BioGARD

Bio-Geosphere Africa 2023

Research for Diversity and Sustainable Development in the Face of Climate Change

BOOK OF ABSTRACTS

Schloss Hohenheim
14. and 15. September 2023

Organized by

EBERHARD KARLS UNIVERSITÄT TÜBINGEN

UNIVERSITY OF HOHENHEIM

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Preface

The UN Sustainable Development Goals have challenged the scientific community to ensure a sustainable future for all amidst escalation of complex crises threatening the world. Given the challenge, cross-cultural partnerships are increasingly important in building actions that allow for successful implementation of environment friendly solutions. The University of Hohenheim and the Eberhard Karls University of Tübingen have, hence, come together to engage researchers from Germany and Africa, to share ideas on how to foster sustainable development in Africa, in this age of climate change.

The BioGARD conference is envisioned to bring together field experts, scholars, fellows, and students to discuss the underlying causes and interlinkages among environmental, social, and political challenges in Africa, focusing on the topics of bio- and geo-diversity, resilient agriculture, and health and well-being. The conference is intended to be a vehicle to exchange knowledge and ideas that would identify future directions for the integrative and sustainable development of Africa and to facilitate the adaptive capacity of social, health, ecological and agricultural systems in the face of climate crisis.

The conference is jointly organized by the University of Hohenheim and the Eberhard Karls University of Tübingen, both universities having a long-lasting tradition of having worked in different parts of the world, especially in the tropics and subtropics. The two universities have been conducting numerous collaborative research, training, developmental and teaching projects across all faculties, with diverse partners throughout the African continent. These partnerships span across universities, national research organizations, and international organizations based in Africa covering the topics concerning both bio- and geo-sphere.

This book of abstracts contains contributions from 53 authors in the form of 42 oral preorientation and 11 posters covering the subthemes:

- ***Bio- and geodiversity of Africa: Current status and challenges in the face of environmental change***
- ***Resilient agriculture and resource use in an increasingly unpredictable future***
- ***Resilient Health and Human Wellbeing under novel climatic and ecological settings***

As the scientific and organizing committee, we are delighted to welcome you to the BioGARD conference, and we look forward to the much-needed interaction and knowledge exchange in these issues that face us all in an era of dramatic climate change.

We gratefully acknowledge the financial support from the Ministry of Science, Research and Arts Baden-Württemberg through the University of Hohenheim and the Eberhard Karls University of Tübingen. Furthermore, we would like to express our gratitude to Foundation fiat panis for their generous support in funding the participation of three African scientists in the conference.

The BioGARD Scientific Committee

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Keynote Speakers

Dr Veronica Mwangi

Session: Resilient Agriculture

Day 1 14. September 2023 09:30 – 10:30:

Lecturer in Economic Geography at the Department of Geography, Population and Environmental Studies, University of Nairobi and researcher at the Centre for Training and Integrated Research in ASAL Development (CETRAD), Nanyuki and the African Cities Research Consortium (ACRC)

Veronica Mwangi is a lecturer in Economic Geography at the Department of Geography, Population and Environmental Studies, University of Nairobi. She is also a researcher at the Centre for Training and Integrated Research in ASAL Development (CETRAD), Nanyuki and the African Cities Research Consortium (ACRC). Veronica has broad research interests in rural and urban food systems, food security, poverty and livelihoods in sub-Saharan Africa. She is the chairperson, KAAD Association of Scholars of East Africa (KASEA) and a member of the International Association for the Study of the Commons (IASC); and the Young African Researchers in Agriculture Network (YARA).

Professor Dr Marc Mendelson

Session: Resilient Health and Human Wellbeing

Day 1 14. September 2023 14:30 – 15:30

Professor of Infectious Diseases and Head of the Division of Infectious Diseases and HIV Medicine at University of Cape Town, South Africa

Marc Mendelson is Professor of Infectious Diseases and Head of the Division of Infectious Diseases & HIV Medicine at Groote Schuur Hospital, University of Cape Town. He undertook his PhD and Infectious Diseases training in Cambridge before moving to The Rockefeller University in New York and then to UCT in 2001 for postdoctoral work. He is Chair of the Ministerial Advisory Committee on Antimicrobial Resistance (AMR) and co-founder of the South African Antibiotic Stewardship Programme. His focus is on national and international policy development to mitigate AMR and is a jobbing infectious diseases physician and antimicrobial steward. Marc works as a technical advisor to several international organizations including the WHO, GARDP, GHSA, and the Vivli AMR Register. He has held the presidencies of the Federation of Infectious Diseases Societies of Southern Africa and the International Society for Infectious Diseases and is a Fellow of the Royal Society of South Africa.

Professor Dr Guy Midgley

Session: Bio- and Geodiversity

Day 2 15. September 2023 09:30 – 10:30

Professor, and Acting Director of the School for Climate Studies and Center for Invasive Biology at Stellenbosch University, South Africa

Guy Midgley is a Distinguished Professor, and Acting Director of the School for Climate Studies and Center for Invasive Biology at Stellenbosch University, South Africa. With strong interests in global change biology, biogeography and plant ecology, he is amongst global leading experts in the fields of biodiversity and global change science, cutting across the science/policy continuum under the UNFCCC and the CBD and focusing on social-ecological impacts and adaptative strategies. He is listed by Thomson Reuters as amongst the most influential 200 climate change scientists globally. He has served as coordinating lead author on the 4th, 5th and 6th IPCC assessment report, and Global Assessment Reports of the Intergovernmental Platform for Biodiversity and Ecosystem Services (IPBES). He chaired South Africa's Global Change Science Committee for more than 10 years. Recently he was recognized by the South African Royal Society Marloth Medal for contributions to science and policy and by the Alexander von Humboldt Foundation award for lifetime contributions to science.

Resilient agriculture and resource use in an increasingly unpredictable future

PANEL 1

Sorghum rhizosphere traits and the phosphorus exploitation strategies in an African iron-rich Acrisol

Sara Loftus[1], Rozy Munene[1], Osman Mustafa[1], Callum C. Banfield[2], Mutez A. Ahmed[3], Michaela A. Dippold[2]
[1]Georg-August University of Göttingen, Biogeochemistry of Agroecosystems, Germany, [2]Eberhard Karls University of Tübingen, Geo-Biosphere Interactions, Germany, [3]Bayreuth University, Soil Physics, Germany

The mobilization and uptake of highly immobile nutrients, such as phosphorus (P), are driven by root morphology and plant-microbe interactions in the rhizosphere, such as symbiosis with arbuscular mycorrhiza fungi (AMF). Soils in the sub-tropics are often P-depleted and have a low P availability. Changing environmental conditions, like drought reduce nutrient availability to a higher extent. To ensure sustainable food production, crops with high efficiency for P mining and drought adaptation mechanisms are required. Therefore, we applied a novel experimental setup, that not only allowed the quantification of different P mobilization mechanisms, but also to disentangle the uptake by plants (sorghum) and / or microorganisms. The 'double-ring pot', is a system where two layers of hyphae-penetrable but root-impenetrable gauze surround a hydraulic barrier and effectively separate two soil volumes (rhizo-mycosphere and mycosphere). By applying 33P – labelled P sources in both compartments, the contribution to plant P uptake by eighter root-rhizosphere interactions or accurate quantification of AMF's P mobilization and transport towards the symbiotic partner are feasible. P uptake was measured under well-watered and drought conditions.
The 33P-recovery from the rhizo-mycosphere compartment in root and shoot tissue of sorghum was twofold higher under well-watered than under drought conditions. However, the recovery from the mycosphere compartment was only pronounced under drought, indicating that sorghum- AMF interactions are intensified under stress conditions. These results were confirmed by the 33P-recovery of polar membrane lipids of the soil microorganisms (33P-PLFA), where water scarcity triggered microbial activity in the mycosphere, likely driven by an increased allocation of photo-assimilated carbon by the sorghum plants to their AMF.
AMF root colonization rate displayed not to be a suitable proxy for its P mobilization efficiency nor the hyphae extension ability, as plant P uptake from root inaccessible P sources was proven and its potential to enhance microbial activity was of significance under drought conditions, although root colonization was reduced.
In summary, our data suggest that the genetic potential of rhizosphere traits and the exploitation of root-soil-microbiome interaction for P nutrition is far from fully exploited and bears great potential for crop improvement in the tropics.

Social Networks and Usage of Climate Change Adaptation Strategies by Smallholder Farmers in Laikipia County, Kenya

Florence Opondo[1], Poti Abaja Owili[2]
[1]Laikipia University, Kenya, Commerce, Kenya, [2]Laikipia University, Kenya, Mathematics, Kenya

Social networks can be effectively used to enhance resilience by influencing a number of operations as well as coordinating activities within the food systems. Strengthening Ubuntu (togetherness) offers opportunities to build resilience to food shocks among vulnerable populations and households while reducing reliance on emergency food assistance. Enhancing resilience through inclusive social networks is paramount to improving the capacity of the food system to withstand climatic change related shocks
Farmers in Laikipia County heavily rely on rain fed agriculture which makes them disposed to climate change.Furthermore, they have been experiencing climate variability which has negatively impacted their agricultural activities. In the earlier days, farmers used to plant at specific times. However, due to the changing weather, the planting seasons are not definite. In response to climate change variabilities, Laikipia County Government has encouraged farmers to diversify production and adopt fast maturing and drought tolerant crop varieties and practice on-farm adaptation practices such as harvesting of rain water and practicing climate smart agriculture.
The study applied qualitative and quantitative methods to explore how social networks can enhance the resilience of food systems in Laikipia County. The target population was smallholder farmers engaged in farming activities. Purposive sampling was used to select Laikipia West and Laikipia East sub-Counties from which 348 farmer respondents were selected. A semi-structure questionnaire was used to collect data. Primary data collected encompassed household characteristics, knowledge on climate change, social networks and information system, ICT usage and climate shocks and livelihood resources.
The findings revealed that majority of the farmers belong welfare groups (59%) while very few (35%) belonged to farmer based groups. Most of the farmers who belong to farmer based groups use the platforms to connect with fellow farmers (17%). About 8% of the respondents engage in discussions on adaptation to climate change and conservative agriculture. Notably, 7% of the farmers often get information regarding current weather patterns and new farming techniques.
Farmer groups are perceived to be useful channels particularly for communities to engage in climate change discussions. Most farmers in Laikipia County belong to welfare groups that either offer credit facilities or socialization

Tree Growing on Farmlands in Rwanda: Farmers' Preferences for Adopting Agroforestry in the Eastern Drylands

Jean Bosco Nkurikiye[1], Valens Uwizeyimana[1], Iris Vanermen[1], Kato Van Ruymbeke[1], Bruno Verbist[1], Alfred Bizoza[2], Liesbet Vranken[1]
[1]KU Leuven, Earth & Environmental Sciences, Belgium, [2]University of Rwanda, Agriculture, Rural Development and Agricultural Economics, Rwanda

Background: In Rwanda, land degradation and effects of climate change and variability drive efforts towards land restoration with aim to make vulnerable smallholder farmers more resilient through investments in soil conservation and agroforestry. Effective agroforestry implementation requires involving farmers, and understanding their choices to adopt it. Still, there is little information about farmers' preferences for tree planting in Rwanda. Thus, this study explores these preferences in the country's eastern region.
Methods: We conducted a discrete choice experiment to elicit preferences for tree attributes among 248 farmers. Eight attributes (number of woody and fruit trees, root system and canopy, change in maize yield caused by tree planting, frequency of extension visits, extra labour for tree management, distance from plot to tree nursery, and tree seedling cost) were selected after qualitative methods, and evaluated using mixed logit and generalized multinomial logit models to investigate preference and scale heterogeneity, respectively; and latent class model for class-specific preferences.
Results: Results show that farmers positively value planting woody and fruit trees on their farmlands. They prefer trees with deep roots and small canopy, and trees which would increase crop yields, but dislike increase in the tree seedling cost. WTP measures indicate that deep and shallow root systems with small canopy, seasonal visits, and change in maize yield are the most valuable attributes. However, there is preference and scale heterogeneity among farmers across agroclimatic zones. Farmers are split into two latent classes with notables similarities and differences in their preferences for agroforestry practices.
Conclusion: Our findings demonstrate that farmers are willing to participate in agroforestry practices. They prefer woody trees for their products (timber, fire woods, stakes…), and fruit trees for their multi-functionality and role in food security and nutrition. This calls for increasing the share of fruit trees in agroforestry interventions. Furthermore, preferences for increased (maize) yields suggest focusing on N-fixing tree species; while preference for trees with deep root systems and small canopy calls not only for improved fruit varieties, but also for building farmers' capacity in tree management.
Keywords: Farmer preferences, choice experiment, land restoration, Rwanda

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High-quality and affordable fish feeds to support the resilience of Beninese fish farmers in a climate change context

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The Beninese government is promoting fish farming to ensure food and nutrition security as food demand continues to grow due to population growth while agricultural production is threatened by climate change reducing arable land. In several areas of Benin, the population depends on aquaculture. Fish feed, mostly imported, accounts for 60 - 75% of the total costs of fish production, allowing marginal profitability for fish farmers. Recently, Beninese and Dutch researchers received financial support from the Netherlands Organization for Scientific Research (NWO-WOTRO) to develop and promote affordable, nutritive and floating fish feeds based on locally available feed ingredients in Benin. The project started by the screening of the local feed ingredients of Benin for their nutritional quality and cost. Next, feed formulas were developed with local feed ingredients using linear algebra optimization software. The nutritional profile of feeds was established by laboratory analysis. Further, approach was developed to confer adequate physical properties to the produced pellets. To achieve this goal, we tested various sources of starch, including maize, cassava and wheat flours, to confer adequate floatability to the granules. The effects of developed feed granules were assessed on the growth performance and carcass composition of Clarias (catfish) and Tilapia fish. Moreover, we tested the effects of 2 formulas on the growth of the larvae of catfish and Tilapia. Three feed formulas were successfully developed, namely for Clarias (catfish), Tilapia and fish larvae. A low-cost extruder was constructed locally to produce fish feed pellets. The project generated fish granules with a protein content as high as 34% for Tilapia, 41% for Clarias and 45% for larvae. These protein levels are comparable to those of imported fish feeds currently commercialized in Benin. Results from the bio-efficacy study showed that the Profish feeds performed well for fish growth. The Clarias feed even performed better than the imported feed, since its protein efficiency ratio was 2.57 against 2.43 for the imported feed. We trained farmers and local SMEs in fish feed formulation and processing. Project results were disseminated to stakeholders via trainings, professional and scientific publications.
Keywords: fish feed, feed formulation, Clarias, tilapia, climate changes

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Microbial remediation of overexploited soils in Malawi

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Aims
Soil loss is a major problem which results in reduced fertility and cultivable soil depth. By this, fields are no further suitable for agricultural production resulting in a general decline in profitability of crop production. Healthy soils are an invaluable resource for sustainable ecosystems and are correlated with plant or animal health. Mostly, chemical or physical parameters are used to describe soil health. In this study, we analysed the effect of biological indicators which includes microbial diversity and specific soil functional groups. We used different soil types which were described as chemical healthy or overexploited soils in respect to their agricultural use throughout the last decades. The comparison yielded to investigate differences in the composition regarding specific genera and species.
Methods
Soil samples were selected from adjacent agricultural farms in Malawi, Africa. These samples originated from overexploited, chemical healthy and conventional soils which differentiated in agricultural usage during the last decades. Sequencing analyses were performed to investigate differences in the microbial diversity between the soil types. For this, DNA was isolated from the different soil samples and used for 16S rRNA gene as well as metagenome sequencing.
Results
16S rRNA sequencing of the samples revealed significant differences in the microbiota between overexploited, healthy and conventional soils on phyla or genera level. The microbiota in the soils represented those typical for soil in that area. By metagenome analysis significant differences on species level were identified when comparing the soil types. The analysis showed that the agricultural use had an effect on the soil microbiota of these samples.
Conclusion
Chemical healthy soils were compared to overexploited or conventional soils collected in Malawi. By metagenome analysis significant differences in the microbial diversity of the different soil types were found. The comparison yielded to understand weather important functional genera or species were lost through agricultural usage and weather restoration of overexploited soil by providing important soil functional groups is possible to maintain fertility and soil health.

PANEL 2

Agro-biodiversity, risks, and resilience. Insights from Burkina Faso and Ghana

Thomas Daum[1], Michael Olatain[1], Paul Effah[1], Viviane Yameogo[1], Lilli Scheiterle[1], Felix Asante[2], Nerbéwendé Sawadogo[3], Regina Birner[1]
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Crop genetic diversity, or agro-biodiversity, is believed to be key to making agriculture more resilient to climate change and reducing vulnerability to pests and diseases. The rising genetic uniformity on farmer's fields in many parts of Africa is therefore an increasing concern, which has led to large efforts to conserve crop genetic diversity, both in situ and ex-situ. From the perspective of individual farmers, who typically aims to strike a balance between returns and risks, maintaining high levels of crop genetic diversity is rarely a goal in itself, and only one way to deal with risks and uncertainties. Farmer's crop and varietal choices are shaped by a range of technological, socioeconomic, cultural, and political aspects. On the one hand, technological changes such as the spread of pesticides and improved seeds (including those with traits related to resilience) and socioeconomic changes such as increasing vertical integration may increase the returns and reduce the risks associated with lower crop genetic diversity. On the other hand, concurrent crises related to global trade shocks, climate change, political instability, armed conflicts, and internal migration, may also affect farmer "returns-risks"-trade-offs. Following a comparative case study approach in two countries in West Africa, Burkina Faso and Ghana, this study examines factors and actors that influence farmers' seed management strategies, and subsequently crop genetic diversity, in the context of rapid technological and socio-economic changes and environmental and political crises. In particular, the study assesses the role that crop genetic diversity plays in the array of risk management options that farmers use for coping with different types of experienced and/or perceived risks, and on examining the benefits and costs associated with different crop genetic diversity-related risk management options. The study is based on a range of different qualitative (e.g., participatory mapping, focus group discussion) and quantitative methods such as household surveys with 120 farm households from each country. The study shows how perceived and experiences risks and risk management strategies have changed over time and how the above-mentioned technological and socio-economic changes and environmental and political crises affect risk and seed management strategies, and, subsequently, agro-biodiversity.

Below ground exploration of sorghum genotypes to overcome nitrogen limitation in nutrient-deficient tropical soils under drought

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[1]University of Goettingen, Biogeochemistry of Agroecosystems, Germany, [2]University of Khartoum, Sudan, [3]Institute of Bio- and Geosciences (IBG), Germany, [4]Jaramogi Oginga Odinga University of Science. & Technology, School of Biological and Physical Sciences, Kenya, [5]University of Tübingen, Geo-Biosphere interactions, Germany, [6]Technical University of Munich, School of Life Sciences, Germany

Distribution and variability of precipitation are projected to change globally and are expected to result in an increase in frequency and duration of droughts, especially in sub-Saharan Africa posing a major challenge to food security in the region. Coupled with highly depleted soils, water limitation is a key drawback to nutrients mobilization and uptake by plant roots. Crops with adaptive strategies to reduced nutrient and water requirements such as sorghum are paramount to global agriculture. Rhizosphere attributes play an important role in nutrient acquisition especially nitrogen (N); dominant limiting nutrient in the ecosystem. In this study, we aimed to assess the shift of rhizosphere strategies of sorghum genotypes in mobilization and uptake of N in response to drought in a Plinthols of Siaya (Kenya). Therefore, ^{15}N labelling to trace and quantify N uptake from different depths; 15cm, 45cm and 75cm, was conducted in a field experiment with three sorghum genotypes, the landrace Makueni local (Mkl), the open-pollinated variety Gadam (Gd), and the hybrid IESH, which were exposed to two soil moisture treatments; rainfed (natural precipitation) and drought (induced by rainout-shelters). Our preliminary results show that drought considerably reduced plant biomass accumulation as well as grain yield. Chitinase and Leucine aminopeptidase (LAP) enzymes were affected by drought with limited loss of activity in the dried-out topsoil. Tracer analysis in the plant tissues together with root area colonization by arbuscular mycorrhizal fungi (AMF) will reveal the influence of drought on the uptake and transport of ^{15}N and the role of AMF for the different sorghum genotypes.
We postulate that enhanced AMF symbiosis is an essential trait compensating reduced rhizosphere enzyme activities under drought to ensure N acquisition and mobilization, especially in soil with low N stocks. Therefore, understanding the interactions at the soil-root interface represents a critical step in establishing how and why sorghum genotypes differ in their ability to cope with combined water and N deficit, a stress combination predicted to increase with global change.

Small ruminant farmers' feeding strategies to cope with climate change across five agroecological zones of Benin (West Africa)

Euvrard Landry Romaric Gninkplekpo[1], Bossima Ivan Koura[1], P. Lesse[1], I. Toko[1], M. Houinato[1], D. Demblon[2], J.-F. Cabaraux[3]
Institute/Organisation
[1]University of Abomey-Calavi, Abomey- Calavi, Benin, [2] Hainaut- Condorcet, Bruxelles, Belgium, [3] Univertsity of Liege, Liege, Belgium

This study aimed to understand feeding strategies used by small ruminant farmers to cope with climatic change in the five contrasting agro-ecological zones of Benin Republic, and to identify the determinants of adopting these strategies. Based on a semi-structured questionnaire, surveys were conducted on 400 smallholders' farms in the poorest rural areas of Benin. Data was collected on production systems characteristics, farmers' perception of climatic changes' impacts on livestock production, and their coping strategies. Cross tabulations with Chi^2 statistic and the non-parametric Kruskal Wallis test were used to compare farmers' perception and coping strategies between the five agroecological zones. Then, the binomial logistic regression was used to identify determinants of using a particular adaptive feeding strategies. The surveyed farmers perceived climatic changes as rainfall delays, drought period during rainy season, decreased rainfall, increased sunshine duration, and increased temperature. These changes negatively affected grassland biomass production (86.3, 86.3 and 77.5% of respondents in South Borgou, Atacora chain, and Ouemey-valley AEZs, respectively) and water availability (100, 93.7, and 85% of respondents in Ouemey-valley, Plateau and Mekrou-penjari AEZs, respectively). Consequently, farmers mentioned decreased in animal growth (58.8 and 45% of respondents in Plateau and South Borgou AEZs, respectively) and increased mortalities (43.8% in Plateau AEZ). Farmers' current and future coping strategies varied significantly ($p<0.05$) among agro-ecological zones. These strategies included more diversification of feed resources used, more free raving of animals, and feeding intensification with supplements as current strategies, and new feed resource exploration and forage cultivation as future strategies. Logistic regression showed that the herder gender, his education level and main activity, and the climatic and agro-ecological zones where the farm is located influenced the strategies used. Limitations to adoption of these strategies could be assessed in future studies.
Keywords**:** Sheep, Goat, Smallholders, Climate-smart agriculture, sub-Saharan Africa.

Mobilizing natural enemies for sustainable plant pests and diseases management

James M. Mwangi1, Ruth N. Kariuki1, Eric K. Kuria1 & Eunice W. Githae1

Smallholder farmers contribute approx. 70% of food supply in Africa. They produce for their subsistence use and sell the surplus in the local market. These farmers make a substantial contribution to sustainable food security in the global south. Their capacity to upscale production is however constrained by shrinking land sizes, high cost of agricultural inputs, impact of climate change as well as damage by pest and disease. Majority of smallholder farmers rely on cultural techniques to keep pests and diseases below economic threshold level. However, persistent use of agricultural chemicals predispose farmers to risks associated with mishandling and misuse of pesticides. Besides, consumers are exposed to adverse effects of pesticides due to chemical residue in food. To boost food production, there is need for ecologically sustainable pest control methods to minimize agri-pollution, boost productivity and promote biodiversity in Africa. Such methods include use of natural enemies (biocontrol agents) for pests and diseases management. We carried out a survey for potential fungal microbes that parasitize and destroy plant nematode eggs for use as biocontrol agent against potato cyst nematodes (PCN) Globodera rostochiensis and, G. pallida in Kenya. Soil samples were collected from smallholder farms in six leading potato-producing counties of Kenya. The samples were processed in the laboratory and PCN cysts extracted using floatation techniques in Fenwick can. Extracted cysts and eggs were visually examined for fungal infestation. Those showing symptoms of fungal infestation were selected, culture on PDA media and incubated at room temperature, fungal growth were monitored for several days. Fungal colonies were sub-cultured to generate pure culture for further analysis. Ninety-five percent of the soil samples tested positive for PCN infestation. However, the prevalence of PCN in the six counties differed significantly ($P < 0.05$). Fifteen fungal isolates were found associating with PCN cysts and eggs. Characterization of these fungal isolates is under way. The efficacy of these isolates is being tested in-vitro and in-vivo before being processed for use as biocontrol agent again PCN. If successful, the natural enemy will significantly contribute in reduction on use of synthetic chemicals in nematode management besides boosting potato production.
Key Words: Biocontrol, Nematophagous fungi, Potato Cyst Nematodes, Globodera spp., smallholder farmers

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Performance of push-pull system under pigeon pea intensification

Sylvia Buleti, Shem Kuyah, Samuel Were, Moses Gichua
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African farming systems are increasingly being intensified to address need for food and challenge on diminishing arable land. Push-pull technology is promoted in western Kenya as a sustainable conservation strategy for management of stem borer, fall armyworm and Striga weed. Integration of push-pull systems with other sustainable intensification practices has potential to advance its acceptability and adaptability among smallholders. Push-pull is currently limited in diversity of utility mainly because the companion crops, desmodium(push crop) and brachiaria(pull crop) are not edible. Participatory research carried out among smallholder farmers in western Kenya revealed intercropping, agroforestry and crop-livestock integration as priorities for further intensification of push-pull farming systems. The aim of the study was to determine the effectiveness of push-pull system integrated with pigeon pea (*Cajanas cajan)* on productivity and soil fertility. Field experiments consisting of four treatments (climate smart push-pull (maize+desmodium+brachiaria), push-pull + pigeon pea, maize+ pigeon pea, and maize monocrop) were established on fifteen farms in three counties of western Kenya. A section of the plot was demarcated and used for data collection on growth, grain and stover yield. Preliminary results show that growth and yield vary across counties, seasons and treatments. Overall productivity of the intensified system was best in Siaya county followed by Kisumu and Vihiga counties respectively. Push-pull + pigeon pea and maize +pigeon pea were superior in performance based on maize growth and stover yield for season one. Maize + pigeon pea and push-pull performed better in grain yield than push-pull+ pigeon pea and maize monocrop for both seasons. Intensification of push-pull with pigeon pea may reduce maize grain yield per unit area, though this is leveraged by alternative products such as fodder, firewood and diversified diets. High stover yield demonstrates potential for fodder and residue production. Intensification resulted in better stover and grain yield in the long rain season. It was noted that intensification with pigeon pea provides additional products such asalternative diets in dry season, firewood from twigs and stems, fodder from leaves, soil organic matter from litter and overal system resilience. Push-pull diversification can guarantee successful upscaling of push-pull in East Africa. Effect on soil fertility will be discussed.

PANEL 3

Agroecology – A guiding concept to lead Africa's food systems transformation?

Marcus Giese[1], **Juliet Kariuki[1]**, Maria Oguche[1], A. Lutta[2]
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Land, water and soil degradation, climate change and biodiversity losses are of global concern for agriculture, especially because their impacts are often unequally distributed. Interactions between challenges have influenced paradigm shifts supporting integrated approaches for achieving sustainability and resilience of food systems. However, debate abounds regarding how to increase productivity while minimising trade-offs that undermine the natural and socio-economic resources required for agriculture to survive and thrive. Africa's increasing population and changing consumption patterns have led to growing food demands and drastically transformed land use patterns. Consequently, the continent is witnessing the emergence, permanence and disappearance of competing paradigms to address production challenges. Within this context the DAAD Agriculture-Alumni Training Network organised thematic travelling workshops, webinars and a World Café session bringing together multidisciplinary stakeholders to discuss competing pathways to achieve sustainable food systems. The World Café on 'Decoding Agroecology' was an extension of discussions from the travelling workshop themed 'Paradigm shifts in Agricultural Systems towards Sustainable Land-use in Africa''. The aim was to decipher complementarities and constraints of adopting competing agroecology concepts. Perspectives were divided. Some viewed agroecological practices as beneficial for climate adaptation and mitigation and complementary to climate smart agricultural approaches. Agroecology was considered appropriate across scales from farm to landscape, with considerable suitability for small land sizes. Whereas, for others the unclear definition of agroecology undermined successes, especially as the complexity of agroecology requires scientific knowledge which is lacking. Formal definition also eclipses the view that agroecological approaches have been traditionally practiced in African farming systems. Where agroecology is purposefully applied, increased labour demand did not always have commensurate productivity returns and inequitable gendered dynamics of labour and income control were often amplified. Overall, while agroecology has the potential to increase system resilience, there is a need to strengthen policies and education systems, increase farmer-to-farmer learning, and create an enabling environment whereby inputs that support agroecological approaches can be accessible to smallholders in particular.

Effectiveness of Drought-based Early Warning System Towards Household Food Security in Makueni, Kenya

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There is no doubt that drought conditions negatively impact food security and consequent human well-being components. Agricultural production is significantly affected by environmental factors. Weather influences crop growth and development, causing large intra-seasonal yield variability. Early warning systems provide information on various forms hydrologic events like drought, which however tend not to reach all its intended recipients in time for a variety of reasons. In addition, incorporation of technology in early warning, drought preparedness and food security analysis has been a challenge. My assessed drought-based early warning system and its implications on land and hence crop production in order to contribute to policy and practices towards ending drought emergencies in Makueni, a dry land agro-ecosystem. Geo Information System-based special data was used for assessment and monitoring of crop growth and their condition during this season of growth. The outputs were regressed with crop yields to come up with yield estimates. Questionnaires were administered during this study for the socio-economic part of the study that assessed the reach and effectiveness of the existing drought early warning information system. Principal Component Analysis was used to choose the most significant months for the rainfall and temperature data before analysis was done. Five rainy seasons were lineary regressed where the Water Requirement Satisfaction Index was compared with actual production of maize in tonnes per hectare and the R2 values for the seasons obtained. Satellite imagery was found to be highly accurate in giving the estimates of the highs and lows of the seasonal production.

Perspectives for sustainable development to subsistent apiculture: the case of Ethiopia

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Since the inception of the term sustainable development at the end of the 20th century as a reconciliation between the needs for socio-economic development and environmental protection, various concepts and production systems have been initiated to address demands for food and other products. These include organic agriculture and sustainable intensification, which vary with the sector and local context.
Here, we provide outlooks to sustainable development aspects of apiculture focusing on a major subsistent beekeeping country that tries to transform – Ethiopia. For this, a review was conducted to assess the sustainability of apicultural transformation initiatives and suggest intervention strategies. The major points are: 1) Annual honey production improved from 25,000 ton in 2005 to 150,000 ton in 2020 by increasing the number of honey bee colonies from 4.2 to 7 million (65%) and through provision of higher yielding frame hives (17.9 kg per hive per year) and top-bar hives (13) compared to fixed-comb traditional hives (9.31). 2) Average honey yield of simple top-bar hives over the period was 40% higher than that of traditional hives. 3) Following the trends in honey production, export volume grew from 274 ton in 2009 to 481 ton in 2016 despite a high local demand. 4) Development initiatives focused on the introduction of frame hives (3%) compared to locally developed top-bar hives (1%). Frame hives use larger comb-cell foundation sheets that can erode the resistance of the honey bees against varroa mite. However, the traditional beehives which provide low yield and involve unsustainable management remained dominant (96%). To promote food security and honey bee welfare, a sustainable apiculture development needs to focus on domestic markets, improving honey yield gaps; integrating beekeeping with crop farming; capacitating beekeepers to rear suitable queens and colonies locally.

Agroforestry and Permaculture for sustainable development of human and nature

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The ever-changing and unpredictable climate is affecting most of the smallholding farmers in sub-Shaman Africa. To develop reliance and enhance adaption to climate change an integrated natural resource management approach with the framework of Agroforestry and Permaculture will enhance the sustainable and resilient livelihood for the small holding farmers.
Agroforestry is a dynamic, ecologically based natural resources management system that promotes the integration of trees in farmland and rangeland. It also promotes biodiversity to ensure sustainability, productivity, profitability, health and sustainable land-use systems to create socially, economically, and environmentally sustainable communities at each level. Permaculture is also a harmonious integration of landscape and people, providing their food, energy, shelter and other material and non-material needs in a sustainable way to maintain stable social order. Integrating the two concepts will enhance the sustainable development of humans and nature.
Teaching the local farming community to adapt to an integrated resource management approach is a long process and they learn through observation. Accelerating the adaptation by smallholding farmers upgrading the existing infrastructure (Farmer training centre) to perfect demonstration sites through the farmer-based initiative is the way forward to reach as many as possible farmers to build resilience to the ever-changing climate.
In the southern region of Ethiopia, the local development association is working with its local and international partners to train 7,000 farmers to adopt sustainable natural resources management through practicing agroforestry and Permaculture. The approach is to address the local farmers and convince them to adopt the resilient through regenerating the entire ecosystem. The project is enabling the fanners and extension workers to transform the farmer training centre to a more productive and resilient ecosystem where the fanners can learn through observation and adapt.

Agricultural sustainability with a focus on greenhouse gas emissions of cash crop vs. mixed crop-livestock rotation systems

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Agriculture interacts with both man-made and natural systems, with production systems impacting the environment through greenhouse gas (GHG) emissions. Crop rotation strategies were explored for GHG mitigation by leveraging synergies between rotation phases and ecosystem functions as production resources.

Three crop rotation systems were investigated from a long-term trial on Langgewens Research Farm in a Mediterranean climate zone of South Africa. Wheat–wheat–wheat–canola (WWWC); wheat–canola–wheat–cover crop mixture (WCWL); and wheat–medic pasture–canola–medic pasture (WMCM) where sheep grazed on legume pastures. Carbon (C) sequestration was modelled on soil organic C changes over 21 years. Soil methane and nitrous oxide emissions were sampled weekly for one year using the closed chamber method. Emissions for inputs (seeds, fuel, fertilizer, pesticides), livestock (enteric fermentation and manure), and land use change impacts were quantified from emission factors. Outputs were aggregated into grain equivalents (GE)s. Using a lifecycle assessment approach, total GHG emissions were calculated per GE and per hectare (ha) production area.

Soil C increased but was not different between rotations. Methane emissions were negligible. Nitrous oxide did not differ between rotations, but a strong emission spike followed a summer rainfall event for WMCM and WCWL, while not for WWWC. A legacy of legume incorporation increased available nitrogen (N) in the soil organic fraction, confirmed by significant differences in wheat protein content over 21 years. Rotation WMCM had the highest protein levels and yields, while WWWC had the lowest yields and protein levels which had a downward trend. Compared to WWWC, WCWL had 35% less GHGs per GE, and 15% less per ha, and WMCM had 11% less GHGs per GE and 7% less per ha. If the medic pastures were considered as fodder production phases and the livestock as part of a separate production system, WMCM had 55% less GHGs per GE, and 35% less per ha.

The main sources of GHG mitigation were replacing fertiliser with N fixation in the pasture or cover crop and yield increases from improved ecosystem functioning. Soil C sequestration was an important C removal strategy in all systems. Incorporating livestock and legumes into rotations decreased the global warming potential of wheat production. This study provides evidence for substantial GHG reductions, adding to other known benefits of diversifying production systems through rotation.

Resilient Health and Human Wellbeing under novel climatic and ecological settings

PANEL 1

Low-cost observations for water-air-soil of pesticides/pollutants in African soils using time-integrated samplers (LOWPESTS)

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Agricultural topsoils in Africa have accumulated a variety of persistent organic pollutants (POPs), such as DDT, glyphosate, and now Per- and poly-fluoroalkyl substances. It is presumed that they act as a long-term source of atmospheric and groundwater contamination. Processes controlling the release of POPs from topsoils (e.g., transformation, leaching, volatilization) are likely highly dependent on climate conditions (e.g., rainfall, temperature, wind). As the climate changes, temperature and inter-annual rainfall variability are expected to increase across Africa, resulting in increased droughts and floods from heavy rain. During dry periods, semi-volatile POPs, such as DDT, are expected to be volatilized. Hydrophobic POPs, such as PFAS and glyphosate, are expected to be retained and transported on dust particles. During wet periods, POPs are expected to migrate from the topsoil to groundwater due to leaching. These climate changes, combined with the intense input of pesticides and PFAS at agroecosystems, put long-term food security and clean water availability at risk.
The direction of contaminant flux can be directly measured using diffuse passive samplers. However, current passive samplers rely on highly specialized sorbent and sophisticated analytical equipment (e.g., LC-MS/MS). LOWPESTS are intended to develop a low-cost, time-integrating passive sampling approach to determine the magnitude and direction of pesticide fluxes across air and water soil interfaces. We modified the self-integrating accumulator, a vadose zone passive sampler developed by *TerrAquat* (Nürtingen, Germany), to measure the loading rates of DDT and glyphosate fluxes from soil to groundwater. We also refined extraction methods for a dual-chamber air passive sampler developed by *TIEM (*Marktredwitz, Germany) to extract DDT and glyphosate from polyurethane foam disks and polyester filters. We will expand these approaches to include PFAS, an emerging group of ubiquitous environmental POPs. This approach allows for a cost-effective way to monitor contaminants' long-term fate and transport in the atmosphere and groundwater.

On the Impact of Climate Shocks on Gender-related Employment: Evidence from Central Africa Sub-region

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This article investigates the impact of climate shocks such as atmospheric pollution on gender-related employment. Considering that the theory highlights three mechanisms which link climate shocks to employment outcomes, and using data on CO2 exposure from the World Bank database for the 6 member countries of the Central Africa Sub-region covering the period 1996-2020, we carried out global and sectoral empirical analysis in linear and non-linear specification with various estimation methods. This gymnastic made it possible to lead to the following main results: firstly, climate shocks have an evident influence on the overall employment of both men and women. Secondly, the link between climate shock and jobs is far from linear since the relationship has an inverted “U” shape. Thirdly, the results obtained so far remain robust to the use of correction methods for econometric problems such as the Driscoll-Kraay method and the approach of Lewbel and Kinkyreg (2012) developed by Kiviet (2020). Finally, the analysis of the effects of climate shock on jobs by sector of activity has highlighted two fundamental results: a “U” relationship when considering the agricultural sector and an inverted “U” relationship for industrial and service sectors.

The effect of COVID-19 vaccination hesitancy on future malaria immunization campaigns

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In October 2021, WHO recommended widespread use among children of the first ever malaria vaccine (RTS,S/AS01). Because in Sub-Saharan Africa malaria remains a primary cause of death, successful immunization campaigns against this disease could save tens of thousands young lives every year. However, since the COVID-19 pandemic, a growing body of research on vaccine attitudes suggests that immunization acceptance has declined not only for vaccines against COVID-19 but also against other diseases (e.g., influenza). In fact, most determinants of vaccination hesitancy are not specific to the COVID-19 vaccine (e.g., mistrust in pharmaceutical companies, (too) rapid development of vaccines, and concerns about severe side effects). In this study, we investigate whether recalling personal opinions about COVID-19 immunization affects short-term malaria vaccination hesitancy. We test this hypothesis by means of a randomized controlled trial (RCT) where the individuals in the treatment group are asked to reveal their beliefs about COVID-19 vaccine efficacy and safety before being asked about their attitudes towards the newly WHO licensed malaria vaccine. Conversely, the control group will answer the same questions about malaria immunization without any direct or indirect recall to COVID-19. The study's primary data consists of telephone surveys from a randomly drawn representative sample of adult individuals from selected Kenyan counties facing medium to high risk of P. falciparum malaria transmission. Further, we will carry out heterogeneity analyses at different levels of COVID-19 vaccination hesitancy, and a mediation analysis for stress and mental health (measured by the Depression and Anxiety Scales-21 (DASS-21). The timeline of this ongoing project consists in completing the data collection activities by June 2023, and to produce the final results by August 2023. This research's results will contribute to inform public health policy makers at different levels on how to structure their anti-malaria vaccination campaigns to maximize immunization uptake.

PANEL 2

Minor livestock species for food production in Africa, zoonotic diseases, and One Heath – Biological and ethical perspectives

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Wildlife has been playing a role in the origin and spread of several of the recently emerged zoonoses, constituting a major public health crisis and concern affecting Africa. The ensuing ban on the consumption of some categories of livestock resulting from zoonotic diseases, such as Ebola, also linked to the consumption of bushmeat in Central and West Africa, has resulted in many households increasing their production of minor livestock species such as grasscutter, guinea pig, rabbits and guinea fowl as a coping strategy. However, the implications of intensifying these minor species to meet the growing demand for animal-sourced food (ASF) remain poorly researched. Therefore, before promoting intensification of minor livestock species in Africa, where there is little attention and investment in disease prevention and veterinary medicine, further research is important. To address this knowledge gap, a review was set up to analyse i) the relationship between zoonotic diseases and the consumption of these species; ii) the directions of infection and which species have been linked to the spread of zoonosis; iii) the strengths and weaknesses of the One Health approach regarding livestock intensification. Applying the checklist for "Preferred Reporting Items for Systematic Review and Meta-Analysis" (PRISMA) and using the Boolean search operators in academic search engines, 73 articles were selected for the review. The results show that infection can occur directly through consuming contaminated or/and undercooked meat, raw milk from an infected animal and indirectly through contact with infected animal's faeces, hairs, meat handling and exchanges at slaughterhouses or meat markets. Directions of infection can be from humans to livestock or vice versa; species such as grasscutter, rabbit are linked to some zoonotic diseases. The One Health approach helps to broaden the perspective also beyond the mentioned ASF and safety for public health: Considering the great nutritional potential, issues of animal welfare, food ethics, and environment have to be recognised and reflected when it comes to consumption, production, and intensification of minor livestock species.
Key words: zoonotic diseases, Africa, minor livestock species, One Health, ethics

Knowledge of the impacts of climate change on malaria prevalence in the upper river region of The Gambia

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Despite a substantial decrease in its burden, thanks to the scale-up of control interventions such as insecticide-treated bed nets and seasonal malaria chemoprevention, malaria remains an important cause of morbidity and mortality in The Gambia. Environmental conditions and climate changes can have a substantial influence on malaria transmission. Moreover, climate change could affect the coverage of preventive interventions. This work aims at establishing the relationship between climate change and malaria transmission in the Upper River Region, The Gambia. Climatic variables (temperature, rainfall, and humidity) covering the period 1992-2021 was obtained from The Gambia Department of Water Resources while data on malaria incidence from 2011- 2022 was extracted from the Primary Health Centres' database of the Upper River Region. Descriptive statistics was used to explore the climatic variables and malaria cases, admission and death. Spearman's correlation analysis was performed to determine the relationship between the monthly climatic variables and malaria data and for the identification of the climatic variable that mostly influences malaria incidence. For the primary quantitative data, the univariate analysis will be carried out using simple frequency calculations and means, after which a multivariate analysis and comparison of proportions between groups will be done using Chi-square (X^2) and Fisher's exact tests. Thematic analysis will be carried out for the qualitative part using Nvivo. Results will inform efforts to adapt and mitigate the effect of climate changes, in The Gambia, with a particular focus on malaria transmission.

Household nutritional resilience against climate variability in the Karamoja border region of Kenya and Uganda

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Objectives of the study: The main objective is to assess household nutritional resilience against climate variability in the Karamoja border region of Kenya and Uganda.
There are several specific objectives which are:
i. To assess the state of household food and nutrition security of households within the Karamoja border region of Kenya and Uganda.
ii. To determine households' resilience against climate variability in relation to socio-economic and demographic characteristics of households.
iii. To evaluate the barriers and enablers to household nutritional resilience in the study region.
iv. To evaluate interventions for nutritional resilience of households in the study region.
Methodology: Both quantitative and qualitative research methods will be used. Quantitative data collection was done in the wet and dry seasons and focused on these key nutritional and food security items: HFIAS (Household Food Insecurity Access Scale), MAHFP (Months of Adequate Household Food Provisioning), 24-hr recall and Anthropometric measures. Analysis will be done with R. Qualitative data collection will use KIIs and FGDs (with the questioning route designed on the basis of data from the baseline quantitative survey). Analysis for qualitative data will be done using Nvivo.
Expected outcomes:
i. Assessment of the State of household food security and nutritional status in the study region.
ii. Households' resilience against climate variability in relation to socio-economic and demographic characteristics of households, food security and nutrition status in the study region.
iii. Effects of climate variability on household nutritional resilience in the study region.
iv. Interventions that promote nutritional resilience in the study region

Keywords: Nutritional resilience, Climate variability, Qualitative, Quantitative, Karamoja border region of Kenya and Uganda.

Bio- and geodiversity of Africa: Current status and challenges in the face of environmental change

PANEL 1

The economic dependency of Ghana's cocoa sector on pollination services

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The cocoa economy of Ghana essentially depends on insect pollination. Here we combine a systematic literature review on cocoa pollination with an economic analysis to explore the role of cocoa pollinators in the economy of Ghana. The systematic literature review revealed \textit{Ceratopogonidae} midges and especially the genus of \textit{Forcipomyia} to be the most important cocoa pollinators in Ghana. We use an economy-wide computable general equilibrium (CGE) model with an explicit representation of the ten former regions of Ghana to model a decline in the cocoa pollinator population. Model scenarios are guided by the systematic literature review, supplemented with expert interviews. Changes in pollinator populations affect poor and rural households more than urban and rich households. Substantial income losses and decreased food consumption are observed in the Western region, the major cocoa-growing region. Declining cocoa pollinator numbers lead to an increased production of all other agricultural commodities, as factors of production are freed from cocoa production. Food processors benefit from this increased production. At the same time, the cocoa processing sector suffers high losses. Apart from activities related to agriculture, substantial changes are observed in the mining and finance industry with both considerably increasing their output if pollinator numbers are on the decline. Our results emphasize that conservation of biodiversity is not an isolated issue and rather a complex issue that is interlinked with other objectives such as economic development and food security.

Liana community structure in relation to climatic, edaphic and physiognomic attributes of forests across five forest ecosystem types in Ghana.

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In the past four decades, tropical ecologists have been puzzled by the factors that determine the distribution and ecology of woody climbing plants, also known as lianas and the reasons for their recent surge in abundance in tropical forests. Leading factors suggested to account for the rise in liana density in pantropical analysis included decreasing mean annual rainfall, increasing rainfall seasonality, rise in atmospheric carbon dioxide, temperature rise and anthropogenic disturbance. Due to limited data, the pantropical pattern of drivers of liana ecology and distribution may not sufficiently represent the status of liana ecology in paleotropical forests. Thus, this study investigated the drivers of liana ecology and distribution in 15 Ghanaian forests within 5 forest ecosystem types selected along a rainfall gradient. Specifically, we investigated how liana abundance and richness were affected by climatic factors, edaphic properties and forest physiognomic attributes. Liana inventory was conducted in seventy-five 50m*50m plots in 15 forests evenly distributed among dry semi-deciduous (DSD), southern marginal (SM), moist semi-deciduous (MSD), moist evergreen (ME) and wet evergreen (WE) forest ecosystems (in order of increasing rainfall and decreasing seasonality). One-way Analysis of variance, diversity permutation test and multiple regression analysis were carried out to determine how liana abundance and richness differed among sites and their significant predictors. Liana abundance in DSD was significantly lower than SM, MSD, ME and WE forest ecosystems. Liana abundance in the SM forests was also considerably lower than MSD, ME and WE forests. MSD, ME and WE were all similar in mean liana abundance. Liana species richness observed in SM was significantly higher than DSD, comparable with MSD but substantially lower than both ME and WE forest ecosystems. Other pairwise comparisons showed significant differences. Liana abundance was predicted (positively) by only tree abundance and base saturation, while liana species richness was affected variously by forest stand attributes, soil properties and climatic factors. Overall, the pattern that emerged from our study deviated from pantropical observation. Liana abundance and diversity did not increase with decreasing rainfall and increasing seasonality. Host tree availability and soil factors were significant predictors of liana community structure in the forest ecosystems of Ghana.

Efficacy of pilot-scale UV treatment to reduce microbial contamination and occurrence of microbial recovery after treatment in irrigation water sources

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In South Africa, agricultural production is largely dependent on surface water for irrigation. The continuing deterioration of the microbial quality of many South African rivers has been well documented and this is an undeniable threat to consumer health. Disinfection of surface water prior to agricultural irrigation will become a necessity rather than a choice.
UV irradiation as a disinfection method for large volumes of water is a rapidly developing field. The efficacy of the process can depend on various factors including differences in UV sensitivity between microorganisms. An important consideration is also the ability of some bacteria to recover from UV irradiation using various light-dependent and light-independent repair processes. Factors that need to be considered when determining the optimal UV dose for the log reduction of food pathogens that may be present in irrigation water, include the microbial type, load present and the presence of microbial repair mechanisms.
The aim of this study was to determine the disinfection efficiency of a pilot-scale, medium-pressure UV-C system treating river water with a single, double or triple UV radiation dose of 20 $mJ.cm^{-2}$. This was done by comparing microbial loads before and after UV treatment, determining the recovery potential of naturally occurring bacteria and isolating and identifying surviving colonies.
Findings indicated that *E. coli* levels were sufficiently reduced in all samples during UV treatment, and although recovery occurred, levels remained within the guideline limits. The presence of *L. monocytogenes* could not be detected after UV and no recovery post-UV was observed. As an important pathogen frequently associated with fresh produce, the recovery observed post-UV of *Salmonella* spp. is concerning. Recoveries post-UV were also observed for the coliform and HPC populations. The potential risk this could have for consumers of fresh produce should be explored further as it is clear from the surviving bacteria identified in this study, that when given time and favourable conditions for recovery, opportunistic pathogens might remain after UV irradiation. The UV irradiation does however decrease the populations significantly, which would also limit the risk of transfer during irrigation. UV irradiation could be successfully utilised as part of a hurdle strategy to improve the safety of irrigation water and prevent pathogens from entering the fresh produce supply chain.

Land use Changes in a changing environmental pattern: Agricultural land Verse Small Scale Gold Mining Trade-off in Ghana

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Ghana is blessed with large volumes of natural minerals and agricultural resources. Small-scale gold mining is a source of livelihood and income for rural communities and poverty-ridden populations in sub-Saharan Africa. Despite this, small-scale gold mining contributes to vegetation loss, farmland degradation, river sedimentation, soil erosion, air pollution, and noise pollution and affects public health and safety. In Ghana and other mineral-rich nations in sub-Saharan Africa, the dilemma of shifting land usage between agricultural areas and small-scale gold mining is reaching an upsurge. Most of the mining activities occur close to productive agricultural lands leading to a reduction in crop yields through the invasion of farms and destruction of cultivated crops. The objectives of this study are to determine the land use changes that have occurred from 2010 to 2020 in the Ashanti Region of Ghana and what factors drive these farmers to trade off their agricultural land for small-scale gold mining. Remote sensing and geographic information systems, as well as the Cragg Double Hurdle model, were employed. Both Landsat satellite images and cross-sectional data from the study area were used. A total of 570 GPS reference points were collected in the field for different Land Use Land Cover classes. Through a multistage sampling technique, 400 cocoa farmers were randomly selected for the study. Results from the study revealed that about 12201 Ha of cocoa farms representing 62.26% had been converted to small-scale gold mining between 2010 and 2020. On the contrary, mining increased from 2989 Ha (2.43%) in 2010 to 20859 Ha (16.97%) in 2020, representing a 17872 Ha (598.32%) increase in mining. Econometrics model results revealed that the age of the farmer, total farm size, perceptions of farmers on low cocoa yields, artisanal small-scale gold mining pays more than cocoa farming and urgent need for financial capital significantly influence farmers' decision to give out their farmlands for mining. Most of the previously reserved land for farming has been exchanged for small-scale gold mining. There is a need for cooperation between economic and environmental experts toward developing detailed and comprehensive policy instruments that balance the economic advantages and environmental disadvantages in Ghana, and other mineral-rich countries in sub-Saharan Africa. Also, a policy of land-for-land should be pursued and effectively implemented.

PANEL 2

The diversity and biomass of savanna ungulates respond differently to land use, resource gradients and drought

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Declines in environmental resources, intensifying human use or climatic disturbances may alter ungulate diversity and biomass in contrasting ways. Among African savanna ungulates, resource-dependent grazers such as wildebeest (*Connochaetes taurinus*) and zebra (*Equus quagga*) or megaherbivores such as the African elephant (*Loxodonta africana*) decline or move away when resources diminish such as during drought. The more resistant and rarer species such as gazelles (*Eudorcas* and *Nanger*) or impala (*Aepyceros melampus*) can fill up the abandoned space. These mixed feeders can survive food and water stress by eating more shrubs and drinking less water. More species with fewer individuals are more diverse than fewer species with many individuals. This can increase community stability. But if high ungulate diversity is associated with low biomass, the aggregate body mass of all individuals in a community, it may have cascading effects on vegetation structure and composition, nutrient cycling and energy flows in savannas. This can alter the community diversity and population dynamics of other organisms. Consequently, it is important to understand how ungulate diversity and biomass respond to human use and resource gradients, how these responses differ and are modified by drought. To do this, we used data from fine-resolution mapping censuses of the ungulate community inhabiting the Maasai Mara National Reserve and its adjacent pastoral lands in Kenya in a drought year (1999) and a normal rainfall year (2002). Ungulate diversity peaked primarily on the pastoral lands within 10 km from the reserve's boundary, but not the bias-adjusted species richness within 1.1 to 1.2 km from occupied settlements. Diversity decreased in the reserve's interior where ungulate biomass peaked. Ungulate biomass decreased on the pastoral lands with increasing distance from the boundary. In the drought year, migratory ungulates moved farther into the reserve. Our results suggest that ungulate diversity peaks in multiple use landscapes if human use does not exceed intermediate levels, whereas ungulate biomass is more sensitive to human use and resource reductions such as occurs during drought. Ungulates need buffer zones and habitat corridors in pastoral landscapes preferably be located farther than 1–2 km from settlements with few sheep and goats, within 2–3 km from rivers or water points and on flat terrain to maintain their diversity and minimize biomass loss in drought years.

Genomic copy number variations for adaptation of livestock to climate change in Africa: review

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Domestication has altered the genomes of all living things on Earth. Changes in temperature and climate shaped the genetic landscape of the populations. Genomic copy number variations (CNVs) are shaped using mutation, selection, and demographic history within and between livestock species. Genomic copy number variations play significant roles in designing and implementing genetic intervention plans for climate resilience and improving livestock production in developed and developing countries. For instance, copy number variable genes are olfactory receptors (ORs), which play important roles for food foraging, mate recognition, and the detection of volatile chemicals in the environment. Copy number variations are important in surveying the unique adaptive, productive, and survivability traits of African livestock populations facing environmental pressures, disease, nutritional deficiencies, and water scarcity. Therefore, this review focused on genomic copy number variations associated with the adaptation of livestock to climate change, which are appropriate for future scientific knowledge and create strong research, design, and development projects in animal biotechnology to improve heat resilience in Africa to maximize their productivity and subsequently reduce their overall carbon footprint due to the changing climate.

*A geochemical baseline study of giant kelp (***Macrocystis pyrifera***) at the Atlantic Ocean kelp blue farm to assess carbon sequestration potential.*

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Gigantic kelp, also known as *Macrocystis pyrifera*, is a species of brown algae that grows in dense forests in shallow coastal waters. Kelp forests cover vast regions and help capture and store carbon dioxide from the atmosphere to reduce climate change. The CO*2* is used to produce organic matter, such as sugars and carbohydrates, which the kelp uses for growth and maintenance. This process helps to reduce the amount of CO*2* in the surrounding water, which can help mitigate ocean acidification. The study researched the biogeochemical changes at a new Atlantic Ocean Kelp Pilot farm near Luderitz, as well as nearby and farther regions along the Namibian coast. We evaluated the results to determine if the giant kelp can sequester CO*2*, by comparing the geochemical line observed before and after artificial cultivation of blue kelp on the farm. Sediment samples were collected at these offshore locations, including those further north of Walvis Bay. This study examined the sediments for trace metals, carbon content, and nutrient concentrations, developed sediment carbon baselines, and identified sediment hotspots. The study revealed that farmed kelp can thrive alongside other wild kelp populations in the ecosystem, particularly during periods of high nutrients and strong winds. To quantify the carbon sequestration capacity of these enormous kelps, a carbon dioxide removal model is being developed. To ensure a healthy kelp forest growth and a successful expansion of operations, it is essential to constantly and closely monitor alterations in the water and sediment geochemistry.

Carbon stock potential and Allometric models for predicting fruit production of Anacardium occidentale L in the municipality of Ouessa, Burkina Faso

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In Burkina Faso, the agricultural sector is one of the least efficient on the continent. Unfavorable soil, climatic conditions and ongoing soil degradation processes significantly reduce agricultural yields. The association of cashew with food crops is presented as an alternative to raise the level of soil fertility and diversify farmers' income sources. This study was conducted in southwestern Burkina Faso to assess the yields of cashew-based cropping systems and the carbon stock potential of cashew trees.
To this end, 82 cashew farmers were surveyed and dendrometric measurements were made to assess the impact of crop association on growth parameters, cashew productivity and carbon storage capacity. Thus, 302 cashew trees were sampled in two types of plantations (plantation associated with crops and pure plantation). For each tree, the following parameters were measured: fruit biomass, Diameter at Breast Height (DBH), canopy diameter and total height. Nut yield and above-ground carbon stock were assessed in both plantation types. Correlation and regression tests between dry nut biomass and dendrometric parameters were used to fit prediction equations for nut and kernel production of the species.
The results show that nut and kernel yield of *A. occidentale* is significantly influenced by the type of plantation. The yields of mixed plantations (7.71±3.36 kg/tree) were indeed higher than those of monospecific plantations (5.52±3.91 kg/tree). Among the prediction models for nut and kernel production developed, the simple linear regressions linking the DBH (in cm) to the total fresh nut and kernel biomass (NB and KB; in kg) were the best models and were expressed by (1) $NB = 1.0243 \times DBH^{1.1841}$; and (2) $KB = 1.0297 \times DBH^{1.1956}$; respectively for nut and almond. Aboveground carbon stock ranged from 0.06 ± 0.03 tC/ha in mixed plantation to 0.08 ± 0.04 tC/ha in pure plantation. The prediction models developed can be used in environmental conditions similar to the study area.
Keywords: Agroforestry systems, *Anacardium occidentale* L., allometric equation, carbon

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PANEL 3

Plant Functional Traits as Predictors of Species Vulnerability to Multiple Drivers of Environmental Change in the South African Cape Floristic Region

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A generalized understanding of species' vulnerabilities to environmental change is fundamental for successful conservation management that mitigates future biodiversity losses. Differentiated species-specific responses to multiple aspects of environmental change poses a challenge for such integrated risk assessments. In the field of plant ecology, functional traits are an established approach to generalize findings across species, which is of particular importance for highly species-rich ecosystems.
We investigate how plant functional traits determine species' vulnerabilities to multiple drivers of environmental change over the entire distribution ranges of 26 Proteaceae species in the South African Cape Floristic Region. The study builds on demographic analyses for the species-specific parameterization of population models that enable range-wide population viability analyses under different scenarios of multiple and interacting environmental changes (climate change scenarios, changing fire regimes, land transformation and wildflower harvesting). Variation in species' vulnerabilities to environmental change is then related to a set of plant functional traits (e.g. leave traits, seed traits and plant architecture) that determine demographic responses for example to fire regime, wildflower harvesting and extreme drought events.
The combined analysis of functional trait data and simulated population viability identifies sub-regions where Proteaceae are particularly threated, both within and outside of present reserve networks, and provides a trait-based understanding of species' vulnerability to multiple drivers of environmental change. These results contribute to ongoing broader stakeholder initiatives on biodiversity risk assessments and conservation prioritization and can be integrated across the study species to assess general threats to functional and phylogenetic biodiversity in this plant biodiversity hotspot.

The Hidden Oases: Uncovering the Trophic Connectivity of Namib's Fog-Plant

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Aims
On the sand dunes of the hyperarid Namib Desert, the endemic grass species *Stipagrostis sabulicola* establishes trophic hotspots: the Fog Plant Oases (FPOs). The FPOs are sustained entirely on fog, and their fates in the future of fog intensity change are currently unknown. We aim to understand i) how *S. sabulicola* and the above- and belowground invertebrate fauna are interconnected through food webs and ii) the importance of FPOs on soil biogeochemical cycling.
Methods
Fieldwork was carried out during the fog season in early September 2022 at Naukluft National Park. Topsoils (0-4 cm) were sampled randomly from a total of 7 FPOs with contrasting plant colony sizes. Nematodes were extracted from soil samples using a modified Baermann method, while other above- and belowground invertebrate faunas were collected using the flotation method and bush-beating. To determine the trophic link between *S. sabulicola* and the faunas that it sustains, we compared the natural variations in stable carbon and nitrogen isotopes of different basal resources (producers) to that of consumers (faunas). To link trophic connectivity to soil nutrient cycling, the activities of eight extracellular enzymes involved in the cycling of carbon, nitrogen, sulfur, and phosphorus were measured together with the in-situ concentration of these elements.
Results
Early results showed that soils under matured FPOs harbored significantly higher densities of soil faunas as compared to the open desert. In general, very low densities of soil faunas were found under young FPOs. Soils under matured FPOs held an astonishingly rich nematode fauna (up to 1500 individual/100g dry soil with up to 9 species) that was dominated by bacterial and fungal feeders. Mites were found in low density under matured FPOs, and evidence of springtails was found. Aboveground, the plant stem and leaves are inhabited by a rich community of parasitic and predatory insects and arachnids. Consistent with the results of soil fauna densities, soil extracellular enzyme activities were significantly higher under matured FPOs as compared to the open desert, while no significant differences were observed between soil under young FPOs and its surrounding.
Conclusion
Our results already showed that FPOs established by *S.sabulicola* are important trophic hotspots that support a high biodiversity of soil and aboveground invertebrates. Belowground, FPOs have an important contribution to biogeochemical cycling in this region.

Hidden biodiversity and disease: the case of echinococcosis in Africa

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Cystic echinococcosis (CE) is a potentially fatal, neglected zoonotic disease of humans, livestock and wildlife, caused by tapeworms (*Echinococcus* spp.) of carnivores, whose larval stages form cysts in internal organs of intermediate hosts leading to organ failure. CE agents are various cryptic species and genotypes of *Echinococcus granulosus* s.l., most of them globally distributed and frequent in northern, eastern and southern Africa. *Echinococcus* spp. are trophically transmitted in carnivore-herbivore lifecycles involving domestic animals (dogs and livestock) and/or large wild mammals. Humans become accidentally infected by ingestion of *Echinococcus* eggs from carnivore faeces via contaminated food or water. Molecular methods have been crucial to unravel the transmission pathways of the various *Echinococcus* taxa. Our studies in Africa of the past 15 years have established, that these taxa differ significantly in their impact on human health, explaining the focal distribution of high-endemicity areas across the continent: most affected are the sheep-raising areas in northern Africa, the nomadic pastoralists in parts of eastern Africa, and the cape region in the south. In contrast, livestock and – as far as known – wildlife is commonly affected throughout the continent with the exception of high-rainfall regions of central and western Africa with little livestock husbandry. As the *Echinococcus* taxa are closely adapted to different host species, human disease foci are hypothetically explained by sheep husbandry (with unsupervised home slaughter) favouring the most human pathogenic species, *E. granulosus* s.s.. Where human CE is rare, other *Echinococcus* taxa prevail, namely *E. ortleppi*, closely adapted to cattle. Shifts in climatic conditions and resulting shifts in host species has therefore a direct impact on human disease, e.g. by replacing cattle production with sheep or game farming. There are also conservation aspects: anthropogenic introduction of a horse-adapted *Echinococcus* has led to CE infection of (probably) most zebras in southern Africa. On the other hand, regarding parasites as members of natural ecosystems, range contractions of wild host mammals also cause the parasite to disappear, as is the case for *E. felidis*, adapted to a transmission between lions and warthogs. Here, we present data on transmission systems of *Echinococcus*

*Genes under selection in two inverted chromosomal regions of the Western Honey bee (*Apis mellifera)

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The western honey bee (*Apis mellifera)* is characterized by its large native range, living from high mountains to low tropics, thus being well adapted to various climatic conditions. East African mountain regions are particularly interesting as high mountains are populated by monticola subspecies, denoted as mountain bee that differs in phenotype compared to bees of surrounding savannahs (*scutellata* subspecies). Morphologically and behaviourally, they can be distinguished, with *monticola* being less aggressive, darker and larger. However, the distinction between the two subspecies is still debated since genetically, only a little differentiation exists, except for two regions on chromosome 7 (r7) and chromosome 9 (r9). Both regions were identified as inversion polymorphisms. These mutations are frequently associated with adaptation. Inversions suppress recombination, leading to the selection of favourable variants. r7 and r9 include genes involved in memory formation, learning and metabolism, which are good candidates for high-altitude adaptation. This study focuses on the detection of sites under positive selection in genes located in r7 and r9 to narrow down potential adaptation signs. Data was collected from 52 East African honey bee samples from four whole-genome projects (PRJNA357367, PRJNA294105, PRJNA237819, PRJNA481428). McDonald-Kreitmann test (MKT) was used to detect signals of positive selection. First, we tested both *scutellata* and *monticola* populations as a whole big East African population and then we separated the two to find specific genes under significant selection pressure. After this, we tested Untranslated regions (UTRs) by using Tajima's D and Fay and Wu's H test with an outgroup to clarify if 3'-UTR and the 5'-UTR evolved non-neutrally. UTRs have a very important role in post-transcriptional modification and gene expression. Uncharacterized proteins under selection were passed through PANNZER2 software to assign the highest possible number of GO terms. We found one uncharacterized protein under positive selection in r9 inversion common to both *scutellata* and *monticola*. Three genes were under selection in both *scutellata* and *monticola* in r7 region and two were under selection only in *monticola* in r7 region. Further analysis will include genomic and transcriptomic data from additional samples to elucidate the regulatory network underlying A. mellifera adaptation to high-elevation habitats.

PANEL 4

Exploring the interrelated dynamics of land tenure, cropping systems and biodiversity through field types

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AIMS: The presentation explores how the field type concept can elucidate interrelations between land tenure, cropping systems and biodiversity dynamics. A field type is characterized by its mix of crops, ecological context, and cropping method.
METHODS: We conducted 2 mixed-methods village case studies during 9 months of fieldwork in 2022. Data collection methods included questionnaires, network interviews, semi-structured interviews, focus groups and participant observation.
RESULTS: In the Ghanan village the field types are cocoa and oil palm farms. Land tenure arrangements include standard clauses for all stages of plantation development. Tenants must give half of their cocoa or a third of their oil palm harvest to landowners, but as long as trees are productive, they cannot be evicted. Once old oil palms need to be felled and tapped the land is split between landlords and tenants. Food crops are only planted in newly established plantations. Once the canopy closes farmers need to seek a new land for food crops. Also, revenues from tree crop harvest and labour time are freed up to be invested in new plantations. While this offers opportunities for social mobility, it also creates a dynamic of constant habitat loss through forest conversion.
The Nigerian village no longer has virgin land. The field types are cocoa farms or annual cropping land ('papa'). The cocoa farms are much more diverse than in the Ghanaian village, with an overstory of e.g. kola or orange and an understory with pineapple and yams. Oil palms spread naturally in both cocoa farms and 'papa' and are rented out to specialized palm oil producers separately from the plot they stand on. As cocoa farms are more diverse and not intersected by exposing oil palm plantations, there was more wildlife. Tree crops have been established by the parents' and grandparents' generations' and are mostly rented out on an annual basis for a fixed sum of money. These less secure land rights provide little incentive for plantation maintenance resulting in more dead wood in the plantations but also higher disease pressure and thus fungicide use.
CONCLUSION: In both village cases, the field type forms a system connecting land tenure, cropping practices and biodiversity dynamics. As spatial entities, field types can connect social science research with spatially explicit approaches from agronomy and geography. The concept also elucidates the contexts in which research and interventions on biodiversity take place.

Safety considerations of seaweed in Senegal: heavy metals hazards

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To meet the problem of nourishing a global population of estimated 9.7 billion by 2050, as well as the impact of climate change on food production and use, expanded use of seaweed has been proposed and is a promising approach for long-term development in West Africa. The role of seaweeds in the functioning of aquatic ecosystems and in meeting the needs of health, aesthetics, water purification, refuse and nurseries for certain aquatic species, food industry, absorption of carbon dioxide explain the importance of their preservation and enhancement. Studies on the biological diversity and valorization of the seaweeds present on the Senegalese coast take place and continue within the framework of research by universities and the General Directorate of Seabed in Senegal. Results from this research indicate development possibilities and production constraints such as the concentration of heavy metals in seaweeds. Dangerous heavy metals such as arsenic (As), mercury (Hg), lead (Pb), and cadmium (Cd) can accumulate in seaweeds and become toxic above a specific threshold. From April to July 2022, 41 samples of 25 different seaweed species were gathered along the Senegalese coast between the Cap-Vert peninsula and the Petite Côte. Microwave Plasma Atomic Emission Spectroscopy and XRF-fluorescence spectrophotometrie were used to determine concentrations. The results demonstrate that 36% of the studied specimens have As concentrations exceeding the Norwegian National Institute of Nutrition and Seafood Research (NIFES, 2016) threshold of 10 mg kg^{-1} of dry seaweed. All specimens have Cd concentrations exceeding 0.5 mg kg^{-1} of dry seaweed, a threshold for toxicity by French health agencies. For 97% of the samples, the values for Cd were less than 10 mg kg^{-1}, which is the minimum concentration that can be determined with acceptable uncertainty. *Hypnea musciformis*, stranding in substantial quantities along Senegal's coastline, contained Pb concentrations higher than four times the maximum suggested limit by French health agencies. An extension of the study area to the entire coastline over two years was intended to identify seasonal variations in heavy metal concentrations.
Keywords: Heavy metals, concentrations, Seaweed, Cap-Vert peninsula, Petite Côte, Senegal.

Addressing agricultural labour issues is key to biodiversity-smart farming

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There is an urgent need for biodiversity-smart agricultural development strategies that reconcile agricultural production and biodiversity conservation. This is especially true in the Global South where population growth is rapid and much of the world's remaining biodiversity is located. Combining conceptual thoughts with empirical insights from case studies in Indonesia and Ethiopia, we argue that such strategies will have to pay more attention to agricultural labour dynamics. Farmers have a strong motivation to reduce the heavy toil associated with farming by adopting technologies that save labour but negatively affect biodiversity. Labour constraints can also prevent farmers from adopting technologies that improve biodiversity but often increase labour burden. Without explicitly accounting for labour issues, conservation efforts can hardly be successful. Our empirical insights suggest that technological and institutional options to reconcile farmers' socio-economic goals and biodiversity conservation exist but that more needs to be done to implement such options at scale.

Effect of Tephrosia vogelii *formulation with rabbit urine on insect pests and yield of sesame in Singida, Tanzania*

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A field experiment was conducted to assess the efficacy of *Tephrosia vogelii* formulated with rabbit urine on insect pests and yield of sesame. The experiment was done with five treatments namely 10% *T. vogelii* (w/v), 50% rabbit urine (v/v), 10% *T. vogelii* + 50% rabbit urine, Water and synthetic pesticide [Duduba 450 EC (Cypermethrin 100g/l + chlorpyrifos 350g/l)]. Results show that, sesame plants sprayed with the formulation of 10% *T. vogelii* + 50% rabbit urine significantly ($p \leq 0.001$) decreased the number of identified insect pests and encouraged high numbers of natural enemies compared with sesame plants sprayed with other treatments. For instances, Sesame plants sprayed with 10% *T. vogelii* + 50% rabbit urine had lower numbers of *Antigastra Catalaunalis* and *Alocypha bimaculata* that decreased as from week 1 to 5 compared with other treatments. Also, sesame plants sprayed with 10% *T. vogelii* + 50% rabbit urine possessed significantly ($p \leq 0.001$) lower percentage damage of sesame compared with other treatments from weeks 1 up to 5 respectively. The results also indicated that, the formulation of 10% *T. vogelii* + 50% rabbit urine was significantly ($p \leq 0.001$) increased sesame yield compared with other treatments. The highest yield was (740.59kg/ha) followed by that of a positive control (721.78kg/ha) and the lowest yield was (672.78kg/ha) that from negative control. Therefore, this study suggests that, treatment 10% *T. vogelii* + 50% rabbit urine can be used by the smallholder farmers to combat insect pests on sesame fields in Africa.

Poster Session

A meta-analysis with systematic review reveals that grain legume integration into the cassava cropping system enhances resilience to climate vulnerabilities in Africa

Adam Muhammed Adam, University of Hohenheim (Germany)

Evaluation of Ethiopian durum wheat (Triticum turgidum L. var. durum) genotypes for drought tolerance at varying sowing density

Fikeremariam Awdamet, University of Hohenheim (Germany)

Evidence gaps in AMR One Health data in Africa: a systematic review

Primrose Beryl, University Hospital Tübingen (Germany)

Isolation and characterization of bacteria with antimicrobial activity from Malawian soil samples

Manuel Pufal, University of Hohenheim (Germany)

Policy performance and stakeholders' perspectives on achieving sustainable food production in Namibia

Gideon Mawenge, University of Hohenheim (Germany)

Utilization of climate-resilient crops for complementary food among agro-pastoralists of Benna-Tsemay district, South-Omo zone, Ethiopia: Qualitative study

Derese Desta, Hawassa University (Ethiopia)

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