FEED THE FUTURE
The U.S. Government's Global Hunger & Food Security Initiative

SUMMARY REPORT

of the

Sustainable Intensification Thought Leaders' Summit

(February 6 – 7, 2024, Manhattan, Kansas)

Hosted by:

Feed the Future Innovation Lab for Collaborative Research on Sustainable Intensification, Kansas State University
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Summit Agenda

Participant Bios

Acronyms

AGRA	African Organization, formerly known as the Alliance for a Green Revolution in Africa
AI	Artificial Intelligence
BMP	Best Management Practices
CBE	Circular Bioeconomy
CSA	Climate-Smart Agriculture
CGIAR	Consultative Group on International Agricultural Research
ESG	Environmental, Social, and Governance
SIIL	Feed the Future Sustainable Intensification Innovation Lab
GxExMxP	Genetics x Environment x Management x Policy
GxExMxS	Genetics x Environment x Management x Social System
GIS	Geographic Information Systems
GAP	Good Agricultural Practice
GHG	Greenhouse Gas
HEI	Higher Education Institution
HICD	Human and Institutional Capacity Development
IPM	Integrated Pest Management
IARS/IARCS	International Agricultural Research (Center) System
IOT	Internet of Things
KSU	Kansas State University
LCA	Life Cycle Analysis
MITA	Market for Agricultural Innovation and Technology
NARS/NARES	National Agricultural Research (and Extension) System
PA	Participatory Approach
PV	Photovoltaic
PPP	Public-Private Partnership
R4D	Research for Development
RUE	Resource Use Efficiency
SME	Small and Medium Enterprises
SOC	Soil Organic Carbon
SAI	Sustainable Agricultural Intensification
SI	Sustainable Intensification
SIAF	Sustainable Intensification Assessment Framework
VACS	The Vision for Adapted Crops and Soils
FFA/4-H	U.S.-origin Agricultural Student/Positive Youth Development Organizations
SDG	UN Sustainable Development Goal
USAID	United States Agency for International Development
USG	United States Government
UBI	Universal Basic Income
WRT	Water Rights Trading

Introduction

Sustainable Intensification focuses on improving the efficient use of resources for agriculture, with the goal of producing more food on the same amount of land but with reduced negative environmental or social impacts. The intent of the *Sustainable Intensification (SI) Thought Leaders' Summit* was to share findings and capitalize on the collective knowledge of the participants regarding advancements, existing gaps, and future research needs on SI for improving international agriculture research for development to address objectives of the Global Food Security Strategy initiatives of United States Agency for International Development (USAID) and other associated organizations. Focusing largely on the research needed to improve the livelihoods of rural households, smallholder farmers, agrifood value-chain actors, and the National Agricultural Research and Extension Systems (NARES) of the Global South (less developed or developing countries). SI thought leaders workshop was divided into six discussion topic themes to identify current research gaps, research opportunities to address the current gaps, and collectively develop strategies to address the key gaps. These actionable strategies can be used by targeted institutions and organizations, such as universities, private sector and NARES that manage agrifood systems research and capacity building projects in the Global South.

The definition of SI has evolved to include non-biophysical dimensions such as social issues, and human condition, in addition to the traditional dimensions of productivity, economics, and environments. The SI community is addressing smallholder farming contexts where agricultural production is closely linked with global development goals such as alleviating poverty, avoiding land degradation, supporting biological diversity, increasing household food security, improving childhood and maternal nutrition outcomes, while supporting women's socioeconomic empowerment and positive youth development. The research gaps and opportunities identified by the 30 SI thought leaders at this summit offered strategies to consider and balance the productivity, environmental, economic, social and human objectives of agrifood systems change.

The grand challenge for SI is to continue reducing global hunger, poverty, and malnutrition rates while addressing increasingly complex environmental, social, economic and ecological issues exacerbated by erratic weather patterns, changing environment, changing farm management and volatile commodity prices. Countless past agricultural research and development "solutions" have failed due to a missing perspective from a key demographic or unique feature of the ecosystem and typology of farming systems and farmers. The SI thought leaders made it very clear that strategic SI solutions need to use more representative, locally adapted, and must use participatory approaches that include diverse partners, stakeholders, including farmers and those with expertise on adoption and scaling of technologies. Building bridges between stakeholders is foundational to the creation of a resilient, gender-transformative, and nourishing global agrifood system for all.

Methods

SI thought leaders representing a wide range of disciplines and geographic areas in the world gathered in Manhattan, Kansas, from February 6-7, 2024. These leaders (see Appendix K and participant bios) were tasked to create strategic plans to tackle gaps in global SI efforts (see summit agenda at the end of the document). Focusing largely on smallholder farming systems in the Global South, 30 SI thought leaders were divided into six discussion topic themes (listed below) among which they identified current research gaps, research opportunities to address gaps, and then thematically organized the gaps and opportunities. The six topics were as follows:

1. Climate Smart and Sustainable Agrifood Systems (inclusive of regenerative systems and nature-based solutions).
2. Resilience of Agrifood Systems (inclusive of biophysical and social aspects: farming systems, nutrition, and people).
3. Resource Use Efficiency (e.g., nutrients, water, labor; inclusive of minimizing waste and circular systems).
4. Digital and Precision Management Practices and Tools (inclusive of biophysical, social, and knowledge management).
5. Approaches for Enhancing Adoption and Scaling (inclusive of biophysical and social innovations).
6. Building Human, Social, and Institutional Capacity for Local-Led Agricultural Research and Development.

On the second day, three themes found among the first day's gap-opportunity clusters were identified as uniting themes that address all six topics. These three themes (ecological intensification; socio-economic resilience; and resource use efficiency – circular bioeconomy) were selected for deep-dive to focus on development of well deliberated strategies. Thought leaders were divided into the new three thematic discussion groups and were tasked to devise strategic plans while considering the cross-cutting themes (gender, youth engagement, public-private-partnerships (PPPs), inclusivity, and participatory approaches).They were also asked to incorporate digital tools, scaling and capacity building where appropriate. All groups rotated through the three topics to ensure that inputs from all participants were captured. Finally, at the conclusion of the Summit, participants were asked to identify strengths of land-grant university systems. The results of which were coded, thematically analyzed, and reported here by the evaluation team in the section below. Please see appendices A-F for the definitions and participation notes for the six topics, appendices G-J for the definitions and participation notes for the three themes and land-grant systems activity and see below for outcomes the discussion results.

Outcomes and Recommendations

Three key themes were identified by leadership from the initial brainstorming activity that connected all six topics (see appendices G-I for flipchart work). The groups developed these strategic plans for addressing each key theme—each key theme identified as a salient "research gap-opportunity cluster" for current SI investments, research and development (R&D) activities, policy considerations, and PPPs. These three overarching themes included circular bioeconomy, ecological intensification, and socioeconomic resiliency. When tasked on the second day to find strategic plans for the key themes, participants identified and, in rotating groups, refined the following as actionable plans:

1. **Ecological Intensification**: Participants emphasized that work in ecological intensification requires a landscape or systems-based approach to activities. Landscape approaches integrate considerations of competing land uses and recognize that systems-based approaches are necessary for creation of policy and practice when human interests conflict with environmental goals. Through that lens, they identified six major considerations for all ecological intensification strategies and investment: human capital / capacity, natural resources flow, improved agronomy, value addition to agricultural products and byproducts, functional value chains, and water management/harvesting. Integrated within every step of the strategy efforts should also mobilize social groups, utilize modeling/mapping technology, and use market data to help inform decisions. While there are many systems within a given ecological system, the group decided, for the sake of exercise, to use the sustainable increase of biomass productivity as their example of a SI approach.

During this activity, the participants identified additional components to a total of 12 (albeit, not exhaustive), that needed to be addressed for a given strategy (see appendix H for the full list). Participants were able to identify the main components that every strategy should consider whether for sustainably increasing biomass (above and below ground) or for supporting another ecosystem service. When implemented, ecological intensification strategies should devise activities and inputs that yield outcomes that work towards these 12 components: utilize digital landscape and mapping tools, increase diversification (value-chain, species, livestock, etc.), increase nutrient availability and access, improve rainwater management, improve genetics, use and develop best management practices (BMPs), enable social groups, improve market systems, increase financial services, increase social protections, add value, and increase labor and energy productivity.

This approach effectively tailors the systems strategy to the unique features of an agroecosystem or value-chain to optimize the feasibility and success rate of the strategy. In this regard, the cross-cutting themes of mobilizing youth, gender, inclusivity, PPPs, and participatory approach are acknowledged, and room is left for them to be incorporated in each unique context.

2. **Socioeconomic Resiliency**: The thought leaders' identified participatory approaches as the foundation for inclusive scaling and effective technology transfer for more climate-smart and resilient agrifood systems. They devised a decision framework for tailoring technologies, research and capacity building strategies, and research investments to be more aligned with the unique features and people of the targeted agroecosystem. Taking more widely adaptable climate-smart and climate-resilient concepts and tailoring them with evidence-based, gender-sensitive/gender-transformative strategies to local conditions and preferences may make them significantly more adoptable. Scaling of SI technologies and tools through improved enabling environments for their adoption, private investment, and readaptation to local contexts, particularly by women and youth, will require diverse strategies across enable greater socioeconomic resiliency when facing challenges or other major disruptions (i.e., regional political conflicts, shifts in global markets, massive land/nutrient changes as a result of weather or human-induced harm). Utilizing a decision framework also allows for strategies to be adjusted or reoriented when new information or tools are made available.

   The first step to this framework is to gather data of the ecosystem in conjunction with traditional knowledge and local assets. The specific data points to be collected depend on factors such as location, context, scale, and geographical considerations. Participants highlighted various variables that should be taken into account, including (but not exclusive to) the type of farms (subsistence vs. commercial), geographical location, soil quality, climate, resources and market availability, gender-related aspects (decision-making and power dynamics), and the aspirations of farmers (whether they aim to sustain their current farming practices, scale up, or transition out of farming). This data can help identify the particular vulnerabilities of the ecosystem, local assets, and other features of the ecosystem pertinent to the strategy and create a model.

   While devising the strategy for an activity, development and implementation happen in parallel with the key stakeholders and local populations to improve its viability while actively getting feedback to respond to unforeseen pitfalls and continually improving the strategy and implementation tactics. For example, the team learns that their technology contradicts the female farmers' risk management strategies, giving them the opportunity to modify the intervention before scaling investments. If an idea is accepted, then the strategy moves to delivery/implementation. Here, who does what and when should identified based on the site/context and its outputs can be measured to track success and failure. The final stage is policy – after implementing the intervention/strategy, the state or regional government can set policy to address gaps or failures that cannot be addressed at the farm or household level. Cooperation and participation must be influenced from the farm, or "ground level," up at the policy or regional government levels in this framework to be successful.

The insights gained during the delivery/implementation phase will actively inform the development of effective policies, ensuring a responsive and adaptive approach to address emerging challenges and opportunities. At any step of this given framework, the strategists may return to previous steps if their strategy fails in some way (i.e., not accepted by Indigenous peoples, contradicts policy, does not adequately resolve issues as intended). This iterative process thus allows a strategy to be *dynamic (adaptive)* and increasingly tailored to the ecosystem – identifying vulnerabilities and increasing the capacity for local assets to be mobilized to address them, optimizing resiliency – thereby increasing the likelihood of success. To emphasize, this framework supports socioeconomic *resiliency* because it is dynamic – allowing for challenges to be overcome with better fit between strategy and the ecosystem and in some cases, anticipating and preventing challenges before they arise by identifying vulnerabilities and means to fix them in the first place. Additional aspects that were recognized that still need to be addressed are *who* will be involved and responsible for implementation and how strategies can be scaled.

3. **Resource Use Efficiency – Circular Bioeconomy**: For this topic, the participants identified the key questions that all decision makers and/or strategists will need to address for the creation of a circular bioeconomy (see appendix G). The first thing needed is to reframe our linear thinking on how products, money, and natural resources flow through the economy into a cyclical process. As agricultural scientists, the group naturally gravitated towards enumerating four key nutrient cycles—water, carbon, nitrogen, and phosphorous—and looking for integration across the cycles with the value-chain and on-farm activities. A key component of circular bioeconomy is redefining "wastes" from our currently segregated and linear economy by managing them properly as "resources" that are productive assets in the ecosystem.

   A key consideration for biocircular economic development is defining what is the scale of the bioeconomy? (On-farm? Regionally? Globally? Where are the boundaries of the circle(s)?) Essentially, participants were in agreement that true sustainability and an authentically circular bioeconomy has to be done on a global scale, but it is a more useful exercise to think about on-farm and regional economies (e.g., economies of scale) to seek answers and solutions related to synergies and tradeoffs for stakeholders implementing these strategies. There are many social considerations – Do we need to change how we value ecosystem services or natural resources—even if enacting on a local scale? What will change and who will be involved in these processes? How does a change in one part of the system affect another? How does money cycle through this new economy? Who, when, and how much are they profiting?

   By asking these questions, participants recognized the cyclical nature of the intermediate parts of a system. Therefore household, farm, and industrial systems cannot be broken into individual units, just like the first group emphasized landscape and systems approaches. For example, an on-farm solution that reduces carbon emissions may result in a tradeoff in another nutrient cycle. Strategic approaches must have a more inclusive understanding of the ecosystem they are working with, including all the interrelated cycles within the greater system. Useful natural and financial capital must be drawn out from the reducing, reusing, and recycling of all various byproducts and other sustainable practices for the circular bioeconomy to be successful. In summary, efforts must be integrated throughout all systems, but closing gaps in smaller circles and systems contributes to the resilience of the whole system. It is important to note that technology is expected to play a large role in monitoring, measuring, and analyzing the cycles, so development of a circular index for comparing interrelated systems may be useful.

Overall, the three initial groups approached their strategies in very different, but complementary ways. The ecological intensification group used an example to demonstrate the key considerations and landscape approach that would be necessary across all strategic approaches. The socioeconomic resiliency group provided an implementation framework necessary for consideration of dynamic and diverse systems that can be utilized at each decision stage in the former strategy *and* be used to tackle and prevent challenges and issues that arise. Finally, the resource use efficiency – circular bioeconomy group provided insights into the details that needed to be flushed out by the first group by highlighting that strategies needed to address the complex circular nature of biophysical systems in relationship to our global economy. This latter group also recognized the importance of gathering metrics and measuring using a circular index that reflects the inherent circular nature of the systems as well as identifying and establishing efficient communication with diverse and representative stakeholders in the agrifood system.

Common themes were to begin using landscape, systems, and participatory approaches when establishing new research and development activities. It is fundamental to implementation success to identify what and who will be involved and at what stages in the process; it is important to constantly reevaluate what gaps exist and how changing strategies affects general populations and specifically women and youth. While all groups recognized that scaling is a major hurdle, they recognize that the need for regional-specificity and social context considerations, economics and return on investments is what naturally hinders scaling. All groups discussed what tools or frameworks could be devised to making local adaptation more streamlined, and in turn making local needs more central to the approach is a key component of scaling. Strategies and tools can be scaled, but the implementation must be translated across different ecosystems and local cultures.

After devising SI strategy for two days, a final question remained—who or what will be responsible for taking the initiative of utilizing this strategy in research? One powerful tool at hand is the U.S. land-grant universities. Participants recognized many benefits of the integrated education, research and extension model, most frequently identifying its capacity to support research and development (including provisions of infrastructure, financial support, equipment, regulatory bodies, etc.), skilled and successful extension units (including understanding public needs and impacts, training the next generation (e.g., scientists, farmers), capacity building, and the availability of data (i.e., foundational research, transparency in research). At the closing of the SI Thought Leaders' Summit, a participant reminded us of an oft-overlooked part of the Green Revolution in India. With the assistance of key U.S. land-grant universities and early USAID investment, led to the development initial Indian Agricultural Universities established with Indian-led tripartite education, research, and extension model which disseminated technologies, and information to farmers. That system continues to exist in most agricultural universities.

The SI Thought Leaders represented diverse experiences and perspectives from numerous National and International Agricultural Research Systems (IARS) in both the Global North (developed countries) and the Global South. Establishment and capacity building of universities in the target countries with their own leadership could enable the rapid dissemination of key SI technologies, strategies, and tools. As such, it is recommended that land-grant universities in the US should disseminate the findings from this report, continue creating partnerships with other HEIs (higher education institutes) and NARES/IARS to assist in strategic planning and capacity building, and support and spur development, dissemination, adoption and scaling of SI technologies to positively impact lives and livelihoods of people.

Appendix A

Topic: Climate Smart and Sustainable Agrifood Systems (Inclusive of Regenerative Systems and Nature-Based Solutions)

Key Definitions

Climate-smart and sustainable agricultural practices: Integrated and holistic approaches/practices to manage landscapes (e.g., cropland, livestock, forest), fisheries, and resources that address the interlinked challenges in agrifood systems related to food, nutrition, climate, and sustainable development. These practices simultaneously boost productivity, use sustainability principles, and include adaptation, mitigation, and resilience of systems and people to climate. These are tailored to specific agrohydroecological conditions and socioeconomic contexts.

Adaptation (in relation to climate change): The process of adjusting (natural or human systems) in response to actual or anticipated effects of climate stimuli/change.

Mitigation: (in relation to climate change): the process of reducing sources or practices that emit greenhouse gases into the atmosphere or enhancing sinks that store greenhouse gases.

Resilience (in relation to climate change): The capacity of social, economic, and ecosystems to maintain their functions and bounce back in the face of climate stresses/shocks and to adapt in anticipation of future events or shocks.

Note. The following italicized comments were written by thought leader participants and have been lightly edited to protect confidentiality and enhance readability.

Gaps in the Research

- *Climate risk reduction - quantifying failure risk reduction.*
- *Convincing stakeholders that sustainable ag practices do not compromise productivity.*
- *Costing the transition to adopt climate smart solutions.*
- *Cultural barriers to adoption.*
- *Ecological intensification over energy-intensive inputs.*
- *Food and agriculture are interwoven with natural and socio-economic systems.*
- *Increase labor productivity with minimum increase in fossil fuel or metabolic energy inputs.*
- *Jumpstarting increased productivity.*
- *Lack of climate information at the farm level to adapt their current agricultural practices.*
- *Lack of context specific understanding of sustainable ag practices.*
- *Lack of coordinated efforts to quantify the impacts of sustainable ag practices from underdeveloped countries.*
- *Land mapping capability - needed to refine CSA practices (site specific).*
- *Market linkages.*
- *Mechanisms to reward outcomes monetarily.*
- *Mechanization opportunities (labor productivity).*
- *Private public partnerships.*
- *Profitability versus productivity (still talking about yields).*

- *Regional specific recommendations (ecological and cultural).*
- *Shortening the time between research and communication to stakeholders for the sake of improving adaptability.*
- *Social acceptance - question assumptions.*
- *Yield versus profitability issues.*

Research Opportunities

- *AI or some tools for better projections of weather, then farmers can make their decisions.*
- *Develop integrated system to improve nutritional quality and reduce risks.*
- *Digital "leapfrogging"- overcomes some traditional barriers to adoption, attractive to youth, can be empowering to women by increasing information reach.*
- *Digital databases of locally adapted climate smart practices.*
- *Gene-editing to reduce the risk of biotic stress viruses.*
- *Identifying and partnering with local leaders (political, cultural, religious, etc.) to normalize climate-smart practices.*
- *Increase woody perennials (trees and shrubs) in cropping and pastoral systems as climate smart solution.*
- *Indigenous crops are provided less support/need more genetic improvement to indigenous crops.*
- *Integration of climate information to technological packages, to be considered as an input like seeds and fertilizers.*
- *Jumpstart through humanure and urine recycling.*
- *More diversification for push-pull level efficiency in pest regulation and incorporation on non-legume N-fixation.*
- *Need for investment on capturing high-res soil and weather data.*
- *Opportunity for crops to leverage existing platforms and methods to expedite crop improvement and use of modern tools like digital and genomics.*
- *Perennial incorporation and perennialization. Nutrient acquisition and retention, water infiltration, lower energy input.*
- *Remote/automated sensing - high-resolution, real-time information; can reach isolated, hard to reach areas; can link local information to global systems.*
- *Start systematic data collection (e.g., long-term field experts) to identify region specific sustainable ag practices that optimize our agronomic and ecological benefits.*
- *Strengthen extension-like networks to distribute knowledge about climate-smart practices.*
- *Utilize farmers' Indigenous knowledge and developing adaptive management practices.*

Clusters of gaps and opportunities

Note. Thought leader participants grouped gaps and opportunities into clusters and titled the clusters. Cluster titles are numbered and bolded below.

1. **Ecological intensification**

   Gaps in the research:
   - *Ecological intensification over energy-intensive inputs.*
   - *Increase labor productivity with minimum increase in fossil fuel or metabolic energy inputs.*
   - *Jumpstarting increased productivity.*
   - *Mechanization opportunities (labor productivity).*

Research opportunities:

- *Develop integrated system to improve nutritional quality and reduce risks.*
- *Gene-editing to reduce the risk of biotic stress viruses.*
- *Increase woody perennials (trees and shrubs) in cropping and pastoral systems as climate smart solution.*
- *Indigenous crops are provided less support/need more genetic improvement to indigenous crops.*
- *Jumpstart through humanure and urine recycling.*
- *More diversification for push-pull level efficiency in pest regulation and incorporation on non-legume N-fixation.*
- *Opportunity for crops to leverage existing platforms and methods to expedite crop improvement and use of modern tools like digital and genomics.*
- *Perennial incorporation and perennialization. Nutrient acquisition and retention, water infiltration, lower energy input.*

2. Economic intensification

Gaps in the research:

- *Market linkages.*
- *Mechanisms to reward outcomes monetarily.*
- *Profitability versus productivity (still talking about yields).*
- *Yield versus profitability issues.*

Research opportunities:

No opportunities were identified by the thought leader participants.

3. Information intensification

Gaps in the research:

- *Climate risk reduction - quantifying failure risk reduction.*
- *Lack of climate information at the farm level to adapt their current agricultural practices.*
- *Lack of context specific understanding of sustainable ag practices.*
- *Lack of coordinated efforts to quantify the impacts of sustainable ag practices from underdeveloped countries.*
- *Land mapping capability - needed to refine CSA practices (site specific).*

Research opportunities:

- *AI or some tools for better projections of weather, then farmers can make their decisions.*
- *Digital "leapfrogging"- overcomes some traditional barriers to adoption, attractive to youth, can be empowering to women by increasing information reach.*
- *Digital databases of locally adapted climate smart practices.*
- *Integration of climate information to technological packages, to be considered as an input like seeds and fertilizers.*
- *Need for investment on capturing high-res soil and weather data.*
- *Remote/automated sensing - high-resolution, real-time information; can reach isolated, hard to reach areas; can link local information to global systems.*
- *Start systematic data collection (e.g., long-term field experts) to identify region specific sustainable ag practices that optimize our agronomic and ecological benefits.*

4. Scaling intensification

Gaps in the research:

- *Convincing stakeholders that sustainable ag practices do not compromise productivity.*
- *Private public partnerships.*
- *Regional specific recommendations (ecological and cultural).*
- *Shortening the time between research and communication to stakeholders for the sake of improving adaptability.*

Research opportunities:

- *Strengthen extension-like networks to distribute knowledge about climate-smart practices.*

5. Social intensification

Gaps in the research:

- *Costing the transition to adopt climate smart solutions.*
- *Cultural barriers to adoption.*
- *Food and ag is interwoven with natural and socio-economic systems.*
- *Social acceptance – question assumptions.*

Research opportunities:

- *Identifying and partnering with local leaders (political, cultural, religious, etc.) to normalize climate-smart practices.*
- *Utilize farmers' Indigenous knowledge and developing adaptive management practices.*

Appendix B

Topic: Resilience of Agrifood Systems
(Inclusive of Biophysical and Social Aspects: Farming Systems, Nutrition, and People)

Key Definitions

Resilience of agrifood systems: Our agrifood systems are vulnerable to a wide range of shocks and risks including climate shocks, natural disasters, pests and disease outbreaks, conflicts and wars, supply chain disruptions, economic, price and policy shocks. Ability of systems, institutions, people to prevent, resist, absorb, adapt, respond, and recover when confronted with shock or risks.

From an agrifood systems perspective – it is defined as the ability to prepare and plan for, absorb, recover from, and more successfully adapt and transform in response to adverse events.

The focus should be to achieve food and nutrition security and improve the livelihoods of actors within the agrifood system at an appropriate scale (field or farm; individual or communities; and region or country).

Note. The following italicized comments were written by thought leader participants and have been lightly edited to protect confidentiality and enhance readability.

Gaps in the Research

- *Agroecology, farmers knowledge, and agriculture-livestock integration are not investigated sufficiently.*
- *Better farmer safety nets (insurance/policies).*
- *Context-specific diversified livelihood options.*
- *Establishing trustable and science- and data-based metrics to evaluate current state and changes in resilience.*
- *Gap in biophysical models to help inform risks to shocks from farm to fork (along value chain, e.g., digital twins for reassessing resilience).*
- *Gap in understanding agrifood systems at different scales: farm, supply chains, shocks to different components along supply chains. Gap in wastes, understanding losses opportunities.*
- *How to engage/identify needed stakeholders (PPP) for system transformation for adverse events and opportunities.*
- *Lack of knowledge about food supply chains differing in different regions.*
- *Limited tools available to decide what the key decision is at a specific place and time. 1) where to plant, 2) what to plant, 3) how to manage, and 4) how to implement (VACS, Vision for Adapted Crops and Soils).*
- *Limited understanding of impact of soil type and landscape position on long-term resilience (shallow soils, soils with argillic horizons).*
- *Limited understanding of thresholds and especially how land degradation resources resilience to extreme events (climate).*
- *Long-term systems research to document resilience.*
- *Monitoring networks.*
- *Need for systems thinking/perspectives and understanding interdependencies among components. Complex systems dynamic!*
- *Need to facilitate access to relevant information for specific location/time/issue.*
- *Quantify all dimensions and outputs of diversified/polyculture production systems.*

- *Resolving resource/land tenure issues.*
- *Strengthening food system players (third party providers).*
- *Support for entities (NARS, SMEs, others) to allow production of locally adapted crop cultivars/animal breeds for sale to farmers – can be same entity that bred them or not.*
- *Support for entities (NARS, SMEs, other) to breed, test, etc., new locally adapted crop cultivars and animal breeds considering GxExMxS (Genotype x Environment x Management x Social).*
- *Understanding links with social protection (amount and type).*

Research Opportunities

- *Agriculture to resilience pathways... with examples. Farm: consumption of owned produce, income on farm (markets), (re)investment in lands/soils, nutritional status, blue/green water access, food safety. Off farm: off farm payments, insurance.*
- *Analyzing vulnerability in the food supply chain. Explore new system for decentralized or localized food supply chain.*
- *Can resilience of soils be modeled in terms of productivity, environment, resource sustainability?*
- *Design to minimize resilience - productivity trade-offs.*
- *Develop frameworks for innovation systems (farming, supply chains, etc.) to be more resilient to potential shocks (e.g., digital twins to evaluate multiple likely outcomes)*
- *Develop new technologies in precision agriculture, remote sensing, genetic engineering for resilient agrifood systems.*
- *Develop systems to help policy makers, extension, and farmers identify and make the highest impact decision at each place and time. 1) where to plant, 2) what to plant, 3) how to manage, and 4) how to implement (VACS – Vision for Adapted Crops and Soils).*
- *Develop transdisciplinary/multidimensional targeting tools for decision support at landscape level.*
- *Domestication of micro-flora and fauna, and use of advanced processing to diversify the raw material base for proteins and oils for food.*
- *Economic resiliency - market access, price stability, and sufficient funds.*
- *Empower youth as valuable entrepreneurs for community: data curators, service delivery, marketing, knowledge, advisory, filtering.*
- *Explore and improve genetics and agronomics of dual-purpose cultivars to enhance resiliency.*
- *Include land degradation status and trends in modeling and research on climate change impacts on resilience.*
- *Learn from others' mistakes - publish negative outcomes?*
- *Opportunity to explore synergies and mutual benefits of incorporating sustainable intensification and One Health and circular bioeconomy system. How these approaches can be beneficial to each other? (regarding resilience, etc.).*
- *Producing good yields and minimizing yield variability.*
- *Promoting agroecology and the integration of agriculture-livestock to help improve soil fertility, upscale multi-usage crops, and to limit the use of chemicals and pesticides.*
- *Reduce post-harvest losses by promoting circular economies.*
- *Repurpose research resources developed for one objective for new opportunities (resources can be markets, delivery pipelines, genetic resources, digital apps, soil and climate atlases).*
- *Research and model community impacts of soil type and landscape position on long-term resilience (erodible soil, shallow to root, limiting layer).*
- *Social protection payments - insurance, universal basic income (UBI), transfers.*

- *Tap into traditional food patterns to stimulate diversification and food and nutrition security.*
- *The genetic diversity in the world's gene banks.*
- *Understand the impact of climate change. Develop technologies to mitigate the impact.*

Clusters of gaps and opportunities

Note. Thought leader participants grouped gaps and opportunities into clusters and titled the clusters. Cluster titles are numbered and bolded below.

1. **Agroecology**

   Gaps in the research:
   - *Agroecology, farmers knowledge, and agriculture-livestock integration are not investigated sufficiently.*

   Research opportunities:
   - *Develop new technologies in precision agriculture, remote sensing, genetic engineering for resilient agrifood systems.*
   - *Explore and improve genetics and agronomics of dual-purpose cultivars to enhance resiliency.*
   - *Producing good yields and minimizing yield variability*
   - *Promoting agroecology and the integration of agriculture-livestock to help improve soil fertility, upscale multi-usage crops, and to limit the use of chemicals and pesticides.*

2. **Context-specific information**

   Gaps in the research:
   - *Context-specific diversified livelihood options.*
   - *Lack of knowledge about food supply chains differing in different regions.*
   - *Need to facilitate access to relevant information for specific location/time/issue.*
   - *Quantify all dimensions and outputs of diversified/polyculture production systems.*

   Research opportunities:
   - *Tap into traditional food patterns to stimulate diversification and food and nutrition security.*
   - *Understand the impact of climate change. Develop technologies to mitigate the impact.*

3. **Genetic diversity**

   Gaps in the research:
   - *Support for entities (NARs, SMEs, others) to allow production of locally adapted crop cultivars/animal breeds for sale to farmers – can be same entity that bred them or not.*
   - *Support for entities (NARS, SMEs, other) to breed, test, etc., new locally adapted crop cultivars and animal breeds considering GxExMxS.*

   Research opportunities:
   - *Domestication of micro-flora and fauna, and use of advanced processing to diversify the raw material base for proteins and oils for food.*
   - *Producing good yields and minimizing yield variability.*
   - *The genetic diversity in the world's gene banks.*

4. **Learning from mistakes**

   Gaps in the research:
   - *Establishing trustable and science- and data-based metrics to evaluate current state and changes in resilience.*

- *Monitoring networks.*

Research opportunities:

- *Learn from others' mistakes - publish negative outcomes?*

5. **Socioeconomic resiliency**

Gaps in the research:

- *Better farmer safety nets (insurance/policies).*
- *Gap in biophysical models to help inform risks to shocks from farm to fork (along value chain, e.g., digital twins for reassessing resilience).*
- *Resolving resource/land tenure issues.*
- *Understanding links with social protection (amount and type).*

Research opportunities:

- *Agriculture to resilience pathways... with examples. Farm: Consumption of owned produce, income on farm (markets), (re)investment in lands/soils, nutritional status, blue/green water access, food safety. Off farm: off farm payments, insurance.*
- *Design to minimize resilience - productivity trade-offs.*
- *Economic resiliency - market access, price stability, and sufficient funds.*
- *Repurpose research resources developed for one objective for new opportunities (resources can be markets, delivery pipelines, genetic resources, digital apps, soil and climate atlases).*
- *Social protection payments - insurance, UBI, transfers.*

6. **Supply chain/food systems**

Gaps in the research:

- *How to engage/identify needed stakeholders (PPP) for system transformation for adverse events and opportunities.*
- *Strengthening food system players (third party providers).*

Research opportunities:

- *Analyzing vulnerability in the food supply chain. Explore new system for decentralized or localized food supply chain.*
- *Empower youth as value adding entrepreneurs for community: data curators, service delivery, marketing, knowledge, advisory, filtering).*
- *Reduce post-harvest losses by promoting circular economies.*

7. **Systems dynamics and thresholds**

Gaps in the research:

- *Limited understanding of thresholds, and especially how land degradation resources resilience to extreme events (climate).*
- *Need for systems thinking/perspectives and understanding interdependencies among components. Complex systems dynamic!*

Research opportunities:

- *Develop frameworks for innovation systems (farming, supply chains, etc.) to be more resilient to potential shocks (e.g., digital twins to evaluate multiple likely outcomes).*
- *Include land degradation status and trends in modeling and research on climate change impacts on resilience.*
- *Opportunity to explore synergies and mutual benefits of incorporating sustainable intensification and One Health and circular bioeconomy system. How these approaches can be beneficial to each other? (regarding resilience, etc.).*

8. Targeting in space and time

<u>Gaps in the research:</u>

- *Gap in understanding agrifood systems at different scales: farm, supply chains, shocks to different components along supply chains. Gap in wastes understanding losses opportunities.*
- *Limited tools available to decide what the key decision is at a specific place and time. 1) where to plant, 2) what to plant, 3) how to manage, and 4) how to implement (VACS).*
- *Limited understanding of impact of soil type and landscape position on long-term resilience (shallow soils, soils with argillic horizons).*
- *Long-term systems research to document resilience.*

<u>Research opportunities:</u>

- *Can resilience of soils be modeled in terms of productivity, environment, resource sustainability?*
- *Develop systems to help policy makers, extension, and farmers identify and make the highest impact decision at each place and time. 1) where to plant, 2) what to plant, 3) how to manage, and 4) how to implement (VACS).*
- *Develop transdisciplinary/multidimensional targeting tools for decision support at landscape level.*
- *Research and model community impacts of soil type and landscape position on long-term resilience (erodible soil, shallow to root, limiting layer).*

Appendix C

Topic: Resource Use Efficiency
(e.g., Nutrients, Water, Labor; Inclusive of Minimizing Waste and Circular Systems)

Key Definitions

Resource use efficiency: It measures how efficiently various resources (e.g., land, seeds, nutrients, water, light, energy, labor, machines, tools, and knowledge) are used on a unit basis in the agrifood system.

From an ecological or agricultural perspective, it measures the proportion of supplied resources which is converted into an economic product (e.g., biomass, grain yield, nutrients, natural capital, or biodiversity).

This is inclusive of concepts that minimize or recycle or repurpose "wastes" using circular systems in both production and consumption aspects of the agrifood systems.

The concept should capture productivity, diversity, and outputs on both spatial (locations or place) and temporal (time or season) scales.

Note. The following italicized comments were written by thought leader participants and have been lightly edited to protect confidentiality and enhance readability.

Gaps in the Research

- *Diversification within intensification of efficiency.*
- *Efficiently recycle nutrients and water within food/cropping systems. Production <-> consumption.*
- *Establishing open, accessible, and scale-based databases for different resource use efficiencies.*
- *Facilitate access to knowledge and information necessary to match land use to its sustainable potential to increase land use efficiency.*
- *How to incentivize resource use efficiency (e.g., reduce fertilizer, improve soil health) for small holder farmers who face capital and land tenure constraints.*
- *How to increase inputs generated within the farmscape (biological, energy, "weeds").*
- *How to optimize labor use efficiently and farm power use to specific socio-tech conditions.*
- *How to reduce cold/cool chain gaps in electricity constrained systems - to reduce waste in veg/meat/dairy.*
- *How to repurpose contaminated crops to give them an economic value and remove them from the human diet (e.g., toxin contamination, upcycling).*
- *Irrigation systems are not always efficient to get more out of the water available to produce food (water waste).*
- *Issue: farmers view efficiency differently. Plot scale advice assumes homogeneity, acceptance of technical definition, and target. Q: how do different farmers approach RUE? How does that influence practices, adoption? Implications for PA, inclusion, gender, PPP.*
- *Issue: RUE interaction at multiple scales (i.e., how practices and RUE at pilot relates to RUE at catchment/watershed or other landscape unit) for specific outcomes/targets. Q: What are tradeoffs by scale?*
- *Issue: RUE when land use (rights) is seasonal/shifting. Q: how to achieve "efficiency" with seasonal land users and uses (temporal)? Implications for participatory approaches, inclusivity, gender.*

- *Lack of community and engagement with engineers who are working on biomass conversion to other products.*
- *Most agricultural equipment is not adapted to farmers. (More labor demand with conservation ag and ecosystem services, but not mechanization to address).*
- *Not enough certified seeds at the farm level in relation to the availability of new varieties adapted to farmers' conditions.*
- *Payment for ecosystem services (climate mitigation; design/implementation at farm and landscape level).*
- *Policy and regulatory mechanisms for enhancing circular systems and food safety.*
- *Use "wasted" biomass for products for human needs beyond food, feed, fiber, energy.*
- *Why still not treat human waste as a resource?*

Research Opportunities

- *A recent study shared that <0.5% of innovation funds for the seed sector go to farmer-scale and local-scale seed.*
- *Agrivoltaic: on farm energy, vegetables under panels, grazing. (Food, energy, water; climate-energy crisis).*
- *Better mechanisms to aggregate/pool resources for small holders to gain efficiency or access opportunity.*
- *Bringing in energy and learning to recycle for peak efficiency.*
- *Crop, livestock, integrated systems.*
- *Developing varieties adapted to climate change and to farmers' working conditions (types of soil, market needs, seed production, etc.).*
- *Engage efforts (PPP) working on electrification of Haber-Bosch process to "eliminate" CO2 emissions caused by producing synthetic N fertilizer.*
- *ESG connecting consumers to producers to increase efficiencies (LCA Mars, Nestle, Starbucks).*
- *Input services provision (not only owning machines, etc.).*
- *Intensifying farming systems to produce more food in small scale agriculture using GAP (better seeds, agroecology, IPM, adapted mechanization).*
- *Introducing and testing more efficient irrigation systems to minimize water waste.*
- *Investigate what land tenure models allow best resource use and how those could be implemented, considering policy, culture, etc.*
- *Is it too early to ask questions about potential use of cellular food (meat)?*
- *Opportunity to leverage digital for resource use efficiency recommendations (i.e., N use, water use, AI, machine learning, data science).*
- *Partnerships to understand incentives for companies that sell inputs or buy outputs WRT targeted RUE (e.g., fertilizer companies, off-taker companies, input sales to women farmers).*
- *Perennial-based systems: labor productivity, resilience, ecological intensification, sustainability for wide range of land types.*
- *Relay/intercropping for diversification and efficiencies and add fruit and vegetables (nutrition human markets).*
- *Repurpose resources developed for one objective for new opportunities.*
- *Use "waste" for making nonfood related products.*

Clusters of gaps and opportunities

Note. Thought leader participants grouped gaps and opportunities into clusters and titled the clusters. Cluster titles are numbered and bolded below.

1. **Circular bioeconomy**

   Gaps in the research:
   - *How to repurpose contaminated crops to give them an economic value and remove them from the human diet (e.g., toxin contamination, upcycling).*
   - *Lack of community and engagement with engineers who are working on biomass conversion to other products.*
   - *Use "wasted" biomass for products for human needs beyond food, feed, fiber, energy.*
   - *Why still not treat human waste as a resource?*

   Research opportunities:
   - *Repurpose resources developed for one objective for new opportunities.*
   - *Use "waste" for making nonfood related products.*

2. **Digital ag knowledge**

   Gaps in the research:
   - *Establishing open, accessible, and scale-based databases for different resource use efficiencies.*

   Research opportunities:
   - *Opportunity to leverage digital for resource use efficiency recommendations (i.e., N use, water use, AI, machine learning, data science).*

3. **Diversification**

   Gaps in the research:
   - *Diversification within intensification of efficiency.*
   - *Efficiently recycle nutrients and water within food/cropping systems. Production <-> consumption.*
   - *How to increase inputs generated within the farmscape (biological, energy, "weeds").*

   Research opportunities:
   - *Crop, livestock, integrated systems.*
   - *Perennial-based systems: labor productivity, resilience, ecological intensification, sustainability for wide range of land types.*
   - *Relay/intercropping for diversification and efficiencies and add fruit and vegetables (nutrition human markets).*

4. **Energy**

   Gaps in the research:
   - *How to reduce cold/cool chain gaps in electricity constrained systems – to reduce waste in veg/meat/dairy.*
   - *Irrigation systems are not always efficient to get more out of the water available to produce food (water waste).*

   Research opportunities:
   - *Agrivoltaic: on farm energy, vegetables under panels, grazing (Food, energy, water; climate-energy crisis).*
   - *Bringing in energy and learning to recycle for peak efficiency.*

- *Engage efforts (PPP) working on electrification of Haber-Bosch process to "eliminate" CO2 emissions caused by producing synthetic N fertilizer.*
- *Introducing and testing more efficient irrigation systems to minimize water waste.*
- *Is it too early to ask questions about potential use of cellular food (meat)?*

5. Labor and mechanization

Gaps in the research:

- *How to optimize labor use efficiently and farm power use to specific socio-tech conditions.*
- *Most agricultural equipment is not adapted to farmers (more labor demand with conservation ag and ecosystem services, but not mechanization to address).*

Research opportunities:

- *Input services provision (not only owning machines, etc.).*

6. Land use

Gaps in the research:

- *Facilitate access to knowledge and information necessary to match land use to its sustainable potential to increase land use efficiency.*
- *How to incentivize resource use efficiency (e.g., reduce fertilizer, improve soil health) for small holder farmers who face capital and land tenure constraints.*
- *Issue: RUE interaction at multiple scales (i.e., how practices and RUE at pilot relates to RUE at catchment/watershed or other landscape unit) for specific outcomes/targets. Q: What are tradeoffs by scale?*
- *Issue: RUE when land use (rights) is seasonal/shifting. Q: how to achieve "efficiency" with seasonal land users and uses (temporal)? Implications for participatory approaches, inclusivity, gender.*

Research opportunities:

- *Investigate what land tenure models allow best resource use and how those could be implemented, considering policy, culture, etc.*

7. Market innovations

Gaps in the research:

- *Issue: farmers view efficiency differently. Plot scale advice assumes homogeneity, acceptance of technical definition and target. Q: how do different farmers approach RUE? How does that influence practices, adoption? Implications for PA, inclusion, gender, PPP.*
- *Payment for ecosystem services (climate mitigation; design/implementation at farm and landscape level).*

Research opportunities:

- *Better mechanisms to aggregate/pool resources for small holders to gain efficiency or access opportunity.*
- *ESG connecting consumers to producers to increase efficiencies (LCA Mars, Nestle, Starbucks).*
- *Partnerships to understand incentives for companies that sell inputs or buy outputs WRT targeted RUE (e.g., fertilizer companies, off-taker companies, input sales to women farmers).*

8. Policy and regulatory systems

Gaps in the research:

- *Not enough certified seeds at the farm level in relation to the availability of new varieties adapted to farmers' conditions.*

- *Policy and regulatory mechanisms for enhancing circular systems and food safety.*

Research opportunities:

- *A recent study shared that <0.5% of innovation funds for the seed sector go to farmer-scale and local-scale seed.*
- *Developing varieties adapted to climate change and to farmers' working conditions (types of soil, market needs, seed production, etc.).*
- *Intensifying farming systems to produce more food in small scale agriculture using GAP (better seeds, agroecology, IPM, adapted mechanization).*

Appendix D

Topic: Digital and Precision Management Practices and Tools (Inclusive of Biophysical, Social, and Knowledge Management)

Key Definitions

Digital and precision agricultural practices: Practices that use data and digital techniques to monitor and optimize input/resource use efficiency, productivity, quality, input costs, profitability, minimize environmental impact, improve sustainability considering the variability within fields, farms, soils, or typologies.

The tools measure, observe, analyze the needs of fields, and prescribe various inputs for crops/plants or needs of individual animals.

The tools are inclusive of various sensors (handheld, mounted on machines, towers, drones, or satellites).

These include use of mobile devices (smart phones, tablets) to access real-time data on climate, weather, soil, or plant health, pest and disease incidence, resource use and availability, price and markets, loans and subsidies and more, access to knowledge and information. The primary goal is making informed decisions.

Note. The following italicized comments were written by thought leader participants and have been lightly edited to protect confidentiality and enhance readability.

Gaps in the Research

- *Ability to use technologies and provide social-human nutrition context.*
- *Access/ability to act on recommendation (capacity holding).*
- *Clarity on value defined for who? Farmer, market, research only? With gender and youth dimensions.*
- *Communication bandwidth.*
- *Developing new tools for smallholders including more real-time data and taking actions.*
- *Digital twins to assess resilience, stress test, framework.*
- *Equity – analysis of winners and losers in digital uptake.*
- *From: do better with new tech. To: reimagined system given the new technology.*
- *From: narrow focus-field economics. To: human health-field to well-being.*
- *Gaps on transforming from data to actionable intervention.*
- *How to harness digital transformation to engage youth and develop future leaders.*
- *Lack of communication bandwidth (IOT, reach) and source of truth (formal vs informal markets) to enable recommendations.*
- *Limited connections between soil, climate, and crop production.*
- *Limited data resources at farm level such as fertilizers usage that can help residues investigate the relationship between production and climate at global scale.*
- *Need to facilitate access to relevant info for specific location/time/issue.*
- *Not enough knowledge sharing and networking using digital platforms.*
- *The uncertainty of crop modelling (I like the parameters).*

Research Opportunities

- *Activate systems approaches to reimagine healthy agriculture.*
- *An opportunity to unify data standards while scaling and building up use of open-source data.*
- *Bringing precision ag to small-scale ag. Can these tools be scaled and accessible to small systems (through mobile phone)?*
- *Connecting to other sectors to enable SDG's (i.e., Fintech for loans, subsidies, and policy).*
- *Develop shiny apps/visualization tools.*
- *Develop systems to help farmers and policy makers determine when AI-generated "knowledge" is wrong (AI-BS).*
- *Developing new, open, accessible databases for establishing foundational data for understanding all domains of the SIAF (data integration).*
- *Establish new frameworks for exploration of digital twins within the context of GxExMxP.*
- *Establishing data sharing policies. Accessibility of data.*
- *Facilitate the access of digital platforms to farmers by developing AI applications (easy to use for farmers, agro-dealers, and policy makers).*
- *Harness digital ag data and digital twins to develop and implement stress tests in pig and human health.*
- *Harness the power of AI crop-soil models with integration of animal, economic, social, and human nutrition models.*
- *Investigative effect of digital exclusion.*
- *Leverage data science to harness complexity of the system and ability to be more targeted in interventions.*
- *Moving info and data both directions (researchers <-> small holders) and utilizing cell phones and commonly used tools (WhatsApp) to reach farmers and agribusiness.*
- *Use AI to leverage data to bridge knowledge gaps from molecule (soil) to molecule (human)?*

Clusters of gaps and opportunities

Note. Thought leader participants grouped gaps and opportunities into clusters and titled the clusters. Cluster titles are numbered and bolded below.

1. **Data infrastructure and governance**

   Gaps in the research:
   - *Communication bandwidth.*
   - *Lack of communication bandwidth (IOT, reach) and source of truth (formal vs informal markets) to enable recommendations.*
   - *Limited data resources at farm level such as fertilizers usage that can help residues investigate the relationship between production and climate at global scale.*
   - *Need to facilitate access to relevant info for specific location/time/issue.*
   - *Not enough knowledge sharing and networking using digital platforms.*

   Research opportunities:
   - *An opportunity to unify data standards while scaling and building up use of open-source data.*
   - *Developing new, open, accessible databases for establishing foundational data for understanding all domains of the SIAF (data integration).*
   - *Establishing data sharing policies. Accessibility of data.*
   - *Moving info and data both directions (researchers <-> small holders) and utilizing cell phones and commonly used tools (WhatsApp) to reach farmers and agribusiness.*

2. Decision-making

<u>Gaps in the research:</u>

- *Developing new tools for smallholders including more real-time data and taking actions.*
- *Gaps on transforming from data to actionable intervention.*

<u>Research opportunities:</u>

- *Bringing precision ag to small-scale ag. Can these tools be scaled and accessible to small systems (through mobile phone)?*
- *Develop shiny apps/visualization tools.*
- *Develop systems to help farmers and policy makers determine when AI-generated "knowledge" is wrong (AI-BS).*
- *Facilitate the access of digital platforms to farmers by developing AI applications (easy to use for farmers, agro-dealers and policy makers).*

3. Social and human dimensions for a healthy agriculture

<u>Gaps in the research:</u>

- *Ability to use technologies and provide social-human nutrition context.*
- *Access/ability to act on recommendation (capacity holding).*
- *Clarity on value defined for who? Farmer, market, research only? With gender and youth dimensions.*
- *Equity – analysis of winners and losers in digital uptake.*
- *From: narrow focus-field economics. To: human health-field to well-being.*
- *How to harness digital transformation to engage youth and develop future leaders.*

<u>Research opportunities:</u>

- *Activate systems approaches to reimagine healthy agriculture.*
- *Connecting to other sectors to enable SDG's (i.e., Fintech for loans, subsidies, and policy).*
- *Investigative effect of digital exclusion.*

4. Systems thinking

<u>Gaps in the research:</u>

- *Digital twins to assess resilience, stress test, framework.*
- *From: do better with new tech. To: reimagined system given the new technology.*
- *Limited connections between soil, climate, and crop production.*
- *The uncertainty of crop modelling (I like the parameters).*

<u>Research opportunities:</u>

- *Establish new frameworks for exploration of digital twins within the context of GxExMxP (genetics x environment x management x policy).*
- *Harness digital ag data and digital twins to develop and implement stress tests in pig and human health.*
- *Harness the power of AI crop-soil models with integration of animal, economic, social, and human nutrition models.*
- *Leverage data science to harness complexity of the system and ability to be more targeted in interventions.*
- *Use AI to leverage data to bridge knowledge gaps from molecule (soil) to molecule (human)?*

Appendix E

Topic: Approaches for Enhancing Adoption and Scaling (Inclusive of Biophysical and Social Innovations)

Key Definitions

Adoption: The process of acceptance or usage of new technologies or practices by stakeholders (e.g., producer, consumer, or practitioner). It is a dynamic process involving – understanding, learning, experimenting, redesigning, and adapting to local or individual contexts (e.g., biophysical or socio-economic).

Adoption theory: Science that explains why some individuals (e.g., farmers or consumers) adopt new technology and others do not; or dis-adopt. It is complex and needs multidisciplinary team science to understand factors that influence decision making (e.g., intrinsic factors like tacit knowledge, attitude, perception, culture, context; and extrinsic factors like environment, cost, resources).

Scaling: The process of expanding the use of technologies or practices over large geographies, agro-ecologies, and across communities and organizations to impact larger numbers of people.

Scaling process (approaches and instruments): An important goal of this process should be to sustain and grow, so that impacts continue over time and space to have positive impact on food, nutrition, and climate security at a larger scale.

Note. The following italicized comments were written by thought leader participants and have been lightly edited to protect confidentiality and enhance readability.

Gaps in the Research

- *Bidirectional tailoring: research on "leapfrog" to tailor information and practices to match land and social contexts, and user capacity to tailor.*
- *Bundling: understanding packages of multidisciplinary info and technologies to enable adoption and impact (finance, agro, social).*
- *Challenges of extrapolation of research results.*
- *Education, training, and continuing learning to foster adoption of innovation and new approaches (collaborations with gov't and PPPs).*
- *Farmer and institutional innovation to modify, mishmash, and make it work.*
- *How can climate finance instruments be leveraged for scaling up practices/technologies?*
- *Incentives for adoption of technologies and practices: markets, policies, benefits (financial, social, cultural, environmental).*
- *Lack of good evaluation data on instruments for innovation/scaling (e.g., platforms, incubators, networks, etc.).*
- *Lack of understanding how monitoring systems and targets (dis)incentivize sustainable scaling.*
- *Need for critical analysis of scaling approaches used by large agencies (e.g., CGIAR and others).*
- *Need of adult, women, and minorities participation in adoption process.*
- *Need to incorporate existing knowledge with innovation to promote better adoption and acceptance.*
- *Reluctance to adapt to new technologies due to lack of better incentives to persuade/encourage consumers/farmers to adopt (human behavior innovations).*

- *Research and funding to support the linkage and coordination of research outputs with disseminating partners and end-users.*
- *Research on the pathways to drive (incentivize) adoption and impact (private, public, NGO).*
- *Strengthening last mile delivery systems: extension context, input delivery, farmer (extension).*
- *What outreach activities are effective and why?*

Research Opportunities

- *Complementing public extension with local village-based advisors with appropriate context and facilitation.*
- *Continuous monitoring and evaluation for technology adoption (agri-practice).*
- *Developing and implementing: 1) agro-parks to showcase technologies and 2) agricultural markets of technologies (MITA).*
- *Donors embrace development/improve. Biophysical modeling for combining with economic models for scaling.*
- *Evaluate framework and approaches to scaling used by large agencies [e.g., AGRA, CGIAR] (including packages/bundles).*
- *Evaluate the effect of targets and indicators on scaling practices and outcomes (e.g., USAID, CGIAR).*
- *Extrapolation: connecting geospatial relevant data and crop models with user-sourced (indigenous) information to tailor suitable recommendations.*
- *Identifying revenue options for private sector extension to function sustainably.*
- *Improving extrapolation of research through digital and targeted pathways.*
- *Incentives for local participation focusing on women and youth involvement.*
- *Optimizing recommendation and technologies to match user objectives (e.g., production vs. profit vs. efficiency vs. labor).*
- *Promote value chain approaches with innovation platforms and multi-actors' partnership to improve engagement of private sector and adoption of new innovations and technologies.*
- *Review instruments for innovation/scaling with view to institutionalizing (e.g., platforms, networks, incubators, grants, prizes).*
- *Supporting local platforms to guide research and scaling/impact pathways.*
- *Trained new AI models for agronomists and extension from ag to community.*
- *Use AI to augment extension services where insufficient.*

Clusters of gaps and opportunities

Note. Thought leader participants grouped gaps and opportunities into clusters and titled the clusters. Cluster titles are numbered and bolded below.

1. **Analytical tools**

   Gaps in the research:
   - *Bidirectional tailoring: research on "leapfrog" to tailor information and practices to match land and social contexts, and user capacity to tailor.*
   - *Challenges of extrapolation of research results.*

   Research opportunities:
   - *Donors embrace development/improve. Biophysical modeling for combining with economic models for scaling.*
   - *Extrapolation: connecting geospatial relevant data and crop models with user-sourced (indigenous) information to tailor suitable recommendations.*

- *Improving extrapolation of research through digital and targeted pathways.*
- *Optimizing recommendation and technologies to match user objectives (e.g., production vs. profit vs. efficiency vs. labor).*
- *Trained new AI models for agronomists and extension from ag to community.*

2. Delivery

Gaps in the research:

- *Bundling: understanding packages of multidisciplinary info and technologies to enable adoption and impact (finance, agro, social).*
- *Education, training, and continuing learning to foster adoption of innovation and new approaches (collaborations with gov't and PPPs).*
- *Farmer and institutional innovation to modify, mishmash, and make it work.*
- *Need for critical analysis of scaling approaches used by large agencies (e.g., CGIAR and others).*
- *Need to incorporate existing knowledge with innovation to promote better adoption and acceptance.*
- *Research on the pathways to drive (incentivize) adoption and impact (private, public, NGO).*
- *Strengthening last mile delivery systems: extension context, input delivery, farmer (extension).*
- *What outreach activities are effective and why?*

Research opportunities:

- *Complementing public extension with local village-based advisors with appropriate context and facilitation.*
- *Evaluate framework and approaches to scaling used by large agencies [e.g., AGRA, CGIAR] (including packages/bundles).*
- *Identifying revenue options for private sector extension to function sustainably.*
- *Use AI to augment extension services where insufficient.*

3. Incentives

Gaps in the research:

- *How can climate finance instruments be leveraged for scaling up practices/technologies?*
- *Incentives for adoption of technologies and practices: markets, policies, benefits (financial, social, cultural, environmental).*
- *Lack of understanding how monitoring systems and targets (dis)incentivize sustainable scaling.*
- *Reluctance to adapt to new technologies due to lack of better incentives to persuade/encourage consumers/farmers to adopt (human behavior innovations).*

Research opportunities:

- *Continuous monitoring and evaluation for technology adoption (agri-practice).*
- *Evaluate the effect of targets and indicators on scaling practices and outcomes (e.g., USAID, CGIAR).*
- *Incentives for local participation focusing on women and youth involvement.*

4. Scaling instruments

Gaps in the research:

- *Lack of good evaluation data on instruments for innovation/scaling (e.g., platforms, incubators, networks, etc.).*
- *Need of adult, women, and minorities participation in adoption process.*
- *Research and funding to support the linkage and coordination of research outputs with disseminating partners and end-users.*

Research opportunities:

- *Developing and implementing: 1) agricultural technology parks to showcase technologies and 2) agricultural markets of technologies (MITA).*
- *Promote value chain approaches with innovation platforms and multi-actors' partnership to improve engagement of private sector and adoption of new innovations and technologies.*
- *Review instruments for innovation/scaling with view to institutionalizing (e.g., platforms, networks, incubators, grants, prizes).*
- *Supporting local platforms to guide research and scaling/impact pathways.*

Appendix F

Topic: Building Human, Social, and Institutional Capacity for Local-Led Agricultural Research and Development

Key Definitions

Capacity: The ability of people, organizations, and society to manage their affairs successfully. Capacity building or development is the process whereby people, organizations, and society as a whole unleash, strengthen, create, adapt, and maintain these abilities over time.

Social Capital: A set of shared values or resources that allow individuals to work together to effectively achieve a common purpose. It facilitates collective action and the ability to obtain resources, information, and knowledge through effective networking, communication, shared governance, and ownership.

Human capacity: The development of improvement or training of individuals to enhance their knowledge, skill, technical expertise, competencies, or abilities to analyze, learn, and attain education, that can help them to be productive, adaptive, and resilient to changes. It should include local, Indigenous, and traditional knowledge.

Institutional capacity: The ability of an institution to conduct research, education, outreach, leadership, and service activities. This includes the ability to utilize resources effectively and efficiently (e.g., human and social capital, infrastructure, financial resources), coordinate activities, develop collaborations, networks, and partnerships.

Note. The following italicized comments were written by thought leader participants and have been lightly edited to protect confidentiality and enhance readability.

Gaps in the Research

- *Ability of change agents to recognize and value local innovation.*
- *Accuracy of baseline/census data.*
- *Connecting young urban people to their food systems.*
- *Creating and capacitating village-based advisories/service providers.*
- *Elevating role and importance of women.*
- *Employment pipeline gaps (or capital access for entrepreneurship).*
- *Empower local ownership and leadership of processes and priorities.*
- *Food and agriculture are not sexy enough for youth to choose it as a profession of choice.*
- *Ground truthing of general assumptions.*
- *How education curricula cover sustainability/equity and the effect on graduates.*
- *Insufficient investment in admin/funding; management capacity of science staff.*
- *Lack of key informant diversity and representation.*
- *Local asset based.*
- *Providing interdisciplinary opportunities for learning new skills (future jobs).*
- *Research in context of local social-cultural practices (experiential learning).*
- *Research is not very active to implement incubators to train youth and women to become agripreneurs.*

- *Set up local groups to try alternatives and discuss results with the group.*
- *What are the skills needed for the workforce in the agrifood supply chain?*
- *What outreach activities are effective and why?*

Research Opportunities

- *Create digital interactive games to "play" exciting scenarios to be important contributor and successful professional.*
- *Create K-12 educational programs that excite youth to choose a career in food and agricultural systems.*
- *Create research questions for K-12 (or beyond) to perform citizen science, such as monitoring, or creating software, or even competitions. Work with participants to analyze results and draw conclusions.*
- *Develop locally relevant and modern curricula for formal and informal ag science and education.*
- *Developing curriculum with systems thinking.*
- *Evaluate where policy and implementation breakdowns occur in governments.*
- *Explore opportunities to align private sector incentives with long-term sustainability.*
- *FFA/4-H type youth organizations.*
- *Funding/Monitoring, Evaluation & Learning incentives – increase diversity and representation of Key Informants.*
- *Ground truthing/census data – we have GIS, sampling strategies, and methods to improve accuracy.*
- *Incorporating Indigenous knowledge in decision-making.*
- *Research station locations.*
- *Research to fully participate in implementation of incubators to train youth and women (new innovating technologies).*
- *School feeding programs re-introduce traditional foods and establish participatory engagement.*
- *Technologies that will make community grown products valuable for one-health objectives.*
- *Train workforce in systems thinking and highly adaptable.*
- *Understand the capacity and skills private companies need to get and manage impact investors.*
- *Understand capacity and skills the private sector companies need now and to expand/build markets.*
- *Workforce development focused on food processing/value addition.*

Clusters of gaps and opportunities

Note. Thought leader participants grouped gaps and opportunities into clusters and titled the clusters. Cluster titles are numbered and bolded below.

1. **Community driven approaches**

   Gaps in the research:
   - *Ability of change agents to recognize and value local innovation.*
   - *Creating and capacitating village-based advisories/service providers.*
   - *Empower local ownership and leadership of processes and priorities.*
   - *Local asset based.*
   - *Set up local groups to try alternatives and discuss results with the group.*

   Research opportunities:
   - *Create research questions for K-12 (or beyond) to perform citizen science, such as monitoring, or creating software, or even competitions. Work with participants to analyze results and draw conclusions.*
   - *Incorporating Indigenous knowledge in decision-making.*

- *Research station locations.*
- *Understand capacity and skills the private sector companies need now and to expand/build markets.*
- *Understanding capacity in "SAI" of extension and advisory services (public/private).*
- *Utilizing positive deviance strategies for community-based development (behavior theory).*

2. Create enabling environment

Gaps in the research:

- *Elevating role and importance of women.*
- *Insufficient investment in admin/funding; management capacity of science staff.*

Research opportunities:

- *Evaluate where policy and implementation breakdowns occur in governments.*
- *Explore opportunities to align private sector incentives with long-term sustainability.*
- *Technologies that will make community grown products valuable for one-health objectives.*
- *Understand the capacity and skills private companies need to get and manage impact investors.*

3. Exciting youth

Gaps in the research:

- *Connecting young urban people to their food systems.*
- *Food and agriculture are not sexy enough for youth to choose it as a profession of choice.*
- *Research in context of local social-cultural practices (experiential learning).*
- *What outreach activities are effective and why?*

Research opportunities:

- *Create digital interactive games to "play" exciting scenarios to be important contributor and successful professional.*
- *Create K-12 educational programs that excite youth to choose a career in food and agricultural systems.*
- *FFA/4-H type youth organizations.*
- *Research to fully participate in implementation of incubators to train youth and women (new innovating technologies).*
- *School feeding programs re-introduce traditional foods and establish participatory engagement.*

4. (Formal) educational and workforce development

Gaps in the research:

- *Employment pipeline gaps (or capital access for entrepreneurship).*
- *How education curricula cover sustainability/equity and the effect on graduates.*
- *Research is not very active to implement incubators to train youth and women to become agripreneurs.*
- *What are the skills needed for the workforce in the agrifood supply chain?*

Research opportunities:

- *Develop locally relevant and modern curricula for formal and informal ag science and education.*
- *Train workforce in systems thinking and highly adaptable.*
- *Workforce development focused on food processing/value addition.*

5. Quantifying baseline assumptions

Gaps in the research:

- *Accuracy of baseline/census data.*
- *Ground truthing of general assumptions.*
- *Lack of key informant diversity and representation.*

Research opportunities:

- *Funding/MEL incentives – increase diversity and representation of key informants.*
- *Ground truthing/census data – we have GIS, sampling strategies, and methods to improve accuracy.*

6. Systems thinking, transdisciplinary approaches

Gaps in the research:

- *Providing interdisciplinary opportunities for learning new skills (future jobs).*

Research opportunities:

- *Developing curriculum with systems thinking.*

Appendix G

Key Identified Theme: Resource Use Efficiency – Circular Bioeconomy

The groups were instructed to develop strategies for the three key topics that integrate gender focused approaches, engagement of youth, women, private, public partnerships (PPPs), and Indigenous knowledge, where appropriate. The definitions are included below.

Key Definitions

Participatory approach: A process in which individuals or groups share knowledge, ideas, options, votes, materials, resources, labor, and finances in order to reach a common consensus or to make joint decisions in a transparent way.

Inclusivity: Approach used to ensure that everyone, regardless of their social, economic, or political status and identities (including race, ethnicity, gender, age, beliefs, geographical location, health status, migrant status), is fully and actively involved in benefiting from the development process.

Gender integration: The process of applying strategies in program and policy planning, design, implementation, monitoring, and evaluation to consider gender norms and compensate for gender-based inequalities. It is a continuum and includes several approaches (gender-blind – that ignores gender aspects; gender-response – that acknowledges and addresses gender specific barriers; gender-transformative – that examines, challenges, and transforms underlying gender inequalities and creates equitable gender relations and structures).

Youth integration: The process if recognizing the importance of youth (10 to 29 years) in agrifood systems through listening, nurturing their contributions, addressing their needs, improving their access to resources, allowing their participation in decision making, improving the quality of on-farm work, facilitating youth-focused inclusive agricultural transformation.

Public private partnerships (PPPs): Innovative partnerships that bring together businesses, industries, entrepreneurs, government, and civil society actors for testing, developing, and scaling technologies for agricultural-led growth, productivity, profitability, and sustainability of agrifood systems.

Note. Italicized additions are inserted from the evaluation team for clarifications based on notes taken from the team members themselves.

Order of rotation:

1. Black marker group
2. Green marker group
3. Orange marker group

Resource Use Efficiency (RUE) – Circular Bioeconomy

Flipchart Page 1:

Create products for bioeconomy – e.g., Food, energy, other
Nutrient recycling – rural à urban à rural
Principles – reduce inputs
    Best use of input (reduce waste, keep in system)
    Best use of all outputs (includes waste)
    Economically viable
    → Profit curve, building markets
        Processing
How to use byproducts? How to create markets?
    Who? To use? To process/market? à examples: PV array/shade farming, human/crop waste, cocoa pod, rice byproducts
Do we know of the cases? How to apply models to analyze?

agree
    *Successes?
    *Failures?
    At what SCALE? à farm scale? Other scales?
    Biz opportunities?

System

How to incorporate (renewable) energy? Farm under panels

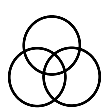
What will be disrupted by the shift to bioecon?
    Who will lose?
    Who can benefit?
What is the IK (Indigenous knowledge) and existing experiences? (positive deviance) and why?
    e.g., what is biomass used for now?
    Will change/involve increased transport/GHG?
RUE/circular economy

Inclusion and approaches to research and scaling

Flipchart Page 2:

Parking: Communications – outreach – 'uptake' Terminology of 'waste' re-brand to by-products

Different systems have individual bio-system ß suitability and context i.e., won't work everywhere
- Household
- Farm
- Industry



Interactions?
How inter-related? How to integrate or strengthen?
Mitigation opportunities? Risk increasing GHG?
How will climate affect viability in context?

Tools/approaches
- Model application to resource use efficiencies
- > digital twinning/simulations
    - e.g., model set of crops within/across seasons
        - !! livestock integrations

Inclusion — Gender – how is intra-hh and gender relations excluded?
How to redress the gender-blind models/tools?

Flipchart Page 3:

Digital and Tools

Whole!

→ Farm scale model nested in landscape models (soil, water/hydrological, econ/markets)
(isolated plot-scale misses larger systems)
Lack of validation persists and barriers to use

R4D – Scaling issues

How to communicate? [communicate change to practices]
- What systems/info is useful? (to farmers) via NARES or who?
- What are effective tools to communicate?
- Two-way communication – how to improve?
- "informal" or community "extension"-knowledge sharing
  - e.g., use of cell phone groups

Incentives systems? Labor/drudgery; opportunity cost of staying/migrating; youth-digital

Flipchart Page 4:

capacity

What capacity will be needed?
Whose capacity will need to be strengthened?
Do we have the right partners?
- What/who partnering?
- How to partner?

Youth → Capacity in research process
Youth → Capacity in research result use/application

- Digital incentives?

Not what we "think" – research incentives = job opportunities
↓
Context specific

-water
-carbon
-energy
-nutrients
-bio products

Flipchart Page 5:

Circular bioeconomy
Assumption discussion
Does a circular bioeconomy require (assume) plot level efficiency?
Is plot-level RUE failing because it's not linked to other systems in the bioeconomy?
What is the causal direction? Will a bioeconomy lead to/cause RUE at smaller scale, on-farm/plot? Or is RUE required for CBE to work/profit?
Assumes circular bioeconomy will increase revenue for farmer?

→ What are the incentives needed? Permanent or temporary?

→ What technology must be developed to make CBE more profitable?

Policy: Global North doing better at recycling human produced manure

Research. Question: Where are the largest gains for recycling? Scale of production?

Q. What institutions are needed to manage?
→ Private v. public/regional/local

- Health tradeoffs – use of waste; periurban situations
- Quality assurance of the material

*Understanding nutrient budgeting and carbon budgeting – different scales
*Utilize (IK) Indigenous knowledge for what we already know/do – social group information exchange
*Water cycle mapping and analysis – where, how used, when, for what, nutrients

*How/what role does biodiversity play in plant cycles
- opportunities
*What are the opportunities for renewable energy within system [PV and others]
*Link rural à Peri urban à urban systems
-energy production, decentralized systems

Approach to research:
*Robust critique (assessment) of energy implications within the circular bioeconomy (LCA) life cycle analysis
- energetic tradeoffs à nutrient capture and reuse resource
- evaluate energy outputs to carbon to nutrients to water to capital
*** Focus on tradeoffs for energy opportunities ***
*Techno Economic Analysis and tradeoffs
- understanding prospective changes and incentives
*Effort to identify policies that are limiting
- toxic subsidies à referring to a World Bank report --? Ill-advised subsidies
-local, regional, global

LCA
-metric standards
-methods to measure/report 'circular index'

Appendix H

Key Identified Theme: Ecological Intensification

The groups were instructed to develop strategies for the three key topics that integrate gender focused approaches, engagement of youth, women, private, public partnerships (PPPs), and Indigenous knowledge, where appropriate. The definitions are included below.

Key Definitions

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Inclusivity: Approach used to ensure that everyone, regardless of their social, economic, or political status and identities (including race, ethnicity, gender, age, beliefs, geographical location, health status, migrant status), is fully and actively involved in benefiting from the development process.

Gender integration: The process of applying strategies in program and policy planning, design, implementation, monitoring, and evaluation to consider gender norms and compensate for gender-based inequalities. It is a continuum and includes several approaches (gender-blind – that ignores gender aspects; gender-response – that acknowledges and addresses gender specific barriers; gender-transformative – that examines, challenges, and transforms underlying gender inequalities and creates equitable gender relations and structures).

Youth integration: The process if recognizing the importance of youth (10 to 29 years) in agrifood systems through listening, nurturing their contributions, addressing their needs, improving their access to resources, allowing their participation in decision making, improving the quality of on-farm work, facilitating youth-focused inclusive agricultural transformation.

Public private partnerships (PPPs): Innovative partnerships that bring together businesses, industries, entrepreneurs, government, and civil society actors for testing, developing, and scaling technologies for agricultural-led growth, productivity, profitability, and sustainability of agrifood systems.

Note. Italicized additions are inserted from the evaluation team for clarifications based on notes taken from the team members themselves.

Order of rotation:

1. Orange marker group
2. Black marker group
3. Green marker group

Flipchart Page 1:

Strategies (Sketch Draft)
[initial action to take] Landscape approach *(help assess needs and assets specific to region)*:

- Use land mapping/capability
- Soil mapping/health

Major considerations for strategy to address:

- Human Capital/Capacity
- Resource flow
- Better agronomy
- Value Addition
- Value Chains
- Water management/harvesting

Note. Orange group indicated along the side of the flipchart that community approach (social groups), market analysis, and modeling/technology will need to be integrated into each consideration.

Extra considerations:

- Scaling!!! – needs more work!!!
- Policy and issues with land tenure→ needs to be addressed.
- Inclusivity such as gender and youth needs more work
    - Is biomass productivity the right goal/metric?

Flipchart Page 2:

Increasing sustainable biomass productivity *(as a strategic example – just one pillar of many)* – above and below ground. *sustainably is a must*

1. *Use* landscape approach
    a. Mapping, productivity potential farming systems
    b. Increased access to digitalization
2. Diversification
    a. Value chain diversification
    b. Perennials (*relevant to parts* 2, 3)
    c. Crop/livestock
    d. Aquaculture
3. Increase nutrient availability and access
    a. Increase SOC (Soil Organic Carbon)
    b. Internal recycling
4. Rainwater management
    a. Micro-catchment
    b. Zai pits
5. Genetics – improved
    a. Drought tolerant crops
    b. Perennial use
6. BMPs -use BMPs (Best Management Practices)
    a. Timing of planting based on weather info
    b. Use of modeling

Flipchart Page 3:

Increasing sustainable biomass productivity above and below ground.

7. Enable social groups
    a. Improve extension delivery
    b. Knowledge sharing about trade-offs/externalities
8. Improve market systems
    a. Build capacity of seed systems
    b. Link farmers to output markets
9. Increase access to financial services
    a. Access to credit (for different system actors)
10. Increase access to social protection
    a. Crop insurance
11. Add value
    a. Use post-harvest storage
    b. On farm processing – gender opportunities
    c. Improve nutritional quality
12. Increase labor and energy productivity
    a. Use mechanization
    b. Workforce development
    c. Training youth – legacy

Flipchart Page 4:

- Ecological services as circular system (non-linear)
- System-wide trade-offs (not only social)
- Diversification is much broader
- Intensification and sustainability: efficient use of inputs i.e.: agro chemicals.
- Create on-farm resources as part of diversification as well. I.e., composting
- What are the new/noel ecological approaches to management?
- Should biomass productivity be the only goal? (just an example)
- How to scale institutional capacity? How to diversify potential solutions? Local context
- Greater emphasis on cropping rotations/cropping systems
- Agroecology? à integrated with data science (models)
- [how to incentivize/implement strategies with gender relations (outmigration, time poverty, drudgery, etc.)?] *(brackets and underline emphasis by orange team)*.
- Go back to climate smart and GHG *(Greenhouse Gas)* reduction strategies
- Sealing: what partnerships are needed?

Flipchart Page 5:

Define agrotyping and metrics of efficiencies at different scales (reward function)

Landscape design (farm) - function of region

- Objective 1. Efficiency
- Objective 2. Productivity
- Objective 3. Resilience

Diversification
Time-Space

Define technology development objectives

- Genetic improvement
- Nutrition content --? Cities and human nutrition
- Agronomic practices
- Design tools
- Define policy
- Do we have an enduring market?
- What are stressors?

Leverages "platforms" to hasten learning AI-enabled -extension

Develop "adaptive emergence agriculture") so farm behaves as complex "adaptive" systems

Flipchart Page 6:

Future scenario

1. Increase poverty periurban areas and rural
2. Increase value of carbon
3. Increase population in periurban and rural situations?
   - Migrating youth

Ecological Intensification à fruit and vegetable systems in periurban areas

From: solving problem in rural areas with decreasing populations and increasing poverty
To: create condition in periurban areas to "accept" receive migrating populations to spur economic development within a bioeconomy circular system…

Appendix I

Key Identified Theme: Socioeconomic Resiliency

The groups were instructed to develop strategies for the three key topics that integrate gender focused approaches, engagement of youth, women, private, public partnerships (PPPs), and Indigenous knowledge, where appropriate. The definitions are included below.

Key Definitions

Participatory approach: A process in which individuals or groups share knowledge, ideas, options, votes, materials, resources, labor, and finances in order to reach a common consensus or to make joint decisions in a transparent way.

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Youth integration: The process if recognizing the importance of youth (10 to 29 years) in agrifood systems through listening, nurturing their contributions, addressing their needs, improving their access to resources, allowing their participation in decision making, improving the quality of on-farm work, facilitating youth-focused inclusive agricultural transformation.

Public private partnerships (PPPs): Innovative partnerships that bring together businesses, industries, entrepreneurs, government, and civil society actors for testing, developing, and scaling technologies for agricultural-led growth, productivity, profitability, and sustainability of agrifood systems.

Note. Italicized additions are inserted from the evaluation team for clarifications based on notes taken from the team members themselves.

Order of rotation:

1. Green marker group
2. Orange marker group
3. Black marker group

Flipchart Page 1:

(Renamed) Resilience of Agrifood Systems
Framework – can move to new situations à single farms; populations of farms

1 Data	2 Models***	3 Decisions	4 Delivery	5 Policy
Depends on • For whom (subsistence vs. commercial) • Geography • Soil/climate • Resources and markets available • Gender (decision, power) • Aspirations Hanging in stepping up stepping out • And many more variables	Questions Testing possible interventions** vulnerabilities* Who uses the models #13 (*Gaps and opportunities sticky reference)*	Interventions Access to cell phones Social protection payments Crop insurance Microloans Etc. *if decisions/interventions contradict farmer's risk management, policies, etc., use this as new data and try model *(framework)* again	Who does? Capacity building New market access Other Initiating cooperatives Strengthening extension	Setting priorities Can't address everything at once - To address possible interventions when they can't be done at farmer/region level

Digital tools especially in steps 1, 2, 3, and 4

Data collection
Must be participatory with users } distribution of "model" inputs
Traditional knowledge
The "who" and scaling are difficult

Gaps and opportunities stickies references:
*#6, 35, 37
**#43, 38, 15, 21
***#12

**6: Resolving resource/land tenure issues. 35: Repurpose research resources developed for one objective for new opportunities (resources can be markets, delivery pipelines, genetic resources, digital apps, soil and climates atlases, etc.). 37: Market access, price stability, and sufficient $. 43: Design to minimize resilience-productivity tradeoffs. 38: Social protection payments (insurance, UBI, transfers). 15: Understanding links with social protection (amount and type). 21: Better farmer safety nets (insurance/policies). 12: Strengthening food system players (3rd party providers).*

Flipchart Page 2:

HOW (specific examples)

- Identify sources of lack of resilience
  - Understanding geopolitical and climate change shocks
- Invest in plant breeding for resilience and local seed distribution
- Identify who (regional actors – empower to set agenda)
  - Opportunities for women and youth
- Invest in pest control – use all tools, in order of ecological safety and utility
- Invest in analysis of how social protection programs can support agricultural resilience
- Design metrics to measure not only improvement in main intervention but also secondary/unintended or bonus consequences.
- Repurpose (research) resources developed for one objective for new opportunities. (resources can be markets, delivery pipelines, genetic resources, digital apps, soil and climate atlases, (data)…

Flipchart Page 3:

Increase access to advisory and information services

- Real time market conditions
- Access to weather and climate services
- Early warning systems

} Don't exacerbate digital divide

★ Consider your audiences and how they are getting info

- Social media
- WhatsApp
- Farmer to Farmer
- Extension

Increase access to infrastructure

- Storage
- Processing
- Irrigation
- Mechanization

} Study first to determine which needed and who buys/owns

Opportunities ^risks for new or increased markets and products

Diversification

- Increase value chain diversification ⟺ w/SMEs?
- Increase livelihood diversification

Flipchart Page 4:

Good points, but who does?

- Have distinction in resilience strategies: robustness and stability vs. bouncing back capacities
- Soil health key component of resiliency
- Integration of livestock in agriculture
- Diversification: #8 *(gaps and opportunities card reference)* diverse commodities/sources of stable income
- Minimize post-harvest loss, reduce need for cold chain
- Activity during hunger season – more opportunities here to stabilize incomes, food, and nutrition security
- Diversify end-use, product transformation
- Food prices – stabilize and make affordable
- Resilience should come from the whole food system not just farm gate
- Holding buffer stocks – resilience mechanism
- Milk cooperative in India as an example
    - Create cooperation to build more robust/resilient systems/create vs engage
    - ✓ Social grouping as a resilience strategy
    - ✓ Cooperative – be creative n cooperation and social reciprocity

★Gender and youth: access to capital, land, resources…manage within the systems that exist.

Flipchart Page 5:

- Engage and actively build
- Partnerships – system actor linkages. Regional engagement building alliances
- Youth – attract in ag – reduce risk/barriers to entry à global connections
- Community engagement
- Land rights and enabling environments for long term investments.

Appendix J

Benefits of Land Grant University Systems

Table 1. Benefits of Land Grant University Systems (*n* = 31)

Theme	Frequency
Skilled and successful extension units (including understanding public needs and impact).	8
Ability to translate/communicate research findings to target audiences.	6
Large capacity for research and development (provides resources, infrastructure, financial support, equipment, regulatory bodies, etc.).	6
Training the next generation (e.g., scientists, farmers).	6
Availability of data (i.e., transparency in research).	5
Capacity building (e.g., human, institutional).	5
Interdisciplinary team science.	4
Development of tools, services, curricula, etc.	3
Engagement of diverse populations (e.g., gender, students, youth).	3
Integration of research, academics, and extension.	3
Systems approach to sustainable agriculture intensification.	2
Ability to pivot research.	1

Note. Frequencies sum to greater than *n* because responses could be coded into multiple themes.

List of verbatim responses

Note. The following italicized comments were written by thought leader participants and have been lightly edited to protect confidentiality and enhance readability.

- *A source/wealth of innovation, open source, transparency, understanding complex system that impact the broad public.*
- *Ability to organize, structure, and roll-out research agendas connecting aspects on the spectrum from basic science, applied science, and deployed science.*
- *Ability to pivot research to new directions quickly.*
- *Building an interdisciplinary team including researchers, educators, and extension experts to tackle complex problems.*
- *Curricula that can be transferable.*
- *Deliver solutions end-to-end, idea-to-farmer, while teaching the next generation of science, teachers, farmers, or building human capital.*
- *Diversity of students, disciplines, and validation of agro and food systems, and the underlying natural resources that support innovations.*
- *Educating and training students, professional development, and experience.*
- *Extension: linking research with the end users/stakeholders/consumers. Training: training students/faculty to address global/local/regional issues of concerns.*
- *Financial support for graduate students to engage in research.*
- *Formal capacity building for youth (with research experience).*
- *Great opportunity for translation of basic research, applied research for ag. and environmental.*
- *Historical/current research and data foundation/base for large scale, big scope analysis.*

- *Integrate knowledge development, extending knowledge for economic and human/community development, and preparing the next generation to make products and services essential for quality of life.*
- *Integration of all three missions: research, academic programs, and engagement.*
- *Integration of research – extension services – teaching (part of my evaluation).*
- *Interdisciplinary research on ecosystems for outreach and knowledge.*
- *Leveraging other aligned research including foundational basic research.*
- *Long-term data dealing with soil health can help educate a number of sustainability questions.*
- *Many models for cooperative extension.*
- *Multiple levels of human and institutional capacity building.*
- *Proven drivers of gender inclusivity and youth engagement.*
- *Proven models for conducting research to fit end-user needs.*
- *Provides institutional (legal, financial, etc.) knowledge of USG regulations (facilitation).*
- *Research fundings and output, people diversity.*
- *Strength in "system" level approach to SAI.*
- *Strengthening connections to rural America and bi-lateral development of new tools, services, and insights.*
- *Substantial infrastructure related to agriculture research.*
- *Use state-of-the-art traditional and molecular plant breeding to develop or improve relevant germplasm (crops, trees, livestock).*
- *World class breeding program for vegetables, trees/fruits, and associated predictive breeding.*
- *Years of experience in delivering USAID programs.*

Appendix K

Participants

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Stewart, Zachary	zastewart@usaid.gov	United States Agency for International Development

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Verma, Brahm	verma@uga.edu	University of Georgia
Warburton, Marilyn	marilyn.warburton@usda.gov	United State Department of Agriculture, Agricultural Research Service
Zhang, Lina	linaz@ksu.edu	Kansas State University

Invited Guests

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Chapman, Grant	grantchapman@k-state.edu	Kansas State University
Diehl, Lisa	lisa@martinezmediamarketing.com	Martinez Media and Marketing Group

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Means, Jessica	jess552@ksu.edu	Business Manager
Middendorf, B. Jan	jmiddend@ksu.edu	Associate Director
Williams, Sanders	sander3@ksu.edu	International Communications Officer

Office of Educational Innovation & Evaluation Team

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Miller, Michael	mmile24@ksu.edu	Research/Evaluation Associate

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Sustainable Intensification Thought Leaders' Summit
February 6-7, 2024, Agenda
Bluemont Hotel, Manhattan, Kansas

Day 1 – Tuesday, February 6

7:30 AM – 8:00 AM	**Registration Sign-in** – Conference Room on 5th floor (please look for signs).
8:00 AM – 8:10 AM	*Welcome Remarks* – P.V. Vara Prasad, Director, Feed the Future Innovation Lab on Sustainable Intensification (SIIL), Kansas State University (KSU).
8:10 AM – 8:30 AM	*Introductions* – B. Jan Middendorf, Associate Director, SIIL, KSU.
8:30 AM – 8:45 AM	*Remarks* – Jerry D. Glover, Acting Director, Center for Agriculture Led Growth, United States Agency for International Development (USAID).
8:45 AM – 9:00 AM	*Remarks* – Zachary P. Stewart, Production Systems Specialist, Bureau for Resilience, Environment, and Food Security, USAID.
9:00 AM – 10:00 AM	*Setting the Stage* – Challenges in Agrifood Systems and Sustainable Agricultural Intensification: Status, Learnings and Highlights – P.V. Vara Prasad
10:00 AM – 10:30 AM	**Coffee & Tea Break**
10:30 AM – 10:40 AM	*Program Overview and Plan of Action*: B. Jan Middendorf - Why are we here? - What are you being asked to do? - What will be the results from our time together? - Ground rules
10:40 AM – 12:00 PM	*Guided Facilitation: GAPS on the Following Topics / Themes**: 1. Climate Smart & Sustainable Agrifood Systems (inclusive of regenerative systems and nature-based solutions). 2. Resilience of Agrifood Systems (inclusive of biophysical and social aspects: farming systems, nutrition, and people). 3. Resource Use Efficiency (e.g., nutrients, water, labor; inclusive of minimizing waste and circular systems). 4. Digital and Precision Management Practices, and Tools (inclusive of biophysical, social and knowledge management). 5. Approaches for Enhancing Adoption and Scaling (inclusive of biophysical and social Innovations). 6. Building Human, Social and Institutional Capacity for Local-Led Agricultural Research and Development.

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	*All themes should integrate gender focused approaches, engagement of youth, women, private, public, partnerships (PPPs), and indigenous knowledge, where appropriate.
12:00 PM – 01:00 PM	**Lunch**
01:00 PM – 02:30 PM	*Guided Facilitation: RESEARCH OPPORTUNITIES on the Following Topics / Themes**: 1. Climate Smart & Sustainable Agrifood Systems (inclusive of regenerative systems and nature-based solutions). 2. Resilience of Agrifood Systems (inclusive of biophysical and social aspects: farming systems, nutrition, and people). 3. Resource Use Efficiency (e.g., nutrients, water, labor; inclusive of minimizing waste and circular systems). 4. Digital and Precision Management Practices, and Tools (inclusive of biophysical, social and knowledge management). 5. Approaches for Enhancing Adoption and Scaling (inclusive of biophysical and social Innovations). 6. Building Human, Social and Institutional Capacity for Local-Led Agricultural Research and Development. *All themes should integrate gender focused approaches, engagement of youth, women, private, public, partnerships (PPPs), and indigenous knowledge, where appropriate.
02:30 PM – 03:00 PM	*Identify 4 to 5 Critical Areas in Each Theme*
03:00 PM – 03:30 PM	**Coffee & Tea Break**
03:30 PM – 04:00 PM	*Report Out on 4 to 5 Critical Areas in Each Theme (for Developing Strategies)*
04:00 PM – 04:50 PM	*Reflections*: USAID and Participants
04:50 PM – 05:00 PM	*Closing Remarks* – P.V. Vara Prasad
5:00 PM	*Adjourn*
6:00 PM – 8:00 PM	**Social Hour and Dinner**

Day 2 – Wednesday, February 7

8:30 AM – 8:45 AM	*Recap of Day 1* – P.V. Vara Prasad, Director, SIIL
8:45 AM – 10:00 AM	*Developing Strategies (Deep Dive) for Key Identified Topics Within Each Theme*: 1. Ecological Intensification 2. Socioeconomic Resilience 3. Resource Use Efficiency – Circular Bioeconomy [Crosscutting: Digital and Precision Management Practices, and Associated Tools; Approaches and Instruments for Enhanced Adoption and Scaling; Building Human, Social and Institutional Capacity] *All themes should integrate gender focused approaches, engagement of youth, women, private, public, partnerships (PPPs), and indigenous knowledge, where appropriate.
10:00 AM – 10:30 AM	**Coffee & Tea Break**
10:30 AM – 12:00 PM	*Continued Developing Strategies (Deep Dive) for Key Identified Topics Within Each Theme* 1. Ecological Intensification 2. Socioeconomic Resilience 3. Resource Use Efficiency – Circular Bioeconomy [Crosscutting: Digital and Precision Management Practices, and Associated Tools; Approaches and Instruments for Enhanced Adoption and Scaling; Building Human, Social and Institutional Capacity] *All themes should integrate gender focused approaches, engagement of youth, women, private, public, partnerships (PPPs), and indigenous knowledge, where appropriate.
12:00 PM – 01:00 PM	**Lunch**
01:00 PM – 03:00 PM	*Continued Strategies Deep Dive and Next Steps*
03:00 PM – 03:30 PM	**Coffee & Tea Break**
03:30 PM – 04:30 PM	*Wrap Up and Reflections*
04:30 PM – 05:00 PM	*Closing Remarks* – P.V. Vara Prasad
5:00 PM	*Adjourn*
6:00 PM – 8:00 PM	**Social Hour and Dinner**

Emergency Contacts and Number:

- Jan Middendorf, Associate Director, SIIL
  (785) 313-2872, jmiddend@ksu.edu
- Layne Davis, Program Administrator, SIIL
  (979) 571-2643, laynewilson@ksu.edu

Hotels Address and Number:

- Bluemont Hotel, 1212 Bluemont Avenue, Manhattan, KS 66502
  Front Desk – (785) 473-7091
  Website: www.bluemonthotel.com

- Courtyard-by-Marriot Hotel, Aggieville, 715 N 12th Street, Manhattan, KS 66502
  Front Desk – (785) 587-1972
  Website: Courtyard-by-Marriot

Link to Pre-Reading Materials:
https://www.dropbox.com/scl/fo/yxixddeqwzczc703tr8r2/h?rlkey=whidofxfh9y8ns7wkrs4e6vrd&dl=0

Link to Participants Bios:
https://www.dropbox.com/scl/fi/p683w12hswe7ebkabmk4s/SI-Summit-Participants-Bios.pdf?rlkey=ldx2x9fz95ng2zoroqvm8jxfv&dl=0

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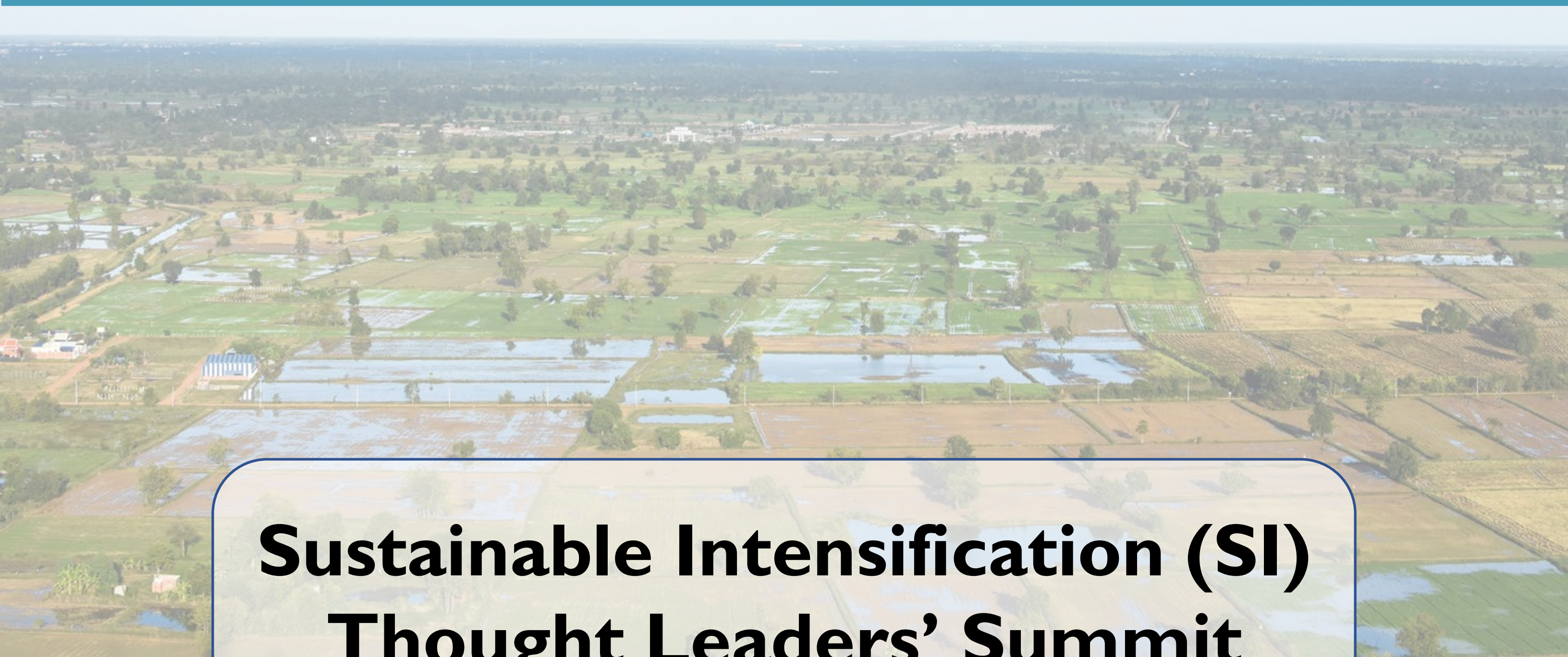

Sustainable Intensification (SI) Thought Leaders' Summit

February 6-7, 2024 | Bluemont Hotel, Manhattan KS

The Sustainable Intensification (SI) Summit is hosted by the Feed the Future Innovation Lab for Collaborative Research on Sustainable Intensification (SIIL).

The experience and perspective that will be shared at the summit will be vitally important in prioritizing the future of sustainable intensification and establishing an action plan with key stakeholders, the donor community, and others.

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Sustainable Intensification Summit Speakers

Jerry Glover – USAID jglover@usaid.gov

Dr. Jerry Glover is the Acting Director for the Center for Agriculture Led Growth with the United States Agency for International Development (USAID). He works to develop innovative and sustainable strategies for small-holder farmers around the world. Jerry earned Bachelor degrees in soil science and philosophy and then a Ph.D. in soil science at Washington State University. Jerry has studied native grasslands and farming systems, including no-till, perennial, organic, and integrated systems. His work in soil science and perennial-based farming systems has been highlighted in documentaries which identified Jerry as "one of five crop researchers who can change the world." Jerry has interpreted his scientific work for the general public, serving as the technical content curator of the U.S. Botanic Garden's exhibit "Exposed: The Secret Life of Roots" in Washington, D.C. He is an Elected Fellow of the American Association for the Advancement of Science, the American Society of Agronomy, the Soil Science Society of America, and the Crop Science Society of America.

Zachary Stewart – USAID zastewart@usaid.gov

Dr. Zachary P. Stewart is the Production Systems Specialist with the United States Agency for International Development (USAID) within the Bureau for Resilience, Environment and Food Security. He has over 15 years of experience in international agricultural research and development. He earned his Bachelor's degrees in Biology, Environmental Sciences, and International Relations from Creighton University, Master's degree in Control of Infectious Diseases from the London School of Hygiene and Tropical Medicine, and Ph.D. in Soil Science and Crop Physiology from the University of Nebraska-Lincoln. Prior to his work at USAID, Dr. Stewart was a Research Assistant Professor at Kansas State University where he served as a Principal Investigator on research activities across sub-Saharan Africa and Southeast Asia. He also served as the Program Manager and helped establish the SOILS Consortium with the Feed the Future Innovation Lab for Collaborative Research on Sustainable Intensification and International Fertilizer Development Center. His research is primarily related to the sustainable intensification of smallholder farming systems and improving the health and fertility of soils as the foundation for nutritious food production and resilient and sustainable livelihoods.

Vara Prasad – Kansas State University vara@ksu.edu

Dr. P.V. Vara Prasad is a University Distinguished Professor and the R.O. Kruse Professor of Agriculture at Kansas State University. He serves as the Director of the Feed the Future Innovation Lab for Collaborative Research on Sustainable Intensification (SIIL). He obtained his Bachelor's and Master's degrees from Andhra Pradesh Agricultural University in India, followed by a Ph.D. from the University of Reading in the United Kingdom. His research focuses on comprehending how crops respond to changing environments and management practices His work extends to developing optimal management strategies to enhance and safeguard yields. Passionate about education and outreach, he actively builds human and institutional capacity. His impactful programs in Africa and Asia focus on innovative solutions for food, nutrition, and climate security, ultimately are improving the lives of smallholder farmers. He was the former President of the Crop Science Society of America.

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Sustainable Intensification Summit Participants

Tilahun Amede – AGRA tamede@agra.org

Dr. Tilahun Amede is the Head of the climate, resilience and soil health unit at Alliance for Green Revolution in Africa (AGRA). Tilahun is a systems agronomist with profound experience in African Agriculture. Before joining AGRA, Tilahun worked for the Consultative Group on International Agricultural Research (CGIAR) system as a Principal Scientist developing, promoting, and facilitating landscape-based soil fertility management models and approaches, farming system-based niche identification tools, and dryland technologies and practices in small-scale settings of Eastern and Southern Africa for the last 20+ years, with a particular focus on Ethiopia, Kenya, Tanzania, Uganda, and Mozambique. He is published widely in high0impact journals in sustainability, agronomy, soil fertility, drought physiology, legume intensification, biofortification, and integrated watershed management.

Amarjit Basra – OCP a.basra@ocpna.com

Dr. Amarjit S. Basra works for the Office Chérifien des Phosphates (OCP) North America as a Director and Chief Research Scientist, and is responsible for expanding the Group's innovation. Dr. Basra has over 30 years of work experience in various research and development roles, primarily focused on the fields of plant physiology, genetics, and biotechnology. He has worked for several companies, including, commercial, and business development activities in North America. Prior to that, he worked as a Principal Advisor for Larta Institute, where he provided professional guidance in strategic business planning, market and product development, and the regulatory process. Amarjit has also held senior positions at Plant Impact, Syngenta, Monsanto, and UC Davis, where they conducted research projects and managed biotech teams. He has a Ph.D. in Plant Physiology from Michigan State University and has published numerous research articles.

Ignacio Ciampitti – KSU ciampitti@ksu.edu

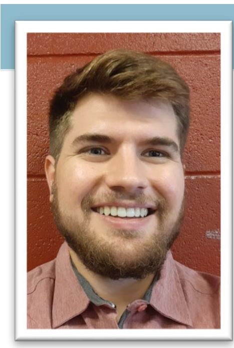
Dr. Ignacio Ciampitti is a professor and Integrated Farming Systems/Agronomist in the Department of Agronomy at Kansas State University (KSU). He currently serves as the director for the Digital Tools, Farming Systems, and Geospatial Tools Consortium of the Sustainable Intensification Innovation Lab. In addition, he leads the crop modeling section, integration of data products with remote sensing and assists in examining innovations and integration of data products. Dr. Ciampitti earned his B.S. and M.S. degrees from the University of Buenos Aires, and his Ph.D. degree from Purdue University. His program focuses on integrating field, statistics, remote sensing, and modeling research for understanding plant responses to management practices and environments. He serves as a technical editor for Crop Science, Associate Editor-in-Chief of the European Journal of Agronomy, and on the Editorial Board for Field Crops Research, and Remote Sensing.

Julia Compton – CGIAR julia.a.compton@gmail.com

Dr. Julia Compton is currently an independent consultant. Recently, she managed the Commission on Sustainable Agricultural Intensification (CoSAI). She was also a researcher at the Consultative Group on International Agricultural Research (CGIAR) organizations for many years. Her research focuses on water, land, and ecosystems. She has over 30 years of experience in agriculture and rural development, including in participatory technology development with small-scale farmers and traders. She has held long-term posts in three developing countries and made working visits to over 15 countries; this included positions in two African Ministries of Agriculture. She spent seven years at the UK Natural Resources Institute (Food Security/Post Harvest Depts) and 10 years at the UK Department for International Development. Since 2010, she has been an independent consultant specializing in evaluation, results and performance, and has also worked part-time for the UK's Overseas Development Institute and the University of London (SOAS) distance learning program. She has two Master's degrees in Crop Protection (Imperial College) and Agricultural Economics (Wye College) and a Ph.D. from the University of London.

Tim Crews – Land Institute tim.crews@landinstitute.org

Dr. Tim Crews works at the Land Institute and currently serves as the Chief Scientist along with being the Director of International Programs & Ecological Intensification. Dr. Crews first visited The Land Institute in 1981 after reading *New Roots for Agriculture* as an undergraduate majoring in agroecology at the University of California-Santa Cruz. Over the next three decades, he pursued a doctorate degree at Cornell, carried out a post-doc fellowship at Stanford, and developed an agroecology program at Prescott College in Northern Arizona. But all along, he continued to track the work of The Land Institute and, in 2000, began to collaborate directly. In 2012, he joined the staff as director of research and an ecologist. He helps facilitate and coordinate the research efforts of his colleagues and conducts work on the ecosystem functions performed by soils. In his words, he is at the Land Institute because "the work is the most focused and far-reaching of any organization I know. It promises to transform agriculture from being an ecological liability to an asset."



Nicholas Detter – Kansas State University ndetter@ksu.edu

Nick Detter is a graduate student and research assistant. His research focuses on summer annual forages and the unique role they play in western Kansas cropping systems due to the region's environmental conditions and economic demands. Nick plans to graduate in the Spring of 2024 with his Master of Science in Agronomy. Upon graduation, he plans to pursue work in the regenerative and sustainable agriculture field.

Alioune Fall – CORAF a.fall@coraf.org

Dr. Alioune Fall is the Acting Executive Director of Conseil Ouest et Centre Africain pour la Recherche et le Développement Agricoles (CORAF) while also being the Chairperson of the Forum for Agricultural Research in Africa Board of Directors and the former Director General of Senegal's National Institute for Agricultural Research (ISRA). He is also a member of the Scientific Council of Centre de coopération internationale en recherche agronomique pour le développement (France) since 2016 and was appointed as President of the council in 2019 for a 3-year term. He holds a Master of Science degree in Agriculture from the Sam Houston State University, Texas, United States, and a Doctorate degree in Agricultural Engineering from Michigan State University, United States. Dr. Fall's career in research spans three and a half decades. He joined ISRA in 1984 as a researcher and rose quickly to become Regional Coordinator of Farm Mechanization and Post-harvest Technology projects. Dr. Fall served as the Scientific Director of ISRA from 2008 to 2013 when he was appointed to the Director General. He served as the Chairperson of CORAF's Board of Directors from 2014 to 2018.

Cornelia Flora – Iowa State University cflora@iastate.edu

Dr. Cornelia Flora is an Emeritus Distinguished Professor in the Department of Sociology at Iowa State University along with being an External Advisory Board member for the Sustainable Intensification Innovation Lab. Her research interests include international and domestic development, community, and the sociology of science and technology, particularly as related to agriculture and participatory change. Socio-technical regime change and capital transformations guide her current research which includes work on community development, sustainable agriculture and natural resource management, with particular attention to how class, gender, and ethnicity influence and are influenced by technology and policy. She has published 14 books, with a 15th co-authored book in preparation. She has served as president of the Rural Sociological Society, the Agriculture, Food and Human Values Society, and the Community Development Society. Her B.A. degree is from the University of California at Berkeley and her M.S. and Ph.D. degrees are from Cornell University.

Aastha Gautam – Kansas State University abgautam@ksu.edu

Aastha Gautam is a Ph.D. student in the Department of Agronomy at Kansas State University (KSU). She has recently joined KSU's Wheat Team starting Spring of 2024. Aastha completed her Bachelor's degree in Agricultural Science from Agriculture and Forestry University, Nepal, and her Master's in Plant Science from South Dakota State University, Brookings, South Dakota. Currently, she is involved in the GRIP project with a focus on developing models for sustainable wheat production and intensification.

Jeff Herrick - USDA/ARS jeff.herrick@usda.gov

Dr. Jeff Herrick currently serves as a liaison with senior leadership in the US Department of State and the US Department of Agriculture to ensure inclusion and coordination of agriculture-related policies involving climate change, food security, foreign and food assistance, and expansion of international marketing opportunities for U.S. agricultural products. Dr. Jeff Herrick is a research scientist with the Jornada Experimental Range of the USDA Agricultural Research Service. He was also chair of the executive committee for ARIDnet, serves as a national advisor to several US government agencies and is affiliated with New Mexico State University in Las Cruces New Mexico. Dr. Herrick's work includes research on the factors that control the resistance and resilience of arid and semi-arid ecosystems, and applied research leading to the development of protocols for inventory, assessment and monitoring of pasture plot to national scales. His work includes projects in Latin America, Asia, and Africa. He has published many research articles on topics related to drought, desertification, and soil quality, in addition to numerous technical guides. These protocols have been translated into several languages and are now applied throughout the United States and in a number of other countries.

Sindhu Jagadamma – University of Tennessee sjagada1@utk.edu

Dr. Sindhu Jagadamma is an Associate Professor at the University of Tennessee in both Biosystems Engineering and Soil Science. She is a distinguished researcher with expertise in soil and nutrient management in agroecosystems, specializing in soil carbon dynamics. With three years of experience at the Oak Ridge National Laboratory, she conducted neutron scattering experiments at the Spallation Neutron Source. Dr. Jagadamma excels in genome-enabled analysis of environmental contaminants, demonstrating strong analytical and instrumentation skills. Her contributions extend to designing and implementing research projects, leading to successful grant proposals, technical reports, and peer-reviewed research articles. She has fostered national and international research collaborations. Dr. Jagadamma is a seasoned professional making impactful strides in environmental research. She earned her doctoral and Master's degrees in soil science and agronomy from Ohio State University.

James Jones – University of Florida jimj@ufl.edu

Dr. James (Jim) Jones is a Distinguished Professor Emeritus in the Agricultural and Biological Engineering Department, at the University of Florida, retiring from the department in 2010. He continued to work on research projects until 2016 when he accepted an invitation to serve as a Program Director at the National Science Foundation (NSF) and co-lead the major funding multidisciplinary and multi-agency opportunity (Innovations at the Nexus of Food, Energy, and Water Systems, jointly funded by NSF and USDA-NIFA). While at NSF, he led the development of a new multidisciplinary research initiative called Signals in the Soil (SitS). He completed his responsibilities at NSF late in 2019, and he now works part time at the University of Florida on various initiatives locally, nationally, and internationally. He developed a remarkable career based on mathematical modeling and computer simulation to integrate scientific knowledge from different disciplines for use in agricultural decision-making. His work has been acknowledged through his advanced rank at the university, through numerous awards and honors, and through the careers of many scientists he has trained. Dr. Jones was elected to the National Academy of Engineering in 2012.

Shibu Jose – University of Missouri joses@missoui.edu

Dr. Shibu Jose is the Associate Dean of Research and Director of the Missouri Agricultural Experiment Station at The University of Missouri (UM). Prior to this he was the director of the Center for Agroforestry and the Endowed Professor and the H. Gene Garrett Chair of Agroforestry. Before UM, he was at the University of Florida in Gainesville, where he served as a professor of forest ecology. Shibu's research program has the overarching goal of identifying and quantifying key ecological processes and interactions that define ecological sustainability. He uses the ecological information in designing agroforestry systems and restoring degraded and damaged ecosystems. Over the past 25 years, Jose and his research team have conducted studies in the U.S., Australia, Costa Rica, Belize, Bangladesh, and India. He spent six months in Bangladesh as a Fulbright Scholar conducting, teaching, and researching. He also served as Editor-In-Chief of Agroforestry Systems; Associate Editor, International Journal of Ecology; and Associate Editor, Journal of Forestry.

Nicole Lefore – University of Nebraska nlefore@Nebraska.edu

Dr. Nicole Lefore is the Director of the Feed the Future Innovation Lab for Irrigation and Mechanization Systems. She is also an Associate Director of Sustainable Agriculture Water Management at the University of Nebraska through their Daughtry Water for Food Institute (DWFI). She strengthens and expands the institute's global program by developing, managing, and leading new activities on accessing and managing water for sustainable agriculture for smallholder farmers. Dr. Lefore has over 30 years of international experience in research for development, policy advocacy, and project implementation in Sub-Saharan Africa and the developing world. She has worked with policy think tanks, the International Water Management Institute (Ghana and South Africa) and previously served as Director of the Feed the Future Innovation Lab for Small Scale Irrigation at Texas A&M University. Her expertise includes water and land institutions and governance; markets and finance in small scale irrigation; equity in development; and gender. She obtained her Ph.D. from University of Virginia and M.S. from the School of Oriental and African Studies at the University of London.

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Nina Lilja – Kansas State University nlilja@k-state.edu

Dr. Nina Lilja is the Associate Dean of International Agricultural Programs (IAP) in the College of Agriculture (COA) at Kansas State University (KSU). She is responsible for the activities related to international scholars, faculty exchanges, and coordination of research partnerships for the COA. Prior to joining KSU, she spent 12 years working for the Consultative Group on International Agricultural Research (CGIAR). She was stationed in West Africa and Latin America, and she led and evaluated global agricultural research projects aimed at poverty alleviation. She obtained her B.S. in International Service and Development from World College West (California), M.S. in Agricultural Economics from University of Illinois at Champaign-Urbana, and Ph.D. in Agricultural Economics from Purdue University.

Charlie Messina – University of Florida cmessina@ufl.edu

Dr. Charlie Messina is a professor of predictive breeding in the Department of Horticultural Sciences at the University of Florida. Dr. Messina works with breeders to improve the nutritional value crops and promotes agriculture as a solution to climate change. He specializes in developing Artificial Intelligence (AI) tools for plant breeding, which he believes will enable society to harmonize crop improvement efforts for regenerative agricultural systems that improve human health, nutrient security, and adaptation to climate change. He developed crop models to predict how plants respond to changing environment and ensure that models help decision making for farmers. Since his childhood, Dr. Messina "wanted to help people produce food worldwide, while also preserving the environment." He obtained his B.S. and M.S. degrees from University of Buenos Aires, and Ph.D. from the University of Florida. After completing his doctorate, he worked for 17 years in the private sector, focusing on crop models and breeding. While in the private sector, Messina pioneered research based on embedding crop-growth models within a quantitative genetics framework, now known as crop growth model-whole genome prediction.

Ajay Ramalingam – Kansas State University ajayprasanthram@ksu.edu

Ajay Prasanth Ramalingam is from India and is pursuing his Ph.D. in Agronomy at Kansas State University. Ajay completed his Master's degree in Agricultural Biotechnology and Bachelor's degree in Agronomy at India. GWAS and metabolomics were areas his expertise focused on for his research on sorghum plant breeding and genomics study. Ajay's current research focuses on developing prediction models for cold tolerance in sorghum hybrids to identify potential cold tolerant sorghum hybrids and promote early planting sorghum in Kansas. Furthermore, his research broadens to identify potential drought tolerant pearl millet parents for promoting pearl millet hybrid production in Kansas. His goal is to continue working in academia as a plant breeder and researcher, advancing science and directing the course of global food security.

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Chuck Rice – Kansas State University cwrice@ksu.edu

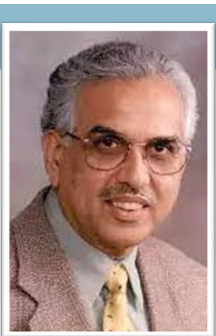
Dr. Chuck Rice is a University Distinguished Professor and holds Vanier University Professorship at Kansas State University. He specializes in soil microbiology, carbon cycling, and climate change. Dr. Rice received his B.S. in Geography from Northern Illinois University. Rice began his undergraduate work in biology but it was a honors geography water resource class that would lead him to switching his major. University of Kentucky is where he earned both his M.S. and Ph.D. degrees in Agronomy. In 1988 Rice joined the Agronomy faculty at K-State. He is co-winner of the 2007 Nobel Peace Prize for his work with the United Nations' Intergovernmental Panel on Climate Change. Rice's research has been supported by more than $15 million in grants from the USDA, U.S. Department of Energy, National Science Foundation, and others. He has advised more than 50 graduate students and have more than 250 publications. He is a fellow of Soil Science Society of America, American Society of Agronomy, and the American Association for the Advancement of Sciences. His leadership roles included: President of the Soil Science Society of America; Chair of the U.S, National Academies Board on Agriculture and Natural Resources.

Stella Salvo – Bayer Crop Science stella.salvo@bayer.com

Dr. Stella Salvo is Head of Breeding Partnerships for Smallholder Farming at Bayer Crop Science. She works to collaboratively bringing technologies that deliver a positive impact for farmers across the globe through modern agriculture and partnerships that increase agricultural productivity sustainably. Supporting global teams that drive creative innovations in the areas of data science, genomics, phenomics, and analytics. Over 20 years of experiences in plant breeding, leading discovery, deployment, and across-function projects focused on capacity building and development in Asia and Africa. An enthusiastic influencer, creative people connector, and a diplomatic leader creating strategies that embrace the complexity of a dynamic workforce.

Jelle Van Loon – CIMMYT j.vanloon@cigar.org

Dr. Jelle Van Loon currently serves as Associate Director for Latin America of the International Maize and Wheat Improvement Center's (CIMMYT) Sustainable Agrifood System Program, leading research initiatives aimed at building pathways toward resilient food systems and long-term rural development. He is an agricultural engineer with a Ph.D. in biosystems modelling, and over a decade of experience in agricultural research for development in Latin America. Leading the innovations for development team, he coordinates a transdisciplinary team, including aspects like farmers market linkages and responsible sourcing, capacity development, and community-based outreach and explores the multiple interfaces between adaption, adoption and scaling from a socio-technical viewpoint in research for agricultural development. In addition, Jelle has ample expertise in scale-appropriate mechanization from smallholder farm solutions to precision agriculture applications, has actively progressed to work in innovation systems thinking, and in addition he serves CIMMYT as representative for Latin America in which he focusses this line of work to establish impactful partnerships and innovative business models.



Brahm Verma - University of Georgia verma@uga.edu

Dr. Brahm Verma is professor Emeritus and Associate Director Emeritus of the Faculty of Engineering which was officially organized as College of Engineering at the University of Georgia. Since the mid-1980's he has championed for the then emerging discipline of biological engineering and served as the founding president of the Institute of Biological Engineering (IBE) – A Society for Advancing *Biology-Inspired* Engineering. He has also created other organizations including the successful Faculty of Engineering at the University of Georgia. The Faculty of Engineering conceptualized as a new kind of school/college of engineering with open borders and a self-organizing governance system influenced by living systems. Dr. Verma received his B.S., M.S., and Ph.D. degrees in agricultural engineering. He has over 350 publications and presentations at professional meetings and many patents. He has published on similitude in engineering; mechanization/automation of greenhouse and nursery; modeling using artificial intelligence techniques; and information systems and decision methodology. He has received numerous awards, for example, best research paper awards, IBE Lifetime Visionary Award, ASAE/ASABE Fellow and IBE Fellow. The IBE Visionary Award is named after his wife and him to recognize visionary individuals in Biological Engineering. Recently he has been leading efforts on "Circular Bioeconomy Systems" at the ASABE, to address challenges in our agri-food systems.

Marilyn Warburton – USDA/ARS marilyn.warburton@usda.gov

Dr. Marilyn Warburton is a dedicated researcher leader with a focus on leveraging natural allelic diversity in crops to address challenges in biotic and abiotic stress resistance at United States Department of Agriculture/Agricultural Research Service (USDA/ARS). With 25 years of experience, she played a pivotal role measurement of genetic diversity in maize and wheat, contributing to the understanding of constraints to conservation and the utilization of plant genetic resources. She has made significant contributions to identifying genetic sequences associated with disease, insect, and drought tolerance, as well as nutritional content in maize, enabling advancements through marker-assisted selection. Dr. Warburton is currently serving as the leader of the Plant Germplasm Introduction and Testing Research Unit at the USDA/ARS. She is a former President of the Crop Science Society of America.

Lina Zhang – Kansas State University linaz@ksu.edu

Lina Zhang, is a Ph.D. student in Agronomy from Kansas State University. She mainly studies the intricate relationship between climate change and the yield of pivotal food crops and explores the adaptability of variety improvement strategies to mitigate the effects of climate change on crop production, specifically winter wheat and corn. Presently, Lina's research is dedicated to examining the broader implications of climate variations on winter wheat at the national level in the United States, utilizing big data analysis techniques.

Other Invited Guests

Dena Bunnel – Kansas State University denab@ksu.edu

Dena Bunnel serves as Head of Research and International Initiatives. She is focused on strategic investments in international agricultural research programs at Kansas State University's College of Agriculture. Her position supports the Associate Dean and Director for research and graduate programs, and the Associate Dean for international agricultural programs. Bunnel assists faculty with international special projects, coordinates international visitors and scholars, and facilitates interdisciplinary research through collaboration events and identification of funding opportunities. Bunnel also teaches the capstone course for the global food systems leadership secondary major.

Grant Chapman – Kansas State University grantchapman@k-state.edu

Dr. Grant Chapman currently serves as the Associate Provost for International Programs at Kansas State. Grant has held key administrative roles, including Associate Vice President for Academic Affairs, Assistant Provost, and Provost, with a primary focus on international education and programs. Having served in international education positions both within and outside the United States, Chapman brings a global perspective. His contributions extend beyond institutions and Webster Foundation Geneva, along with leadership at Webster University campuses in Ghana and Thailand. As a Fulbright Scholar and Phi Beta Kappa member, his expertise encompasses international education, law, and higher education, marked by a commitment to fostering global engagement and educational excellence.

Lisa Diehl – MMMC lisa@martinezmediamarketing.com

Lisa Diehl currently works for the Martinez Media and Marketing Group as a digital professional. She is a seasoned marketing and communications professional with over 25 years of experience encompassing print, online, and social media. As a project manager, she has successfully led cross-functional teams in executing strategically significant and technically complex projects. Lisa's exceptional interpersonal and communication skills, coupled with her proficiency in team development and coaching, have contributed to her success. Recognized as Communicator of the Year by the United Methodist Association of Communicators in 2012, Lisa is now a valued member of the award-winning marketing team at Presbyterian Manors of Mid-America, overseeing 15 senior living communities in Kansas and Missouri.

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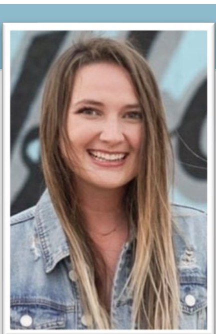
Sustainable Intensification Innovation Lab Management Entity Team

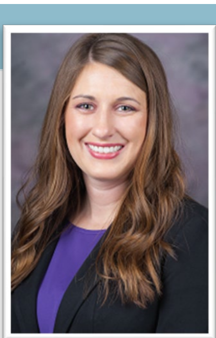
B. Jan Middendorf - Associate Director jmiddend@ksu.edu

Dr. B. Jan Middendorf is the Associate Director of the Feed the Future Innovation Lab for Sustainable Intensification (SIIL) at Kansas State University. With executive-level expertise, Dr. Middendorf efficiently manages and provides leadership for SIIL's substantial $75 million portfolio, funded by the U.S. Agency for International Development (USAID). Her responsibilities span program coordination, operational leadership, and strategic guidance for diverse projects across the globe. She also oversees consortia and capacity-building initiatives in Cambodia, Guatemala, Haiti, and West Africa. Dr. Middendorf earned her Ph.D. from KSU, complementing her M.A. from Ohio University and B.S. from the University of Rhode Island. With over 30 years of experience, Dr. Middendorf continues to be a driving force in advancing sustainable intensification initiatives and making a lasting impact on global agriculture.



Layne Davis - Program Administrator laynewilson@ksu.edu

Layne Davis serves as the Program Administrator for the Feed the Future Innovation Lab for Collaborative Research on Sustainable Intensification (SIIL). She collaborates with the Lab's domestic and international partners to help manage the program's monitoring and evaluation, communication, reporting, and knowledge management needs. Layne works with all of SIIL's projects, consortiums, and initiatives to provide regular updates and progress. Layne graduated from Texas Tech University with a Bachelor of Science in Agricultural Communications and a minor in Agribusiness Management.



Jessica Means - Business Manager jess522@ksu.edu

Jessica Means serves as the Business Manager for the Sustainable Intensification Innovation Lab. She is responsible for the financial management of all grants, including post-award accounting, travel planning, distribution of funding for sub-awards, and working with pre- and post-award services. Jessica holds a B.S. in Business Administration – Accounting with a minor in Leadership Studies, as well as a Masters in Accountancy, both from Kansas State University. Additionally, she has previous experience as an auditor, providing her with much grant compliance and financial experience and prior university experience at Kansas State, Oklahoma State, and University of North Texas.

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Collaborative Research on Sustainable Intensification

KANSAS STATE UNIVERSITY

Sanders Williams - International Communications Officer sander3@ksu.edu

Sanders Williams serves as the International Communications Officer for the for SIIL. Sanders helps to expand and promote communication strategies, success stories, SIIL newsletters, and social media content from project activities for effective outreach. Sanders graduated from Kansas State University (KSU) with a major in Agricultural Economics, with a pre-law focus. While her time at KSU, she performed as a fellow with the K-State's Food and Agriculture Policy Fellowship and served two years in the college MANRRS chapter. Sanders recently served as the Conservation & Sustainability Fellow for the Kansas Grain Sorghum's Producer Association where she assisted in connecting sustainability projects focusing on farm-oriented programming. During her time as a student, Sanders had the opportunity to travel to Morocco for an agriculturally focused exchange. She is also the recipient of the 2022 George Washington Carver Leadership and Legacy Award.

Elizabeth (Beth) Guertal – Program Director guertea@ksu.edu

Dr. Beth Guertal currently serves as the Project Director of the Center of Excellence on Mitigation, Adaptation, and Resilience to Climate Change in Haiti (CEMARCH) managed by the SIIL at KSU. Prior to joining the SIIL team Dr. Guertal was the Rowe Endowed Professor in the Crop, Soil and Environmental Sciences Department at Auburn University, Alabama. Dr. Guertal received her BS and MS degrees from The Ohio State University, and her Ph.D. from Oklahoma State University. Her research program focuses on soil fertility issues in turfgrass management. Guertal served as a Technical Editor for Crop Science, and as an Associate Editor for the Soil Science Society of America (SSSA) Journal, Crop Science, and Agronomy Journal. She is a past-Chair of Division C-5. She is a Fulbright Fellow and a Fellow of the CSSA, SSSA and American Society of Agronomy. She is a former President of the CSSA.

Emma Flemmig - Program Manager eflemmig@gmail.com

Emma is from Glidden, Iowa and now lives in Salina, Kansas. She has a B.S. in Agronomy from Iowa State University and an M.S. in Crop Science from North Carolina State University. Before coming to the SIIL, Emma worked at the Land Institute as a Grant Project Manager. She moved from a research background in plant breeding into monitoring and evaluation and project development activities, primarily working in grant writing and international project support.

Marleigh Hutchinson - Student Research Assistant marhut@ksu.edu

Marleigh Hutchinson is a Student Research Assistant for the SIIL. She is a junior majoring in Environment Engineering with a Natural Resources and Environmental Sciences as a secondary major. In her role she helps create and execute laboratory communication strategies and research reports. She recently spent a semester studying in Prague, Czech Republic on a exchange program. Marleigh also serves as an undergraduate research assistant in the College of Engineering, is an Ambassador for the College of Engineering and also serves as a Learning/Teaching Assistant for the Connecting Across Topics Community "Global Engineers", and a mentor for K-State's Women in Engineering Program. Marleigh will graduate in May 2025.

Office of Education Innovation & Evaluation Team

Mukesh Bhattarai - Research/Evaluation Assistant mukeshb@ksu.edu

Mukesh Bhattarai is a Research/Evaluation Assistant with the Office of Educational Innovation and Evaluation (OEIE) at Kansas State University (KSU). He is a Ph.D. candidate in Environmental Resources and Policy program at Southern Illinois University Carbondale and has a dual Master's degree in Public Policy and Environmental Science. Mukesh's role involves evaluation design, data collection and analysis, and report preparation. Prior to his time at OEIE and post-graduate work, Mukesh dedicated several years to impactful community development projects with Non-Governmental Organizations in Nepal, showcasing his commitment to driving positive change.

Shelby Hunt - Research/Evaluation Assistant shelbyhunt@kus.edu

Shelby is a public health professional and Certified Athletic Trainer with health education, programming, and evaluation experience using evidence-based methods. She also serves as a Research/Evaluation Assistant Office of Educational Innovation and Evaluation (OEIE). Shelby has a passion for helping people adopt healthy lifestyle behaviors that accommodate their goals, priorities, and abilities. Shelby is passionate about building and engaging in community. As a nationally ranked triathlete, she believes physical activity and sport can help bridge barriers, build confidence, and strengthen community.

Adrienne McCarthy – Research/Evaluation Associate mccarthya@ksu.edu

Adrienne L. McCarthy is a Research/Evaluation Associate at the Office of Educational Innovation and Evaluation (OEIE), providing evaluation services for projects that involve a wide range of topics from quantum science to early childcare professionals. She has a varied educational background that consists of a graduate degree in criminal justice from Eastern Kentucky University and a dual focus of biochemistry and sociology as an undergraduate from Willamette University. Currently, Adrienne is a Ph.D. candidate at Kansas State University, Department of Sociology, Anthropology, and Social Work. Her work focuses on social movements, labor, political economy, the production of ideology, and social/criminological theory.

Michael Miller –Research/Evaluation Associate mmile24@ksu.edu

Michael Miller is a Research/Evaluation Associate with the Office of Educational Innovation and Evaluation (OEIE) at Kansas State University (KSU). He earned a Ph.D. in Sociology from KSU, with emphasis in social inequality, food, agriculture, and rural development. His work has been published in several journals, including Rural Sociology, and he has worked on the evaluation of numerous grant-funded projects in his position at OEIE. He is an advocate for making data-informed decisions and eager to work with individuals from different disciplines and backgrounds to implement their project or program as productive as possible.