitudes towards insect-friendly insect-friendly farming practices. Understanding these attitudes are of crucial importance for farmers' willingness to conduct insect-friendly farming. In a recent study, we conducted 23 semi-structured interviews with farmers in two Northern-German landscapes to reveal their perceptions and attitudes regarding these aspects. We qualitatively analysed the interviews applying semantic web analysis. Our study revealed in-depth insights into farmers' thinking about insects and how farmers contextualise their arguments: 1) Most farmers reported the importance of insects' ecosystem services and disservices related to agricultural production rather than mentioning the holistic ecological value of insects. 2) Regarding the awareness of the insect biodiversity loss, about half of the farmers perceived a loss, whereas a similar number doubted there has been a decrease of insects. Both groups of farmers based their statements on own observations in their landscapes. 3) The majority of farmers is open-minded towards insect-friendly farming practices if financially compensated. 4) Farmers often commented that economic pressure to be competitive on the global market, unbalanced agricultural policies, and a low appreciation of farmers' work by consumers would hinder implementing insect-friendly measures. Thus, farmers often advocated for a joint societal responsibility for insects. Our study enabled the identification of overlaps in farmers' mental models, which paves the way for the agroecology-oriented co-design process in the landscape labs. Such local transformation efforts can also indicate new pathways for a shift on a regional or even national scale.

Poster

A consideration of the social and ecological potential of single trees as stepping stones for agro ecological transformation in a palm oil plantation in the Province Jambi, Sumatra, Indonesia

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General background: Taking an interdisciplinary perspective, this case study focuses on ecosystem functions and services provided by single trees in oil palm-dominated landscapes and their potential for agroecological transformation. The research was embedded in the EFForTS-BEE experiment (Ecological and Socioeconomic Functions of Tropical Lowland Rainforest Transformation Systems) run by the University of Göttingen and Indonesian Partner Universities (Jambi, Bogor, and Tadulako) that aims at identifying potentials for biodiversity enrichment in oil palm plantations.

Question: Can single trees within an oil palm plantation provide ecosystem functions and services that exert a positive influence on biodiversity and the social surrounding within oil palm plantations, like in other agricultural systems? What are the drivers that explain the presence of single trees embedded in this monocultural production system?

Location: Jambi Province, Sumatra, Indonesia

Methods: To study the biodiversity potential of the single trees, a seed rain survey, a microhabitat assessment, as well as a vegetation analysis were carried out. For the analysis of ecosystem services, data was collected in the social environment of the research unit through guided interviews with relevant stakeholders. For the social empirical analysis, the ecosystem service classification of the Millennium ecosystem assessment was used. We extended this by adding the perspective of the newly introduced Nature contribution to Humans concept.

Results: The seed rain study showed that single trees can serve as nuclei of seed dispersal in the study area. This also applies to the provisioning of microhabitats. The social empirical study provides insights into the potential of single trees to provide ecosystem services. Further, interviews revealed that these potentials are already used and accepted by the local stakeholders and decision-makers. With this approach, we could show that the existence of single trees in the plantation depends strongly on the value that is attributed to a tree by humans.

Conclusion: The integration of natural science approach with empirical social science methods in ecosystem research are recommended as an important step to support agroecological transition processes. Agroecological transformation takes place in a field of tension between conservation and economical needs. By integrating local knowledge it was possible to identify these needs but also potential obstacles on the way to more improved biodiversity and sustainability in oil palm plantations. It also shows which drivers might lead to the future existence of single trees inside the plantation. In summary, this work shows that there are close links between ecosystem functions and ecosystem services, provided by single trees in monocultural landscapes. The research was also able to show, how important and valuable an interdisciplinary approach can be to achieve implementation-oriented results in the field of nature conservation and therefore making an important contribution forward agro ecological transition.

Simulation of Dynamic Adaptation of Social-Ecological-System in Agricultural Landscapes

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Keywords: Ecosystem Services, Agricultural Landscapes, Agent-based Modelling

Agricultural landscapes endow a wide range of biotic and abiotic services that are highly beneficial to the society. A mismatch between demand and supply of ecosystem services (ESS) triggers researchers to develop several social-ecological system simulation models to help reduce the gap between them. However, existing models calculate the demands based on the consumption rate of services especially for provisional and regulatory ones while assessing the impacts of different economic policies on the provision of ESS and on the change of land use. We present a prototype agent-based model that underpins the decision making process of minimizing this spatial gap between supply and demand. Moreover, it helps mitigate land use conflicts among several groups of beneficiaries at a landscape scale. We assume two decision adaptation pathways: supply-driven demand and demand-driven supply. The former depicts the adaptation of demands for ESS in space according to available supplies whereas the latter adopts several management options to adapt the supply to the demands. The model is encoded in an open source software (Netlogo 6.1.1) that has the advantage of a spatial visualization of the transition of landscapes. The objective of this model is to simulate and project the progress of the status-quo in several case studies with different landscape characteristics under cooperative and non-cooperative interaction between actors. Additionally it aims at investigating the drivers, obstacles and impacts that could inform multi-level governance to satisfy the demands for ESS in a cooperative manner. The model would be a promising tool that helps decision makers and landscape planners in shaping and managing agricultural landscapes.

Ecosystem services of spatial and temporal within-field transition zones around kettle holes on arable land

Carsten Paul; Marina Gerling; Klarissa Kober; Michael Glemnitz; Marina Müller; Marlene Pätzig

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Smart use of agricultural landscapes must account for interactions between semi natural landscape elements and cropping fields in order to achieve high yields and resource use efficiency while optimizing the supply of ecosystem services. For this, a better understanding of ecosystem functions and of their effect on ecosystem services or disservices is needed.

In the past, kettle holes (small water bodies) inside agricultural fields were often seen as an obstacle to efficient agricultural management. Spring floods can hinder the cultivation of adjacent areas and lead to crop failures, while microclimatic peculiarities (oasis effects) can increase the spread of microbes and phytopathogenic fungi. On the other hand, kettle holes also offer habitats for insect species that reduce pest pressure on arable lands.

The SWBTrans project empirically investigates individual ecosystem functions and services from kettle holes in the ZALF's AgroScapeLab Quillow. Hydrological and small scale remote sensing studies of their water and moisture dynamics, and of their transition zones are carried out. These are accompanied by microbiological investigations about the possible spread of phytopathogenic fungi from weeds (intermediate hosts) established on kettle hole edges into agricultural fields, as well as investigations about biodiversity-related ecosystem services (measured with ""Rapid ecosystem function assessment methods (REFA)). The field surveys are complemented by an impact assessment, which synthesizes the results for different ecosystem services into a comprehensive assessment, discusses implications for agricultural management and highlights synergies and trade-offs.

Through a literature review, we determined which ecosystem services are supplied by kettle holes and identified linkages with agricultural management. We found references to a total of eight ecosystem services, of which the four services hydrological cycle and flood control, chemical condition of freshwaters, nursery populations and habitats, and biotic remediation of wastes are addressed most often in the literature. For the influence of kettle holes on crop diseases, our multi-temporal studies on differences in the occurrence and diversity of Fusarium spp. show that kettle holes are a source of fungal infections. Both autumn and winter seasons plants of the genus Poaceae have a Fusarium load that is more than twice as high as on herbaceous plants. The total fungus load in autumn 2019/winter 2020 was significantly higher than in autumn/winter 2018. Kettle holes are also a preferred overwintering habitat for insects. For the effect on biodiversity driven regulative services such as matter transformation in soils, weed seed consumption (granivory), and pest regulation (carnivory), essential and positive spill-over effects onto neighbouring fields lands are expected. Our first results show that this is strongly affected by available soil moisture, which is an important frame condition affecting the activity of insects on arable land. In some cases, effects in the area surrounding kettle holes were contrary to the expected trends.

Our project generates knowledge relevant for locally adjusted agricultural management and thereby contributes to an agroecological transition.

SESSION 6:
CROSS SCALE SYSTEMS

6.4 Multi-scale scenario design for European agriculture and food systems to frame future diversification contexts

Convenors:

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Katrin Karner, University of Natural Resources and Life Sciences, Vienna (BOKU), Austria

Hermine Mitter, University of Natural Resources and Life Sciences, Vienna (BOKU), Austria

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Scenario development for agriculture and food systems has gained in importance in recent years because of its wide applicability in research and practice. Scenarios can support ex-ante assessments or directly inform decision makers about relevant drivers of future developments, potential impacts and responses towards sustainable land use systems. To analyse diversification activities in agriculture and food systems, scenarios can outline future contexts, opportunities and requirements in a consistent manner. Scenarios for agriculture and food systems have been developed at multiple scales for diverse sub-sectors and purposes.

In this session, we discuss five different cases in order to analyse the potential of scenarios for landscape-level sustainability and resilience research in agriculture. Thereby, we will focus on the framework conditions for diversification. The presented scenarios cover the agriculture and food systems at regional and national scales (Eur-Agri-SSPs and AT-Agri-SSPs), environmental scenarios taking the farmer in the focus, as well as scenarios that focus on specific management practices or technologies in agriculture (i.e. digitalisation (DAKIS), pesticide reduction, legume cultivation, and soil improving management (DE-SMPs)). This session brings together recent and ongoing scenario development activities. It will discuss exemplary current states of scenarios and scenario design in agriculture and food systems and addresses future needs of scenario design with a particular focus on diversification in agriculture and food systems.

Orals

Nested Shared Socio-economic Pathways for agriculture and food systems: The Eur-Agri-SSPs and the AT-Agri-SSPs

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Keywords: Protocol, participatory, plausible scenarios, land use

Agriculture and food systems need to be changed to respond to increasing global challenges and to contribute to the achievement of the United Nations Sustainable Development Goals. Effective actions are required and should be coordinated between actors and across scales. Socio-economic scenarios have been widely applied to broaden the understanding for plausible future developments between public, private and academic actors and to inform actions at landscape, national, continental and global scales. Scenarios are typically developed with a thematic priority and a regional and temporal focus. They are based on a set of drivers and their relationships and describe how these drivers may shape the future in a comprehensive and consistent manner. However, scenario development has often been criticized for being non-transparent and irreproducible and for ignoring existing and thematically related scenarios, e.g. at larger scales. We have followed a protocol (Mitter et al., 2019) to develop Shared Socio-economic Pathways (SSPs) for agriculture and food systems at continental (Mitter et al., 2020) and national scales in a nested, participatory process. The protocol defines nine working steps, suggests adequate methods for each working step, and advices whether and how stakeholders should be engaged to increase legitimacy and creativity of the scenarios. The resulting five scenarios for Europe (Eur-Agri-SSPs) and Austria (AT-Agri-SSPs) outline plausible future developments of agriculture and food systems until 2050. The Eur-Agri-SSPs are consistent with the global SSPs (O'Neill et al., 2017), while the AT-Agri-SSPs are framed by the Eur-Agri-SSPs. Hence, both bundles of scenarios are structured along the two matrix components of challenges for climate change mitigation and adaptation. The Eur-Agri-SSPs and the AT-Agri-SSPs provide considerable sectoral detail and can thus be directly applied for further analyses. They specify main actors and address a large variety of drivers, which can be assigned to the categories population and urbanization, economic development, policies and institutions, environment and natural resources. Plausible directions of change have been identified in collaboration with stakeholders. They form the basis for scenario narratives and for quantifying selected drivers to be used as input in integrated assessments and land use models. Integrated assessments and land use models shall finally inform policy and industry decision making towards diversification and a more sustainable agriculture at landscape, national and European scales. Using larger scale scenarios (i.e. global SSPs) as boundary conditions is useful for structuring and classifying scenario processes and for enhancing comparability of research results across scales. The protocol-based scenario development increases scientific rigor, methodological transparency and legitimacy resulting from stakeholder engagement. A major challenge for developing the Eur-Agri-SSPs and the AT-Agri-SSPs are consistency checks within single scenarios and across scales.

References:

Mitter, H., Techen, A.-K., Sinabell, F. et al. (2019). Journal of Environmental Management 252, 109701. https://doi.org/10.1016/j.jenvman.2019.109701

Mitter, H., Techen, A.-K., Sinabell, F. et al. (2020). Global Environmental Change 65, 102159. https://doi.org/10.1016/j.gloenvcha.2020.102159

O'Neill, B. C., Kriegler, E., Ebi, K. L. et al. (2017). Global Environmental Change 42, 169–180. https://doi.org/10.1016/j.gloenvcha.2015.01.004

German National Soil Management Pathways: DE-SMPs

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German National Soil Management Pathways (DE-SMPs), scenario storylines that describe plausible qualitative trends of main drivers affecting future soil management in Germany by 2050. The development of scenarios enables to identify the opportunities and barriers for sustainable soil management solutions. Hence, key recommendations towards sustainable soil management can be provided to different groups of stakeholders.

The qualitative DE-SMP storyline elements were based on the Shared Socio-economic Pathways for European agriculture and food systems (Eur-Agri-SSPs) (Mitter et al., 2020) and Shared Socioeconomic Pathways (SSPs) narratives (Riahi et al., 2017) and adjusted with the focus on soil management and agricultural practices at the German national level. The four categories of storyline elements such as (1) Economy, (2) Policies and institutions, (3) Technology, and (4) Environment and natural resources were assessed using the stakeholder participation method, while defined trends of the fifth category, i.e. Population and urbanization, by Mitter et al. (2020) were applied.

About 100 participants from agricultural associations (e.g. DBV, DLG, ABL, KTBL), civil societies (e.g. NABU, WWF, LWK, VLK), enterprises (John Deere, CLAAS, Bayer, Hanse-Agro GmbH), policy-makers (BLE, BMU, BZL, BGR) and researchers were involved for the validation of the storyline elements' trends within the five established DE-SMPs scenarios on future soil management in Germany by 2050. The five DE-SMPs scenario narratives were titled as (1) Soil management on sustainable paths, (2) Soil management on established paths, (3) Soil management on nationwide paths, (4) Soil management on divided paths, and (5) Soil management on high-tech paths. Such collaborative and transparent way of DE-SMPs development allows transdisciplinary assessment of soil management. Furthermore, this approach will also be downscaled to the regional specifications in order to assess impacts and feasibility of innovative soil management practices and solutions in each German federal state using participatory scenario impact assessment.

Scenarios for legume protein in European agricultural and food systems

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Refocusing diets and agriculture to provide a growing world population with healthy diets from sustainable food systems is considered an immense challenge, placed high in the policy and scientific agendas. In addressing this challenge, legumes can be an important lever of change towards nutrient-rich, varied, and sustainable consumption and production patterns. Legumes are used for a wide range of food and feed products and can contribute to novel food systems and diversified diets. Crop diversification with legumes can reduce fertilizer and pesticide use while increasing domestic plant protein production along with European protein self-sufficiency. It can improve the resilience of European farming systems to socio-economic and climatic variability, enhance local biodiversity and ecosystem services, and reduce greenhouse gas emissions and deforestation in other parts of the world.

Yet currently, farmers in the European Union (EU) devote less than 2% of their arable land to grain legumes and more than 70% of the EU supplementary vegetable protein supply is imported (Watson et al., 2017). This is due to several factors, such as low yields and high yield variability, sub-optimal management practices, low investments in breeding, limitations in farmers’ experience in, knowledge of, and attitude to growing grain legumes, as well as the predominance of meat-based diets.

Within this complex system, what is the future of production and consumption of legumes in Europe and their contribution to diversification of agricultural and food systems as well as landscapes? What are the economic, technological, and policy drivers of change? How are diets and legume demand going to develop? What are the benefits, challenges, and limitations for the producers? What are the anticipated impacts on human and ecosystems health, value chains, and EU’s protein self-sufficiency?

To explore these questions, we develop a set of novel scenarios for legume protein in European agricultural and food systems. The scenarios are developed in consistency with narratives on future European agriculture, namely the Eur-Agri-SSPs (Mitter et al., 2020), which, in turn, are consistent with the Shared Socioeconomic Pathways (Riahi et al., 2017). To develop the scenarios, first, we used the Drivers-Pressures-State-Impact-Response framework to improve systems understanding and causalities within the consumption-production-global markets nexus of legumes. Second, we developed five narratives across this nexus in an interactive workshop with experts. The narratives cover highly sustainable, fragmented, unequal, high-tech, and business-as-usual developments. Third, we substantiated the qualitative narratives with literature and data analysis.

Here, we present the results of these different methodological steps and a summary of the developed scenarios, with a focus on how diversification plays out within agricultural and food systems under the five diverse futures. The exercise allows us to better evaluate the potential of legumes to enhance sustainability and diversification under different framework conditions and consequently stir robust developments with respect to the future of legumes in Europe.

Modelling land-use dynamics from semi-directive interviews and assessing their impact on food-energy autonomy at insular-system level

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Reunion Island is an overseas French region located in the Indian Ocean. Recent crises (COVID-19, social movements) have disrupted trade and production chains, underlining the vulnerability of such an insular system. This in turn has fostered public and political considerations toward a more self-sufficient territory. Indeed, Reunion Island is increasingly dependent on importations to fulfil the food and energy needs of its growing population. Moreover, local production systems have to cope with space constraints, since land is a sought-after resource, at the crossroads of multiple stakes: biodiversity conservation, rapid urbanization and agriculture. Most notably, local agriculture biomass production is used as food for inhabitants and cattle, but it also contributes to the local electricity production capacity, essentially by feeding sugar cane bagasse to power plants. Thus, long-term trend towards food and electricity self-sufficiency requires balancing different land-uses and biomass productions at territorial scale.

In order to explore possible land-use scenarios for the island, we conducted a first round of 24 semi-directive interviews with local stakeholders representing different administrations, civil societies, or agricultural and industrial organizations. A structural analysis method, as used in foresight studies (Delgado-Serrano, M. del M. and al., 2015), allowed identifying key ongoing 'processes' in the current system, as well as future possible trends referred to as 'hypotheses'. The interviews highlighted several recurrent processes and hypotheses, which impact, or are expected to affect, the local landscape, and thus, domestic food and electricity production. Examples of ongoing processes are the diversification of the sugar cane systems, and the urbanisation fragmenting agricultural lands. Examples of hypotheses are the development of non-biomass renewable energy, and changes in local climate. Six key ongoing processes contribute to the 'business as usual' scenario, whereas different sets of hypotheses will modify the ongoing processes into different trajectories that constitute contrasting scenarios.

The land-use dynamics model of Reunion Island and the different scenarios were built using the Ocelet spatial dynamics modelling software (Degenne, P., Lo Seen, D., 2016). In this modelling approach, the system considered is composed of interaction graphs. On the nodes of the graphs are spatial entities (e.g. plots of land, residential areas) whereas the edges hold interaction functions that can be activated during a scenario to change the state of the system (including land-use types). Processes are modelled as interaction functions that are called in coordination during the scenarios.

The system is initialised with the existing 2019 land cover map as input data. The map was produced using high-resolution satellite images (Dupuy, S., Gaetano, R., 2020). Previous land-cover maps from between 2017 and 2019 were used to estimate certain parameters of the transition rules expressed in the processes. Different indicators, such as those related to self-sufficiency levels were implemented in the model in order to monitor the state of the system and compare the different scenarios. In a second round of interviews, the model simulations will be discussed with some of the stakeholders. They will be asked to evaluate outcomes and possibly review some hypothesis and internal transition rules, in a co-design process.

Exploring chemical pesticide-free cropping systems in Europe in 2050

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The foresight study « Pathways to Chemical Pesticide-free Agriculture in Europe in 2050 » is part of the French National Priority Research Programme 'Growing and Protecting Crops Differently', led by INRAE and launched at the request of the French Government. The aim of the foresight study is twofold. It will develop scenarios of chemical pesticide-free agriculture in the European Union in 2050, showing what could be the different forms of a chemical pesticide-free agriculture in Europe and assessing what could be the impacts of such changes on land use, production, trade and biodiversity. Then, it will examine what could be the different pathways towards these different forms of chemical pesticide-free agriculture. The foresight study uses a systemic scenario approach based on a morphological analysis coupled with a quantitative simulation of the scenarios produced.

The paper describes the general foresight approach: the foresight system, the scenario building process, the quantitative simulations as well as the various expert groups involved. It then focuses on the specific part of the scenario building process, which is devoted to the building of alternative strategies of plant health protection and the related changes in cropping systems in the EU in 2050.The method used for building these assumptions is first detailed. Then, several plant protection strategies together with corresponding cropping systems are proposed and discussed. The paper concludes with the next steps of the foresight and their expected results.

The method for building scenarios for alternative plant protection strategies relies on a sociological analysis called 'Innovation through Withdrawal' (Goulet and Vinck, 2015). This theory focuses on innovation based on reducing or withdrawing use of a practice (zero-till technology, pesticide-free agriculture or city centre without cars for instance). In our case, we use this theory in a reverse mode, not to describe an existing situation but to imagine possible changes and reconfigurations in the cropping system. This foresight approach proposes to explore related changes in plant protection strategies and cropping systems if we withdraw the use of chemical pesticide through four questions. How to replace chemical pesticides? Does the withdrawal of chemical pesticides give more emphasis in plant protection to some biological entities (such as soils or landscape) or induce a changing role of some component of the plant protection strategies? Does the withdrawal of chemical pesticides change the definition and the meaning of 'pests and diseases'? How the withdrawal of chemical pesticides change the objective and the design of epidemiosurveillance systems?

Three interdisciplinary expert groups were involved to answer the four questions and then imagine future strategies of plant health protection. The first group brought together scientists working on plant resistances. The second group involved scientists interested in the dynamics and regulation of pests and diseases at the field, the farm and the landscape level. The third group mobilised scientists dealing with agricultural machinery, sensors and remote sensing, big data and artificial intelligence.

References:

Goulet F., Vinck, D. (2015). Innovation through Withdrawal. Contribution to a Sociology of Detachment. Revue française de sociologie, 11, 21–44.

SESSION 6:
CROSS SCALE SYSTEMS

6.5 Guiding principles for biodiversity-friendly agricultural landscapes

Convenors:

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The alarming decline of biodiversity in agricultural landscapes has prompted a wide range of responses. Most current efforts are focused on modifying practices at the field and farm scale, and frequently are focused on a few key taxa of concern. However, evidence increasingly suggests that modifying practices at the landscape scale may be required for effective conservation of biodiversity and related ecosystem services, but few guiding principles have been proposed. Effective management of agricultural landscapes to enhance biodiversity requires an integrative framework which includes the full range of the options for transforming the landscape into a more biodiversity-friendly one, the potentials of diversified land use systems, and their acceptability to regional actors. In this light, a process for identifying guiding principles is crucial for co-designing and successfully implementing biodiversity-enhancing strategies at the landscape scale. Developing these principles is an important and novel first step towards meeting societal needs for protecting biodiversity, the provision of ecosystem services including agricultural productivity, and the development of problem-oriented collaborations.

In this session, we aim at bringing together and discussing innovative approaches of biodiversity promotion on the landscape scale to set up guiding principles and to explore how the principles can be regionally identified, established and used to promote biodiversity and meet the needs of land users and other actors. We welcome contributions from all world regions.

Orals

Co-designing ecologically and economically efficient measures for conserving biodiversity at landscape level

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Keywords: Co-design, landscape scale, agri-environmental measures, result-oriented

Despite some partial successes, the loss of biological diversity and the ecosystem services that depend on it (""natural capital"") is progressing rapidly. In particular, there is a lack of broad implementation of existing policy instruments and measures in agriculture. The reasons for this often lie in a lack of acceptance and obstacles that farmers face during implementation. Here, we would like to present the design and first results of a new research project, ECO²SCAPE, to discuss potential guiding principles and success strategies for designing biodiversity-friendly landscapes. ECO²SCAPE aims to integrate scientific and local knowledge to better conserve biodiversity in cultural landscapes. The focus is on the co-design of ecologically and economically efficient agricultural measures in a model region in Saxony. First interview results show which levers can be used to improve agri-environmental measures – especially for bird conservation. In close cooperation with nature conservation experts, local farmers and other stakeholders, regional biodiversity targets and guiding principles will be developed to guide the co-design process. Innovative collaborative and result-oriented measures will be implemented, which are considered particularly effective measures in terms of biodiversity conservation, as they offer financial and social incentives. The ecological and economic efficiency of the measures will be analysed taking into account landscape structure, including the testing of an automated biodiversity monitoring technology. Overall, we would like to advance the latest knowledge on the effective biodiversity conservation at the landscape scale. This includes the landscape-scale approach, stakeholder participation, community involvement and acceptance, and financial and social incentives to implement measures.

Optimizing ecological infrastructure on the landscape scale

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In the last decades, a dramatic loss of biodiversity has been observed, which has been called the sixth mass extinction. This loss has been shown to be mainly driven by land-use changes, caused by a growing human population, urbanization and food demand, which put agricultural systems under pressure to be more productive. On one hand this leads to a higher management intensity on field level with increased use of chemicals to boost productivity and combat problematic weed and pest species, coming along with offside effects. On the other hand, new technologies have led to bigger field sizes and landscape homogenization through the removal of landscape structures (i.e. shrubs, hedges, trees etc.), also called ecological infrastructure, to facilitate intensive farming practices with modern machines. Such techniques increase the efficiency of agriculture, but often come at the expense of biodiversity, threatening not only vulnerable species but ultimately also the functioning of agricultural landscapes, which is essential for farming. To combat the negative effects of intensive agricultural practices on biodiversity, biodiversity promotion schemes have been established and national as well as international goals set. Unfortunately, these goals have not been met so far, while the actual efficiency of biodiversity promotion schemes in fostering biodiversity often remains controversial. We need to find integrative ways to implement sustainable practices across different spatial scales, incorporating not only field-level management but also the role of the composition of agricultural landscapes.

In this study, high resolution biodiversity data were gathered during monitoring in two contrasting agricultural regions in Switzerland. We mapped birds (three survey rounds) and butterflies (seven survey rounds), and the data were combined with land-use and management data on parcel and landscape level, with a focus on the composition and configuration of various kinds of ecological infrastructure on different spatial scales. The structure definitions fit the Swiss Agricultural Life Cycle Assessment for biodiversity (SALCA-BD), which is used to predict the impact of different management options on biodiversity at field level. Preliminary results illustrate the links between various types of ecological infrastructure and biodiversity in dependence on the spatial scale considered. The outcome will complement the knowledge on the role of specific types of ecological infrastructure for different species guilds. This will help to improve biodiversity predictions based on spatial land-use information, with the aim to optimize agricultural planning on the landscape scale (i.e. the efficient placement of ecological infrastructure). Evaluating the effects of agricultural land-use on different spatial scales is of high importance to build novel approaches that foster the efficiency of the current biodiversity promotion schemes and most importantly help to find solutions which favour productive agricultural landscapes as functioning ecosystems that provide a high ecological quality for the species depending on them.

The Potential of Area-based Conservation Measures for Enhancing Farmland Biodiversity

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Keywords: Conservation policy, farmland biodiversity, landscape-scale

European farmed landscapes host a number of species intimately associated with and contributing to agricultural production through the provision of crucial ecosystem services. However, their habitat is rapidly deteriorating due to agricultural intensification and abandonment of marginal land, a tendency that the EU CAP and its set of farm-scale environmental measures have tackled ineffectively to date. This study focuses on farmed Natura 2000 protected sites to empirically evaluate the effectiveness of an area-based conservation measure applying at the landscape-scale in preserving and enhancing high-quality habitat for farmland biodiversity (FB).

The Natura 2000 network of protected sites covers 10.6% of the total EU agricultural land. Aimed at protecting Europe's threatened species and habitats, Natura 2000 does not focus specifically on FB conservation and specific EU-wide studies on its effects on the agroecosystem are lacking. On QGIS, we selected all farmed Natura 2000 sites that include three EU CORINE land cover classes which maximise landscape heterogeneity and the presence of natural and semi-natural areas, while minimising intensively managed land. We used the area covered by such classes as an indicator for high-quality FB habitat, our dependent variable. We then created a control group of sites using buffer areas of 5 km around the Natura 2000 sites and we ran a fixed-effects model to estimate how the area covered by the selected classes changed over time inside and outside the protected sites, before and after their designation.

The results – which make explicit the initial differences between protected and buffer sites – are extremely clear. They show a strong negative trend over the years in controls and, conversely, an almost stationary situation within Natura 2000, which turns significantly positive after some years from the sites' designation. Running the same model on sites designated earlier shows an anticipated positive trend, in accordance and confirming the theoretical expectations.

Although Natura 2000 is still underperforming with regard to its targeted species and habitats, our study shows a significant positive effect on high-quality habitat for FB, in contrast with the recent evaluations of the EU CAP measures for biodiversity conservation. Differently from the latter, Natura 2000 is area-based, applying consistent conservation standards on geographically-defined areas with a spatial extent much wider than the farm-scale. This allows to match the landscape-scale that consistent ecological literature recognises as crucial for the conservation of FB and the related ecosystem services.

In the context of the post-2020 CAP discussions, our study suggests to rely and invest more on the synergies between the CAP and the Natura 2000 network. Moreover, it suggests to overcome the traditional farm-scale perspective and integrate the main features of area-based measures in the design of the future CAP measures – for instance along the lines of the water basins approach of the Water Framework Directive. The collective engagement of neighbouring farmers in implementing coordinated conservation measures is also expected to boost environmental stewardship and reduce operational costs, thus further enhancing policy efficiency.

Developing insect friendly agricultural landscapes: aims and indicator-based assessment of a transformation

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In response to the alarming decline of insects (Cardoso P., Barton P. S. et al., 2020), the FInAL (Facilitating Insects in Agricultural Landscapes) project was established to increase the insect diversity, functionality and biomass at a landscape level in agricultural landscapes in the long-term. The overarching goal of FInAL is to design a roadmap for the transformation of agricultural landscapes into more insect friendly ones while maintaining productive and economically viable agricultural production. The empirical part of the project covers three contrasting agricultural landscapes, in which landscape laboratories were set up. In a transdisciplinary approach, involving several scientific disciplines (agriculture, ecology, entomology, economy, and sociology) as well as farmers and other landscape actors, the project aims to develop, pilot and assess measures that are both ecologically suitable and practicable for and acceptable by landscape actors in an ongoing co-design process. For the transferability and generalization, the theoretical and modelling part of the project aims at deriving guiding principles on how to develop insect friendly agricultural landscapes and how to conceptualize an indicator-based assessment.

As any pathway for an insect-friendly transformation has to be tailored to the conditions in the respective landscapes, in the first project stage the current agricultural systems as well as natural and semi-natural habitats within the landscapes were analysed to evaluate their potentials to support insects. In order to explore the most appropriate transformation pathways for each landscape, an iterative process was established. First, we identified a set of insect friendly measures, and assessed their specific value for different insect groups. Thus, suitable measures were compiled and further developed by the transdisciplinary team in various workshops and were adapted to local conditions. Thus, we derived a selection of specific measures and identified suitable plots of implementation. Second, in order to assess the suitability of the landscape for insects in general and for selected groups the habitat supply was assessed in more detail, by information on agricultural systems (IACS data, detailed information from farmers), and biotope structures (UAV data). The detailed information are available for refining and improving the applied measures.

The transformation of the landscape towards insect-friendly agricultural systems and biotope structures shall improve habitat suitability for insects. These changes may also impact other components of the agro-ecosystem, either in the form of synergies or trade-offs. Therefore, the ecological, agricultural, economic, and social impacts of the transformation process are also accounted for and assessed in FInAL using a set of indicators. These include, for example, environmental indicators such as the environmental risk to non-target terrestrial or aquatic organisms, the environmental risk to field margins, soil erosion, crop production effects such as crop yields, and economic and social indicators such as revenues, opportunity costs and gross margins, acceptability of measures, and social learning. The indicator-based assessment concept was elaborated addressing key stakeholder groups (practitioners, policy makers, scientists).

References:

Cardoso, P., Barton, P. S. et al. (2020). Scientists' warning to humanity on insect extinctions. Biological Conservation 242: 108426. https://doi.org/10.1016/j.biocon.2020.108426

Biodiversity-based agroecological system experiment: what, why, how?

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The biodiversity of agroecosystems and agroecosystem functioning has declined markedly in recent decades with the intensification of agricultural management. Redesigning agricultural landscapes that would deliver services to agriculture has probably never been so high on the political and research agenda. However, shifting to biodiversity-based agriculture with an emphasis on landscape design will require new models of research enhancing the integration of ecological and agronomical knowledge, targeting research for context-specific solutions, and increased empirical testing of existing design concepts. For a long time, agronomists have designed and tested cropping systems on long-term experiments that test the system as a functional entity whose complexity is more than the sum of its parts. Following the same philosophy, Agroecological System Experiments (ASE) adopt a systemic approach, but it comprises the design of the spatio-temporal arrangement and management of fields and semi-natural habitats at the farm level. Agroecological systems are thus a coherent landscape design strategy, a mosaic of adjacent fields with diverse cropping systems and a network of semi-natural habitats. As such, ASE considers and tests the combined effects of land management options implemented at multiple embedded spatial scales. The scientific focus is therefore not limited to the temporal dimension of cropping systems but also includes a spatial dimension that is highly relevant both ecologically (e.g. when tackling the issue of biological pest control) and agronomically, i.e. how to organise a coherent farming strategy at the landscape scale. INRAE has recently set up a landscape-scale ASE over one of its experimental farm (Dijon, France), covering 125 ha. This Co-designed Agroecological System experiment platform CA-SYS (www.inrae.fr/plateforme-casys) aims to design and evaluate new agroecological systems that maximise the use of biological processes and reduce the use of inputs (Cordeau et al., 2015; Petit et al., In press). The CA-SYS platform tests how farm-scale restoration (125 ha) using diverse spatio-temporal crop rotations and ecological infrastructure (14 ha of flower strips, grass strips, hedges) deployed in a zero-pesticide, till/no-till context affects crop yields, biodiversity and ecosystem services. The CA-SYS platform was designed as a pesticide-free ASE that uses (cropped and wild) biodiversity as a means to support production: it tests the expectation that halting pesticide use and enhancing planned biodiversity within the fields and their margins will increase the service of natural pest control. A crucial part of this innovation has been the active involvement of farmers and agricultural advisers from the surrounding area in the co-design of the ASE, and more generally stakeholder involvement, to guide the development of an ambitious but practicable biodiversity-based management system.

Enhancing insect biodiversity in the agricultural landscape of German biosphere reserves – insights from different actors' perspectives

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Keywords: Biodiversity, agri-enviroment schemes, attitudes

Biosphere reserves can serve as models for biodiversity-friendly agricultural landscapes. The decline of insect biodiversity and abundance in Germany, even in protected areas, has motivated five German biosphere reserves to dedicate to an insect-enhancing transformation in their agricultural landscapes. A research and implementation project addresses insect biodiversity at the landscape scale, integrates land managers' perspectives into project activities, and accompanies these by research into agro-ecological and -economic aspects and monitoring. Qualitative interviews with 25 farmers in the five biosphere reserves, alongside a reflection of the first 18 months of project initiation, highlight challenges for implementing biodiversity-enhancing measures at the landscape scale, both, from the perspective of project members and farmers. To potentially biodiversity-interested farmers, the choice whether to engage in insect enhancement follows a weighting of various societal demands, including the different focus organisms in biodiversity-enhancement actions. It is up to them to assess how these demands can be combined into a long-term, integrated management strategy, and probe for trade-offs between the implications they have on their farming and on one another. Along with trade-offs, e.g. between biodiversity enhancement and soil conservation, some farmers recall negative experiences when they lead to conflicts or negative judgments of the respective promoting actors. Farmers' practical, economic, and administrative challenges with biodiversity-enhancing measures are well documented. Yet they still prevail at the practical level, with great differences between farm types, agricultural landscapes, funding environments etc., leaving e.g. little economic and agronomic scope for action for specialized arable and dairy farms compared to other farm types in Germany. With respect to funding environments in the project areas (as of 2020), farmers in Bavaria can choose among 18 biodiversity-effective measures in agri-environmental schemes (AES), with 8 additional measures via contract nature protection schemes available in biosphere reserves. For comparison, only 10 such measures are available in Mecklenburg-West Pomerania, with another 5 in biosphere reserves. As agriculture policy and subsidy schemes contribute to shaping agricultural landscapes, government-financed projects need to embed their activities in the prevalent institutional environment. Simultaneously, testing and promoting adaptations in institutional settings with the objective of biodiversity enhancement are among the goals. E.g., intended measures are subject to minimum management requirements that may conflict with biodiversity-enhancing management. In addition, a highly diversified range of measures and flexible implementation has shown to provide more suitable options at farm level and to incentivize more farmers to pick up measures, while also promoting diverse organisms. Often the most site-specific measures concern the hotspots for biodiversity, such as forest grazing or the arable weed conservation in the project areas. Yet, monitoring, research and project management need some streamlining of measures to be practicable. Faced by the described challenges, project actors need to identify niches for piloting adapted institutional settings, and find compromises between simplification and flexibility. To enhance the impact of farmer participation, farmers' different, farm- and region-dependent scopes for action need to be addressed. Different targets of biodiversity enhancement and, ideally, other societal demands need to be integrated and embedded in long-term.

Exploring the potential of co-designed landscapes to promote biological pest control

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Farming management options reinforcing the control of pests and weeds by their natural enemies can contribute to the overarching goal of reducing pesticide use in modern agriculture. Practices implemented at a field-scale are key drivers of the local intensity of natural biological control but their effect is highly variable and context-dependent. In part, this variability results from a modulation of the impact of local practices on pest control through landscape-scale management. This situation calls for exploring with farmers how their own management decisions and those of their neighbours can affect biological pest control in individual fields across landscapes. Here, we report on the implementation of this approach in five French regions that are part of the two long-term monitoring networks on biodiversity-based ecosystem services in farming landscapes SEBIOPAG (www.sebiopag.inrae.fr) and BACCHUS (www.siteatelier-bacchus.com).

Data collected in the networks demonstrate that crop diversity, proportional cover of semi-natural habitats and the level of pesticide use within a 1km2 area significantly affected biological pest control, often in interaction with the level of pesticide use in the focal fields (Muneret et al., 2018; Ricci et al., 2019). This knowledge led us to conduct an exploration of potential ways to enhance pest control in scenario-based co-designed landscapes. A workshop was organised in each region with local farmers to present our findings. Formalised exchanges were then mobilised to assess which practices and landscape-scale factors farmers would be willing to modify and to what extent as well as to explore with farmers their perception and willingness to engage into concerted management. Outcomes of the workshops were mobilised to develop spatially explicit scenarios of landscape changes for a 3 x 3 km landscape in each region. The procedure for land use allocation in the scenario-based maps takes account of the nature and spatial distribution of farm types and constraints that prevail at the farm level (Martel et al., 2019). The statistical models developed for predicting levels of biological pest control in response to local and landscape scales were then coupled with the land map scenarios. The resulting simulation tool enables us to predict the level of biological pest control for each field of the map. Outcomes of the simulations conducted in each region are due to be discussed with local farmers in a second workshop. In this presentation, we will detail the generic approach and illustrate the different steps with examples derived from the five regions.

References:

Martel, G. et al. (2019). Impacts of farming systems on agricultural landscapes and biodiversity: from plot to farms and landscape scale. European Journal of Agronomy 107, 53–62.

Muneret, L. et al. (2018). Organic farming at local and landscape scales fosters biological pest control in vineyards. Ecological Applications. 29, e01818.

Ricci, B. et al. (2019). Local pesticide use intensity conditions landscape effects on biological pest control. Proc. R. Soc. B 286: 20182898.

Addressing agri-food systems, conservation, and sustainability through local and regional governance in southern Ontario

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Keywords: Municipal capacity, agri-food systems, county/regional planning

This paper provides insight on the capacity of municipal governments to support the agriculture and agri-food sector, to coordinate regional land use, agri-food system, and conservation planning, and to provide leadership and governance related to rural and agricultural land uses.

In Ontario, municipalities are the local level of government responsible for implementing provincial policies and directives and ensuring coordination across the province. Specific to agricultural landscapes and ecosystem services, the province provides guidance related to agricultural systems, natural heritage systems, drinking water source protection, significant landscape features, and the role of conservation authorities. However, the commitment and approach of individual municipalities in implementing and supporting these policies is varied.

In Huron County, the Huronview Demo farm is donated to the farmer-led Huron Soil and Crop Improvement Association to test and demonstrate sustainable agricultural practices. Others, like Wellington County have partnered with local conservation authorities to establish water quality programs and provide financial support to farmers looking to implement best management practices (e.g., tree planting, cover crops, natural area restoration and creation). Initiatives related to agricultural landscape sustainability take many forms and some municipalities are providing leadership by creating spaces for the agricultural community to come together and share ideas (e.g., Dufferin County's agricultural round tables). Similarly, Northumberland County's Ontario Agri-food Venture Center supports both the agricultural community and circular food economy by providing affordable cold storage and processing facilities. The potential role for municipal government in providing leadership and governance for agricultural landscape planning and coordination is significant.

Despite the significant role municipal governments could play, little is known about their structure, knowledge base, and capacity. Research conducted over the last year investigates 66 municipalities in Ontario and includes a review of municipal capacity in the Greater Golden Horseshoe, planning department structure and functions, and the integration of formal and informal networks in local and regional governance. A mixed-method research design was used, including interviews, surveys, and secondary data analysis. This paper addresses the following questions:

1. What is the current state of capacity in municipal planning departments to effectively respond to emerging agricultural and rural issues within their communities?
2. What strategies are being pursued at the municipal level to encourage more sustainable forms of agricultural production and environmental enhancements?
3. What opportunities, either potential or existing, are available to help municipal planning departments build capacity in supporting effective management of agricultural landscapes?

Findings reveal that municipal planning departments are varied and inconsistently staffed. This is the surface of a much larger inconsistency related to financial resources, staff expertise, and council's knowledge of agriculture and agri-food systems. Furthermore, the knowledge gap related to agricultural planning and agri-food issues is increasing, and fewer elected officials/planners have agricultural backgrounds, expertise, or training. This presents a threat to rural and agri-food communities, climate change management and mitigation, and province wide sustainability and conservation planning. Case studies analysis will help to identify key lessons that can be applied in Canada and other countries.

Poster

Effective promotion of benthic invertebrates by identifying key drivers of biodiversity in an agricultural landscape

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Keywords: Kettle holes, conservation, insects, multivariate statistics

Kettle holes are small standing water bodies (SWB) of glacial genesis in north-east Germany where intense agricultural land use is prevalent (Kalettka and Rudat, 2006). Kettle holes are important freshwater habitats for benthic invertebrates but due to location and size especially prone to adverse impacts of intensive agriculture. Habitat loss or water quality degradation leads to biodiversity declines and especially to a decrease in insect diversity.

Biodiversity loss can result in a shift from species diverse communities, including a lot of specialized taxa, to more simplified associations dominated by generalists. This can have wide ranging cascading effects on other trophic levels and consequently on the whole ecosystem (Sánchez-Bayo and Wyckhuys, 2019) and its functions.

Drivers of agricultural SWB biodiversity are not only manifold but additionally interact on many different levels. In order to preserve and promote diverse communities our study aims at quantifying the effects of these drivers on macroinvertebrate communities by multivariate statistical methods. The study is based on a comprehensive dataset from more than 100 kettle holes sampled for benthic invertebrates as well as parameters describing water quality (e.g., plant protection product residues), aquatic habitat diversity, riparian vegetation structures and adjacent land use practices.

Based on our findings SWB can be identified which are most likely to act as biodiversity hotspots and thus especially facilitate aquatic biodiversity on the landscape scale. Consequently, agricultural measures can be refined and spatially applied where the highest potential can be found and where measures are most likely to be effective for biodiversity promotion. If suitable colonization sources in the surrounding landscape are present, water bodies with particular habitat features could be designed in areas if missing.

References:

Kalettka, T., Rudat, C. (2006). Hydrogeomorphic types of glacially created kettle holes in North-East Germany, Limnologica, Volume 36, Issue 1, Pages 54–64, ISSN 0075-9511. https://doi.org/10.1016/j.limno.2005.11.001

Sánchez-Bayo, F., Wyckhuys, K. A. G. (2019). Worldwide decline of the entomofauna: A review of its drivers, Biological Conservation, Volume 232, Pages 8–27, ISSN 0006-3207. https://doi.org/10.1016/j.biocon.2019.01.020

SESSION 7
ADDITIONAL SESSIONS

SESSION 7:
ADDITIONAL SESSIONS

7.1 Uptake, acceptance and impacts of agro-environmental management and policy instruments

Convenor:

Bettina Matzdorf, Leibniz Centre for Agricultural Landscape Research (ZALF), Germany

Targeted agro-environmental policies and measures are often crucial to provide environmental public goods. In practice, it is crucial how interventions finally influence the behaviour of land users. The uptake and acceptance of measures and new technologies is crucial for the impact that can actually be achieved in agricultural landscapes. In this session, different policies will be presented and discussed in terms of their design and impact on the ground.

Orals

Have agri-environmental schemes in Bavaria preserved permanent grassland?

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Keywords: Policy instruments, agri-environmental-schemes, permanent grassland

What policy instruments to choose for environmental protection in agricultural landscapes has been controversially debated. In Europe, agri-environmental policies are strongly determined by the common agricultural policy. Yet, countries and even single states, like in Germany, have a certain degree of freedom in shaping them. In the past, the Bavarian government has emphasized the use of incentive-based measures, like agri-environmental schemes and has made respective adjustments in comparison to laws on the federal level. This has also been the case for the protection of sensitive grassland areas, e.g. on peatlands and steep slopes. This makes Bavaria an interesting showcase for an analysis of the outcome of agri-environmental schemes.

In order to determine the effect of agri-environmental schemes on the preservation of permanent grassland, especially in certain sensitive areas like peatlands, an overlay of different spatially explicit data was carried out. The most important data source are the data from the Integrated Administration and Control System (IACS) for the period of 2005–2020. They include the parcel-specific information (~ 2 million) on use (crop/grassland type) as well as participation in agri-environmental schemes. The classified use changes from grassland to cropland over the period of 16 years, was overlaid with the spatial extent of different protected and sensitive areas.

Bavaria could not reach complete protection of sensitive grassland areas through agri-environmental schemes, but only reduced conversion rates. The effect was smallest for peatlands and areas with high groundwater table. Uptake of agri-environmental schemes was generally higher on sensitive grassland areas, while those areas that were converted from cropland to grassland showed low participation. An ex-post policy analysis like this offers the opportunity to come up with helpful recommendations for future policies. Especially the very high spatial and temporal resolution makes it possible to evaluate the success of agri-environmental schemes.

Conservation costs drive enrolment in agglomeration bonus scheme

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Agglomeration bonus schemes have become important policy tools when the environmental benefit hinges on spatial coordination of conservation sites. We here analyse how spatial factors affect the uptake of an agglomeration payment scheme in a Swiss mountain region, which seeks to establish a network of conservation areas to conserve favorable conditions for biodiversity. We use a combination of spatially explicit farm census (44,279 parcels) and survey data in a spatially lagged explanatory variable model. In addition, we also consider the collaborative process in establishing the eligibility of parcels for receiving the bonus payment. We find that parcels that are more distant from the farm as well as those at steeper slopes are more likely to enter the scheme. This implies that conservation costs are an important driver of the farmers' decisions. The results remain robust when controlling for a wide range of parcel, farm and farmers' characteristics. The analysis also showed that the collaborative process increased the enrollment of parcels cultivated by larger farmers managing their land more intensively. We conclude that the collaborative process increased the weight given to biodiversity from connecting conservation sites in the planning process of the agglomeration bonus scheme.

Farmers' acceptance of results-based agri-environmental schemes – Insights from a case study in North Rhine-Westphalia

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Keywords: Result-based agri-environmental schemes, contingent valuation, social nudge, biodiversity conservation

Biodiversity loss throughout the European Union (EU) continues to require adequate policy responses. While policymakers and society discuss stricter rules for a shift towards more eco-friendly farming, farmers protest against increased environmental production standards under increasing competition from countries with lower environmental standards. This suggests that European agriculture could benefit from policies that support biodiversity conservation while simultaneously reducing farmers' frustrations about stricter regulations under increasing competition from countries with lower environmental standards. To overcome adoption barriers of agri-environmental schemes (AES) related to inflexible land management prescriptions, result-based AES are increasingly being implemented throughout the EU. These schemes compensate farmers for reaching an environmental target, e.g. a fixed amount of indicator species, independent of how they achieve these goals. However, desired large-scale adoption of these result-based schemes is threatened since participating farmers risk losing the premium if they cannot reach the environmental target. This study aims at investigating acceptance of a hypothetically result-based AES for arable farmers in North Rhine-Westphalia (NRW), Germany, using an online contingent validation survey. To account for the increased risk of the result-based AES we use a hybrid approach by combining a process-based scheme with a result-based (top-up) scheme. Additionally, nature conversation requires fundamental changes in human behavior, and purely financial incentives may prove inefficient. The important feature of result-based AES is that they allow building social capital: farmers can use their context-specific knowledge and thereby feel appreciated. Still, it remains unclear how this social dimension of biodiversity conservation can be used to encourage behavioral change in the context of farming. Therefore, we examine the influence of a social nudge on the acceptance of the scheme. The hypothetical scheme targets at increasing biodiversity of pollinators by supporting weed-species richness in intensive arable production. We use a split-treatment design to investigate the influence of a social nudge on scheme participation and area enrolled in the scheme (intensity). We rely on a convenience sample of 63 farmers in NRW and find an average willingness to participate of about 60%. Besides the social-nudge treatment, we considered the role of behavioral factors for decision-making, based on the literature about agri-environmental scheme adoption. Results indicate no influence of the social nudge on participation and intensity. Cognitive factors, such as perceived risks, costs, and benefits of the scheme, determine the willingness to participate. The decision of how much land to enroll is determined by social factors, such as injunctive norms and signaling, and dispositional factors, such as risk tolerance. This study sheds light on farmers' decision-making and delivers a pilot-scheme for follow-up studies. The results could be useful for identifying possible communication strategies to enhance biodiversity conservation practices.

Mainstreaming Push-Pull Technology for Sustainable Intensification in East Africa: Opportunities, Constraints and the UPSCALE agenda

Adewole Olagoke[1]; Felipe Librán-Embid[1]; Mattias Jonsson[2]; Emily Poppenborg Martin[1]

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Reconciling population growth, biodiversity conservation and agricultural productivity for sustained food security is of global interest. In Africa, poor yields, pest infestations, climate change and other environmental issues are common impediments. The challenge is further compounded by the urgent need to adapt cultivation practices to ongoing climate change, and by the fact that conventional practices are unsustainable, environmentally costly and poorly adapted to low-income smallholder farming. Ecosystem-based methods, with low-input and climate-resilient attributes, are now being promoted as viable alternatives. Push-pull technology (PPT), which is based on locally-available companion crops, is one promising example, which can be harnessed for a sustainable intensification of smallholder farming in East Africa and beyond. PPT drives pests away from principal crops using a repellent legume intercrop (the push) and attracts them out to bordering grass trap plants (the pull). Its benefits in natural pest control, suppression of striga weeds, improved soil fertility and water retention, all culminating in ca. 3-fold grain yields and quality fodders for livestock are now well-established. The challenge remains finding effective ways to identify and disseminate decisive processes and prime lessons from on-field trials and early adopters for a facilitated spread of PPT beyond its current scope of application. Here, we present a framework for priority research agenda, envisioned in a multi-actor, cross-scale and interdisciplinary EU Horizon 2020 project named UPSCALE, to realize the transformative potential of push-pull technology by expanding its scope and applicability from individual fields to whole landscapes and regions, and from cereals to other important crops and cultivation systems. Aspects of scale-dependency over space and time, and interactions with community of practice and governance institutions, are well integrated. Through a variety of field-based analyses and socio-ecological modelling of current PPT farms, UPSCALE aims at fostering the design, adaptation and adoption of optimal strategies for integrated agroecological management based on push-pull technology for widespread and climate-resilient sustainable intensification. Overall, this framework will address food security, livelihoods and climate change resilience in East Africa and beyond, while reducing the environmental impact of agricultural practices. The project forms a part of the current EU Sustainable Intensification Programmes in Africa.

SESSION 7:
ADDITIONAL SESSIONS

7.2 Assessing land use change and supply chain impacts on ecosystem services and biodiversity

Convenor:

Katharina Helming, Leibniz Centre for Agricultural Landscape Research (ZALF), Germany

Solutions for agricultural management that are very rarely advantageous in every respect. Most often, improvements in one objective are accompanied by disadvantages for other objectives. In the case of complex systems such as agricultural systems, these trade-offs are particularly evident. They become visible in the debate of achieving multiple sustainable development goals simultaneously.Decisions for improved management therefore require a good anticipation of impacts, synergies, and trade-offs. This requires a systemic approach that mediates between social, ecological and economic processes and their interactions. The assessment need to link the range of spatio-temporal scales and address systemic effects and trade-offs, which include, for example, spillover effects from one location to another, seemingly completely independent location. Another systemic effect is related to rebound, when technology induced resource savings or efficiency gains are reduced of even cancelled out through adjustments in human behaviour.

The quest for improving the provision of ecosystem services and biodiversity through diversified agricultural management is not exemption. It often comes along with trade-offs, which need to be accounted for in management decisions. Understanding such trade-offs is therefore an essential prerequisite for sustainable management. Firstly, it requires a good understanding of the socio-ecological processes and the availability of respective data. Second, and equally important, negotiation of trade-offs must be understood as a deliberative process that takes into account the priorities and values of relevant stakeholders.

This session is dedicated to methods and examples of Assessing land use change and supply chain impacts on ecosystem services and biodiversity. Examples range across the spatial and systems scales.

Orals

Regional crop yield projections for informing Impact Mitigation Regulation measures

Daniela Bendel; Christian Sponagel; Sebastian Gayler; Elisabeth Angenendt; Enno Bahrs; Thilo Streck; Tobias KD Weber

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Land consumption is one of the prevalent threats to soils and their ability to provide ecosystem services, such as the production of food and feed. In Germany, the Impact Mitigation Regulation is an important instrument to impose biodiversity offset duties to compensate for interventions in nature and landscape and for resulting losses in ecosystem services. These obligations are often implemented on agricultural land where they can lead to omission or reduction of yield.

The aim of our study was to quantify the potential loss in future crop yield production caused by consumption of farmland due to construction activities, amplified by conversion of agricultural production sites into compensation areas in order to offset construction projects. As study area, we chose the densely populated Stuttgart Region in the Federal state of Baden-Württemberg, Germany, which is characterized by fertile soils and a high level of agricultural activity.

Potential crop yields were quantified using distributed agro-ecological modelling. To this end, we modelled the yields of winter wheat, winter rape, spring barley, silage maize, grain maize, sugar beet and potatoes for the six districts of the Stuttgart Region up to the year 2050. The spatially explicit soil model was initialised based on the information contained in the soil units of regional digital soil map 1: 50,000 (BK 50). Each of the 3,500 modelled sites was representative for all sites of similar soil properties (similar soil units in the soil map) and weather conditions, in total about 80,000. We used the coupled soil-plant model ExpertN in the configuration GECROS (plant growth), Hydrus-1D (Richards equation; soil water flow), DAISY (heat transport and nitrogen mineralization), and LEACHN (other nitrogen processes). The GECROS model considers the increase of CO2 concentrations in a process-based way.

We calibrated the soil-crop model using crop yield data from the statistical office Baden-Württemberg, which is based on farm surveys in the respective districts and which currently is the best freely available dataset on grain yields. Information on the fields provided by the Integrated Administration and Control System (InVeKoS) was used to allocate the yields to the soil units. Projections were driven by a climate model ensemble (DWD v2018) with six members under the RCP8.5 scenario. The DWD v2018 dataset is the finest resolution climate projection data (5x5 km2) commonly available. It was bias corrected based on the DWD HYRAS dataset we used for model calibration.

The spatially explicit yield data will be used in a geodata-based economic land use optimisation model to evaluate different conservation offsetting scenarios for their impact on yields and to calculate future yield losses based on regional planning instruments, i.e. land use plans.

The possible uses of these yield projections are diverse, but in our case they are intended to provide information about how regional planning and biodiversity offsetting can be implemented with minimal crop yield losses.

Shaping climate change adaptation in agriculture towards regional conditions – an interdisciplinary approach

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Keywords: Climate change, adaptation, mitigation, interdisciplinary evaluation

Climate change imposes multiple challenges on arable farming in Central Europe in the future which will force farmers to modify their agronomic systems. Further, agriculture is challenged to contribute itself to greenhouse gas reduction. Our research aims at identifying reasonable adaptation measures for arable farming. We use a participatory, regionally adapted development approach and assess potential measures by interdisciplinary modelling. We aim at identifying and mitigating trade-offs between ecological advantages and economic viability.

For three research regions in Northern (parts of Schleswig Holstein), Eastern (parts of Brandenburg) and Southwest Germany (Kraichgau and parts of the upper Rhine valley) we identified adaptation and mitigation strategies with respect to arable farming by using a participatory approach. We set up standard cropping patterns by using statistical means, which are regionally adjusted to observed crop prevalence. A clustering approach allows allocating different cropping patterns on a sub-regional scale. Each crop is characterized by specific cultivation methods, fertilization schemes and distinct generic application patterns for pesticide use. We analysed climate from the past and future climate modelling results using 17 CORDEX model chains using the RCP 8.5 pathway on a 12.5 km grid resolution. A statistical approach was used to relate climate parameters to yield levels in observational years to estimate possible yield developments for the time frames of 2040 and 2060 for 10 major crops under current management conditions. Shifts in land use according to profitability are estimated using the optimization model MODAM.

With regard to climate change, we model four adaptation scenarios for each region (increased intercropping, reduced tillage, a regionally adapted measure and a scenario dedicated especially to GHG reduction) taking technical and regulatory constraints into account.

The cropping schemes are evaluated against a multitude of indicators. Economic indicators calculated by the database backed calculation model ADEBAR(BE) evaluate the change in profitability due to climate change and adaptation. Ecological indicators are applied for the calculation of GHG emissions and energy consumption using the MiLA model (Peter et al., 2017), soil conservation and environmental risk using the risk indicator SYNOPS (Strassemeyer et al., 2017). Estimated land use shares allow to extrapolate the crop related results on a landscape level. This enables the analysis of trade-offs among the land use and adaptation options and the identification of especially promising regional adaptation pathways. Finally, efficient agricultural measures to contribute to GHG reduction are identified.

The results will be made available to the public by a web tool were field specific assessments of current and adjusted cropping schemes can be conducted (SYNOPS-WEB+).

References:

Peter, C., Specka, X., Aurbacher, J., Kornatz, P., Herrmann, C., Heiermann, M., Müller, J., Nendel, C. (2017). The MiLA tool. Modeling greenhouse gas emissions and cumulative energy demand of energy crop cultivation in rotation. In: Agricultural Systems 152, S. 67–79.

Strassemeyer, J., Daehmlow, D., Dominic, A. R., Lorenz, S., Golla, B. (2017). SYNOPS-WEB, an online tool for environmental risk assessment to evaluate pesticide strategies on field level. In: Crop Protection 97, S. 28–44.

Confronting hard truths in supply chain sustainability

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International commodity trade is a mainstay for many of the world´s economies. Yet despite widespread efforts and commitments to promote greener, more equitable economies and greater resource efficiency, many of the world´s production and consumption systems are environmentally and socially unsustainable. Sustainability initiatives targeting these consumption-to-production systems face enormous challenges. Some of these we talk about every day. But many of the biggest challenges – what we might call "hard truths" – we repeatedly ignore, overlook or push aside. Sometimes it is because we are genuinely unaware of these hard truths, or at least unaware of how challenging they are. All too often we deliberately avoid thinking or talking about them. They are the proverbial elephants in the room when we debate and design solutions. But until we confront them, transformative change in the sustainability of commodity supply chains will never materialize. The sustainability of global commodity supply chains is replete with challenges that could be considered hard truths by some actors, including the fact that e.g. at the point of sale, too few consumers are willing to pay the price premium necessary to support more sustainable production practices, or the fact that shifts in global markets, especially through rapid increases in demand in countries such as China and India, mean that the share of commodities like soy and palm oil being traded, processed and retailed by actors with strong sustainability commitments is decreasing. We will present a conceptual framework and dialogue approach – supported by empirical examples – to facilitates efforts by sustainability actors to understand, identify and address hard truths such as these. This includes how we define them, the reasons why they are commonly overlooked, and proposed steps for how to confront them. A number of factors combine to make a hard truth in sustainable production and consumption work: it is hard to address, it significantly limits the potential success of our interventions, and it is habitually overlooked or downplayed in planning interventions. There are three overarching reasons why a hard truth may be habitually overlooked (1) Lack of awareness: Some problems are simply not known about or their implications are not adequately understood by the people designing the intervention, (2) Lack of agency: Some problems cannot be solved by a particular actor or group of actors alone, and (3) Lack of motivation: Sometimes actors simply are not sufficiently motivated to confront the hard truth, perhaps because it would clash with their other priorities. By their very nature hard truths cannot easily be addressed, at least not by producers, businesses, governments or other actors working alone. Even when the hard truths cannot be tackled directly, it is better to acknowledge their existence and take account of their implications in framing our discourse and our assumptions about what works and what doesn't. Otherwise we are destined to repeat our mistakes, have unrealistic expectations, and fail in our sustainability goals.

Poster

Modelling the effect of feeding management on on-farm greenhouse gas and nitrogen emissions in dairy cattle farming systems using process-based models

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Feed management decisions are an important element of managing greenhouse gas (GHG) and nitrogen (N) emissions in livestock farming systems. Statistical and empirical models are well-suited for practical applications when evaluating mitigation strategies, such as GHG calculator tools for farmers and for inventory purposes. Process-based simulation models are more likely to provide insights into the impact of biotic and abiotic drivers on GHG and N emissions. These models are based on equations that mathematically describe processes such as fermentation, aerobic and anaerobic respiration, denitrification, etc., and require a greater number of input parameters (eg. climate data, animal data, detailed feed data, soils, and crops data). Combining a whole set of process-based models (or their results) that simulates the variation in GHG and N emissions and the associated whole-farm budget has not been used. The latter represents a valuable approach to delineate underlying processes and their drivers within the system and to evaluate the integral effect on GHG emissions with different mitigation options. Therefore, this study aims to describe how to implement this approach from animal to field level with process-oriented modeling approaches, and the steps of the modeling process in order to have an integral assessment of GHG and N emissions. Two well-monitored case study farms, a confinement system in Germany and a grazing system in New Zealand will be assessed using this methodology and will be compared to evaluate the variation encountered in the Carbon (C) footprint of the two systems. The research is still ongoing, but the preliminary results from animal simulations show substantial differences between the outputs from process-based models and the current default emission factors (EF's) applied in national inventories.

Improving Cd risk management of rice cropping system by integrating source-soil-rice-human chain

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Cadmium (Cd) accumulation in rice (Oryza sativa L.) leads to a large number of public health risks. To better understand the critical processes of Cd-related health risks and to inform mitigation policies, an integrated assessment method was developed by coupling source-soil-rice-human systems, which was subsequently applied to a rapid developing industrial and agricultural area. This assessment method has three major steps: (i) survey of anthropogenic Cd sources from 1990 to 2017 by the mass balance law, (ii) build a prediction method and predict soil Cd concentrations in 2030 according to different mitigation scenarios and to the soil Cd dataset collected in 2003 and 2013 and (iii) evaluate human health risks by undertaking an extensive literature review of Cd related human diseases and the prediction results. Our results indicated that Cd emission sources increased fourfold from 1990 to 2007, and stabilized at the high value from 2008 to 2017 in the study region. The Cd fluxes in 1990–2017 varied from 3.93 to 73.49 mg m-2. Raw coal consumption contributed to approximately 50% of total Cd fluxes. During 2003–2013, the soil Cd concentration increased from -2.34 μg kg-1yr-1 to 7.94 μg kg-1yr-1 with an average 5.14 μg kg-1yr-1. Under the current industry and agriculture developing trends, farmland soil in 2030 will face significant Cd pollution risks and the average soil Cd concentration will increase to 0.35 mg kg-1 which is 1.75 times higher than that of 2003. Consequently, higher Cd concentrations were predicted in rice grain and human blood. About 3.43% and 4.96% people may have obesity and hypertension for adults and higher risks in physical, cognitive, neurobehavioral development for children, respectively. The mitigation solutions of sources reduction and phytoremediation technology in rice system can significantly decrease Cd-related health risks. These strategies are far less effective in heavily polluted soils. This study provides critical information on Cd emission factors, Cd related human diseases, and a novel and useful tool for policy-makers on metals pollution management.

Agricultural Production, distribution and the demands for pesticides in Nigeria

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Talent Upgrade Global Concept

Keywords: Pesticides, Nigeria, farmers, onion, Bambara nut

The demands for all form of agricultural inputs such as the seeds, fertilizers, pesticides all over the world are increasing, but there must be guided agricultural policies related to the usage, supply, regulation and policy frame work so that it can benefit the farmers, agricultural players at large.

This paper focus on the needs to explore the use of the pesticides in preservation, storage systems for Onions and Bambara nut, because here in Nigeria there was a bumper harvest of onion, which was recorded in Sokoto and this year Bambara was translated into a great income and booms for the farmers. The use of the different agrochemicals are based on the individuals purposes in storage, preservation, although the usage must be guided with principles, economically factors, safety of production, distribution systems, food quality and security , understanding the agronomical principles, social factors towards sustainable agricultural systems. Here in Nigeria the different Bambara nut is stored either in special coated sacks or pesticide's treated normal sacks, some weevils like those that destroy beans also attack Bambara nut , so to store effectively someone have to be carefully so that the seeds will not damage, which is a seasonally, many people are engaged in the local processing of Bambara nuts. Girls is involved in the processing, distribution and selling of the crops, it is traded in almost every weekly market in the North. Meanwhile the onion farmers in Nigeria and dealers have made passionate appeals for provision of Morden storage facilities and more support from government in the form of soft loans and others such as fertilizer's, pumping machines and pesticides.

THeKLa: knowledge exchange network for climate change mitigation in agriculture

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Agriculture is facing the major challenge of maintaining stable food production under a changing climate. While environmental changes pose a threat to crop production, agriculture is also an important producer of greenhouse gases (GHG), particularly methane and nitrous oxide. Because these gases are about 25 and 300 times more harmful than CO2, the German Climate Protection Act has given the agricultural sector specific GHG reduction targets. Furthermore, Europe ambitious plan towards climate neutrality and agricultural sustainability expressed in the Green Deal, the Biodiversity and Farm to Fork strategies stress the need for an integrated approach when designing climate mitigation solutions. Although evidence-based climate change mitigation solutions have been developed in various fields of agricultural production in the last 20 years (such as the use of bioenergy crops, reduced tillage, fertility-building crops), the adoption among the farming community is still limited.

During that same period, the agricultural sector has seen tremendous change in how its knowledge is transferred. Agricultural extension services transited towards more privatisation of knowledge transfer. Considering the increasing complexity of multifunctional agriculture expressed by the European climate targets, there is a need to develop a consensus on efficient climate change mitigation and tackle the problems related to GHG emission from the agricultural sector. Cropping system diversification, by increasing the diversity in crop rotations with the introduction of cover crops, break crops, legumes, or grass-leys, has been suggested as both a climate mitigation and adaptation measure, among other environmental benefits. However, its implementation such as in the greening of the Common Agricultural Policy has been challenging so far. There is a need to further assess how moving towards more diverse cropping systems will affect the whole agricultural system considering GHG emissions, the production of food, feed, energy, and raw material crops and indirectly, land use and biodiversity. To achieve this, solutions must be considered from a broad range of perspectives.

Therefore, the Expert Network Greenhouse Gas Assessment and Climate Protection in Agriculture (THeKLa) aims at linking researchers, agricultural extensionists and political stakeholders interested in sharing their expertise on GHG reduction and its application in agricultural practice. The overarching goals are to facilitate knowledge exchange, initiate collaborative projects, facilitate the adoption of mitigation measures for themes related to climate protection. Among others, cropping system diversification could be address as a relevant theme within one of THeKLa’s working groups. The interested participants are welcome to contribute to discovering knowledge gaps and assessing barriers to knowledge use with the purpose to inform either practitioners or decision makers how to take climate mitigation in agriculture a step further.

The importance of Riparian Ecological Infrastructures for biodiversity and Ecosystems Services in intensive Mediterranean agricultural landscapes

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Distinct landscape management strategies have been introduced in European agro-environmental policies to mitigate the biodiversity losses caused by farming intensification. Common approaches include subsidising the allocation of productive land to agricultural practices that are beneficial for soil, water and climate, the so-called Ecological Focus Areas (EFA). However, land and vegetated areas surrounding rivers are not included in the concept of EFA, despite the worldwide recognition of the importance of these zones for biodiversity and the provision of Ecosystems Services (ES).

Under the Optimus Prime project, we set out to determine the effects on biodiversity of remnant riparian ecological infrastructures (EI) in intensive agricultural landscapes using several biodiversity indicators and biodiversity-related ecosystem services (ES). We analysed two intensive irrigated cropland areas located in the floodplain areas of the Tejo and Sorraia Mediterranean rivers in mainland Portugal. Field sampling was conducted from May to July, with sampling sites in the riparian EIs and also in agricultural areas (hereafter, matrix areas). Methods included pitfalls for ants and spiders (2 months; 132 sites; 660 pitfalls); dummy caterpillars (1 month; 59 sites; 590 caterpillars) for predation services; and passive acoustic sampling for bats (3 months; 207 sites; 371917 records). Sampling sites were separated at least by 500m to avoid autocorrelation biases. Taxonomic identification was performed to the highest possible level and records assigned to functional groups. In the case of dummy caterpillars, predation marks were assigned to four predation groups: insects, reptiles, birds and mammals. Bayesian ANOVA with mixed effects was used to assess differences between sites from riparian EI and matrix areas by using study areas and month as random effect variables.

Connecting global frameworks with local insights: Operationalizing the IPBES framework at local scales for management typologies

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Application of the social-ecological theory into the analysis of management strategies is a key step to achieve more sustainable practices. While key global frameworks are increasingly available, their meaningful operationalization at local scales, especially for sites in the global south, remains underexplored. We aim to provide an analytical framework that guides the management typology of Social-Ecological systems at different local scales (the smallholder, the individual plot, and collective land tenure for management) and to assess indicators and their scale of analysis in a long-term placed based research in the global south. We created an analytical framework that brings together the conceptual frameworks of the Intergovernmental Platform on Biodiversity and Ecosystem Services (IPBES), the Essential Ecosystem Services Variables (GEOBON-EESV), and the long-term place-based insights at the Chamela Region in Mexico. By doing so, we identified five key components that modulate the management and production of Nature Contribution´s to People: 1) Ecological supply, 2) Co-production, 3) Benefits from nature contribution´s to people, 4) Demand (use and values), and 5) Management. We found that most of the indicators in the Chamela Region covered three of the five components of our framework: co-production (42% of indicators), ecological supply (18%), and management (21%). Co-production indicators address mainly the resources available to smallholders for managing their plots. Co-production and management had been assessed by indicators at the three management scales in the area (smallholder, individual plots, and communal land tenure for management), while ecological supply has largely been assessed at the individual plot, and Demand (use and values) at the smallholder one. The paramount importance of the interactions across scales that modulate coproduction has led to a proliferation of indicators, while ecological studies have historically focused on a widely used small set of indicators of supply at the individual plot. Co-production played a central role in long-term monitoring because it connected the different elements of the socio-ecological system as well as the different management at local scales. With these results, we offer an analytical framework useful for management professionals that seek to employ a social-ecological system approach to guide management typologies at multiple local scales, as well as the identification of key points that regulate the decision-making.

The spatial and temporal source-sink-dynamics of non-target arthropods under different intensities of plant protection products at the landscape scale simulated with the agent-based model ALMaSS

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The widespread use of plant protection products (PPPs) is considered as one of the main causes of biodiversity loss in agroecosystems during the last decades. Among others, beneficial insects and non-target arthropods (NTAs) are affected by the decline in species. PPPs can strongly affect NTA populations both on the farmland itself and on adjacent (non-target) land. At the same time, neighbouring areas and fields influence the population dynamics of NTAs on the farmland, for example through their land use and management practices during the year and their proportion of landscape elements. In order to be able to assess the risk of PPPs, it is necessary to exceed the field scale and consider the source-sink-dynamics of NTAs at the landscape level. The agent-based model ALMaSS integrates both, the spatial agricultural use and the temporal management measures together to estimate the population dynamics of NTAs under different PPP regimes (Topping et al., 2003). While ALMaSS is currently being applied in seven projects with different species across Europe, in Germany agricultural landscapes in Brandenburg and Lower Saxony were selected for the simulation of the most common ground beetle species (Bembidion lampros). The most important data bases for generating the spatial landscape conditions are topographic maps (ATKIS) and IACS data of one year, as well as soil data of the BÜK200 (soil type). This generates a high-resolution raster map (1 x 1 m) that is linked to the corresponding crop management simulation. It also forms the framework for the simulated population movements in the area.

For the estimation of the temporal variance of environmental conditions for ground beetles, precipitation data, information on vegetation height and cover over the course of the year and information on management measures for the most common crops and extensively used areas are processed. The latter is based on statistical information and expert interviews. The crop cover height and biomass production of the cultivated crops are determined via a vegetation growth model. Together with information on the time windows of PPP applications and tillage measures, they are incorporated into a crop management plan.

This results in a temporally and spatially dynamic pattern of use-specific management practices at landscape and field level. The simulation paints a picture of the population dynamics of ground beetles under different PPP scenarios. In this way, insights are gained into the relationship between PPP application, landscape structures and NTA.

References:

Topping, C. J., Hansen, T. S., Jensen, T. S., Jepsen, J. U., Nikolajsen, F., Odderskær, P. (2003). ALMaSS, an agent-based model for animals in temperate European landscapes. Ecological Modelling, Vol. 167, Issues 1–2, p. 65–82. https://doi.org/10.1016/S0304-3800(03)00173-X

The influence of type and configuration of Ecological Infrastructures on ant assemblages in Mediterranean intensive agricultural areas

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Keywords: Ants, Biodiversity, Ecosystem services, Formicidae, Greening, Portugal

Ants (Hymenoptera, Formicidae) are a ubiquitous and diverse group of insects, which provide valuable ecosystem services in agricultural landscapes. The complex set of changes in ant communities resulting from agricultural intensification may have widespread effects in the agroecosystems, due to their functional roles as omnivorous, phytophagous, predators, seed dispersers, scavengers, among others, and their multiple trophic interactions. Agricultural intensification has usually been associated with a significant reduction of biodiversity in the landscape. Therefore, there is a need to correct this trend. In this regard, the conservation and enhancement of Ecological Infrastructures (EI), i.e., natural or semi-natural vegetation (e.g., field margins, forests patches, hedgerows, riparian buffer strips) are considered important approaches to promote biodiversity and associated ecosystem services in agricultural landscapes.

In the scope of Optimus Prime project – Optimal greening of irrigated farmland to achieve a prime environment, this study aimed at identifying EI types and spatial configurations that may enhance ant biodiversity and associated ecosystem services in Mediterranean intensive agricultural areas. The study was conducted in June and July 2019, in the Sorraia and Tagus valleys of Central Portugal. Ants were collected using pitfall traps in 132 sites, distributed within the agricultural matrix, and in the different EI types (riparian woody, riparian herbaceous, terrestrial woody and terrestrial herbaceous). In each site, five pitfall traps were installed and left in the field for approximately 48 hours. Ant specimens were sorted out and identified at the species level in the laboratory, based on taxonomical keys and reference specimens. Landscape metrics related to connectivity and shape configuration were calculated.

The results showed a higher ant diversity in the EI patches than within the agricultural matrix. In total, 17153 individuals, comprising 47 ant species were identified, 20 in the agricultural matrix and 46 in the EI. Considering diversity, 27 ant species were exclusively associated with EI, while all (but one invasive) ant species in the agricultural matrix were also present in the EI. Apparently, ant diversity in the agricultural matrix is related to the nearest EI, which may act as a source. Large and complex woody EI patches seem to be particularly relevant for ant communities. Riparian and terrestrial woody EI may have a key role in maintaining ecological niches for most ant species, and in particular disturbance-sensitive species, such as cryptic ant species.

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Quantitative assessment of the dynamics of crop sequences at the field level in Germany

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Keywords: Crop rotation, cropping diversity, land-use intensity

The growing demand for agricultural products over the last decades resulted in the intensification of land use, such as the reliance on fewer and more profitable crops and less diverse crop rotations. These changes in management practices have been associated with threats to biodiversity and a decreasing resilience of cropping systems. To analyse changes in crop rotations, we used field level land use data from the Integrated Administration and Control System from 2005 to 2018 for 60,000 km² of cropland in Germany. As a proxy for crop rotations, we classified all crop sequences and identified the paramount crop sequence types for three seven-year periods (2005 to 2011, 2008 to 2014 and 2012 to 2018). Our results reveal that the overall diversity of crop sequences in Germany is high. Approximately, half of the cropland has crop sequences with four or more crop classes within a seven-year period and continuous cropping covers only 2% of the cropland area. The results suggest, that larger farms tend to have more diverse crop sequences, and organic farms tend to have lower shares of cereal crops. We further reveal a recent trend towards less diverse crop sequences, particularly in former East Germany, although diversity remains high overall. Fine-scale spatiotemporal monitoring of changes in crop sequences at the field level sheds light on changes in land-use intensity and is important for assessing how policies and management changes affect crop rotation patterns.

References:

Aramburu Merlos, F. and Hijmans, R. J. (2020). The scale dependency of spatial crop species diversity and its relation to temporal diversity. Proceedings of the National Academy of Sciences: 202011702. https://doi.org/10.1073/pnas.2011702117

Bowles, T. M., Mooshammer, M., Socolar, Y., Calderón, F., Cavigelli, M. A., Culman, S. W., Deen, W., Drury, C. F., Garcia y Garcia, A., Gaudin, A. C. M., Harkcom, W. S., Lehman, R. M., Osborne, S. L., Robertson, G. P., Salerno, J., Schmer, M. R., Strock, J. and Grandy, A. S. (2020). Long-Term Evidence Shows that Crop-Rotation Diversification Increases Agricultural Resilience to Adverse Growing Conditions in North America. One Earth 2(3): 284–293. https://doi.org/10.1016/j.oneear.2020.02.007

Stein, S., Steinmann, H.-H. (2018). Identifying crop rotation practice by the typification of crop sequence patterns for arable farming systems – A case study from Central Europe European Journal of Agronomy 92:30–40. https://doi.org/10.1016/j.eja.2017.09.010

Plant and soil biotic diversity drive forage yield parameters in forest-grassland transition zones

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Understanding ecological spill-overs between land-use systems is essential for collaborative landscape management, particularly for site-specific management that reflects best possible opportunities for habitat protection and agricultural production. Forest-grassland transition zones are sites that can support the needs of diverse species, while also generating forage for dairy and meat production. While plant diversity is typically higher at the forest boundary edge and decreases further into the field, yields are low closest to forest edge, and increase with distance into the field. This trend is often explained with (water, nutrient) competition and micro-climate effects. Since soil biota depend on the plant litter both from forests and grasslands along transition zones, they should follow similar diversity patterns as plant species. Studies have shown that plant diversity controls belowground biota and its diversity, since plant species are substantially different in the belowground communities that they support. On the flip side, soil biodiversity is essential to the decomposition of plant material and turnover of nutrients that stimulate plant growth. But how these functional relationships are affected by abiotic gradients and land-use boundaries is unclear. Investigating the interaction between plant diversity, soil biota, and forage production quantity and quality along microclimate and abiotic gradients in grassland could contribute some insight to this complexity. We studied this relationship in forest-grassland transition zones in 20 different fields, each with one transect, throughout the Uckermark, in north-eastern Germany. Each transect had sampling points 8m in the forest, at the forest edge (0m), and into grassland fields (4,8, 16, and 32m). In the spring of 2020 we inventoried vegetation, collected earthworms and soil samples, and then harvested fodder. Soil samples were analysed for carbon, nitrogen, and bacteria:fungi ratios. Fodder was dried, weighed, and then analysed for its quality (protein, micro and macronutrients). Data will be analysed used structural equation modeling to discern how distance from forest may shape the effects of plant and soil biotic diversity on forage yield parameters. A better understanding of how landscape gradients affect the relationship between plants, earthworms, and microorganisms and the resulting forage yields can be insightful for land users, and help them make better use of marginal areas across landscapes.

Insectary plants in commercial greenhouses: a case study in the Oeste and Sudoeste Alentejo regions, Portugal

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The greenhouses across the Mediterranean Basin are mainly plastic (PE) structures that are not completely closed. As the temperature, crops and weeds inside greenhouses are not very different from outside, pest species in protected and open field crops are similar. Similarly, natural enemies that control these pests are also the same, although the importance of some species, both pests and natural enemies, can differ in protected and open field crops. In such scenario, weeds inside and outside greenhouses and crops outside greenhouses can be seen as source of pests and/or biological control agents. Thus, the management of the vegetation in the vicinity of the greenhouses or even inside greenhouses is crucial to the success of conservation biological control (CBC).

CBC depends on naturally occurring pest enemies and, therefore, is more adapted to deal with their preys. The adoption of CBC strategies allows the construction of a more resilient agricultural ecosystem by increasing the landscape biological diversity and complexity. By promoting greater diversity, it is possible to use a greater number of species of natural enemies naturally present in the ecosystem, that are adapted to the local climate, prey, and hosts. In this context, some species of plants can serve as insectary plants, providing seasonal refuge, food, and water sources for predators, parasitoids, and pollinators. Such strategy results in an offer of beneficial insects in the crop, but it can also end up being a reservoir of pests or diseases. Therefore, CBC requires knowledge, planning, and maintenance. For that, it is essential to select plant species that do not represent a risk to the crop and also to know the host species of the beneficial insects of interest.

In Portugal, tomato is a high economic importance crop, and the consumers' demand for products grown with a lower use of pesticides (integrated pest management, organic, zero residue) has been increasing. Tomato crops are frequently attacked by pests such as the South American tomato moth (Tuta absoluta) and whiteflies (Trialeurodes vaporariorum and Bemisia tabaci). Mirids represent important biological control agents, with some species commercially available and widely used in tomato greenhouses in Europe. In Portugal, growers have been releasing Nesidiocoris tenuis (Nt) into tomato greenhouses, to control these pests. However, Nt is a zoophytophagous species, and when prey is scarce its plant-based feeding becomes a threat to crops. On the other hand, Dicyphus cerastii (Dc), native to the Mediterranean basin, often colonizes greenhouse tomato crops in the Oeste region.

As part of the UMBERT-ECO project (FCT PTDC/ASP-PLA/29110/2017) different plant species are being evaluated as insectary plants inside greenhouses, allowing the increase of populations of natural enemies such as Dc and parasitoids. Evaluation studies of possible mirids hosts and plants that attract whitefly and T. absoluta parasitoids have been performed in commercial greenhouses in the Oeste and Sudoeste Alentejano regions. Among the plants under evaluation are the sweet alyssum (Lobularia maritima), phacelia (Phacelia tanacetifolia) and marigold (Calendula officinalis).

Potential wild bee habitats in Germany as indicator for pollination services

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Wild bees are important pollinators of both crops and wild plants and therefore contribute significantly to the ecosystem service of pollination. Conserving, wild bee habitats such as extensively-used grasslands, hedges and tree rows, will also benefit animal and plant species which are dependent on similar landscape structures such as wild bees. Moreover, hedges and tree rows mitigate the erosion of fertile soil. However, in Germany wild bee habitats, and as a result pollination service, are at risk, especially due to agricultural intensification.

As part of the biodiversity strategy 2020, the EU member states had to report on the condition and services of the ecosystems in their national territory (EU-Commisson, 2011). For this report, we created a monitoring indicator of the habitat potential for solitary wild bees with a short flight range of 200 m on average. We considered all ecosystems in Germany (including forest, agricultural land, semi-natural areas and urban areas). The methodology was adopted from Zulian et al. (2013) who assessed the potential habitat of solitary bees at the European scale. They based their indicator on the CORINE land cover dataset (CLC) which has a minimum spatial resolution of 25 ha. Zulian et al. (2013) evaluated each CLC-class regarding potential occurrence of nesting and foraging habitats, based on expert evaluation. Furthermore, potential edge habitats along water surfaces, forests and roads were considered assuming that those habitats could also benefit wild bees. We transferred the European approach of Zulian et al. (2013) to the more detailed German land cover model (LBM-DE) which has a minimum spatial resolution of 1 ha and includes the CLC-classification. Additionally, we added linear elements from the German topographic-cartographic information system (ATKIS) (hedges, tree rows, rocks, streams, roads, railway lines and lanes) into our model. A national map of 5 x 5 m raster cell size was developed for the time period of 2015 displaying the spatial distribution of potential wild bee habitats in Germany.

Our map shows, that the average habitat potential for wild bees for all ecosystems in total in Germany is relatively low, 0.23 on a scale of 0 (low) to 1 (high). One of the main reasons is the high proportion of agricultural land in Germany. Agricultural land is considered to provide, if any, only temporary foraging opportunities for wild bees and restricted nesting opportunities for both ground and cavity nesting bees. We will present details of our approach including the difficulties to clearly differentiate between habitat types using remote sensing data such as the LBM-DE. Furthermore, opportunities will be discussed to include of additional datasets into the model.

References:

EU-Commission (2011). Communication from the commission to the European parliament, the council, the economic and social committee and the committee of the regions. Our life insurance, our natural capital: an EU biodiversity strategy to 2020. COM(2011) 244 Final. Brussels.

Zulian, G., Maes, J., Paracchini, M. L. (2013). Linking Land Cover Data and Crop Yields for Mapping and Assessment of Pollination Services in Europe. Land 2, 472–492.

Comparison of SOC change scenarios in diversified and non-diversified cropping systems at different scales. A case study from Northern Italy

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Keywords: Crop diversification, soil organic carbon, model prediction, upscaling

Crop diversification in intensive agricultural systems contributes to the environmental sustainability of farming systems. The H2020 Diverfarming project aims to promote low-input innovative practices of crop diversification involving researchers, farmers and agro-industries together in a consortium. In this framework, the aim of this work is to assess how diversified cropping systems can influence soil organic carbon (SOC) content. SOC represents an important soil property that can be effective in evaluating cropping systems. In a case study located in Northern Italy, two crop management scenarios with and without diversification options were investigated. A model was run to predict SOC in soils after a long period of diversification, compared with the same period of monocropping. Model predictions were performed first running the model with point data corresponding to available soil profiles, then generalizing the results to the field to which they belong, to have a comprehensive view of the effect of crop diversification. Since the evaluation of crop diversification effect at landscape scale is necessary to better guide agricultural planning, point model results were also interpolated at landscape scale with a machine learning approach. The spatial framework for this upscaling operation was made up of land units with relatively homogenous conditions (soil, climate and management).

Effects of landscape elements on spatial differences of microclimatic variables – comparison between measurements and modelling approaches

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Landscape elements play an important role in preventing wind erosion and protecting arable land outside of tillage and crop management practices. The wind reducing effect of any landscape element may influence leeward distances up to the 40-fold of its height. In addition, when the sun is shining, areas close to the landscape elements are shaded. Wind velocity and solar radiation are the primary affected parameter, which again have impact on temperature, dew formation, evaporation and soil moisture in the zones influenced by landscape elements (Veste et al., 2020). Therefore, not only the wind erosion susceptibility of a soil but also plant growth factors can vary considerably within short distances.

The combination of large fields and dry climatic conditions are favoring factors for wind erosion in the Federal State of Brandenburg. On the other hand, Brandenburg has a very diverse landscape structure, including forests, alley trees, hedges, small groves and many other habitats. Within the framework of the Cross Compliance regulations ((EC) No 73/2009) for direct support schemes for farmers a method has been developed, to include the influence of landscape structure in the assessment of wind erosion susceptibility of soils (DIN 19706; Funk et al., 2004). This method has been continuously developed and now uses the Digital Surface Model (DSM) from the laser scanning survey of Brandenburg to determine the location and height of any landscape element with a horizontal resolution of 1 x 1 m and a vertical resolution in the centimeter range. The height of each landscape element can be used to calculate the shading effects of the wind or the sun in a GIS. These calculations were compared with detailed measurements of meteorological parameter in and around shelter belts in an orchard.

Effects of agricultural diversification practices on near-saturated soil hydraulic conductivity assessed with the hood infiltrometer

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Keywords: Infiltration, in-field soil heterogeneity, soil texture, new field arrangements

Soil hydraulic conductivity is important to characterize soil structure and function and crucial to understand water movement in the soil. Regional climate change scenarios predict an increase of more frequent water shortage which highlights the need to further improve the knowledge of the soil water balance and water properties. However, knowledge on in-field variability of infiltration rates due to small-scale soil heterogeneity is limited, even though it might improve to manage crops more efficiently. Also, the effect of field management, including crop and soil management practices, on soil hydraulic conductivity is not fully understood and limits the prediction of water infiltration, especially during the early vegetation periods. The objective of this study was to compare the soil surface hydraulic conductivity of patches within a single field, which differ in cultivated crop, soil texture, and management system. The infiltration measurements were conducted in the patchCROP landscape experiment near Müncheberg, Brandenburg, Germany. This field consists of 30 patches which were established in March 2020, having two site-specific, five-year crop rotations that were selected according to the heterogeneous soil conditions of the field. The low yield potential rotation included maize, phacelia, sunflower and lupin. The high yield potential crop rotation had maize, phacelia, soybean, and oats. After harvest of all six summer crops, infiltration rate and hydraulic conductivity were determined with a hood infiltrometer in October and November 2020 in continuous field measurement campaigns. The hood infiltrometer was selected over other infiltrometers as no contact layer is required and the water can infiltrate into the undisturbed soil surface providing relatively precise values. The infiltration rates were obtained using pressure heads of 0 cm (saturated soil), -2 cm and -5 cm water saturation of the surface soil. The average steady state infiltration rates were highest (12.6 cm/h) at saturation and decreased for -2 cm (9.2 cm/h) and -5 cm pressure head (6.1 cm/h). For the six maize patches, which were evaluated directly after harvest, highest infiltration rates were obtained in patches with a topsoil texture of around 81% sand (saturated infiltration rate: 11.5 cm/h), lowest in patches with 77% sand (saturated infiltration rate: 4.0 cm/h). Regardless of soil textural differences, relatively high hydraulic conductivity of up to 19.0 cm/h at 0 cm was found in patches where the cover crop phacelia and rapeseed (canola) crops were already well established. The infiltration rates of the patches were related to plant physiological stage (especially root development), soil texture, and previous tillage activities. In order to design diversified cropping systems of the future, in-field soil heterogeneity should be considered to account for small-scale effects on the water balance and plant water uptake and to select site-specific, adapted crops and their respective management. Future studies should focus on the spatial mapping of soil hydraulic conductivity at the field scale and its dynamic changes depending on soil management and crop development. For this purpose, a larger effort is required including geostatistical analyses, pedotransfer functions, and geospatial

Location factors and dynamics of tree plantation expansion in two coastal river basins in south-central Chile: basis for land use planning

Fernando Peña-Cortés[1]; Cristian Vergara[1]; Jimmy Pincheira[1]; Francisco Aguilera[2]

[1] Universidad Católica de Temuco, Laboratorio de Planificación Territorial;
[2] Universidad de Alcalá (UAH), Departamento de Geología, Geografía y Medio Ambiente

Tree plantations have expanded rapidly during the last decades, specially in Asia and South America, and Chile has shown one of the largest increases in tree plantations in the world. The aim of this study was to analyze the dynamic and factors statistically associated with the expansion of tree plantations in two coastal basins in south-central Chile. We used logistic regression and a multimodel inference approach to assess the association of 13 location factors with tree plantation expansion in two periods (1987–2001; 2001–2015). The area of tree plantations increased by 292% and 196% in the Budi and Lingue basins, respectively. The presence of agriculture fields before conversion to tree plantations showed the greatest effect in both basins, followed by the suitability of the soil for forestry. Likewise, tree plantations were highly associated with the replacement of native vegetation, contributing to ongoing deforestation, and changes in forest policy increased the expansion in indigenous land.

MASTERCLASSES

FARMING SYSTEMS

Masterclass 1:

Cropping system diversification aiming at pesticide use reduction: Developing concepts at the landscape scale

Convenors:

Michael Glemnitz, Leibniz Centre for Agricultural Landscape Research (ZALF), Germany

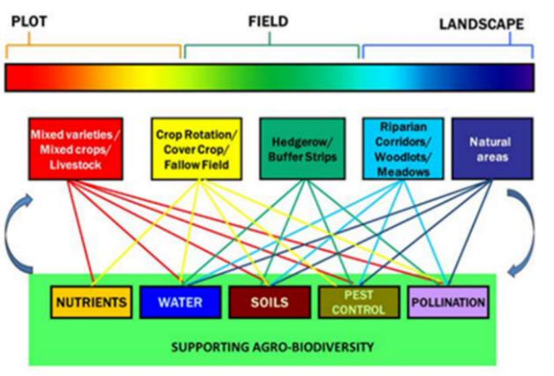
Kathrin Grahmann, Leibniz Centre for Agricultural Landscape Research (ZALF), Germany

Moritz Reckling, Leibniz Centre for Agricultural Landscape Research (ZALF), Germany

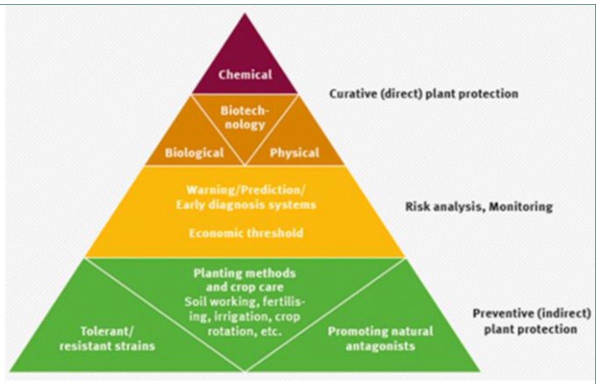
Dachbrodt-Saaydeh, Julius Kühn Institute (JKI) – Federal Research Centre for Cultivated Plants, Germany

Sandrine Petit, INRAE, France

Riccardo Bommarco, Swedish University of Agricultural Sciences (SLU)



Diversified farming systems: an agroecological, systems-based alternative to modern industrial agriculture
(Kremen, C., Iles, A., & Bacon, C. (2012), Ecology and society, 17(4).)



5-Point programme for sustainable plant protection
(Frische, T., Egerer, S., Matezki, S. et al. Environ Sci Eur 30, 8 (2018).)

Reducing pesticide use is a focal target of European agricultural policy and a key for farmers' public appreciation. Pesticide effects on farming systems and landscape ecology are complex which is also the case for any attempts for reducing pesticide use. Cropping system diversification (e.g. rotations, cover crops, legumes, intercropping, elements supporting biodiversity) could increase resilience of cropping systems through more spatial and temporal diversity.

Together with other agro-ecological measures (e.g. mechanical and biological control), cropping system diversification could result in reduced needs of chemical-synthetic pesticides. Empirical examples are still rare and it is challenging to generalize for large-scale farming conditions. A framework is needed to design strategies of diversification and to assess their impacts in terms of reducing pesticide use intensity and compare these in current and diversified systems.

This session will provide a platform for:

- Highlighting case studies of crop diversification and agroecology for increasing environmental benefits and resilience.
- Illustrating examples on the effectiveness of different crop protection strategies in an integrative assessment on environmental effects, biodiversity and agronomic consequences.
- Discussing pros and cons of different indicators for pesticide use intensities in relation to potential effects of crop diversification.

The session will conclude with novel options at the landscape scale on promising crop protection strategies through crop diversification. It aims to design a new framework, integrating aspects of diversification (e.g. Kremen et al., 2012) and pesticide use (e.g. Frische et al., 2018).

Masterclass 2:

Choice Experiments and Agent-based Modelling: Evaluating Preferences for Diverse Agricultural Landscapes

Convenors:

Mostafa Shaaban, Leibniz Centre for Agricultural Landscape Research (ZALF), Germany

Kati Häfner, Leibniz Centre for Agricultural Landscape Research (ZALF), Germany

The aesthetics of agricultural landscapes contribute to human well-being, the rural economy and tourism. It is the appearance of the agricultural landscape with its elements (e.g. hedgerows, stone walls), its structure and composition that defines these aesthetics. However, the perception of landscapes differs across people and conflicts can arise around: 1) what makes an agri-landscape attractive and 2) competing demands from different stakeholder groups (recreation vs. food production vs. nature conservation etc.). Balancing the different points of view and reducing trade-offs can be difficult, as there is only one landscape to be planned.

In this masterclass, we would like to introduce two complementary methodologies that would be promising in achieving a consensus in shaping the aesthetics of agricultural landscapes: discrete choice experiment and agent-based modelling. With these tools we can analyse preferences for diverse landscape views based on choices made in an experimental setting. Additionally, we can simulate the interaction between the choices of different actors and how they adapt their decision in response to other factors. We will illustrate the theory behind both approaches and how to develop such experimental model in an open-access agent-based modelling software (Netlogo 6.1.1). Moreover we will run a live experiment with the participants of the masterclass to design an agreed virtual landscape.

LANDSCAPE MANAGEMENT SYSTEMS

Masterclass 3:
Mapping local actors‘ diversity of demands for soil-based ecosystem services

Convenors:

Elsa Dingkuhn, Wageningen University & Research – WUR and Teagasc, The Netherlands

Tharic Pires Dias Galuchi, Wageningen University & Research – WUR and Devenish Nutrition, The Netherlands

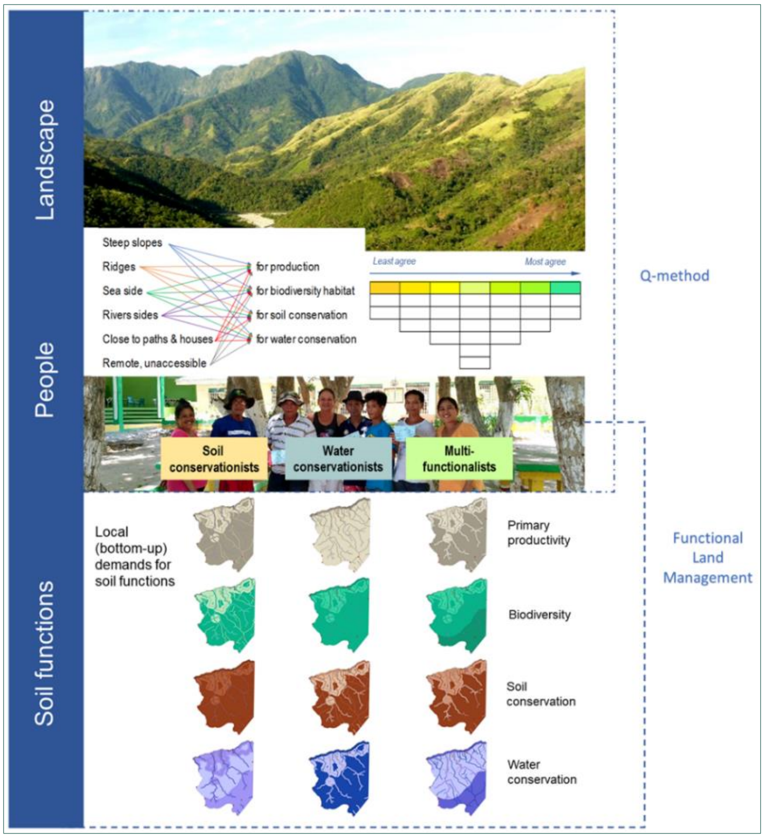


Illustration of a multi-method (Dingkuhn et al., 2019) to assess a landscape from local actors’ perspective. The first dotted frame (at the top) represents the Q-methodology to collect and cluster actors expectation. The second frame (at the bottom) represent the FLM framework (Schulte et al., 2014) to address soil’s ecosystem services and map their spatial distribution.

This masterclass will provide participants from several regions of the world with an integrative and transdisciplinary approach to map local actors' demands for ecosystem services (ES). Through hands-on workshops and practical examples from tropical and temperate landscapes, participants will learn a way to assess demands by mapping actors perspectives for soil's ES on a territory.

The world's lands must simultaneously provide agricultural goods while preserving natural resources and supplying ES. Moreover, people in a landscape may have different, and sometimes divergent, expectations for the land. Hence, in addition to defining sustainable land use and land management strategies that optimally meet demands for ES at a landscape scale, it is critical to determine scenarios that offer the greatest level of congruency and compromise among stakeholders. Understanding perspectives concerning ES in a landscape, and making this diversity legible can inform the design and implementation of governance instruments (e.g. policies) for greater landscape diversification.

The multi-method taught is a combination of Q-methdology, Functional Land Management framework (FLM) and GIS, allying environmental and social sciences. It is an useful tool for scientists and decision makers, as it helps identifying synergies and compromise areas for land(scape) management. It can thereby reveal convergence or resistance when formulating and deploying land-related policies. The outputs are also useful to moderate discussions among stakeholders and reach consensus.

Masterclass 5:

Living Labs for Landscape Research: Concept(s) and potentials for implementation

Convenors:

Lasse Loft, Leibniz Centre for Agricultural Landscape Research (ZALF), Germany

Jana Zscheischler, Leibniz Centre for Agricultural Landscape Research (ZALF), Germany

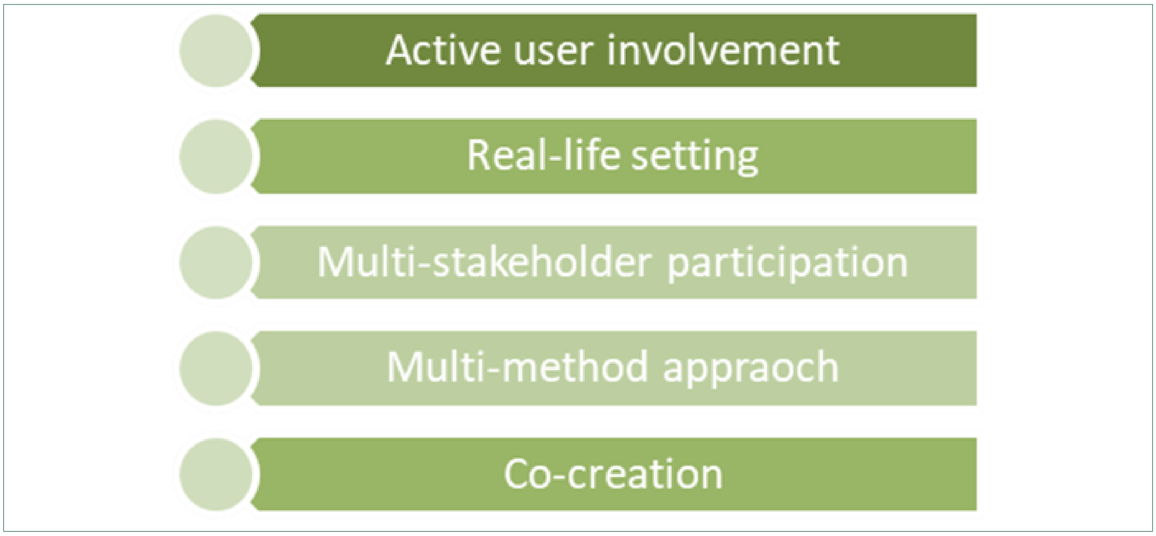
Sebastian Rogga, Leibniz Centre for Agricultural Landscape Research (ZALF), Germany

Maria Busse, Leibniz Centre for Agricultural Landscape Research (ZALF), Germany

Rosemarie Siebert, Leibniz Centre for Agricultural Landscape Research (ZALF), Germany

Bettina Matzdorf, Leibniz Centre for Agricultural Landscape Research (ZALF), Germany

Katharina Helming, Leibniz Centre for Agricultural Landscape Research (ZALF), Germany



Common Elements of Living Labs

Agricultural landscapes and land use are characterized by many social, environmental and economic challenges. Societal pressure is growing to initiate sustainability-oriented change, amongst them approaches for diversification of agricultural landscapes. In this context, a new and intervening role for science in real-world environments is increasingly being discussed. Transformative and action-research approaches such as Living Labs, real-world labs and niche experiments are considered as particularly promising. These labs can be regarded as facilities that enable experimentation and co-creation with users in real-life environments.

Originating in socio-technical innovation research, to date, these transformative research approaches are predominantly discussed and applied in the context of urban developments. The objective of this master class is to initiate a reflection on the potential of the Living Labs concept for linking or advancing inter- and transdisciplinary natural and social sciences research in their pursuit to contribute towards the transformation of agricultural landscapes into more resilient, sustainable social-ecological systems.

We invite participants from different world regions to share their experiences and to discuss whether and how Living Labs are suitable to prototype and test approaches for diversification. In particular we aim to:

- Shed light on Living Labs and alike concepts as an emerging model for interdisciplinary and transformative research;
- Reflect on the core elements, conditions, potentials and challenges for the adaptation of the Living Labs concept for research in agricultural landscapes;
- Sketching out an implementation plan for a Living Lab on a landscape level.

Masterclass 6:

The Net-Map method for social network analysis and its application in research on ecosystem services governance

Convenors:

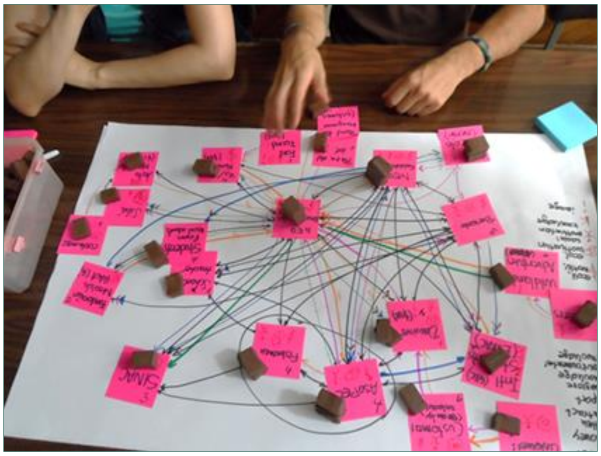
Claudia Sattler, Leibniz Centre for Agricultural Landscape Research (ZALF), Germany

Barbara Schröter, Leibniz Centre for Agricultural Landscape Research (ZALF), Germany

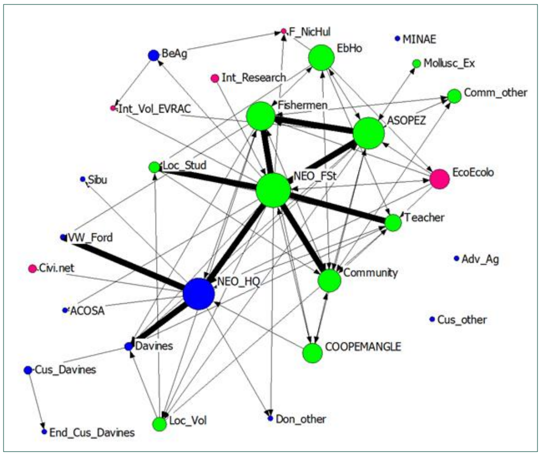
Cheng Chen, Leibniz Centre for Agricultural Landscape Research (ZALF), Germany

Rena Barghusen, Leibniz Centre for Agricultural Landscape Res earch (ZALF), Germany

A ‘physical’ Status-quo Net-Map developed during a face-to-face interview using paper and pens:



A ‚digital‘ Status-quo Net-Map visualized in UCINET/NetDraw (same case study as on the left):



The master class is addressed to junior and senior researchers from all scientific disciplines and geographical regions. It aims to introduce, apply, and discuss the Net-Map method for social network analysis (SNA), an interview-based method for participatory social network mapping. The method is suited to investigate networks for ecosystem services governance in regard to the following questions: Who are the relevant actors involved? How do these actors interact with each other? What are their roles and responsibilities? What motivates their engagement? How influential are they in decision making? Or, what benefit do they gain from their engagement? Two variants exist for its application: While Status-quo Net-Map is focussed on the analysis of a network structure at a given point in time, Process-Net-Map is focussed on the analysis of how a governance network has historically developed over time and/or how it will develop further into the future.

The method can be applied in face-to-face or online interviews. It yields both quantitative as well as qualitative data. The collected quantitative data are analysed and visualized with SNA software (e.g. UCINET/NetDraw, Gephi, or similar). Qualitative data are collected in the form of network narratives which help in explaining and interpreting the emergent network structures. They are analysed with software for qualitative text analysis (e.g. MAXQDA, ATLAS.ti, or similar).

The master class is addressed to everyone who is interested to learn about the Net-Map method and who likes to get a first experience in how it can be applied. The class also aims to stimulate discussion about the merits and limitations of the method.

Masterclass 8:
Community based systems to improve landscape resilience

Convenors:
Ana Paula Turetta, Brazilian Agriculture Research Cooperation, Brasil
Michelle Bonatti, Leibniz Centre for Agricultural Landscape Research (ZALF), Germany
Stefan Sieber, Leibniz Centre for Agricultural Landscape Research (ZALF), Germany

The key elements of CFS

The COVID-19 pandemic exposed the world to unprecedented scenarios in our recent history, revelling the vulnerabilities of our society. This impact also affected food supply systems. However, it can be an opportunity to propose and stimulate initiatives that are able to promote landscape resilience considering the food system. The food to fork must be shortened and diversified where it is viable and feasible, while made affordable for all societal levels.

The community food systems (CFS) approach finds room in this discussion since it copes with relevant principles, including the needs of low-income societies from areas particularly marginalised from mainstream food systems; of which those land areas can also pose as additional insurance in case occurrence of whatever crises. Systematizing the components and contributions of CFS can facilitate the development of strategies to better deal with crises and increase resilience.

Therefore, in this masterclass our start point will be presenting the key elements of CFS; this will be the basis of a co-creation process that the audience will be invited to evaluate, discuss and propose elements to a theoretical framework that could be used by decision makers as a conceptual guide for combating threats to food systems and promote landscape resilience.

CROSS SCALE SYSTEMS

Masterclass 9:
Sustainability impact assessment of agricultural management options: how to make better informed decisions

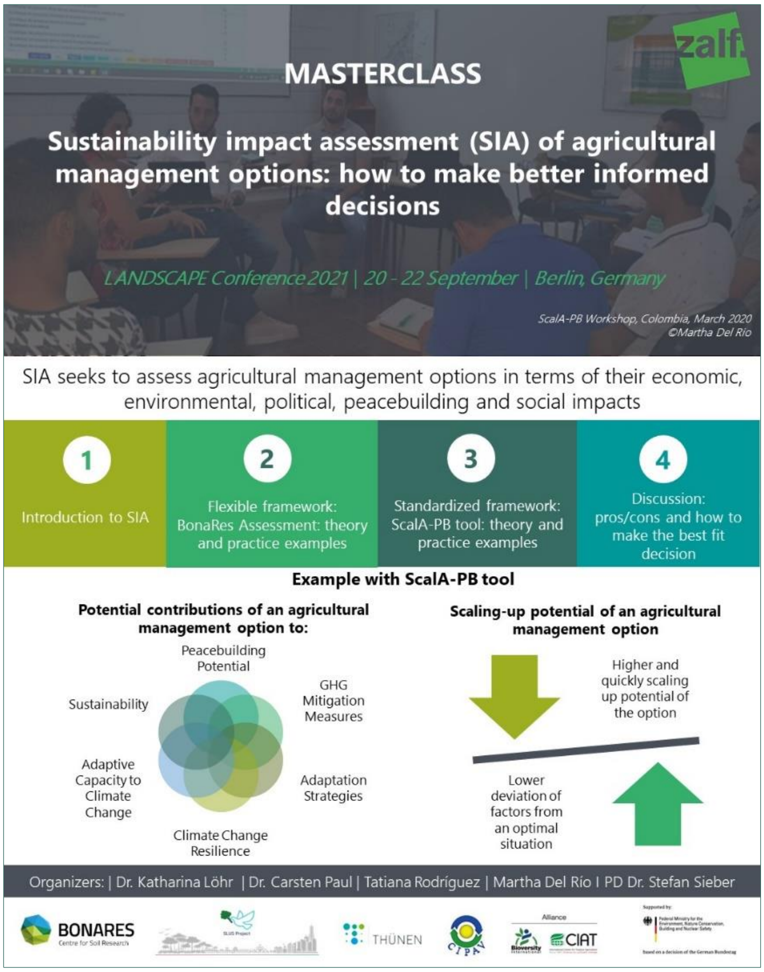
Convenors:

Carsten Paul, Leibniz Centre for Agricultural Landscape Research (ZALF), Germany

Katharina Löhr, Leibniz Centre for Agricultural Landscape Research (ZALF), Germany

Martha Del Rio, Leibniz Centre for Agricultural Landscape Research (ZALF), Germany

Tatiana Rodriguez, Leibniz Centre for Agricultural Landscape Research (ZALF), Germany



Agricultural management options have implications for resource use and for the supply of ecosystem services. Sustainability impact assessment (SIA) seeks to assess options in terms of their economic, environmental, political and social impacts in order to identify synergies and reduce negative impacts. To do a SIA, researchers need to:

- Select a SIA method, either a standardized approach, such as ScalA, or a more flexible framework, such as the BonaRes Impact Assessment Framework.
- With a flexible framework, researchers themselves need to define system boundaries, identify relevant impact areas, select indicators and finally weigh the relative importance of impacts. With a standardized approach, many of these choices have already been made by the tool's developers.
- In the case of ScalA, researchers need to recognize the inherent interlinkages not only between economic, environmental and social dimensions of development but also its relation to climate change and peacebuilding if SIA is applied in conflict affected environments. And to rate a set of pre-defined indicators regarding their sustainability, climate change responsiveness, and peacebuilding potential plus the potential for scaling-up of agricultural practices.

Masterclass participants will be introduced to SIA and two different SIA approaches. They will learn about the impact of methodological choices on assessment results, enabling better informed methodological decisions while mitigating risk of bias and enhancing objectivity.

CROSS SCALE SYSTEMS

Masterclass 10:
Participatory methodologies for the assessment and design of sustainable farming systems

Convenors:

Heitor Mancini Teixeira, Copernicus Institute of Utrecht University, The Netherlands

Heleen Prins, HAS University of Applied Sciences, The Netherlands

Pytrik Reidsma, Wageningen University & Research – WUR, The Netherlands

The management and design of sustainable farming systems is complex, demanding knowledge from different fields and the involvement of multiple stakeholders. The complexities involve social and political contexts, local knowledge and participation, role of organisations and development of new technologies and practices. To address these complexities, the lack of interdisciplinarity and disconnection between farming realities and scientific knowledge is often a problem. In order to overcome this gap, there is a need for strategies and methodological approaches that link science, farmers' practices and social organisations, enabling the horizontal construction of knowledge that is useful and effective on the ground.

Therefore, the main goal of this Master class is to engage participants and present a variety of innovative participatory research methods to assess and design sustainable an diversified farming systems.

After a short introduction on the topic based on a case study in Brazil, participants will be invited to share their own knowledge in a fun and interactive way. In addition, participants will also get the chance to explore, practice and test specific methods and tools. Examples of methods that will be covered during the class include Fuzzy cognitive mapping, Participatory soil quality assessments, Venn diagram and Pedagogical installations. All participants, from different parts of the world, from young to senior researchers, are welcome in this masterclass.

CROSS SCALE SYSTEMS

Masterclass 11:
Diversification in scenarios of future agricultural systems: Pathways, requirements and impacts

Convenors:

Ioanna Mouratiadou, Leibniz Centre for Agricultural Landscape Research (ZALF), Germany

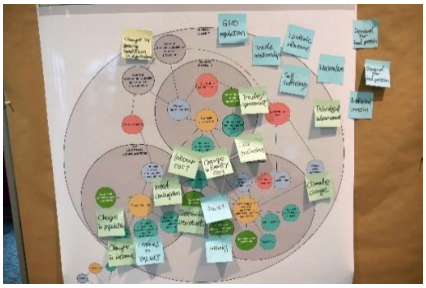
Alevtina Evgrafova, Leibniz Centre for Agricultural Landscape Research (ZALF), Germany

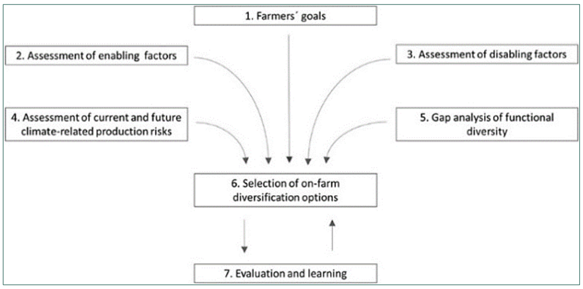
Katharina Helming, Leibniz Centre for Agricultural Landscape Research (ZALF), Germany

Hermine Mitter, University of Natural Resources and Life Sciences, Vienna (BOKU), Austria

Martin Schönhart, University of Natural Resources and Life Sciences, Vienna (BOKU), Austria

Elisabeth Jost, University of Natural Resources and Life Sciences, Vienna (BOKU), Austria





Examples of causal loops (left, Mouratiadou et al., 2020) and decision making frameworks (right, van Zooneveld et al., 2020) to analyse the role and pathways of diversification in the future.

The diversification of agricultural activities, landscapes and value chains involves complex processes inducing uncertainties with respect to the pathways towards it and its impacts (Ridier & Labarthe 2018). Scenario analysis, used as a foresight tool to explore the complexity and uncertainty associated with future developments (Giaoutzi et al. 2012), can be a valuable approach to understand future conditions, opportunities, requirements and risks for diversification and its impacts. Based on state-of-the-art scenario design research, this master class will explore the scope for diversification and its role in shaping sustainable and resilient agricultural systems across multiple scales under different future framework conditions. Succeeding the conference session on multi-scale scenario design for European agriculture, where five scenario studies will be presented, here we will explore how scenario assumptions, logics and scales relate to diversification in the five examples of scenario sets (Eur-Agri-SSPs (Mitter et al. 2020), legume cultivation, soil management, digitalisation, pesticide use).

We will examine what agricultural and food systems diversification means and reflect on the rationales behind the scenarios that lead to diversification. By exploring diversification in different scenario frameworks, the master class will increase understanding of the conditions, technologies, policies, scales, and value chains shaping the opportunities and risks for diversification and its impacts.

CROSS SCALE SYSTEMS

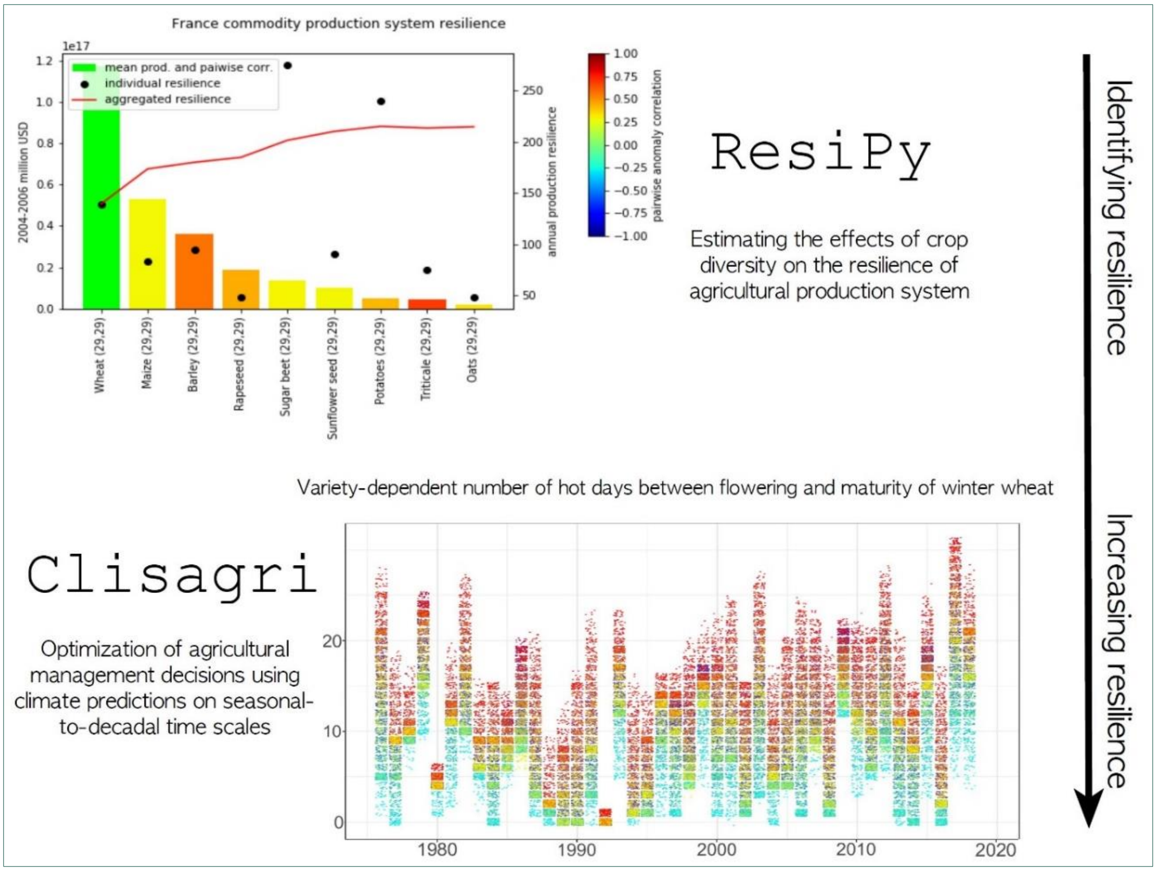
Masterclass 12:
Emerging climate services tools for sustainable resilient agricultural systems

Convenors:

Andrej Ceglar, European Commission

Matteo Zampieri, European Commission

Andrea Toreti, European Commission



This masterclass aims at providing an overview of recent methods and tools developed to enhance resilience of agricultural systems at different spatial scales, from farm scale to national.

These tools are essential to assess, evaluate and monitor agricultural systems, their resilience, and more specifically the role of diversity and crop diversification. Furthermore, it explores and gives participants the possibility to effectively learn two recently released tools: ResiPy and Clisagri.

ResiPy is an open-source python tool to assess the resilience of agricultural production systems in terms of stability and diversity of the production time-series. It can be applied at all scales and offers a simplified, yet powerful, tool evaluate development options to enhance resilience through input intensification, crop selection and diversification in the present climate and future climate change scenarios.

Clisagri is a complex co-design risk assessment tool implemented as an open-source R package. Clisagri quantifies the occurrence of different weather and climate events (including extremes) during sensitive crop growth stages. These sensitive stages generally occur in different periods every year as a consequence of inter-annual climate variability, and Clisagri offers an effective way to dynamically take this variability into account. Furthermore, risk assessment can be performed on a range of spatial scales, going from local to global. Combined with seasonal-to-decadal climate predictions and climate projections, Clisagri provides an effective tool to make informed decisions for a range of end-users (farmers, breeders, as well as regional stakeholders and food companies).

MARKETPLACE

BonaRes Repository

FAIR data management for your agricultural research

Convenors:
Carsten Hoffmann, Leibniz Centre for Agricultural Landscape Research (ZALF), Germany
Nikolai Svoboda, Leibniz Centre for Agricultural Landscape Research (ZALF), Germany
Marcus Schmidt, Leibniz Centre for Agricultural Landscape Research (ZALF), Germany

Our research data management concept follows the modern FAIR data principles to enhance the Findability, Accessibility, Interoperability and Reusability of research data. It is fostered by rich description with standardized metadata and DOI allocation. The specially developed metadata schema combines all elements from DataCite and INSPIRE. Metadata are entered by an online metadata editor and include thesauri (AGROVOC, GEMET), use licenses (Creative Commons: CC-BY for research data, CC-0 for metadata), lineage elements and data access points (geodata portal with OGC services). Data curation services include personal support and metadata review and tools for the whole workflow: data submission, metadata description and publication. Due to the high diversity of agricultural data individually tailored strategies were developed to increase data quality and make them citable.

BONARES

More informations: www.bonares.de

MARKETPLACE

NDICEA and N-Expert

Decision support tools for enhancing fertilization in vegetable production systems

Convenors:

Sarah Tietjen, Leibniz-Institut für Gemüse- und Zierpflanzenbau (IGZ), Germany

Rachel Fischer, Landwirtschaftskammer Nordrhein-Westfalen, Germany

André Sradnick, Leibniz-Institut für Gemüse- und Zierpflanzenbau (IGZ), Germany

The software tools N-Expert and NDICEA can help to improve the nutrient management in farming and lower the ecological and economical risks of nutrient leaching. They are developed to positively affect nutrient management in vegetable production systems. NDICEA gives a profound insight into the soils N- and C-dynamics with regard to the perennial crop rotation. N-Expert offers support in calculating the daily nitrogen demand of a brought variety of vegetable crops. NDICEA and N-Expert were developed independently and are available free of charge as downloads.

Both software is currently revised within the project Nutri@ÖkoGemüse (3/2019 to 2/2022), funded by the Federal Ministry of Food and Agriculture on the basis of a resolution of the German Bundestag within the framework of the Federal Program "Ökologischer Landbau und andere Formen nachhaltiger Landwirtschaft" (BÖLN).

AgoraNatura

Online Marketplace for Certified Nature Conservation Projects

Convenor:

Bettina Matzdorf, Leibniz Centre for Agricultural Landscape Research (ZALF), Germany

Launched in September 2020, the online marketplace AgoraNatura (www.agora-natura.de) provides targeted investment opportunities in certified nature conservation projects in Germany and facilitates an easier engagement for private individuals and companies. Through voluntary, flexible payments they can invest in projects supporting biodiversity and ecosystem services, such as the preservation of meadow orchards, the development of biodiverse agricultural fields or the implementation of protection sites for certain target species.

AgoraNatura aims to generate additional private funding for the safeguarding of nature and to strengthen public knowledge about biodiversity and ecosystem services. To achieve this goal, AgoraNatura connects land users and environmental organisations with committed private individuals and companies. The online marketplace is an engaging, easy-to-use digital tool that strives to facilitate more collaborative, voluntary conservation action on the ground.

AgoraNatura puts the scientific ecosystem services concept into practice: all projects on AgoraNatura are certified according to the science-based and independent Naturplus standard ensuring a high quality of the projects. The actual “products” of the online marketplace are nature conservation certificates, which describe and visualise the expected positive effects on biodiversity and ecosystem services. Each certificate is an area-related share of a certified conservation project with a validity of 100 sqm and one year.

agora natura

More informations: www.agora-natura.de

POST-CONFERENCE WORKSHOPS

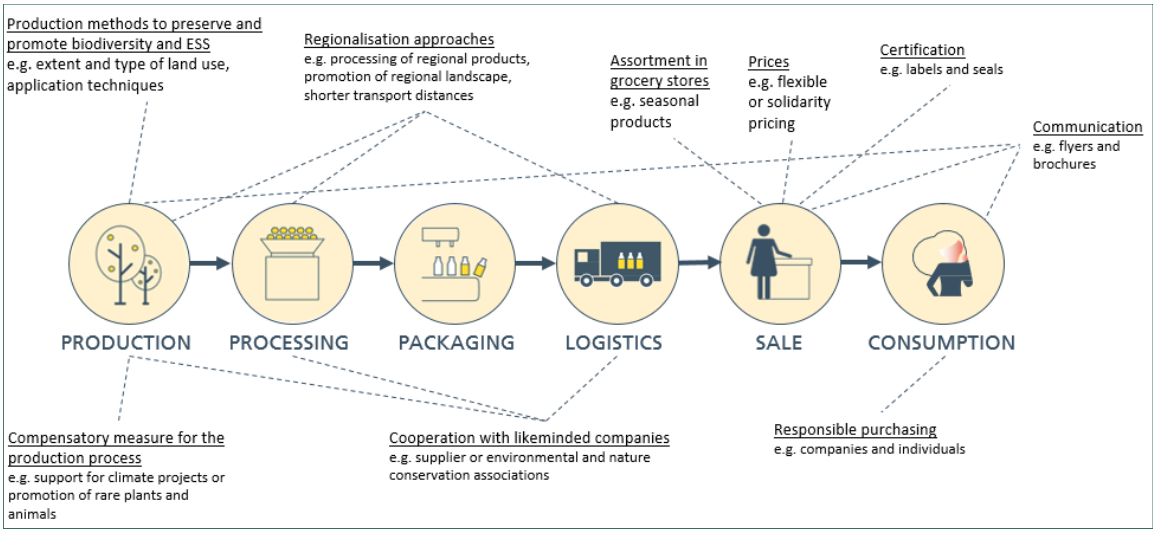
Workshop 1:

Valorisation of biodiversity measures and ecosystem services in different future scenarios

Convenors:

Ariane Voglhuber-Slavinsky, Ewa Dönitz, Björn Moller

Competence Center Foresight, Fraunhofer Institute for Systems and Innovation Research ISI, Germany



Valorisation options of biodiversity measures/ecosystem services

Biodiversity, ecosystems as well as their functions and services are gaining importance in public debate. This fact leads to considering various options of their valorisation. In the past two decades, the responsibility of promoting biodiversity was mainly attributed to agricultural production where the physical implementation/realization of measures takes place. However, due to the restricted possibility of implementing measures in an economically driven system of farming, new approaches have to be identified, enacted and followed. The whole agri-food value chain must be charged with this task.

The analysis in the workshop will cover options of today as well as options that are conceivable in the future. Different options for the valorisation of measures to preserve and promote biodiversity and ecosystem services (ESS) will be presented and analysed according to their strengths and weaknesses. The evaluation will be conducted along the value chain. Examples are products that are more expensive because ESS are promoted in production. On the other hand, innovative valorisation models will be identified and discussed in the context of the different future scenarios.

This should answer the questions, which valorisation options are most appropriate under the changing framework conditions of the different scenarios. Therewith identifying those novel approaches of valorisation that might be applied in one scenario and those applicable in several scenarios.

The work will be divided in a plenary part and breakout sessions for in depth discussions. From a methodological point, we will use the tetralemma approach, which is designed to break down existing bipolar patterns of thinking and to identify different trade-offs between the two poles or new approaches to solutions. Additionally a keynote talk will be held to trigger creativity and out of the box thinking. We want to give the opportunity to discuss with stakeholders along the value chain and provide a room for mutual learning.

Workshop 2:

Machine Learning for (soil) parameter prediction in R – A practical introduction

Convenors:

Marcus Schmidt, Leibniz Centre for Agricultural Landscape Research (ZALF), Germany

Marmar Sabetizadeh, Leibniz Institute for Agricultural Engineering and Bioeconomy (ATB), Germany

Masahiro Ryo, Leibniz Centre for Agricultural Landscape Research (ZALF), Germany

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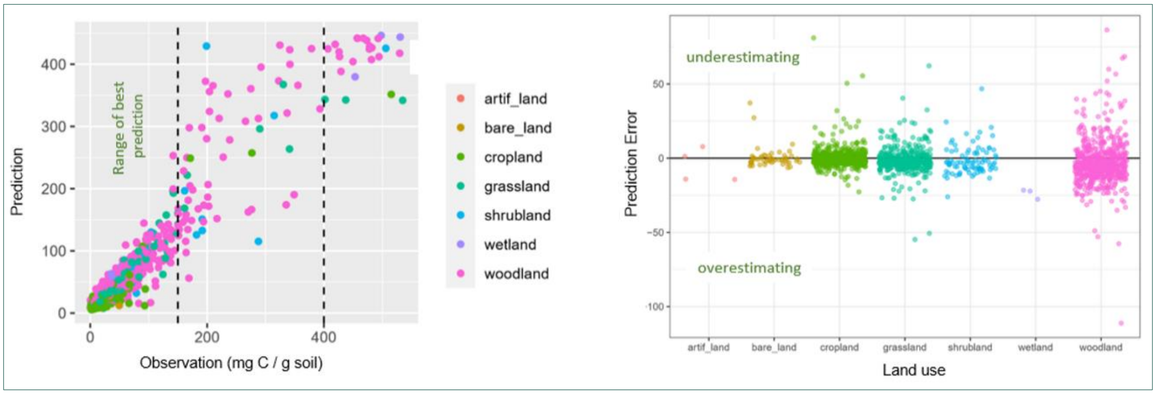


Illustration oft he observation prediction relationship (left) and error distribution (right) from a project on European soil data

Machine learning is everywhere. Movie streaming platforms and social media predict what you will like from vast amounts data. In medicine, machine learning is used to predict protein structures and in soil science, global maps can be filled with data based on similar observations where this data is available.

In this workshop, we will give an introduction to machine learning (especially focused on tabular data analysis; classification and/or regression) and demonstrate how training data is used to create and improve predictions for a parameter of choice. We will also talk about how such models can be interpreted so that they don't remain a black box. Additionally, we will discuss advantages and disadvantages of machine learning in comparison to conventional statistical modelling such as linear models. We will provide a relatively large data set and go through the process of selecting data, building different models and interpreting the results step by step. Our playground will be European soil data.

Our goal is that after this workshop, you will have elementary knowledge about machine learning and efficient tools in hand to apply common machine learning algorithms such as randomForest or k-nearest neighbours (knn) to your own data sets.

To make most out of the workshop, we recommend that you are comfortable with basic data handling in R such as setting up a project, importing & manipulating data, visualizing data in ggplot2 and writing very simple functions.

Workshop 3:

Let's come together! How can CGIAR research better contribute and support landscape approaches?

Convenor:

Natalia Estrada Carmona, The Alliance of Bioversity and CIAT

Integrated landscape approaches (ILA) is a promising strategy for achieving multiple outcomes on conservation, wellbeing, sustainable agriculture, and governance (Carmenta et al., 2020); yet various critical knowledge gaps in terms of performance and efficacity persist (Reed et al., 2020).

To date, CGIAR researcher's contributions to improving, enabling, and facilitating the adoption of ILA remain scattered, despite the critical role that the CGIAR can play in scaling up ILA for multifunctional agricultural landscapes.

The Water, Land and Ecosystems funded project, "Flipping the coin: managing agrolandscapes to tackle multiple global challenges through a landscape approach", worked in 2021 with CGIAR and non-CGIAR researchers to

1. Ascertain how CGIAR' research can improve designing, implementing, and monitoring landscape approaches for evidence-based outcomes at scale.
2. Identify the ideal institutional conditions that enable successful research on landscape approaches.
3. Increase the visibility of CGIAR's research over the past 10 years across Centers and Research Programs (CRPs) on landscape approaches.

Hence, we would like to have this workshop as an open and safe space to:

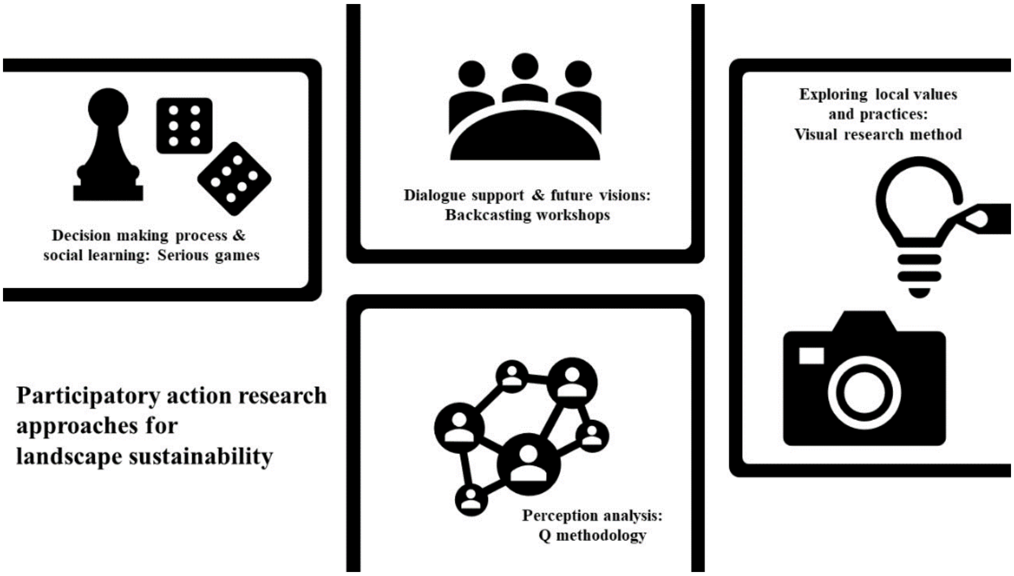
1. reflect with CGIAR and non-CGIAR partners on the findings from the "ascertain, identify and increase" activities, and
2. collectively collectively select, design, and sort-list the critical priorities for better supporting ILA and multifunctional agricultural landscapes in the next ten years.

We would like to use this workshop as a place for reflection, mostly with CGIAR researchers. Nonetheless, non-CGIAR researchers are also welcome to highlight and incorporate how CGIAR research contributing to ILA can be more meaningful and better articulated with existing efforts or initiatives.

Workshop 4:
Participatory action research approaches for landscape sustainability

Convenor:

Federico Andreotti, Wageningen University & Research – WUR, The Netherlands



Land-use change, climate crisis, price crisis, and plant diseases are compromising the diversity, sustainability, and resilience of agricultural landscapes. Supporting dialogue among the stakeholders who work and live the landscape can lead to cooperation and to sustainability transition. Participatory action research approaches showed to support and facilitate dialogue fostering solutions or highlighting conflicts in the landscape. Within these research methods serious games, backcasting workshops, Q methodology, and visual research methods are standing out. While the applications of these methods are spreading, the impact that these research approaches have on stakeholder's perceptions and on landscape management is rarely investigated.

The workshop aims to explore the potential of participatory action research approaches and to foster the discussion on how to assess the impacts of these methods. The workshop is divided into two sessions:

1. An overview of participatory action research approaches will be explored sharing experience from the fieldwork. The participants will discuss in small focus groups these methods reflecting on their experiences.
2. A serious game test on the role that species diversity has in the landscape. The experience will be collectively evaluateted for improving the design and for further reflect on how to assess the impact of this method.

In the first session of the workshop the convenor will share his previous research experiences, while in the second session the participants will test a prototype of an online serious game that the convenor is developing in the frame of the SESAM project.

References:

Andreotti, F., Speelman, E. N., Van den Meersche, K. and Allinne, C. (2020). Combining participatory games and backcasting to support collective scenario evaluation: an action research approach for sustainable agroforestry landscape management. Sustainability Science, 15(5), 1383–1399. https://doi.org/10.1007/s11625-020-00829-3

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