Sustainable Intensification of Mixed Farming Systems

CGIAR

The impact and outcomes of sustainable intensification initiatives in six countries on women, men, and other social groups

A literature review

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The Sustainable Intensification of Mixed Farming Systems Initiative aims to provide equitable, transformative pathways for improved livelihoods of actors in mixed farming systems through sustainable intensification within target agroecologies and socio-economic settings.

Through action research and development partnerships, the Initiative will improve smallholder farmers' resilience to weather-induced shocks, provide a more stable income and significant benefits in welfare, and enhance social justice and inclusion for 13 million people by 2030.

Activities will be implemented in six focus countries globally representing diverse mixed farming systems as follows: Ghana (cereal–root crop mixed), Ethiopia (highland mixed), Malawi: (maize mixed), Bangladesh (rice mixed), Nepal (highland mixed), and Lao People's Democratic Republic (upland intensive mixed/ highland extensive mixed).

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Abbreviations and acronyms

AR4D	Agricultural Research for Development
CGIAR	Consortium of International Agricultural Research Centers
CIFSRF	Canadian International Food Security Research Fund
MFI	Microfinance Institution
R4D	Research for Development
SI	Sustainable intensification
SII	Sustainable intensification initiatives
VSLA	Village savings and loan association

Executive summary

This study reviewed over 160 papers and reports in sustainable intensification, with a focus on the target countries of Malawi, Ghana, Ethiopia, Laos, Bangladesh and Nepal. It collected literature by carrying out searched with both scopus and google scholar with specific key words and combinations. This search focused on target regions and countries as well as social equity. Under "sustainable intensification", we obtained a list of 5493 papers. Sustainable intensification and gender yielded 58, SI in Sub-Saharan Africa produced 545. Country by country the papers were fewer and when gender and social equity were included, the number of papers were far fewer. For example, a broader search of gender transformative approaches and agriculture yields 56 papers. Because this search produced so few on gender in particular, we also searched under specific researchers whose work is known for a gender focus. What is important about this search, is that it illustrated how little overall has been done to include gender and social equity issues in SI projects or analysis.

The Sustainable Intensification Assessment Framework was developed in 2017 to provide guidance and tools to design projects on SI and measure the impacts across the five domains of sustainable intensification: productivity, economic, environment, human condition and social. This framework was deployed in several of the papers we analysed. However, overall, as reviews of SI have observed, very few studies or papers pay attention to all five domains. Most papers and projects focus on productivity, followed by the economic domain (often through modelling). Far less attention is given to the environment, human condition and social domains.

Some important key themes emerge. While many of the technical interventions have clear positive impacts in researcher managed trials, we know far less about their impacts in farmer-managed fields. We know even less about environmental impacts or the social, economic and political context that can hinder or encourage adoption of these impacts. Of related importance is the need for greater participatory action research that can result in better understanding of these broader contextual issues and suggest pathways forward to improve adoption. Part of this participatory action research should focus on farmer experimentation as well as social networks and institutions that affect access to knowledge and key farming resources. In addition, little is known about how social networks influence farmer decision making and how this differs according to gender, age, religion, etc.

All reviews of SI also underscore the necessity of interdisciplinary teams as biophysical sciences alone can not provide all the necessary evidence for ensuring adoption. To better address concerns of equity, there must be more involvement of social scientists from the beginning of project design through to completion. Finally, it is imperative to consider the economic context more fully as without better access to markets and experiencing better benefits from market participation, many innovations will remain "on the shelf".

There is considerable hetereogeneity across regions, countries and within countries and even local contexts. Understanding this heterogeneity is obviously critical. There

are, however, some commonalities to all these contexts. Not surprisingly, labour is a major constraint in all the farming systems in these countries. Farmers have limited household labour and limited cash with which to hire labour, so labour saving technologies are critical. Soil fertility and soil quality is also a major constraint across all countries. Improving soils often takes considerable time, labour and sometimes capital so institutional innovations are particularly essential to provide farmers the incentive and ability to invest in practices that may only produce benefits after considerable time.

Crop diversification, to manage climate uncertainties, market fluctuations and food security is also important in most locations. SI projects must now be designed with greater consideration to the other SI domains as evidence generation has focused mostly on productivity. Adopting a landscape scale to understand farming decisions and impact is important as plots and farms are deeply affected by these wider environmental and social dynamics. In turn, changes on plots have ramifications far beyond the plot and trade-offs are evident at a broader scale.

Introduction

In the last 100 years, technological and institutional innovations in agri-food systems have greatly improved human well-being (Barrett et al. 2020). However, green revolution technologies and agricultural intensification have also led to environmental degradation, negative impacts on public health and nutrition, and increased social differentiation. These negative externalities and increasing challenges due to climate change have led to the call for more sustainable intensification (SI), beginning in the 1990s. The focus of many SI initiatives has been on "smallholder agriculture in the developing world (particularly Africa), where productivity was predominantly low and degradation of natural resources a major concern" (Cook et al. 2015: 1). SI aims at "producing more output from the same area of land while reducing the negative environmental impacts and, at the same time, increasing contributions to natural capital and the flow of environmental services" (Kuyah et al. 2021:2). From about 2010, the concept was adopted as a framework for all types of crop production. However, in some instances, this led to the term being skewed in favour of intensification focused on high-input industrialised agriculture and only slightly paying attention to sustainability by giving a little attention to reducing environmental impacts (Cook et al. 2015).

To intensify agricultural production sustainably, technical solutions must be paired with the social, economic and political innovations that can support their adoption by smallholder farmers (Barrett et al. 2020; Cook et al. 2015; Kuyah et al. 2021). To achieve the goals of sustainable intensification, benefits must be felt by all who are engaged in the farming system. Many interventions, particularly those that focus on improving soil carbon, take time for benefits to be realized. Often, farmers who are able to adopt new practices and new crop varieties are those who have better access to land and resources. Thus, SI interventions need to be designed so that those who have less access to critical resources, can also benefit from change. Attention to gender and social differentiation is thus essential to ensuring that benefits are equitable. Achieving gender equity is crucial for all development goals, but, as Njuki et al. point out, it "has been on the development agenda for decades but remains a persistent and challenging goal that requires contextualized and innovative approaches" (2022: 2). With regards to SI, as Fischer et al. note, when we consider the "conceptualizations of intensified land use under SAI, it is apparent that social outcomes are considered, but a gender analysis of labour, access to inputs and land (as well as the social institutions they are embedded in) goes unmentioned" (2021: 406). This lack of attention to gendered impacts is evident in examination of most pillars of the sustainable agricultural intensification framework (productivity, economic, environment, human and social) as will be discussed below.

To promote agricultural intensification, many African governments have included technologies, such as irrigation, fertilisers and pesticides, improved varieties and agronomic practices in their policy/legislative agendas (Barrett et al. 2020; Kuyah et al. 2021). However, about 70% of Africa's smallholder farmers do not have access to all of these technologies; they are also challenged by "low soil fertility, water stress, crop pests and diseases, and climate change shocks" (Kuyah et al. 2021: 18), resulting in

lower yields and lower quality produce. In some instances, overcropping is the result of smallholders having only small amounts of land on which to grow food and graze cattle (de Roo et al. 2019); therefore, resolving land issues and challenges continues to be key to agricultural transformation on the continent (African Union 2009). Smallholders' access to these resources, especially that of women and youth, requires addressing land tenure/land ownership arrangements including, where necessary, land reform. As stated in the *Declaration on Land Issues and Challenges in Africa*, AU members states resolved that they would "ensure that land laws provide for equitable access to land and related resources among all land users including the youth and other landless and vulnerable groups such as displaced persons; … and strengthen security of land tenure for women which require special attention" (UNECA 2016: 3). However, with respect to SI, improved and equitable land tenure and land ownership should not expand the area of land under cultivation; i.e. agriculture should not lead to land clearing and deforestation (Barrett et al. 2020; Kuyah et al. 2021). Instead, SI advancements involve transforming production methods to reduce the land and water footprint of agriculture.

Investing in on-farm transformations is a challenge to smallholder farmers who have limited access to credit, capital and often information. Improving these factors can incentivise farmers to access new technologies (equipment, inputs and seeds for new varieties) (Barrett et al. 2020). A major challenge to any on-farm transformation is labour. Women are already suffering from "time poverty" and have less cash with which to hire labour. In some S. Asian countries, there is considerable out-migration of men which results in high labour demand on women and youth who are left behind on farms. In addition, interventions in SI need to take into account that many farmers earn some or much of their income from off-farm income generating activities. There may be opportunity costs in investing more labour and capital in agriculture.

Because access to financial resources is a key concern for smallholders, combining technologies (i.e. improved seeds, solar water pumps for irrigation) and economic innovations is important to ensure smallholders can purchase technologies, without taking on high debt. To make such financial transactions feasible, governments need to mobilise funds (including social protection/basic income grants and insurance in the event of crop failure) and private sector investors need to come forward to support such initiatives. Women, youth, poorer farmers all face specific and substantial challenges gaining access to finance. Village savings and loan programs have provided some assistance to these groups, but whether the financial support has resulted in investment in farming is less clear.

All SI innovations are shaped by a wider institutional environment that can hinder or enable adoption (Barrett et al. 2020). Thus, it is critical to assess the institutional and political context in which SI is being promoted. This analysis is essential for designing incentives and processes to address "insufficient leadership, political will, and willingness to find cooperative solutions" for innovations (Barrett et al. 2020, p. 4). As Sartas et al. (2020) observe, innovation depends on the extent to which it is supported - how many people are already using a new technology, who are they, and what networks they are a part of. When less empowered groups do not have a

place to voice their concerns and interests, policies and legislation are unlikely to consider them adequately (Barrett et al. 2020). Importantly, they are less likely to have sufficient support and protection required to successfully adopt an innovation (Sartas et al. 2020). Therefore, upscaling SI requires giving adequate attention to these contextual issues, in particular the concerns of less powerful groups, such as smallholders and farmers' organisations, women's groups, extension officers, and smaller businesses such as local level traders in input supplies, smaller agricultural processors, and markets (e.g. shops, restaurants and end consumers) (Barrett et al. 2020). If this is not done, "socially constructed mechanisms of accessing modern agricultural technologies can reinforce existing poverty dynamics", especially for women (de Roo et al. 2019). Implementers must pay attention to what networks the different stakeholders are embedded in and the extent to which these networks offer protection from risk (Sartas et al. 2020). All relevant stakeholders must be involved in creating solutions together and sharing responsibility (Barrett et al. 2020).

Scaling up transformation and SI must necessarily involve restructuring resources (financial and natural), "decentralized, coordinated action by public, private, and civil society actors" in "socio-technical innovation bundles" (Barrett et al. 2020: 6). To meaningfully transform agriculture, the components of these bundles cannot be implemented independently, but rather together, to complement each other.

There have been numerous efforts to roll out sustainable intensification initiatives (SII) in agriculture, including those undertaken by the CGIAR (Africa Rising, Simlesa, CSISA), the Feed the Future Innovation Lab on Sustainable Intensification, SAIRLA (Sustainable Agricultural Intensification Research and Learning in Africa) and various projects supported by the Water, Land and Ecosystems program of the CGIAR. Many of these projects have sought to address challenges faced by women and youth in particular. To scale the lessons from these initiatives, it is important to identify successes and challenges for SI, including what creates an enabling environment for such transformation. Scaling up is a complex process, affecting livelihoods and relationships between people (Sartas et al. 2020). Assessing the successes and challenges involves a close look at the impacts of the initiatives, particularly with regard to different social groups – men and women of different ages, ethnicities and religions. This study seeks to explore how technologies and institutional issues such as financing, collective action, training, etc. can empower different social groups. It examines what kinds of impact interventions have had (social, economic, biophysical) and what gaps require attention.

The recent emphasis on bundling technologies and interventions (such as design of farmer cooperatives, policy reform, etc) is an important step forward. What these innovations underscore however is the critical importance of understanding the context in which they will be designed and implemented. Indeed, throughout the literature reviewed for this paper, this point is repeated frequently. An essential aspect of context is the social relations and institutions that shape agricultural production. It is critical that these social relations, which consist of gender relations, intergenerational relations, and social hierarchies based on ethnicity, wealth and religion be understood and addressed in the design and implementation of all projects. There are numerous tools available to assess gender and to design gender

transformational approaches. However, projects have often been hindered by the failure to fully integrate these tools, approaches and analysis from the design stage through to completion. Interdisciplinary research is crucial for addressing complex problems, but true integration often remains elusive. Disciplinary integration must start at project conceptualization and follow through implementation. Too often, scientists retreat to their disciplinary silos and networks and opportunities for co-creating knowledge are missed.

Sustainable intensification is not simply a technical solution. It requires a grounded understanding of farming systems and the different perspectives, roles and responsibilities within these systems that shape farming practices. Men, women and youth have both shared and overlapping goals and objectives, but they also have sometimes quite divergent aspirations. It is essential to understand these factors and the differences within communities in order to design interventions that ensure equity, promote empowerment and will be sustained. Njuki et al. in their review of gender transformative approaches, stress that understanding local contexts and framing research within this context is key to understand the socio-cultural gender dynamics at play, to gain insight on who needs to be brought in to effect positive change, and to operationalize the results. Unpacking structural inequalities in the absence of a local lens would be deficient at the very least —and could even lead to misguided structural analysis that could lead to deleterious consequences if used in an applied research context (2022:16).

This observation is echoed by Zulu et al. (2020) and many other researchers of SI. It remains critical for the SI initiative and in shaping the research design and implementation of projects going forward. Fortunately, in most of these national contexts (of SI prioritized countries), there has been considerable groundwork done on understanding gender relations in rural communities where interventions are targeted. However, there are still important gaps that could be addressed by greater interdisciplinary work and more participatory action research in these sites.

Literature review

This literature review collected papers after various searches on scopus and google scholar using specific key words and combinations[1]. This search led then to an examination of references from papers collected to expand the collection with a specific focus on target countries and on social equity topics. A search under "sustainable intensification" turned up 5493 papers. Sustainable intensification and gender yielded 58, SI in Sub-Saharan Africa produced 545. Country by country the counts were: SI and Ghana – 72, with 10 including gender; Laos – 22 on SI and 2 including gender; Bangladesh – 60 on SI, 3 including gender; Ethiopia – 102 on SI, 2 including gender; Malawi – 58 on SI, 7 including gender; Nepal– 36 on SI, 1 including gender. A search of gender transformative approaches and agriculture yields 56 papers. Because this search produced so few on gender in particular, we also searched under specific authors we knew had worked on gender issues in these countries and collected several more papers. Some papers we collected and analysed did not make specific reference to SI but nonetheless had relevant insights. And finally, we collected papers and reports off the project websites of SAIRLA, SIMLESA, CSISA. What this search showed, is that the papers that incorporate gender and social equity issues are *very few* when compared to those focused on yield or economic benefits. More on these gaps will feature below. In the end, we drew on approximately 160 papers. It is important to note that while there are papers on gender transformative approaches, there are few that actually detail how gender relations have been transformed or what specific impacts have been experienced by women, youth and other marginalised members of communities. This literature review attempts to unpack successes and challenges for different social groups, differentiated by gender, age, ethnicity and religion, with a focus on the following questions:

i. To what degree have these projects integrated social-economic and biophysical knowledge and interventions?
ii. How have social-economic and biophysical interventions been bundled or integrated into projects in the target countries and beyond?
iii. What are the biggest knowledge gaps in the literature on SI interventions and their impact on women, youth, marginalized and other social groups?
iv. Where have interventions been gender transformative and at what scales?
v. What strategies have led to gender transformative interventions? (capacity building, specific approaches such as multistakeholder platforms, etc) and what was the time span for these interventions to have an impact? What have been the gendered impacts of SI interventions?
vi. How have trade-offs been assessed in SI interventions and have gender and other social categories been considered?
vii. What are the challenges and obstacles to achieving more socially inclusive SI outcomes?
viii. How can target countries (at different levels) be empowered from a human, technical and institutional perspective towards strengthening gender transformative approaches within mixed farming systems?

[1] For example, gender and sustainable intensification; gender and conservation agriculture; youth and sustainable intensification; gender and intercropping; etc.

These questions are addressed in the sub-sections below. Depending on how the research has been designed and implemented, it is often not possible to answer all of these questions. Nonetheless, insights do emerge. We tackle two main themes when possible: drawing on Barrett's (2020) assertion that success will depend on the "bundling" of interventions, we will explore whether and how such bundling exists and what impact it may or may not have had; 2) how results from projects (mostly through published, peer-reviewed literature) address the five pillars of the sustainable agriculture intensification framework (SAIF): productivity, economic impact, social impact, human impact and environmental impact (Musumba et al. 2017). There is considerable overlap in these five dimensions and most literature addressed more than one of these dimensions. Perhaps the most common, and easiest to assess, is the combination of productivity and economic impact. However, the specifics of economic benefits are often unclear, particularly who benefits and how. Often, benefits and impacts are modelled and supposed, but not measured in actual farms and households.

There are very few papers that address all five dimensions of the SAIF and it is apparent that most projects that focused on SI were not designed to look at all dimensions in an integrated fashion. In their review of over a million papers, Porciello et al. find that "there are consistent gaps in the evidence for outcomes focused on nutrition, social inclusion, and gender empowerment across nearly every domain" (2021: 8). There is a consensus in many of the reviews of SI (Mahon et al. 2017; Porciello et al. 2021; Reich et al. 2021; Smith et al. 2017), that research needs to move beyond its focus on yield and productivity to investigate in more depth the other pillars that have an impact on farmers' decisions and the adoption and outcomes of SI interventions. As Liao and Brown assert "Because many of the rural lands available for increased food production are currently farmed by smallholders, their livelihoods will be affected by changes in production systems and need to be explicitly addressed in the process of agricultural intensification" (2018: 53).

Degree of bundling in SI interventions and the integration of social and biophysical factors

Barrett et al. (2020) and Barrett (2020) emphasise the importance of going beyond the focus on technical innovation and interventions to more integrated approaches that address underlying structural challenges to improved agri-food systems. In agriculture, this involves: "greater emphasis on sustainable increases in dietary quality and total factor productivity to stop focusing solely on yields and dietary energy" (Barrett 2020: 426). We attempt to analyse the impacts of interventions and the way these are typically measured. Where possible, impact on gender and social differentiation will be highlighted. However, as noted above, overall there are very few studies that actually include gender and which look at impact. Most papers that include gender provide in-depth analysis on the local contexts of gender relations and challenges to gender empowerment. However, analysis of impact remains under-explored as overall most studies are taking place on field stations or farms managed by researchers. While this strategy is key for measuring the biophysical impacts of technical interventions, it does not provide the setting for looking at real on-farm and in-household impacts. While projects that introduce new farming

technologies are tailored to the socio-economic and changing biophysical conditions in the places where the intervention is situated, often key social and economic aspects of these contexts are not fully integrated into project design and implementation. In particular, what is needed is more attention to who specifically wins and loses from the adoption of SI technologies and looking beyond the farm plot for how to support farmers in making transitions.

Productivity: Impacts of technical interventions

Oumer et al. have shown that smallholders can enjoy reduced overall costs of farming by deploying a combination of SI technologies: "We find that the use of individual SAI practices increases cost while the combined use of the practices reduces it" (2020: 841). Typically, practices promoted in SI involve: (i) changing the way land is used (e.g. converting fallow systems to permanent cropland); (ii) increasing inputs such as irrigation, fertiliser, pesticide, herbicide, and machinery; (iii) changing labour, and promoting new skills; and (iv) and changing cropping patterns, from mono-cropping, rotational cropping and intercropping to increasing commercialization of crops(Martin et al. 2018: 96). All of these practices will have greater impact if combined in strategic combinations according to crop and socio-economic-environmental context.

While in some instances, technologies and practices have boosted yields and thereby boosted household income and decreased food insecurity (Yahaya et al. 2018), projects are not always successful in achieving widespread adoption or in improving the lives of smallholders. For example, the Rwandan government has promoted their interpretation of "climate-smart agriculture", forcing farmers to consolidate land parcels, monocrop with government-approved varieties, and rely on more purchased inputs but this has led to a decrease in the resilience of farmers, particularly those who are less well off, to climate shocks (Clay and Zimmerer 2020). Most farmers would prefer to diversify their crops and plant sweet potato and cassava for food security, but the government of Rwanda has made those practices illegal.

The success of SI is most often measured in terms of increased yields, and specifically addressing the yield gap. If yield is increased, and surplus sold, then the high investment in inputs such as mineral fertilisers and improved seeds can be offset and be considered feasible (Droppelmann et al. 2017). However, increased yields have to take place within an enabling market environment. If it leads to post-harvest loss, or crop surpluses that cannot be sold at a good price, increased yields may only lead farmers to suffer economic losses. While many papers focus on productivity, few integrate attention to yield with the social and economic factors that increasing productivity might involve.

Other indicators for measuring the impact of technical interventions include soil quality, input use efficiency, pest control, and related greenhouse gas emissions/agricultural carbon footprint (Kuyah et al. 2021). These indicators point to SI as "broadly defined as the investment of inputs and capital to increase crop productivity over the long-term, while protecting the underlying resource base" (p.

139). Typically, these programs are designed by external experts and are presented to farmers in a top-down way, so it is unclear how farmers assess the impact and if the interventions are meeting farmers' demands and criteria for impact. As Zulu et al. have observed, "indicators for detecting gender and intergenerational inequities in SAI costs and benefits sharing often remain overgeneralized, theoretical, or locally irrelevant" (2021: 376). They addressed this challenge by working with community members to develop locally relevant indicators for measuring the impact of SI.

Much of the literature on sustainable land management, which is associated with SI, has indicated that farmers are either not able, or unwilling, to make investments in practices and technologies that only offer longer-term benefits. This constraint is particularly important in Conservation Agriculture (CA) and other Integrated Soil Fertility Management Practices. This challenge requires providing incentives to bridge the gap in possible income or food security loss until benefits can be realized. In addition, it must be considered who bears the cost for implementation, both in terms of financial costs but also in labour. The labour costs of CA are often borne by women who can ill afford any additional labour burden.

While SI projects have documented how new technologies can increase yields, scaling up has been challenging as projects "predominantly privilege uniform crop or market-based interventions rather than holistic agriculture systems processes that pay attention to a complex mix of climate and ecological vulnerabilities, economic realities and socio-cultural practices" (Shilomboleni et al. 2019: 64). Since most of these interventions have not yet been adopted at scale, it is not possible to fully assess whether they are indeed effective and sustainable. Typically, even when interventions are implemented, research focuses on a single intervention, which limits the likely impact (Sartas et al. 2020). For example, a study in Malawi found that many households have intensified their maize production (through better use of farm tools, different farming techniques and access to irrigation) but farmers experienced limited access to extension services, credit and markets. Because many were not using chemical fertilisers and improved varieties, yields only marginally increased (Lindsjö et al. 2021).

In Bangladesh, researchers examined the drivers of cropping system intensification and found that farmers were responding to changes in weather and soil quality (Jamal.et al. 2021). Farmers' adaptation practices highlight different possibilities for SI, all of which could benefit from increased extension and infrastructure development alongside the deployment of farming technologies (such as improved varieties and smart management practices). While the research underlined the importance of farmer experimentation, it did not delve into social differentiation or gender to investigate how different categories of farmer innovated. So, opportunities to understand the gendered and intersectional impacts of these practices were lost.

Papers that focus on productivity often do not include attention to the trade-offs that farmers face and who benefits and who may lose from increasing productivity. Farmers are often lumped together in a single category. And while gender is more frequently included in surveys and in implementation, it often remains at the level of counting the number of women who are included, and less on what productivity

increases mean to them, in terms of income, food security or in terms of labour and other factors. While research may acknowledge that there is considerable heterogeneity across farm households in terms of access to productive resources, supportive institutions, and credit, all of which will influence farmer decision-making and performance, greater analysis of these specifics remains under-explored (Oumer et al. 2020).

In an extensive review of the SI literature for South Asia, Jain et al. (2020) found that there was a high degree of variability in reported yield gains for SI interventions and that the average yield gain was 20 percent. Two practices – crop residue retention and the use of organic fertiliser – had positive effects on yields. However, using organic fertiliser was not always profitable because of various subsidy programs for inorganic fertiliser across South Asia. Another important finding of their review was that research tended to be concentrated in highly productive, irrigated and commodity cropping systems which are not representative of a large part of farming in S. Asia. They also found that most assessment of outcomes of SI interventions were in researcher-managed field trials, rather than in farmers' fields and management systems so this still indicates considerable gaps in knowledge about outcomes under more real-world conditions where farmers' practices, preferences and their own evaluations affect results.

Overall, oo achieve large-scale adoption of SI, there is a need to overcome barriers to adoption, namely, limited financing, lack of a supportive policy and regulatory environment, lack of specialist extension services, shortage of labour, lack or high cost of inputs such as seeds or planting material, and low degree of mechanization income, profitability, income diversification, input use intensity, poverty, market participation (Kuyah et al. 2021: 16).

Economic Impacts

Labour and profitability

Across the Global South, labour is one of the biggest constraints in farming systems. Women's "time poverty" has been highlighted by many scholars and indeed continues to be a topic garnering attention (Bain et al. 2018; Adeyonu 2012; Msigwa and Mofulu 2013; Arora 2015, 2017). In some locations, out-migration of men results in an even greater labour burden on women. This 'feminisation' of agriculture appears to be increasing in some locations. While there is considerable variability according to gender norms in any given context, women usually are responsible for food production and preparation, storage, household maintenance, childcare, earning income, etc. The constraints on women's time, while roughly understood, remain under-investigated when looking at economic impacts. As their labour on-farms is constrained greatly by this broader workload, it inhibits their abilities to take up new innovations and to benefit from them. In Malawi for example, many people from poorer households, and particularly women, engage in labour (*ganyu*)on wealthier households' farms. *Ganyu* helps provide badly needed income to address food security, school fees and health. However, it inhibits their time on their own farms, and at crucial times in the cropping system. Given the need for immediate income, it

may not be feasible or desirable for these farmers to make new investments in their own farms.

In their review of labour and Conservation Agriculture (CA) in five countries in SSA, Montt and Luu (2020) found that, while CA can increase yields[2], labour demands were significantly higher and women, and sometimes children, bore the brunt of this demand. Their study drew upon SIMLESA data and found that very few farmers adopted the full package of CA. Rather, to promote full adoption they suggest that complementary measures be incorporated in CA projects to address the burden of labour by providing greater access to equipment and chemical inputs as well as income support until the benefits of CA can be realized.

While increased productivity can benefit both income and food security, some recent studies on dairy intensification have observed that increasing milk production and sales often results in men taking over what was a product previously controlled by women (Lenjiso 2019). Increasing productivity and profitability has resulted in similar patterns across cropping systems and their commercialisation, where men end up dominating crop production and sales as the crops find more lucrative markets (Fischer and Qaim 2012; Carney and Watts 1991; Dolan 2001; Kumar 1994; Von Braun and Webb 1989; Sørensen 1996; Kasente et al. 2002; Bergman Lodin 2012).

While labour is one element needed to increase productivity, access to resources are also critical. In agricultural development more broadly, women are often at several disadvantages in their ability to adopt new interventions. They have less access to critical resources (land, capital, inputs, knowledge) and participate less in key farming decisions due to gender norms and conflicting responsibilities (domestic work) (Regassa et al. 2014; Fischer 2022).

Thus, increased productivity has to be assessed for its other possible impacts beyond profitability – on labour, on equity, on the environment and on food security. While evidence from SI interventions is overall positive for yield improvements, it is less clear whether increased yield also results in improved income or food security. Much depends on other factors such as post-harvest losses, market access, fairness of markets, fluctuations in market prices, etc.

Environmental impacts

A review of 1.2 million publications on sustainable agricultural intensification found that "there are nearly twice as many research publications focused on technology innovation as compared to both ecosystem services and socio-economic innovations" (Porciello et al. 2021:7). These findings are echoed in other reviews of SI research (Smith et al.2017; Weltin et al. 2018; Reich et al. 2021). A significant, and still under-analysed trade-off in SI is the environmental impact of intensification interventions. In the sustainable intensification literature, there is considerable emphasis on maintaining or enhancing the underlying natural resource base on

[2] Thierfelder et al (2012) found that CA improved maize yields in Malawi particularly through greater soil moisture retention.

which agriculture draws. However, there are few studies that actually look, in an integrated way, at the impact of SI technologies on the environment. Furthermore, when environmental factors are considered, they are usually focused on the plot or farm level, with few studies widening the lens to look at more landscape-scale environmental impacts.

Kuyah et al. (2021), in their review of agronomic innovation in SI, note that there is evidence that "conservation agriculture, doubled-up legume cropping, fertiliser micro-dosing, planting basins, and push-pull technology" have shown positive environmental impacts on soil fertility and soil quality. Intercropping, a practice that farmers have been practising from well before the colonial era, can reduce pest infestations, improve yields, and reduce the risk of crop failure. However, the choice of crops and the management of the farm are essential in designing the right combinations for intercropping to plan for possible plant competition for water and nutrients. Other technologies (which will be discussed in more depth in the country-specific literature) have proven to have positive impacts on both environmental and productivity dimensions. However, various other factors have impeded their adoption – from high labour demand, to costs for inputs (seeds, tree seedlings), to time frame to yield benefits (trees), to insufficient training in new management practices. In the case of conservation agriculture, the use of herbicides and their impact on biodiversity is not adequately understood.

The factors that impede adoption of more environmentally positive SI interventions are particularly acute for women. Time poverty and lack of access to resources and knowledge are key constraints. As Kihara et al. (2022) show, adoption of Integrated Soil Fertility Management practices differed among men and women farmers. Constraints of labour and access to resources resulted in women adopting fewer ISMF components.

Tittonell (2014) proposes a shift in thinking about sustainable intensification. He argues that ecological intensification is a term and an approach that can better address environmental impacts and the contexts in which agricultural development is taking place. Ecological intensification shifts the perspective from the plot and farm scale (where the emphasis has mostly been in increasing yield) to a landscape scale. DeClerck et al.(2016) have contributed to this focus on the environmental impacts of agriculture, by arguing for an ecosystems services (ES) approach to agricultural development. This approach again requires approaching agricultural development with a systems lens and landscape approach in which environmental concerns have equal weight to such goals as yield improvement.

Approaches that bring environmental concerns to the forefront, require interdisciplinary methods and teams which are often absent from SI projects. In order to achieve better social, economic and environmental outcomes, a range of skills and expertise must be incorporated or there will be little change and opportunity for true innovation. While intercropping leguminous species with grain crops may improve environmental outcomes, it remains unclear what the social impacts of these changes are. Will women have more labour to do? Is there a robust market for legumes? Will women or youth have access to any financial benefits that

come from legume production? There are many questions that have to be considered. As environmental impacts often take a longer time period to be realized, we have to assess the costs of waiting for these benefits on different members of the community. For example, if women need cash fast to pay for food, can they afford to wait for delayed economic/productivity gains?

Human impacts: nutrition, food security and capacity to learn and adapt

Evidence for impact in this domain is small when compared to that for productivity and economic domains. While many SI interventions, such as intercropping or relay cropping with legumes potentially improves nutrition, there have been few analyses of whether nutritional outcomes have been reached through these practices. Some agricultural interventions, such as the expansion of orange-fleshed sweet potato have received far more attention and there are many new varieties of bio-fortified crops that have been developed to address nutritional challenges (Vitamin A, Iron, etc.). However, these studies do not tend to be found in the sustainable intensification literature and it is not clear how this evidence is incorporated in SI projects. Ultimately, nutritional outcomes depend on a wide range of factors – adoption for sure, but also consumption patterns, cooking practices, and whether the crops are produced more for the market than for home use.

Various projects have focused on raising awareness about nutrition and much of this focus has been on women who are usually responsible for nutritional choices in households. Increasingly however there have also been attention to bringing men into nutrition training as they have considerable control over what is grown on-farm.

Overall, there is much to be done to better understand and promote the human impacts of SI. As Smith et al. (2017) note, the human well-being domain lacks metrics for measurement and important aspects of well-being, such as food safety, remain unexamined. The capacity to learn and adapt is also not well understood and, when evidence arises, it tends to focus on access to extension and other information networks and opportunities. Zulu et al. (2021) have done much to tailor SAIF indicators to a local context, but there is still much work to be done to determine what can be feasibility measured and how.

Social impacts: achieving inclusivity

In Porciello et al.'s (2021) analysis of SI, they found "consistent gaps in the evidence for outcomes focused on nutrition, social inclusion and gender empowerment across nearly every domain" of the SI pillars. Musumba et al. define the social domain as focusing on: "social interactions of the farming communities or society, including equitable relationships across gender, equitable relationships across social groups, the level of collective action, and the ability to resolve conflicts related to agriculture and natural resource management" (2017: 8). While a handful of studies have analysed the social domain, the actual impacts that are measured are typically over the short-term and it is unclear if these are sustained in the long term (Martin et al. 2018). Most often, impact is measured through proxies like income or increased access to food. Yet far less is known about who benefits across gender and social groups. Non-economic benefits are obviously harder to measure, but they may

influence adoption far more than economic ones depending on the context and related factors (land tenure, social networks, etc.).

Zulu et al. underscore that there is "insufficient context-specific evidence to support efforts to address inequities that arise from SAI investments" (2020: 1). They warn against essentializing narratives, myths and assumptions about gender in Africa that lead to the design of highly problematic interventions that fail to match local conditions. They stress the need to expand the focus from individuals to examining how individuals exist within households, community and social networks as these elements are critical in influencing access to resources and decision-making, as well as impact. This point has been made by others including Kantor et al. (2015). Zulu et al. (2020) argue that much of the gender assessment indices focus narrowly on individual women's status in relation to men. If interventions do not take equity into consideration at the outset of a project, they may exacerbate local inequalities. For example, a study from Malawi noted that because of a lack of attention to socio-economic factors, the interventions involved households that already were better off in terms of assets (farm size, livestock numbers, etc.) (Haile et al. 2015: 1).

A key strategy for improving inclusivity is to engage in participatory action research where the perspectives of women, youth and other marginalised groups can be gained and targeting of interventions improved to ensure equity. While more participatory approaches that capture more locally relevant indicators have been ongoing for decades, "much of it remains in the grey literature and little has focused on SAI" (2021:377). It is also important to account for intersectionality. For example, senior wives in polygamous unions may have very different constraints and opportunities and goals than junior wives. Some youth may have greater access to land than others. Religion, ethnicity, class, caste and other aspects of social differentiation must be well understood in order to adequately ensure equity. These factors can be best understood through thorough contextual research on these social dynamics. Ultimately, as Pretty et al. underscore, SI is as much a "social and institutional challenge as it is a technical one" (2020: 3).

Important advances in understanding inclusivity are facilitated by the range of participatory methods and indicator design (Zulu et al. 2020) that enable projects to both design with inclusivity in mind and to measure success based on locally derived metrics. Mulema et al. show the importance of including women in research design and priority setting from the outset. In so doing "It increases the chance of prioritizing solutions that address their needs and creates a sense of ownership of the process. Involvement of women in the identification of research problems shapes their decision to participate in the subsequent stages" (2019: 134). These tools and examples are essential for ensuring inclusivity in the next phase of SI projects. The literature emphasises repeatedly the importance of a thorough understanding of the local context for designing relevant interventions and ensuring inclusion.

There are insights that emerge from all regions concerning the challenges that women and youth in particular face in engaging in SI. First, is access to resources. For the most part, women and youth across the continents have less access and control over land and other resources (capital, inputs, etc) than men. Men, women

and youth also have different livelihood strategies, goals and interests. In Ghana for example, men focus more on productivity increases because they want to sell surplus on the market. Women, while they also sell on the market, also want higher yields first to meet food security, then sales. Women pursue more crop diversification strategies which again is tied to their responsibilities for food and nutrition in the HH. Additionally, they are more reluctant to take on interventions that increase labour requirements. They have less access to capital, or the social ties with which to hire additional labour (Britwum and Akorsu 2016).

Labour is a key constraint for women. Due to the high demands for their labour on farm and in domestic care, labour saving devices and technologies that are designed with women in mind can aid in increasing ability to engage in SI and realize benefits. For example, in Bangladesh fishing nets were designed to address women's constraints in fishing that are culturally rooted (Kruijssen et al. 2016).

Increasing yields does not necessarily, in and of itself, result in improved livelihoods for farmers. The investments necessary for increasing yields may not be recovered if markets are weak or prices suppressed by farmers producing and marketing surplus of the same crop. Post-harvest losses due to spoilage and insect infestation are also important constraints. These market factors increase vulnerability for some farmers with fewer resources or social networks. Women and youth can be at a particular disadvantage.

Increasing women's access to and involvement in agricultural cooperatives and farmers' groups is seen as one important intervention for empowering women. Interventions typically involve either the formation of new groups or working with pre-existing groups, which are regarded as a way for farmers, their households and their communities to "democratically organize around common goals for prosperity and well-being" (DeMerritt-Verrone and Kellum 2022: 4). Such interventions have been found to have several benefits. They can: build social cohesion; individual and collective agency; enhance access to and control over resources; change harmful and discriminatory gender norms; engage in governance structures to change laws. Further, they may increase access to resources such as land and water; markets, food and productive resources; skills development; and policy- and decision-making; and reduce information asymmetries (Akpalu et al. 2017; IFAD et al. 2012).

However, other literature warns of challenges in equity in agricultural collectives and farmers' groups. Ndiritu et al. (2014) suggest that there are significant information asymmetries between men and women, and between more and less wealthy, influential and powerful members. Indeed, Gelo et al. (2017) and Mwambi et al. (2020) illustrate some of the inequities in distribution of benefits in favour of wealthier, more influential, and more powerful members. This 'elite capture' often excludes women and youth, especially at the leadership level (Mwambi et al. 2020; Omotesho et al. 2019). These groups are also challenged by insufficient management, administrative (e.g. record-keeping) and communication capacity and skills (Bingen et al. 2003; Faure and Kleene, 2004), and experience difficulty in intervening in local and national policy and legislation (de Roo et al. 2019). Corruption can also impede benefits of these groups (Gelo et al. 2017).

To enable participation in pre-existing or intermediary-created organisations (farming cooperatives), the group must have a shared vision and mission, including clear boundaries based on local norms (Petersen et al. 2018). Groups need to agree on collective action, which encompasses (i) inclusive membership rules based on local context and fair distribution of benefits; (ii) the ability of members to modify the rules, and select monitors to track resources and ensure accountability; (iii) appropriate graduated sanctions on members who do not follow the rules, with consideration to "the seriousness and context of the offence" (Petersen et al. 2018: 869).

A SI project in Bangladesh provides an example of the importance of strengthening social groups. There, population increases and shortened fallow periods have led traditional shifting cultivation to become environmentally unsustainable. Through community-based participation, agroforestry was introduced to protect the environment and boost crop yields. The project aimed to "create trust, networks and formal committees to help build social capital … [through] face-to-face interactions … [and integrating] farmers' knowledge with external technical expertise (Nath et al. 2016: 6). Community members selected which crops would be grown based on perceived market returns, ecological considerations, social impacts – including gender. Incomes increased and farmers were keen to invest their own time, labour, land and money in agroforestry. The project enabled the community to strengthen their networks and gain better access to government officials, academics and researchers, and extension services. Regarding the impact on the environment, soil fertility improved, especially because areas of degraded land were chosen for implementation. The key driver of success was the relationships/ partnerships/ networks built between people, the jointly created knowledge, and the joint decision-making process. Implementing technological and land use changes was successful because local buy-in was secured, and therefore, scaling-up involved designing participatory approaches across the governance system, not just in small communities.

However, even in this case, results did not mention "how different categories of households can overcome the obstacles to accessing new technologies … [and] the social mechanisms that affect access control and maintenance in the communities where technologies are being introduced or scaled" (de Roo et al. 2019: 60). When social differentiation is not understood and considered, the introduction of new innovations may undermine the livelihoods of socially vulnerable groups and increase, rather than improve poverty.

Several promising interventions emerge from studies across the regions. Often, these are institutional interventions such as VSLs or cooperative groups. A common finding indicates that women and youth who participate in farmer groups or cooperatives increase their access to resources and knowledge, as extension agents cannot possibly meet with all individual farmers. Membership and participation in groups also builds social capital and individual confidence. Simply changing some institutional factors (land tenure for example) is unlikely to lead to empowerment of women, youth and other marginal groups. More attention to local social factors

must be done and ways for these groups to obtain more access to information, farming services, inputs, credit etc need to be sought in a 'bundle'.

Bundling and scaling-up

Having examined (above) the various measures used to assess the impact of interventions and the gaps therein, we now draw attention to Scaling Readiness, which "not only assesses the maturity of technological innovations, but also of other types of innovations (including social and institutional innovations) … in specific spatial and temporal contexts" (Sartas et al. 2020, p. 2). Unless programs are designed by first analysing, in each locality, what development challenges and opportunities exist, any technical interventions could be inappropriate; and if the projects are top-down, they do little to engage with all actors implementing and affected by the projects which limits possibilities for learning. Scaling-up SI involves "iterative engagements and long-term attention, even if impacts are not immediately apparent" (Shilomboleni et al. 2019: 59).

The literature identifies four common pathways to scale up: (i) intervening at a local, national or international policy level through strategic political engagement partnerships with stakeholders and government; (ii) relying on the private sector, motivated by potential profits, to distribute innovations to farmers; (iii) exchanging information and sharing information platforms and tools to influence farmers to adopt innovations, including using ICTs and extension services; and (iv) rolling out financial services so that farmers can access suitable products for savings, borrowing and insurance (Shilomboleni et al. 2019). However, it is important to consider how to combine efforts. In each of these pathways, it is important to adopt a gender lens to ensure that equity concerns are integrated from the design phase.

Technical interventions benefit from bundling since single interventions only marginally improve yields (Sartas et al. 2020). For example, improved maize seeds may need to be bundled with improving soil fertility and increasing access to input and output markets. Thus, "innovation packages" have to be designed to accurately fit the local context. In Ethiopia, a project on agricultural research for development (AR4D) for barley highlighted some key factors that were essential for scaling up of SI. These include: improving access to new seed varieties sourced from a credible institution, ploughing at least 3 times before planting and 1 time during row planting, rows spaced 20cm apart and planted 3-5 cm deep in rain-fed conditions, a seed rate of 75-100 kg/ha, recommended fertiliser, weeding twice after planting at specified periods, and harvesting the barley when the grain moisture content is lower than 18% (de Roo et al. 2019). These bundled interventions all act together to shape outcomes. However, while it was important to bundle these technical interventions, de Roo et al. (2019) also found that without attention to the socio-political dynamics of the communities in which these interventions took place, scaling resulted in the exclusion of certain groups.

When bundling interventions for scaling up, all stakeholders need to "have an appropriate understanding of the configurations of a system" such that they are clear on all the domains where impacts might be felt and this awareness is

incorporated into decision-making (Shilomboleni et al. 2019: 61). This means that stakeholders need to build a shared vision and identify how they are interdependent (Sartas et al. 2020). It is important to negotiate and forge agreements through an active facilitation process.

Increasing communities' sense of agency and empowerment can sometimes lead to more meaningful effects than any technical intervention (Shilomboleni et al. 2019). Systemic change, rather than simply transferring or deploying technology, can lead to more far-reaching and longer-term impacts. Interventions to increase the capacities of both the target beneficiaries and the local implementers are important. An important capacity for beneficiaries is the ability to more effectively advocate their own priorities. Ensuring that beneficiary concerns are prioritised involves undertaking research and designing interventions together with the end-users so that changes are embedded "within their social structures, material conditions and symbolic practices" (Shilomboleni et al. 2019: 62). In addition, agricultural personnel and scientists must be trained in the co-creation and -construction of knowledge (Barrett et al. 2020). Project teams must be flexible in introducing and implementing interventions in a way that communities own the project, taking into consideration what social learning is required, what economic incentives will be best applied and what political objectives stakeholders want to achieve.

Institutional Innovations

While not part of the SAIF framework or indicators, various institutional innovations are important in enabling adoption of SI practices. Adopting new technologies or practices often requires not only a change in farm management, or new knowledge, but financial investments. Numerous studies have shown that lack of access to finance and credit is a key obstacle to using agricultural technological innovation – especially for women (Adegbite et al. 2021; c.f. Adegbite and Machethe, 2020; Andrews, 2021; Havemann et al. 2020; Ihalainen et al. 2021; McEwan et al. 2021). Therefore, in most African countries, finance/credit needs to be made available to farmers – especially women – who wish to invest in technological innovation at affordable interest rates and with favourable lending terms.

At the individual and community level, given the variability of yields across years, farmers typically need "upfront finance that they can pay back in a flexible way over longer time periods," i.e. credit schemes designed specifically for smallholders that provide "low interest rates, longer maturities and context-specific, flexible repayment schedules" (Alforte et al. 2013: 21). Many credit providers are unwilling to lend to smallholders because they often lack collateral.(Benjamin 2013), even though even small increases in access to finance can help increase yields (Osabohien et al. 2020). Further, the relationship between smallholders and lenders is asymmetrical, with lenders having more information about available products, while smallholders may not be aware of the most appropriate products (Meyer 2015). Nevertheless, "more agro-funding at low-interest rates motivates farmers to secure high-yield seedlings, machinery and other farm implements, organic inputs that positively impact on total. agricultural yield, leading to more food production" (Osabohien et al. 2020: 1).

In some instances, microfinance has been a viable option, depending on how well the microfinancing institution (MFI) manages its lending, including "member accessibility, level of adherence to the rule of law, level of compliance to the management, management service level, allocation of the use of credit funds, and the benefits of credit funds" (Azriani et al. 2018: 1). Further, if MFIs are consistent in how much credit they approve vs the requested amount, and if members comply with the rules of these programs, microfinance can be important in providing borrowers with capital necessary to make changes in their farms. However, there are many factors that affect success, such as education level, gender and the ability of farm changes to produce profits. here are many examples globally of microcredit programs resulting in debt traps for the poor.

Another consideration is that accessing only small amounts of credit only marginally raises incomes – often not enough to lift people out of poverty; therefore, more recently MFIs are also giving attention to other financial products, including "savings, insurance, remittances and other financial services," and supporting smallholders to participate in the whole value chain for their product, not just the produce itself (Meyer 2015: 9). Since the early 2000s, agricultural financing has also shifted focus toward 'financial inclusion' through which men and women smallholders have access to a "full suite of quality financial services, at affordable prices in a convenient manner with respect and dignity, delivered by competitive suppliers" (ibid.).

Other financial options that have been explored are community-based cooperative savings and credit schemes, with the most successful of these keeping the cost of their products and services down, growing their client base slowly, and relying on cooperatives and members to provide resources (Meyer 2015). Donors' attempts to strengthen such organisations in the hope of attaining rapid results have hindered these organisations since slow growth is critical to success.

Further innovation has come through saving groups and village savings and loan associations (VSLAs), which incentivise community members to save; however, the members who benefit the most from savings groups and VSLAs are often the wealthier members of the community who can save more. Yet, Zulu et al. (2020) found that for Malawi, participation in village savings and loan groups was of particular benefit to women. Results overall are mixed on the viability of these schemes for increasing asset ownership, business ownership, spending on business-related activities and achieving profits. Each context will determine both the feasibility and the success of these innovations in achieving SI but also importantly in improving gender equity.

New ICT innovations are now linking savings groups with banks and mobile phone companies to create partnerships in which savings groups can build more trust with members, and the governance skills of members can be strengthened (Meyer 2015). As yet, it is unclear whether this is enabling financial inclusion for all, and thereby enabling access to agricultural technologies. None of the research we found linked financial inclusion and these saving schemes directly to SI, nor were they part of a package deal covering farm inputs, improved farming techniques, access to finance and insurance, and shifting poverty and inequality in recipient communities. While

youth may be more comfortable with ICT, it is unclear whether women will have access and knowledge of these opportunities.

Crop and livestock insurance can assist farmers in taking on new innovations by reducing potential risks that may come from crop failures and other losses due to natural disasters, and even political risks. As Huang and Wang argue, SI involves exploring "how finance can be used to achieve the joint objectives of development, mitigation of and adaptation to climate change in agriculture in [the] developing world" (2014: 698). Many agricultural economists argue that moving to SI requires "significant additional capital" which "cannot be covered by the current financial market setup, which dissociates public and private funders" (c.f. Havemann et al. 2020: 1281). While the private sector might be involved, much of the innovation in agricultural financing will need to come from domestic finance (especially government investment) and foreign aid (Huang and Wang, 2014). As such, financing structures and mechanisms may need to blend public and private financing, with each sector taking on different roles using many different funding modalities (Havemann et al. 2020). Ensuring women, and other more disadvantaged groups, have access to these innovations is critical for achieving equity and meeting the goals of SI overall.

National governments and foreign aid need to be steered towards insurance products, given that, even in the Global North, crop and livestock insurance programmes are typically subsidised by governments. In the , "because most farms are small-scale … private insurance companies normally lack incentives to operate the costly insurance for millions of small farmers" since administrative costs are high (Huang and Wang, 2014: 708). Therefore, arguably, governments need to intervene in agricultural finance by applying the budget to appropriate schemes, providing subsidies and providing credit guarantees, alongside agricultural insurance (Onyiriuba et al. 2020).

Knowledge gaps in the literature on SI interventions

Very few papers are truly interdisciplinary – they are either social science focused, or natural science focused. So, while research may have addressed some of the pillars of the Sustainable Intensification Framework (productivity, economic impact, environmental impact, human impact/factors, and social factors) and been implemented in a holistic way, very few published papers appear to have addressed all the pillars in the framework. As has been noted in other reviews of SI literature, the vast majority of papers focus on productivity. Gaps are substantial concerning knowledge of how various interventions affect environmental or social inclusion goals. Importantly, gains in productivity are known to carry possible costs which are both financial and human (labour, increasing inequity) as well as environmental. However, few papers examine these related costs. This omission raises numerous questions for which there are, at present, quite few answers. As an example, how might intercropping affect the labour demands of women (some papers suggested labour increased, while others suggested a decrease, but they did not differentiate by gender)? Does an increase in maize production benefit household nutrition? Or

are surpluses sold quickly for immediate needs for cash? Does cash income from increased productivity benefit women and youth as well as men within households?

Inclusion concerns require specific strategies for implementation. Africa Rising and SAIRLA projects developed a gender strategy and specific data collection tools and practices that provided detail on the contextual issues that shape gender in specific locations (Zulu et al. 2020, 2021; 2022; Grabowski et al. 2020; Fischer et al., 2020; Fischer 2022). These tools can be scaled out and applied throughout the SI initiative. Some studies have looked at implementation issues – such as how sticking to a strict formula for how SI interventions should be implemented by farmers does not allow for farmer experimentation and adaptation. Indeed, this is an important theme which has emerged – that there needs to be better research on how men and women farmers adapt SI interventions and innovate and how they build on local/existing knowledge.

While there is literature on the challenges of farmers' access to capital to access inputs or access to markets more generally, such as distance to markets, studies generally do not examine how competitive farmers/traders will be in those markets. There is some evidence that as adoption of certain crops increases, and these crops are sold, the prices for consumers improves, but not for the producers as markets experience gluts.

While certain assumptions about environmental impact are made (planting legumes, rotational cropping, intercropping, conservation agriculture), few studies actually present specific data on these environmental impacts (soil fertility, soil erosion, etc) or how environmental impacts may or may not have specific benefits to farmers, and which farmers (differentiation by gender, age, wealth, etc.). Some studies have suggested that soil fertility is linked to wealth – either in increasing wealth or in serving as an indicator of wealth (farmer has resources to devote to maintaining or increasing soil fertility). But generally, links between environmental impacts (ecosystem services for example) and social/economic impacts are underexplored.

There are always trade-offs arising from any intervention. Unfortunately, the literature analysing trade-offs is still scarce. As Reich et al. note: “few reviews have been carried out and we know of no systematic review of research on smallholder SI technologies to assess if yield is the dominant metric or if multiple domains and trade-offs are considered in assessment of performance” (2021: 1). Clearly, far more work needs to be done on assessing trade-offs and as Reich et al. (2021) argue, this can start with developing more relevant indicators for the other SI domains, most importantly the environment and social domains.

Analysing trade-offs also requires going beyond the scale of the farm to the broader landscape and adopting a holistic and multidisciplinary approach. To understand trade-offs sufficiently, a more integrated approach to SI must be implemented. In their review of SI, Weltin et al. (2018) point out the limitations of current practice and point to avenues requiring greater attention:

> *little effort is devoted to study SI as an objective requiring integrated practices, coupling the farm and landscape scales and different fields of action. This also requires addressing decision-making structures of various agents on different scales. In order to pursue a future-oriented SI research agenda, interdisciplinary cooperation is needed to address SI from a holistic perspective. The focus should be on the implementation of approaches paying attention to the behavioural rationales of farmers and land users (Weltin et al. 2018: 78).*

While there are good examples of methods and tools to understand the contextual factors affecting inclusion (Grabowski et al 2021, Zulu et al. 2021), and the SAIF framework (Musumba et a. 2017) provides indicators for ex ante and post project impact measurement in all five pillars, there are still very few papers that actually provide evidence of the specific impacts of SI interventions on gender, youth and other social categories. In part, this may be because the indicators in the human and social domains are often costly to implement and often well outside of the expertise of agricultural scientists, such as in food safety or human health. Other indicators are also very difficult to measure, such as "capacity to experiment". Zulu et al. (2020) propose adapting these indicators to the local context to make them more meaningful. Their work illustrated how beneficiaries defined impact in the key pillars.

Most importantly, projects that take place over a three-year time period, and which focus on understanding productivity and biophysical constraints and outcomes, are not well suited to measuring social impacts. Generally, it takes considerable time just to understand the complex social and institutional dynamics of local contexts at which point the project has reached the end. This is apparent in much of the literature emerging from the projects on SI that have been analysed.

Key points emerging from the literature for future design of SI projects

i. Plan projects with a long lifespan; scale-up must not be viewed as a quick fix, and projects can take decades to reach the desired results (Shilomboleni et al. 2019)
ii. Give attention to the most vulnerable groups when introducing technological and technical interventions (Haile et al. 2015; Kuyah et al. 2021; Martin et al. 2018);
iii. Consider how to implement labour-saving technologies without loss of livelihoods for those who previously provided labour (Ahmed et al. 2021; de Roo et al. 2019; Haile et al. 2015; Oumer et al. 2020);
iv. Address the challenges for land-constrained households (de Roo et al. 2019; Lindsjö et al. 2021);
v. Ensure farmers' organisations and cooperatives are inclusive, build social solidarity and improve resource sharing (de Roo et al. 2019; DeMerritt-Verrone and Kellum, 2022);
vi. Develop the capacity and skills in farmers' organisations and collectives for *inter alia* networking with more wealthy, influential and powerful people; management and administration; marketing and communication; and value chain development (de Roo et al. 2019);

vii. Assess existing local financial systems – such as group savings and credit schemes – and microfinance organisations, alongside national government interventions such as social grants and farming subsidies to identify additional financial products and services needed (de Roo et al. 2019; Masangano and Mthinda, 2012; Meyer, 2015);
viii. Ensure that the costs of interventions are related to the results (Oumer et al. 2020);
ix. Involve community members – including women – in advocacy processes to influence local, national and international policies and legislation (DeMerritt-Verrone and Kellum, 2022; Kuyah et al. 2021; Masangano and Mthinda, 2012).
x. Partner with competent, influential partners to access additional support and resources (Shilomboleni et al. 2019)

Country studies

Malawi

For decades, Malawi has practised various Green Revolution initiatives from maize subsidies programmes to the Green Belt Initiative which was officially launched in 2010 (Chinsinga 2017). Despite the government focus on a green revolution, smallholder farmers have not adopted many of the practices promoted. For smallholders to adopt SI techniques, they need to see positive change, such as enhanced productivity and higher yields; however, SI projects did not always deliver on these expectations (Andersson Djurfeldt et al. 2019). Further, when yields did increase, women typically experienced lower yield increases than men due to their structural disadvantages. In Malawi gender dynamics have been changing over time with women more likely to inherit property, more likely to take on leadership roles and higher social value placed on joint decision-making (Andersson Djurfeldt et al. 2019; Grabowski et al. 2017). Yet, ongoing differences between men and women continue as women have access to fewer assets (especially land) and are challenged by time poverty. Gender specific constraints influence adoption. For example, Tufa et al. found that women were "more likely to adopt intercropping and minimum tillage but less likely to adopt crop rotation and use improved varieties than male plot managers" (2022: 1). In Malawi, while youth are able to provide more physical labour they did not have access to land and the older generation tended to withhold land, even though their yields were much lower (Lindsjö et al. 2021). Their research indicates that maize yields remained low between 2008 and 2017, and that the elderly had the lowest yields. They argue that "the potential for sustainable agricultural intensification therefore remains low until access to land and financial support for the youth receive special attention" (2021: 423). As such, adoption of SI will remain low unless policy gives more attention to youth access to land and financial support.

In Central Malawi, Bouwman et al. (2021) examined the adoption of Conservation Agriculture (CA) practices and found that many interventions were not practised as intended, or smallholders only adopted one technique when a bundle of techniques were needed to achieve optimal yields. Therefore, CA did not provide significant benefits for smallholders in terms of productivity, labour-savings or soil conservation. Further, in communities where herbicides were adopted as part of CA, the lower amount of weeds led to "herbicide induced hunger" for those who had previously undertaken weed removal labour (Bouwman et al. 2021: 244). Wealthier households hired less labour (*ganyu*) and poorer households who depended on this cash income suffered.

Some technical interventions have had a positive impact on some of the SIAF pillars. Doubled up legume (DLR) cropping shows promise in specific agroecological conditions. Snapp et al. (2016) tested two systems: maize rotated with a groundnut/pigeonpea or soybean/pigeonpea intercrop. They found that "DLR can harness the complementary phenology of pigeonpea to build soil quality for the future without reducing maize yields or compromising household food production in the immediate term." (Snapp et al. 2016: 1). Legumes have nutritional benefits for the entire households, but particularly for children. Franke et al. also found benefits

to increased legume production, with the caveat that mostly medium and high resource endowed farmers benefited. They add that:

> *For low resource endowed farmers, legumes can improve food self-sufficiency of households, but only if legumes can be managed with P fertiliser and inoculation in the case of soybean. Given that low resource endowed farmers tend to be risk averse and have few resources to invest, the ability of poorer farmers to adopt legume technologies could be limited (2014: 28).*

A study on farmers' decisions to adopt diversified cultivation with pigeon-pea and maize cultivation, rather than maize monocropping, showed that even though diversification met expected income goals, this was highly dependent on the price ratio of maize grain-legume grain-fertiliser (Snapp et al. 2018). Therefore, poorly-resourced households were less likely to adopt diversified cultivation if the seed price ratio was not favourable – even though diversification buffered the risk of crop failure, provided more stable profits, improved nutrition and improved environmental outcomes. Further, women were more likely to grow crops if they knew they were more nutritional and were therefore more likely to grow pigeon-pea. However, if pigeon-peas became cash crops men were likely to take over production and control the cash generated. Thus, if pigeon-pea growing was promoted as a potential cash crop, it could negatively impact women's income-earning potential and mean reduced consumption of pigeon-pea, with resultant negative impacts for nutrition. To ensure that pigeon-pea cultivation was valued by both genders, Snapp et al. recommended that pigeon-pea be promoted by showing soil fertility improvement, as "[b]oth men and women were found to be interested in soil fertility" (2018:86). Another study found that beyond the framing of messages about pigeon-pea cultivation, policy and educational efforts were needed to "support farmers gaining access to high-quality seeds, amendments for phosphorus-deficient soils, and promotion of multipurpose legumes that build soils through leafy residues and roots, as well as providing grain for food security and sales" (Mhango et al. 2013: 234). Improving farmers' access - especially that of women - to high-yielding pigeon-pea seeds, while paying attention to intra-household dynamics remains key (Me-Nsope and Larkins 2014).

Finally, Snapp et al. (2018) found that legumes were of particular interest to women because they are responsible for nutrition in the household. They emphasize that "the importance of considering female farmer ratings was illustrated as these did not always line up with profitability or productivity traits" (2018: 86). Kerr et al. (2007) found that women were more likely to adopt legume cultivation when participatory research also incorporated nutritional messages. Even though women are interested in legume cultivation, more work needs to improve the adoption of legume-maize rotation that addresses farmers' concerns to reduce labour requirements and marketability of the crop. These conditions are particularly important for women farmers (Ortega et al. 2016).

Komarek et al. also found benefits to maize-groundnut rotation: "maize-groundnut rotation increases the stability of profits, reduces the likelihood of negative profits, and increases risk-adjusted profits" (2018: 1). However, they also found that "maize-

groundnut rotation has a 54% lower average caloric yield and uses more labor than the maize monoculture with mineral fertilization". As labour is a major constraint, particularly for women, these trade-offs are important considerations.

Kassie et al. (2015) found that food insecurity was higher in female headed households than male headed households. The reasons for this difference were many and included access to resources, social networks, access to capital, etc. The significant role of some of the social capital indicates that the root of poverty is not only a lack of money, but also the lack of social networks and support included in social capital. They also found that "within male-headed households, women's bargaining power in terms of control over income use, their control over assets, and their decision-making powers in respect of crop production and consumption have significant positive impacts on household food security" (2015: 1317). Social capital and social networks were found to be particularly important for both men and women in addressing poverty.

Kerr et al. (2017) and Mutenje et al. (2019) suggest that it is critical to engage in participatory research with farmers, both to ensure that interventions are tailored to the local context and to encourage farmer adoption and experimentation. Mutenje et al. (2019) also emphasize that participation in farmers' groups makes access to resources easier and increased farm output more likely. Participation in informal networks was particularly important for women.

Burke et al. (2022) carried out a study on the on-farm yield response to nitrogen fertilizer under 16 different soil and field management regimes. They found:

> *surprisingly low yield response to N applications, highlighting that fertilizer access alone is not sufficient for sustainable intensification. We find complimentary "good agronomy", including effective weed management, crop rotations, and organic fertilizer applications are positive influences on maize yield response to inorganic fertilizers. Encouragingly, results show management practices such as incorporating diverse crop residues and manure for a few years can raise labile carbon levels, improving the soil base on which factors jointly determine yields (2022: 1).*

These findings underscore the complexities of achieving SI and the importance, again, of bundled interventions.

Soil fertility and soil management is a critical challenge for SI in Malawi. Soils have been mined for nutrients for generations and increasing population density and decreasing farm sizes make this an even more critical issue. There is increasing evidence of the increasing non-responsiveness of crops to inorganic fertilizer, particularly maize (Burke et al. 2022; 2020). This situation makes soil management an even more pressing issue. As women have less access to quality land, improved seeds and inputs, their livelihoods are particularly in jeopardy. Burke and Jayne have found: "Remarkably, and perhaps because they seem to be systemically more likely to be allocated poorer quality soils, we find female farmers are more likely to be employing management practices that improve soils" (2021:8). This finding has

important implications. As they argue: “interventions to improve the lowest quality soils would benefit the most disadvantaged farmers by default, and these are disproportionately women” (ibid).

Finally, studies have highlighted the importance of improved agricultural extension services in implementing SI (c.f. Kassie et al. 2015; Masangano and Mthinda 2012)). In Malawi, extension services are provided by many players, though the government remains the main provider. However, the government has few resources, and the many field staff it employs have low qualifications (Masangano and Mthinda 2012). Most organisations sought to improve farmer livelihoods and gave special attention to women farmers, but have few field staff at community level, such that they depend on government staff to reach farmers. Such links between local, district and NGOs are strong, however links with education and research organisations need strengthening.

Recommendations

Malawi is faced with high population density and very small farm sizes. Work in Africa Rising, SAIRLA and other projects over decades has revealed some promising interventions. While technical interventions such as doubled-up legume cropping and relay planting legumes and maize (see above) have had positive results across the SI indicators, there is still much research to be done on how to bundle these interventions with other innovations. While there is evidence of technical bundling (crops plus soil management strategies), there is less attention to bundling technical interventions with institutional ones. For example, improving access to seed through cooperatives; strengthening women’s participation in VSLs, improving soil management through extension advice, etc. Many of the needed innovations to accompany technical interventions are socio-economic. Below in bullet points are recommendations and observations that have come out of the literature review and the interviews:

- Integrated soil fertility management (ISFM) practices are critical for Malawi. The challenge of soil fertility affects women and poorer farmers disproportionately. Investing in ISFM must be done side-by-side with extension services. New models for spreading information and designing incentives for change are needed.
- To address inequities in access to resources and knowledge faced by women and youth, increasing their participation in groups (cooperatives, vsls) may be one intervention that can improve their access to information and resources. Strategic partnerships are essential but also a research plan to document impact.
- Increase access of women and youth to markets and add value to products in the value chain (through processing).
- Build on local knowledge and encourage farmer agency.
- Research farmer innovations and experimentation (from mother and baby trials) to understand farmer decision-making and increase farmer-to-farmer learning.
- Participatory action research

- Legumes, either through doubled-up systems or relay cropping, offer benefits in nutrition, food security and income. However, attention to extension and managing crop residues of legumes is critical for achieving multiple benefits.
- In sum, there are technical interventions that show promise. However, benefits will not be realized without accompanying institutional interventions.

Laos

In Laos, many SI project focus on intensification of rice production, which donors and the Laos government have promoted as solutions to poverty and food insecurity (Suhardiman et al. 2016). The country has doubled rice production since the 1950s and has been rice self-sufficient since 2000. Wade (2014) found that higher rice production did not benefit farmers, as they received lower prices and production costs were high. Further, given the country has one of the highest rice consumption levels in the world, the population has a carbohydrate intensive diet with a high glycaemic index and production of more diversified crops is needed to provide other nutritional components. Nonetheless promotion of SI rice production continues apace and promoters of these projects need to shift gears: "[b]efore defining policy, governments need to understand the farmers' situation and decision-making, for different types of farmers" (Wade 2014: 13).

Similarly, Suhardiman et al. (2016) assessed the implementation of SI to reduce poverty and boost food security using groundwater to boost rice production. However, they found that when farmers had access to groundwater, they preferred to grow vegetables and high value cash crops rather than rice. Given farmers' different strategies for improving their wellbeing, donor agencies and the Laos government's focus on rice intensification is misaligned, especially in a context where there is a move towards commercial, specialised agriculture.

Another study, comparing two villages, demonstrated the diversity of farmer strategies and priorities (Suhardiman et al. 2020). In the village that was relatively close to markets (Ekxang), farmers were more motivated to grow vegetables and high value cash crops. Given the financial opportunities in this case, farmers were more prepared to invest in developing unlined dug wells to access groundwater, especially if they had access to household labour. In the village that was further away from markets (Phousan), the farmers did not view investment in groundwater to be viable because their fields are upland and groundwater is less accessible and less reliable, requiring deeper and more expensive tube wells, because of unavailability. Phousan farmers had also experienced displacement from their land due to a local rubber company, and therefore had different views on farming strategies.

Despite the government's heavy emphasis on rice, some projects are encouraging diversified livelihoods in various ways. For example, the government and donors have been experimenting with 'village livelihood development grants', in which households receive cash grants to invest in Policies are also needed to address the movement of rural youth to urban areas to ensure that young people are retained in rural areas to undertake farming (Wade, 2014).

Bangladesh

In South Asia, Bangladesh has the highest poverty rate, and 87% of households rely on agriculture, so intensified production to increase yields on the same piece of land is considered a priority (Aravindakshan et al. 2021b). A range of literature exists on SI in Bangladesh, addressing cost/benefit analysis (including labour), efficiency/reliability analysis of different inputs, and environmental impacts. However, few addressed the social impacts in any detail, even when they identified the relevance of these factors in assessing appropriate farming systems. While Aravindakshan et al.(2022) mention the relevance of SI policy, they do not examine the issue in-depth.

Because of the importance of rice for Bangladeshi livelihoods, much SI research focuses on this crop. However, rice production in the country has been significantly declining since the mid-1990s (Spielman et al. 2017; Ward and Pede 2015). In part, this reflects the labour constraints and costs faced by smallholder rice farmers which limits their production (Ahmed et al. 2021). Technical interventions including the introduction of new hybrid rice varieties (Shew et al. 2019; Spielman et al. 2017; Ward and Pede 2015), integrated weed management (with herbicides and mechanical weeders) (Ahmed et al. 2021), and using pond sediments from intensive aquaculture (a rapidly growing sector) (Haque et al. 2016) have been promoted. These practices have been shown to result in higher yields, reduce some production costs, reduce labour person-days and reduce environmental impacts (Ahmed et al. 2021; Haque et al. 2016; Shew et al. 2019; Spielman et al. 2017; Ward and Pede 2015).

However, these technical approaches alone have been shown to be insufficient; for example, farmers' willingness to adopt hybrid varieties influences the success of such technical interventions and willingness-to-adopt is dependent on various factors (Ward and Pede 2015). Developing appropriate products, marketing, and economic policy can challenge hybrid use and to address these, more insights are needed into "relationships between industry structure, business strategies, and public policy incentives" (Spielman et al. 2017, p. 154). Therefore, the government might need to incentivise the private sector to invest in hybrid production. In addition, it should properly regulate seed markets, and provide subsidies for seeds and inputs. Consideration must be given to the differential social impacts of interventions. For example, the impact of changes in weed eradication can negatively impact the incomes of labourers who previously undertook labour-intensive weeding. So while, while Ahmed et al. (2021) identified which herbicides and mechanisation tools most efficiently reduced labour person-days and the costs of weed control, they did not examine the impact of these interventions on all community members (Ahmed et al. 2021).

Aravindakshan et al. (2022) explored the production and environmental impact of conservation tillage, in comparison to traditional tillage, for wheat farming in Bangladesh. They found that to optimise environmental performance, farm-specific conservation tillage is needed, alongside appropriate extension services and awareness- raising about managing nutrient loss, with efficient application of fertiliser appropriately. However, they also highlighted (if not in detail) that

government policy did not full address hetereogeneity among farmers, and particularly the difficulties of resource-constrained farmers in implementing conservation tillage. Therefore, Aravindakshan et al.(2022: 14) recommend that small, resource-constrained farmers be financially compensated for "practices that sustain ecosystem services and that reduce pollution", and that they have access to affordable conservation tillage machinery.

One study that considers policy factors more fully focussed on building *resilient* farming systems, drawing lessons from the weaknesses revealed in existing farming systems as a result of the Covid-19 pandemic (Amjath-Babu et al. 2020). The paper highlighted the need for comprehensive monitoring systems that prioritise responding to food system disruptions with appropriate interventions. In particular, the paper emphasises the role of appropriate information channels, and input and output distribution channels and logistics, including "digital extension services, circular nutrient flows, enhanced storage facilities, as well as innovative and robust marketing mechanisms" (p. 761). Other farming-focused recommendations include "innovative labor management tools alongside appropriate farm mechanization" (p. 761). However, the paper goes beyond these farming-focused interventions, and highlights the crucial necessity of social safety nets, and access to credit and other financial services (especially digital access). Proposed social safety nets focus on ramping up cash and food incentives for constructing public goods such as suitable market and food storage facilities, weather-resilient shelters, flood protection structures. While this paper is focused on crisis management, many of these suggestions can be equally applied to SI interventions in non-crisis situations. They are an example of the bundling approach advocated by Barrett.

The importance of farmer-led innovation is evident in Aravindakshan et al. (2021a) study identifying farmer preferences and choices. They found that farmer preferences for crop choice and intensified management practices are driven by significant differences in age, distance to markets, proximity and quality of roads, and level of access to agricultural extension and credit. In the area studied, farmers had strong preferences for rainfed/partially irrigated mungbean instead of land fallowing, followed by irrigated maize instead of rice. Because the area where the study was undertaken is prone to weather shocks such as cyclones, regardless of specific local and environmental factors, most respondents in the study said that the high investment costs of irrigation and fertiliser and associated production risks in the dry season meant they had a negative preference for these options. However, where farmers thought it feasible to introduce in-field drainage to limit waterlogging, most respondents were willing to intensify crop production. The Bangladeshi government's policies promoting rice production instead of land lying fallow, are not embraced by farmers who point to higher labour costs and lower paddy price as a disincentives. Therefore, extension services need to target crop management for the preferred crops, instead of focussing on those selected by the government. Aravindakshan et al. also drew attention to the necessity of well-designed insurance programs and tailored climate information services, and "comprehensive and integrated development programs … to assist in improving within field water management, asphalted roads, context-specific extension and educational programs, alongside access to finance for coastal farmers" (2021a.: 12).

Further, food security and income are strongly associated with the provision of appropriate agricultural extension services and micro-credit (Aravindakshan et al. 2021b).

Ghana

In Ghana, various SI projects have been implemented, such as Africa Rising and SAIRLA, mostly in the northern regions of the country. There, as Kotu et al.(2022) note, all farmers identify soil fertility as a major constraint to farming. Their study focused on assessing farmer preferences sustainable intensification attributes in maize production by focusing of the five domains of the SIAF framework. Overall, not surprisingly, farmers valued interventions that reduce risk of crop failure highly. Intercropping maize and legumes therefore addressed both these concerns. Labour is another major concern, as it is in all farming communities. Labour is increasingly expensive and also increasingly more scarce as more people migrate out of the north in search of other livelihood opportunities, even temporarily. So, any interventions that reduce labour are highly ranked. Of note is farmers' interest in multiple benefits from any one intervention. This aspect is often overlooked but quite common across smallholder farming communities. So, a new crop variety that also improved nutrition is valued. The challenges that Kotu et al. (2022) identify are often institutional ones. For example, it may be difficult to impossible to access improved seeds. Also, there is considerable heterogeneity to farms and to farming households which makes tailoring interventions to these contexts imperative but also more time- and cost-consuming.

Fischer et al.(2021) focus on the relationship of SAI to gender considerations and observe that many SI projects do not pay sufficient attention to equity issues. Additionally important is their emphasis that a focus on one intervention, such as, for example, strengthening land rights alone, will not suffice to address gender and other inequities. Women, and youth, are at a disadvantage in access to information, inputs, and credit. Britwum and Akorsu's (2016) thorough assessment of gender and agriculture in northern Ghana emphasise that women's concern with food preparation leads them to value diversity in crops on farms. Also, labour is a key concern and crops or practices that are easy to cultivate and require less weeding are valued. Because maize is a less traditional crop in the north and is not as highly gendered, women have been able to more easily pick up its cultivation which has helped in food security and cash income.

As soil fertility is a key constraint, women voiced the desire to have better access themselves to fertiliser and also to herbicides (Britwum and Akorsu 2016). They are largely dependent on their husbands to access these inputs. While herbicide has significant labour-saving benefits, the impact on the environment, or on human health, has not been well investigated in these contexts. Anecdotal evidence suggests a significant impact on biodiversity. Adequate information on applying herbicide is often lacking and there is tendency to believe that more is better. Moseley and Pessereau (2022) have shown how ubiquitous herbicides have become in Burkina Faso as India and China began producing these chemicals after the patent that Monsanto had expired. While some projects (Africa Rising) have made

strides in making inputs available to women, it remains to be seen whether accessibility will continue post-project.

Another challenge that arose in Ghana, but has appeared in other country projects as well, is attitudes toward farmer innovation. Often, as projects are keen to measure specific impacts, farmer experimentation and innovation may be discouraged. Extension services often follow a model adapted from the colonial era in which farmers are given advice in a very top-down manner as expertise is considered to reside in those who have education and formal training. Getting new and different information to farmers is clearly essential, but the manner in which it is delivered is also key. Innovations should build upon existing local knowledge, rather than attempt to replace that knowledge. Interesting innovations have been experimented with, such as mobile cinema and radio programs. But, it is unclear what impact these innovations have had. And for women, access and timing of programs continue to be obstacles (Britwum and Akorsu 2016).

Rahman et al. (2020) analysed a groundnut intervention in Ghana using the SIAF framework. The project, which tested different varieties as well as different planting practices, found that one variety in particular showed higher results for productivity and economic impact (assumed income increases). Environmental impact was assessed by examining canopy of the plants impact on soil moisture as well as the nitrogen fixation of the plants. Human impact was assumed by calorie and protein increases. Finally, the social domain included farmer participation in evaluation. Farmers preferred early maturing varieties and denser planting which led to higher weeding demands at first but only one weeding overall. The authors admitted that "assessing most of the indicators under the social and human domains of the SIAF at the plot level were challenging" (Rahman et al. 2020: 3970).

Kotu et al. found that both male and female farmers valued "maize-based cropping systems that align with the domains of sustainable intensification over their current cropping practices" (2022:1). However, while overall farmers valued all five domains, there was considerable heterogeneity in how much value they placed on any one domain, their preferences "vary by region, by gender, and depending on other factors such as household size, exposure to weather shocks, access to social safety nets, participation in contract farming, and awareness of biofortified maize cultivars" (2022: 11). This illustrates well that one-size does not fit all and that diversity must be understood and taken into account in designing interventions that suit different constituencies.

Recommendations

The northern regions of Ghana are characterized by poor and declining soil fertility and increasingly variable climate. There is a distinct gendered division of labour in farming, with men controlling access to land and other resources critical for agriculture. However, women are able to access land through their husbands and, before marriage, through their fathers. The land they are allocated is often less productive. They also intercrop certain crops on their husbands fields. Overall, women are responsible for household nutrition and the studies above indicate that

they are thus interested in meeting food and nutrition needs before turning to crop sales. This focus on food security results in a strong interest in crop diversification (to reduce risk) and crops which serve multiple uses (leaves for vegetables in addition to legumes for consumption).

1) Innovations should build on local knowledge and soil management practices.
2) Increased attention to soil and water management to address the underlying constraint of poor soil fertility and organic matter.
3) Build or strengthen institutions (farmer groups, cooperatives) that can increase access of women and youth to key resources (land and inputs).
4) Make labour saving interventions a priority.
5) Increase youth access to markets.
6) Strengthen women's access to key markets and potential sales contracts for more reliable income.
7) Ensure crop diversification to meet food security and then markets.

Adopt a landscape approach to agricultural innovations which considers the wider environmental factors in intensification.

Ethiopia

The government of Ethiopia and various CGIAR projects (Africa Rising, etc) have invested considerably in sustainable intensification. Various lessons have been learned from this work. Ethiopia has many social divisions and hierarchies and land is scarce in the highlands. Most farms are very small and struggle to meet their food needs. For women and youth, access to resources – whether it is land, information, inputs – is a significant challenge. Workloads for women are high, as they are throughout SSA. Mulema et al.(2019) argue that integrating participatory processes into research design and implementation is critical for increasing the involvement of women and those often ignored by extension or outside agencies. They also find that social networks and social capital are key for women gaining access to resources. Lunt et al. (2018) find that women and youth were most interested in vegetable production due to its quick production cycle and ready market. Seed certification for vegetables, but also for other key crops, can be a challenge for all farmers.

In their paper examining the constraints of scaling, Gebreyes et al. 2021) find that the heterogeneity of both agro-ecological conditions and socio-economic context make scaling challenging. They also noted institutional challenges with farmer cooperatives not having access to improved seeds and inputs, particularly around livestock production (fodder species). Both farmers and experts were often not familiar with several innovations and lacked the new skills necessary to implement them. In addition, as government agents and implementers are held accountable for targets, they were often reluctant to take on new innovations due to concern that targets might not be met. The social and political dynamics are critical factors in innovation scaling success. As they conclude: "scaling of agricultural innovations requires a balanced focus on technical requirements and associated social dynamics surrounding scaling targets, actors involved and their social relations" (Gebreyes. 2021: 16).

The importance of social relations and networks resonates with both Mdee et al's.(2021) work in SI and de Roo et al.'s (2019) study which found that clan identity and other social ties and relationships were critical in gaining access to resources, both material.(e.g. seeds and land) and knowledge. These social networks were critical in both adoption of innovations but importantly in their scaling. Indeed, because of existing social dynamics and hierarchies scaling of innovations unintentionally scaled inequalities as those who were least networked with powerful actors (women, youth and poorer households) were often left at a disadvantage. They argue that understanding these social mechanisms is essential not only for scaling, but for overcoming the possible barriers to access to resources that are embedded locally.

Throughout the literature on SI in Ethiopia, researchers highlight common constraints, such as lack of liquidity with which to make investments in new innovations, high labour demands, small land sizes, distances to markets, and high degrees of heterogeneity both socially but also across the biophysical landscape (Mutyasira et al. 2018; Amede et al. 2019; Horner and Wollni 2021). Results from fertiliser trials demonstrated that landscape position is critical for crop-nutrient balances. Soils in steep slopes are so degraded that applying fertiliser is less effective than trying to increase organic matter and implementing soil conservation measures. These findings point to the need for more careful targeting across these highland landscapes. Horner and Wollni (2021) note that ISFM often leads to higher labour demand, which can result in higher income. However, it may also result in less labour investment on other crops and/or the reduction of off-farm livelihood activities. This shift may make farmers more vulnerable.

These studies point repeatedly to the need for more precise targeting, both socially and geographically in scaling innovations. Studies which analysed either the role of women or the impact of interventions on them, highlighted the high labour demands on women and their limited access to essential resources and often information. As Gebre et al.(2019) note, these constraints lead not to lack of adoption necessarily, but rather to difference in the intensity of adoption. Hammond et al. (2021) argue that productivity in Ethiopia can be increased sustainably and that negative impacts of increasing productivity on the other sustainability domains (economic, social, humans and environmental) were largely positive or neutral. However, when productivity relies on greater use of agro-chemicals, negative impacts on the environment may be observed. These interrelationships (between productivity and sustainability) can best be navigated, they argue, through participatory processes that expose key trade-offs and design strategies for avoiding negative impacts.

Recommendations

1) Design participatory research with farmers and extension agents to ensure greater relevance of innovations to specific geographical and soci-economic contexts.
2) Adopt landscape scale approach to integrate attention to both social and environmental differences that affect impact.

3) Carry out trade-off analysis to ensure equitable and environmentally sustainable interventions.
4) Focus on labour saving interventions to address constraints faced by women in particular.
5) Carry out in-depth research on social networks and dynamics to enable better options for scaling and access to resources (seeds, inputs) that inhibit women and youth in particular from adopting innovations.
6) Improve knowledge in extension services of key innovations.

Nepal

The geographical and socio-economic context in Nepal presents various challenges for sustainable intensification. Considerable area of the country is not serviced by roads and other infrastructure important for supporting SI. Additionally, class, caste and gender relations require careful navigation to prevent benefits from being accrued only by those in more privileged positions. A number of insights into SI impacts and challenges emerge from the literature. SI initiatives in Nepal have focused on increasing and improving access and use of irrigation, mechanisation, improved seeds and inputs. A recurring challenge to success in these initiatives revolves around institutions, whether it concerns water governance, markets, or extension services. Government service providers are accountable upwards, rather than downwards to the communities they serve (Clement et al. 2012).

While various technologies have clear positive impacts on improving yields, such as irrigation, laser assisted land levelling, reapers, seed drills, fertiliser spreaders, etc. there is very little adoption of these interventions (Brown et al. 2021). Some technologies, such as the high speed rotavator, actually resulted in yield losses and deteriorating soil quality (Paudel et al. 2020). There are institutional barriers that inhibit adoption of mechanisation (lack of sufficient training in extension, knowledge, suppliers of spare parts, mechanics, etc) as well as the very significant liquidity constraint faced by farmers in adopting these technologies. Women, and poorer farmers from lower castes, are particularly disadvantaged in accessing these technologies. Subsidies might be one method for improving access, but again must be carefully tailored so those more disadvantaged can achieve the possible benefits. Biggs and Justice (2016) argue that small-scale machinery should receive greater attention as it might be more affordable to more farmers.

Urfels et al. (2020) note a number of important barriers to adoption of irrigation technologies – seasonal cash liquidity challenges, high costs for labour, land tenure and tenancy arrangements. They argue that a single overall strategy is not feasible for irrigation in Nepal due to the high degree of heterogeneity both in geography and in social-economic factors within any community. Greater emphasis on improving water governance is one important step, but also providing low interest financial services, particularly for women and poorer members of the community. In addition, improving services outside of the farm, such as supporting spare-part markets, assuring mechanic services and increasing availability of relevant technology will be important.

Some studies diverge on the benefits of Conservation Agriculture for SI in Nepal and S. Asia. The yield benefits vary according to the crop and to the farming system. Dixon et al. (2020) report higher yields across all the grain crops, while Islam et al. (2019) suggest that gains can be seem more in wheat and maize than in rice. Certainly, the environmental benefits of reduced need for water and increased water productivity are evident. While these benefits in yield increases are promising, there is less known about labour, cash and other socio-economic factors in pursuing CA in S. Asia. Dixon et al. (2020) suggest there is less need for hired labour which could reduce costs, but this also has an impact on those who depend on hiring out their labour to earn essential income. Institutional innovations like farmers' clubs and innovation platforms could scale CA but careful attention needs to ensure equitable access and benefits. Another factor that has not received much attention is the environmental impacts of CA. As Islam et al. (2019) note, there is little known on how CA affects soil physical and chemical properties.

Raut et al. (2010) also suggest that too little is known in Nepal about the environmental impacts, such as soil acidification, soil fertility decline, greenhouse gas emissions of many SI practices. In some of the highland zones, where there is good market access, farmers have shifted from cereal production to high value and intensive vegetable production (Dahal et al. 2007; 2009) but while incomes may have improved, there is less known about the environmental impact, though there is the suggestion that water quality has declined. Furthermore, the benefits are not realised uniformly, but vary greatly according to the caste and gender of the producer and the proximity to markets.

In their study of fertiliser use, Aryal.et al. (2021) find that farmers who are younger and have more education are less likely to use organic fertiliser. They have little interest in the labour demand of carrying organic fertiliser to plots. Inorganic fertiliser is seen to be easier to access and manage. Wealth, gender, education and out-migration all have an effect on adoption rates.

Jain et al. (2020), in their systematic review of SI interventions state that there is evidence that SI practices do result in yield increases, but that these increases in productivity are very heterogeneous. Furthermore, while practices such as residue retention and use of organic fertiliser produced positive yield gains, they were not necessarily profitable. They also found that most of the literature on SI focused on highly productive irrigated and commodity cropping systems that do not necessarily represent the large portion of agricultural systems across S. Asia. Also, most studies looked not at farmer-managed fields but on field station trails.

While national policy supports gender equity, it fails "to provide a clear strategy or … plan to meet these objectives" (Alvi et al. 2021: 103035). The literature on SI and gender and intersectionality in Nepal (Clement and Sugden 2021; Sugden 2009; Sugden et al. 2014; Sugden et al. 2021; Clement et al. 2012; Leder et al. 2017) stresses how important it is to design projects and innovations that consider gender and other inequalities from the outset. To better integrate local knowledge in SI projects, Clement and Sugden emphasise that understanding the local context, and its hierarchies of power and authority, are essential. Whose knowledge counts, for what,

and at what scale? Social hierarchies and land tenure arrangements limit commercialisation and SI due to highly unequal access to resources (Sugden 2009). Poorer households, because of labour and other constraints, may not be able to access training opportunities. They may lack the social networks that enable innovation and knowledge transfer. Women and tenant households are often the most marginal and vulnerable in rural Nepal communities. Women are involved in the most labour intensive farm work and this escalates when men from the household migrate out (Sugden et al. 2014). Leder et al. (2017) argue that it is equally important to understand the differences between women, based on age, marital status, caste, remittance flows and land ownership to ensure that innovations do not only benefit some women over others.

Where farm households sit across the landscape structures their access to resources, the focus of their farming, and their strategies for land use. Sugden et al. (2021) describe the high altitude areas as having very small farms, moderate inequality and no notable large farmer class. The middle zone is characterised by more fertile land and also by landlordism, with inequality being more distinct. Larger farmers from upper castes own up to 70 percent of the land. In the lower zone, inequality is even greater, with a high degree of absentee landlords. Throughout the different altitude zones, there is significant out-migration, with the upper zones having the highest prevalence (probably due to poor access to more local non-farm income opportunities). Households in the different zones invest remittances in different ways which is influenced by class and caste.

Projects which have tried to intensify livestock production or to promote maize/legume intercropping have had mixed success. Labour and cash liquidity is a challenge to adoption of all innovations. Alomia-Hinojosa et al. (2021) found that livestock intensification increased labour to a degree that limited its possibility of adoption. Alomia-Hinojosa et al. (2018) also found that labour scarcity limited the adoption of maize/legume intercropping, together with the challenges of access to inputs. These constraints, of labour and cash, affect low and medium-resourced farmers the most.

One important factor in implementing any project is taking into account the performative behaviour of project participants. When asked about the adoption and non-adoption of innovations, one farmer in Nepal said: “only if a project comes next year, I will change my practices, otherwise I will keep doing the same” practices (Alomia-Hinojosa et al. 2018: 90). These performative practices are important in Nepal given the politics of development there but resonate in contexts around the globe as project participants strategize to find specific benefits in participating in usually externally driven initiatives. These relations underpin most development and research projects and thus require careful facilitation and mixed methods to get beyond staged performance.

Recommendations

1) Due to the considerable social and geographical heterogeneity of Nepal, careful targeting of innovations must be carried out to ensure relevance to these specific contexts.
2) Labour is a significant constraint in agriculture in Nepal due, in part, to considerable out-migration of men and youth. Thus, innovations that reduce labour are essential. However, increasing access to labour-saving technologies for women in particular is essential for ensuring equity.
3) Technical innovations must be designed together with institutional innovations (training in maintaining and fixing agricultural machinery for example).
4) Building and working with social networks and groups will be important for increasing access to information and resources.
5) More research is needed on environmental and social impacts of most technical interventions.

Conclusions

As is evident in the discussion above, common themes emerge, particularly around gaps in the literature. To address these gaps, and obtain a better understanding of what kinds of crop combinations and what combination of technical and socio-institutional innovations would suite a particular context, a participatory action research approach should be instituted. To ensure greater uptake of results, both by farmers but also key decision makers in the agricultural sector, stakeholder inclusion and consultation from project inception through to completion is critical. While stakeholder identification is rarely mentioned in the published literature, most projects have carried out this documentation and this information should be incorporated into new initiatives.

There are many tools and approaches that guide researchers on understanding the contextual factors that shape gender relations and social differentiation. Tools specific to Africa Rising and other projects, as well as gender strategies, are available. New work should draw upon these tools and the insights already produced to plan interventions that can lead to greater equity.

Hockett and Richardson emphasize that little is understood about "the drivers and motivations of smallholder experimentation and the decision-making processes of farmers regarding new technologies. Special emphasis should be given to the priorities and capacities of women farmers" (2016: 2).

Greater attention needs to be given to institutional innovations that can be bundled with technical practices. A broader approach to SI requires greater interdisciplinarity so it is imperative that there is inclusion of more expertise in social, policy, gender, economic and nutritional science. In sum, as Weltin et al, have emphasized:

> A broad portfolio of SI practices and detailed assessments of single SI approaches exist. However, little effort is devoted to study SI as an objective requiring integrated practices, coupling the farm and landscape scales and different fields of action. This also requires addressing decision-making structures of various agents on different scales. In order to pursue a future-oriented SI research agenda, interdisciplinary cooperation is needed to address SI from a holistic perspective. The focus should be on the implementation of approaches paying attention to the behavioural rationales of farmers and land users. In many contexts, coordinated and collective decision-making will be required which is facilitated by local discussion and coordination" (2018: 78).

References

- Adegbite, O.O., Machethe, C.L. 2020. Bridging the financial inclusion gender gap in smallholder agriculture in Nigeria: An untapped potential for sustainable development. *World Development*, 127, 104755. https://doi.org/10.1016/j.worlddev.2019.104755

- Adegbite, O.O., Machethe, C.L., Anderson, C.L. 2021. Revisiting the measurement of financial inclusion of rural smallholder farmers in Nigeria. *Agric. Finance Rev.* 81, 554–567. https://doi.org/10.1108/AFR-07-2020-0099

- African Union, 2009. *Land policy in Africa: A framework to strengthen land rights, enhance productivity and secure livelihoods*. African Union and Economic Commission for Africa, Addis Ababa, Ethiopia.

- Ahmed, S., Kumar, V., Alam, M., Dewan, M.R., Bhuiyan, K.A., Miajy, A.A., Saha, A., Singh, S., Timsina, J., Krupnik, T.J. 2021. Integrated weed management in transplanted rice: options for addressing labor constraints and improving farmers' income in Bangladesh. *Weed Technology* 35, 697–709. https://doi.org/10.1017/wet.2021.50

- Akpalu, W., Matshe, I., Senbet, L.W. 2017. Effects of large-scale procurement on smallholders: An overview, in: Akpalu, W., Matshe, I., Senbet, L.W. (Eds.) L*inking Smallholder Farmers to Markets: Impact of the Purchase for Progress Pilot Programme*. University of Nairobi Press and African Economic Research Consortium, Nairobi, Kenya, pp. 1–15.

- Alforte, A., Matias, D., Munden, L., Perron, J. 2013. *Financing sustainable agriculture and mitigation: Smallholders and the Landscape Fund* (Working Paper No. 52). CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS), Copenhagen, Denmark.

- Alomia-Hinojosa, V., Groot, J. C., Andersson, J. A., Speelman, E. N., McDonald, A. J., & Tittonell, P. 2022. Assessing farmer perceptions on livestock intensification and associated trade-offs using fuzzy cognitive maps; a study in mixed farming systems in the mid-hills of Nepal. *Systems Research and Behavioral Science*.

- Alomia-Hinojosa, V., Speelman, E. N., Thapa, A., Wei, H. E., McDonald, A. J., Tittonell, P., & Groot, J. C. 2018. Exploring farmer perceptions of agricultural innovations for maize-legume intensification in the mid-hills region of Nepal. *International Journal of Agricultural Sustainability*, 16(1), 74-93.

- Alvi, M., Barooah, P., Gupta, S., & Saini, S. 2021. Women's access to agriculture extension amidst COVID-19: Insights from Gujarat, India and Dang, Nepal. *Agricultural Systems*, 188, 103035.

- Amede, T., Gashaw, T., Legesse, G., Tamene, L., Mekonen, K., Thorne, P., & Schultz, S. 2020. Landscape positions dictating crop fertilizer responses in wheat-based farming systems of East African Highlands. *Renewable Agriculture and Food Systems*, 1-13.

- Amjath-Babu, T.S., Krupnik, T.J., Thilsted, S.H., McDonald, A.J. 2020. Key indicators for monitoring food system disruptions caused by the COVID-19 pandemic: Insights from Bangladesh towards effective response. *Food Security*, 12, 761–768. https://doi.org/10.1007/s12571-020-01083-2

- Andersson Djurfeldt, A., Djurfeldt, G., Hillbom, E., Isinika, A.C., Joshua, M.D.K., Kaleng'a, W.C., Kalindi, A., Msuya, E., Mulwafu, W., Wamulume, M. 2019. Is there such a thing as sustainable agricultural intensification in smallholder-based farming in sub-Saharan Africa? Understanding yield differences in relation to gender in Malawi, Tanzania and Zambia. *Development Studies Research,* 6, 62–75. https://doi.org/10.1080/21665095.2019.1593048

- Andrews, D. 2021. Gendered and ecological struggles in Southern Africa: Land and seed. Gend. *Quest*, 9, 1–18. https://doi.org/10.25159/2412-8457/7399

- Aryal, J. P., Sapkota, T. B., Krupnik, T. J., Rahut, D. B., Jat, M. L., & Stirling, C. M. 2021. Factors affecting farmers' use of organic and inorganic fertilizers in South Asia. *Environmental Science and Pollution Research*, 28(37), 51480-51496.

- Aravindakshan, S., Al Qahtany, A., Arshad, M., Manjunatha, A.V., Krupnik, T.J. 2022. A metafrontier approach and fractional regression model to analyze the environmental efficiency of alternative tillage practices for wheat in Bangladesh. *Environ. Sci. Pollut*. Res., 29, 41231–41246. https://doi.org/10.1007/s11356-021-18296-3

- Aravindakshan, S., Krupnik, T.J., Amjath-Babu, T.S., Speelman, S., Tur-Cardona, J., Tittonell, P., Groot, J.C.J., 2021a. Quantifying farmers' preferences for cropping systems intensification: A choice experiment approach applied in coastal Bangladesh's risk prone farming systems. *Agricultural Systems*, 189, 103069. https://doi.org/10.1016/j.agsy.2021.103069

- Aravindakshan, S., Krupnik, T.J., Shahrin, S., Tittonell, P., Siddique, K.H.M., Ditzler, L., Groot, J.C.J. 2021b. Socio-cognitive constraints and opportunities for sustainable intensification in South Asia: Insights from fuzzy cognitive mapping in coastal Bangladesh. *Environ. Dev. Sustain*., 23, 16588–16616. https://doi.org/10.1007/s10668-021-01342-y

- Arora, D., 2015. Gender differences in time-poverty in rural Mozambique. *Review of Social Economy,* 73: 196-221.

- Adeyonu, Abigail Gbemisola. 2012. Gender Dimensions of Time Allocation of Rural Farming Households in Southwest Nigeria. *Current Research Journal of Social Sciences*, 4(4): 269–76.

- Azriani, Z., Paloma, C., Usman, Y. 2018. The mapping of microfinance institutions for supporting sustainable agriculture financing in Padang City. *J. Agro Ekon*., 35, 1–10. https://doi.org/10.21082/jae.v35n1.2017.1-10

- Bain, C., Ransom, E., & Halimatusa'diyah, I. 2018. 'Weak winners' of Women's empowerment: The gendered effects of dairy livestock assets on time poverty in Uganda. *Journal of Rural Studies*, 61, 100-109.

- Barrett, C.B., Benton, T.G., Fanzo, J., Herrero, M.T., Nelson, R., Bageant, E., Buckler, E., Cooper, K.A., Culotta, I., Fan, S., Gandhi, R., James, S., Kahn, M., Lawson-Lartego, L., Liu, J., Marshall, Q., Mason-D'Croz, D., Mathys, A., Mathys, C., Mazariegos-Anastassiou, V., Miller, A., Misra, K., Mude, A.G., Shen, J., Sibanda, L.M., Song, C., Steiner, R., Thornton, P.K., Wood, S.A. 2020. *Socio-technical innovation bundles for agri-food systems transformation (Expert Panel Report).* Cornell Atkinson Center for Sustainability and Springer Nature, Ithaca, New York and London, England.

- Benjamin, E.O. 2013. Credit risk modelling and sustainable agriculture: Asset evaluation and rural carbon revenue. *J. Sustain. Finance Invest*., 3, 57–69. https://doi.org/10.1080/20430795.2013.765382

- Bergman Lodin, J. 2012. Intrahousehold bargaining and distributional outcomes regarding NERICA upland rice proceeds in Hoima district, Uganda. *Gender, Technology and Development,* 16(3): 253–78.

- Bernard, T., Doss, C., Hidrobo, M., Hoel, J., & Kieran, C. 2019. Ask me why: Patterns of intrahousehold decision-making. *World Development*, *125*.

- Bingen, J., Serrano, A., Howard, J. 2003. Linking farmers to markets: Different approaches to human capital development. *Food Policy*, Special Issue on Input Use and Market Development in Sub-Saharan Africa 28, 405–419. https://doi.org/10.1016/j.foodpol.2003.08.007

- Bourjac, M., Ferrand, P., Castella, J.-C. 2017. Sustainable intensification of rainfed lowland rice systems: A case study in Xieng Khouang Province in Lao PDR, in: *Conference Proceedings. The 6th Biennial ECHO Asia Agriculture and Community Development Conference*. ECHO Asia Regional Impact Center, Chiang Mai, Thailand, pp. 37–40.

- Bouwman, T.I., Andersson, J.A., Giller, K.E. 2021a. Adapting yet not adopting? Conservation agriculture in Central Malawi. Agric. Ecosyst. Environ., 307, 107224. https://doi.org/10.1016/j.agee.2020.107224

- Bouwman, T.I., Andersson, J.A., Giller, K.E. 2021b. Herbicide induced hunger? Conservation agriculture, Ganyu Labour and rural poverty in Central Malawi. J. Dev. Stud., 57, 244–263. https://doi.org/10.1080/00220388.2020.1786062

- Britwum, A.O., Akorsu, A.D. 2016. Qualitative gender evaluation of agricultural intensification practices in northern Ghana, Africa RISING. International Institute of Tropical Agriculture, Ibadan, Nigeria.

- Brown, B., Karki, E., Sharma, A., Suri, B., & Chaudhary, A. 2021. Herbicides and Zero Tillage in South Asia: Are we creating a gendered problem?. *Outlook on Agriculture*, 50(3), 238-246.

- Burke, W. J., Snapp, S. S., Peter, B. G., & Jayne, T. S. 2022. Sustainable intensification in jeopardy: Transdisciplinary evidence from Malawi. *Science of The Total Environment*, 837, 155758.

- Burke, W. J., & Jayne, T. S. 2021. Disparate access to quality land and fertilizers explain Malawi's gender yield gap. *Food Policy*, 100, 102002.

- Burke, W.J., Snapp, S.S., Jayne, T.S. 2020. An in-depth examination of maize yield response to fertilizer in Central Malawi reveals low profits and too many weeds. *Agricultural Economics*, 51 (6), 923–940.

- Carney, J. and Watts, M. 1991. Disciplining women? Rice, mechanization, and the evolution of Mandinka gender relations in Senegambia. *Signs: Journal of Women in Culture and Society*, 16(4): 651-681.

- Clay, N., Zimmerer, K.S. 2020. Who is resilient in Africa's Green Revolution? Sustainable intensification and Climate Smart Agriculture in Rwanda. *Land Use Policy,* 97, 104558. https://doi.org/10.1016/j.landusepol.2020.104558

- Clement, F., & Sugden, F. 2021. Unheard vulnerability discourses from Tarai-Madhesh, Nepal. *Geoforum*, 126, 68-79.

- Clement, F., Banset, G., & Bharati, L. 2012. Rethinking development models and irrigation projects in Nepal. *Hydro Nepal: Journal of Water, Energy and Environment*, 112-120.

- Cook, S., Silici, L., Adolph, B. 2015. *Sustainable intensification revisited* (Briefing). International Institute for Environment and Development (IIED), London, England.

- Dahal, B. M., Nyborg, I., Sitaula, B. K., & Bajracharya, R. M. 2009. Agricultural intensification: food insecurity to income security in a mid-hill watershed of Nepal. *International Journal of Agricultural Sustainability*, 7(4), 249-260.

- Dahal, B. M., Sitaula, B. K., & Bajracharya, R. M. 2008. Sustainable agricultural intensification for livelihood and food security in Nepal. *Asian Journal of Water, Environment and Pollution*, 5(2), 1-12.

- Dawson, I.K., Park, S.E., Attwood, S.J., Jamnadass, R., Powell, W., Sunderland, T., Carsan, S. 2019. Contributions of biodiversity to the sustainable intensification of food production. *Global Food Security*, 21, 23–37. https://doi.org/10.1016/j.gfs.2019.07.002.

- DeClerck, F. A., Jones, S. K., Attwood, S., Bossio, D., Girvetz, E., Chaplin-Kramer, B., ... & Zhang, W. 2016. Agricultural ecosystems and their services: the vanguard of sustainability?. *Current Opinion in Environmental Sustainability*, 23, 92-99.

- de Roo, N., Almekinders, C., Leeuwis, C., Tefera, T. 2019. Scaling modern technology or scaling exclusion? The socio-political dynamics of accessing in malt barley innovation in two highland communities in Southern Ethiopia. *Agricultural Systems*, 174, 52–62. https://doi.org/10.1016/j.agsy.2019.04.004

- DeMerritt-Verrone, P., Kellum, J. 2022. *The role of agricultural collectives in gender transformative food and water systems*. CARE International, Atlanta, Georgia.

- Dixon, J., Rola-Rubzen, M. F., Timsina, J., Cummins, J., & Tiwari, T. P. 2020. Socioeconomic impacts of conservation agriculture based sustainable intensification (CASI) with particular reference to South Asia. In *No-till Farming Systems for Sustainable Agriculture* (pp. 377-394). Springer, Cham.

- Dolan, C. 2001 The 'good wife': struggles over resources in the Kenyan horticultural sector. *Journal of Development Studies* 37(3): 39–70. DOI:10.1080/00220380412331321961.

- Droppelmann, K.J., Snapp, S.S., Waddington, S.R. 2017. Sustainable intensification options for smallholder maize-based farming systems in sub-Saharan Africa. *Food Security*, 9, 133–150. https://doi.org/10.1007/s12571-016-0636-0

- Faure, G., Kleene, P. 2004. Lessons from new experiences in extension in West Africa: Management advice for family farms and farmers' governance. *J. Agric. Educ. Ext*, 10, 37–49. https://doi.org/10.1080/13892240485300061

- Fischer, G., Darkwah, A., Kamoto, J., Kampanje-Phiri, J., Grabowski, P., Djenontin, I. 2021. Sustainable agricultural intensification and gender-biased land tenure systems: an exploration and conceptualization of interactions. *Int. J. Agric. Sustain*, 19, 403–422. https://doi.org/10.1080/14735903.2020.1791425

- Fischer, E. and M. Qaim. 2012. Gender, agricultural commercialization, and collective action in Kenya. *Food Security,* 4(3): 441–53.

- Franke, A. C., Van Den Brand, G. J., & Giller, K. E. 2014. Which farmers benefit most from sustainable intensification? An ex-ante impact assessment of expanding grain legume production in Malawi. *European Journal of Agronomy*, 58, 28-38.

- Gebre, G.G., Isoda, H., Rahut, D.B., Amekawa, Y., Nomura, H. 2019. Gender differences in the adoption of agricultural technology: The case of improved maize varieties in southern Ethiopia. *Womens Stud. Int. Forum* 76, 102264. https://doi.org/10.1016/j.wsif.2019.102264

- Gebreyes, M., Mekonnen, K., Thorne, P., Derseh, M., Adie, A., Mulema, A., Kemal, S.A., Tamene, L., Amede, T., Haileslassie, A., Gebrekirstos, A., Mupangwa, W.T., Ebrahim, M., Alene, T., Asfaw, A., Dubale, W., Yasabu, S. 2021. Overcoming constraints of scaling: Critical and empirical perspectives on agricultural innovation scaling. *PLOS ONE 16*, e0251958. https://doi.org/10.1371/journal.pone.0251958

- Gelo, D., Muchapondwa, E., Shimeles, A. 2017. Return to investment in agricultural cooperatives: Evidence from a natural experiment, in: Akpalu, W., Matshe, I., Senbet, L.W. (Eds.), *Linking Smallholder Farmers to Markets: Impact of the Purchase for Progress Pilot Programme*. University of Nairobi Press and African Economic Research Consortium, Nairobi, Kenya, pp. 16–40.

- Grabowski, P. P., Djenontin, I., Zulu, L., Kamoto, J., Kampanje-Phiri, J., Darkwah, A., ... & Fischer, G. 2021. Gender-and youth-sensitive data collection tools to support decision making for inclusive sustainable agricultural intensification. *International Journal of Agricultural Sustainability*, 19(5-6), 359-375.

- Grabowski, P., Fischer, G., Egyir, I., Kamoto, J., Kamphanje-Phiri, J., Kotu, B., Darkwah, A., Zulu, L. 2017. *Gender and agriculture issues in Ghana and Malawi - A desk study*. International Institute of Tropical Agriculture, Ibadan, Nigeria.

- Haggar, J., & Rodenburg, J. 2021. Lessons on enabling African smallholder farmers, especially women and youth, to benefit from sustainable agricultural intensification. *International Journal of Agricultural Sustainability*, 19(5-6), 636-640.

- Haggar, J., Nelson, V., Lamboll, R., & Rodenburg, J. 2021. Understanding and informing decisions on sustainable agricultural intensification in Sub-Saharan Africa. *International Journal of Agricultural Sustainability*, 19(5-6), 349-358.

- Haile, B., Azzarri, C., Roberts, C., Guo, Z., Comanescu, M. 2015. *Characterizing adopters of sustainable intensification innovations: Evidence from the Africa RISING (AR) program in Malawi and Tanzania*. Presented at the International

Conference on Integrated Systems Research, International Food Policy Research Institute, Ibadan, Nigeria.

- Hammond, J., van Wijk, M., Teufel, N., Mekonnen, K., Thorne, P. 2021. Assessing smallholder sustainable intensification in the Ethiopian highlands. *Agricultural Systems,* 194, 103266. https://doi.org/10.1016/j.agsy.2021.103266

- Haque, M.M., Belton, B., Alam, Md.M., Ahmed, A.G., Alam, Md.R. 2016. Reuse of fish pond sediments as fertilizer for fodder grass production in Bangladesh: Potential for sustainable intensification and improved nutrition. *Agric. Ecosyst. Environ.*, 216, 226–236. https://doi.org/10.1016/j.agee.2015.10.004

- Havemann, T., Negra, C., Werneck, F. 2020. Blended finance for agriculture: exploring the constraints and possibilities of combining financial instruments for sustainable transitions. *Agriculture and Human Values*, 37, 1281–1292. https://doi.org/10.1007/s10460-020-10131-8

- Hirpa Tufa, A., Alene, A.D., Cole, S.M., Manda, J., Feleke, S., Abdoulaye, T., Chikoye, D., Manyong, V. 2022. Gender differences in technology adoption and agricultural productivity: Evidence from Malawi. *World Development*, 159, 106027. https://doi.org/10.1016/j.worlddev.2022.106027

- Hockett, Michele, and Robert B. Richardson. 2018. Examining the drivers of agricultural experimentation among smallholder farmers in Malawi. Experimental Agriculture 54(1): 45-65.

- Hörner, D., Wollni, M. 2021. Integrated soil fertility management and household welfare in Ethiopia. *Food Policy 100*, 102022. https://doi.org/10.1016/j.foodpol.2020.102022

- Huang, J., Wang, Y. 2014. Financing sustainable agriculture under climate change. *J. Integr. Agric.*, 13, 698–712. https://doi.org/10.1016/S2095-3119(13)60698-X

- IFAD, World Food Programme, FAO. 2012. *Agricultural cooperatives: Paving the way for food security and rural development, 2012 International Year of Cooperatives*. Food and Agriculture Organization of the United Nations, International Fund for Agricultural Development, and World Food Programme, Rome, Italy.

- Ihalainen, M., Shaikh, S., Mujawamariya, G., Mayanja, S., Adetonah, S., Tavenner, K., Elias, M. 2021. Promise and contradiction: Value chain participation and women's empowerment, in: Pyburn, R., van Eerdewijk, A. (Eds.), *Advancing Gender Equality through Agricultural and Environmental Research: Past, Present, and Future*. International Food Policy Research Institute (IFPRI), Washington DC, pp. 147–188.

- Islam, S., Gathala, M. K., Tiwari, T. P., Timsina, J., Laing, A. M., Maharjan, S., ... & Gérard, B. 2019. Conservation agriculture based sustainable intensification: increasing yields and water productivity for smallholders of the Eastern Gangetic Plains. *Field Crops Research*, 238, 1-17.

- Jain, M., Solomon, D., Capnerhurst, H., Arnold, A., Elliott, A., Kinzer, A.T., Knauss, C., Peters, M., Rolf, B., Weil, A., Weinstein, C. 2020. How much can sustainable intensification increase yields across South Asia? a systematic review of the evidence. *Environ. Res. Lett.* 15 https://doi.org/10.1088/1748-9326/ab8b10, 083004.

- Jamal, Md.R., Kristiansen, P., Kabir, Md.J., Kumar, L., Lobry de Bruyn, L. 2021. Trajectories of cropping system intensification under changing environment in south-west coastal Bangladesh. *Int. J. Agric. Sustain*., Advanced online publication, 1–21. https://doi.org/10.1080/14735903.2021.1975436

- Kantor, P., Morgan, M., & Choudhury, A. 2015. Amplifying outcomes by addressing inequality: the role of gender-transformative approaches in agricultural research for development. *Gender, Technology and Development*, 19(3), 292-319.

- Kasente, D., Lockwood, M., Vivian, J. and Whitehead, A. 2002. Gender and the expansion of non-traditional agricultural exports in Uganda. In Razavi, S (ed) *Shifting Burdens: Gender and Agrarian Change under Neoliberalism*. Bloomfield, CT, Kumarian Press. Pp. 35-65.

- Kassie, M., Teklewold, H., Jaleta, M., Marenya, P., & Erenstein, O. 2015. Understanding the adoption of a portfolio of sustainable intensification practices in eastern and southern Africa. *Land Use Policy*, 42, 400-411.

- Kassie, M., Stage, J., Teklewold, H., & Erenstein, O. 2015. Gendered food security in rural Malawi: why is women's food security status lower?. *Food Security*, 7(6), 1299-1320.

- Komarek, A. M., Koo, J., Haile, B., Msangi, S., & Azzarri, C. 2018. Trade-offs and synergies between yield, labor, profit, and risk in Malawian maize-based cropping systems. *Agronomy for Sustainable Development*, 38(3), 1-10.

- Kotu, B.H., Oyinbo, O., Hoeschle-Zeledon, I., Nurudeen, A.R., Kizito, F., Boyubie, B. 2022. Smallholder farmers' preferences for sustainable intensification attributes in maize production: Evidence from Ghana. *World Development*, 152, 105789. https://doi.org/10.1016/j.worlddev.2021.105789

- Kumar, S.K. 1994. *Adoption of hybrid maize in Zambia: effects on gender roles, food consumption, and nutrition. Research Report No. 100*. Washington, DC: International Food Policy Research Institute.

- Kuyah, S., Sileshi, G.W., Nkurunziza, L., Chirinda, N., Ndayisaba, P.C., Dimobe, K., Öborn, I. 2021. Innovative agronomic practices for sustainable intensification in sub-Saharan Africa. A review. *Agron. Sustain. Dev.*, 41, 16–27. https://doi.org/10.1007/s13593-021-00673-4

- Leder, S., Clement, F., & Karki, E. 2017. Reframing women's empowerment in water security programmes in Western Nepal. *Gender & Development*, 25(2), 235-251.

- Lenjiso, B. M. 2019. Defeminizing effect: How improved dairy technology adoption affected women's and men's time allocation and milk income share in Ethiopia. In *Gender, Agriculture and Agrarian Transformations* (pp. 129-146). Routledge.

- Liao, C., & Brown, D. G. 2018. Assessments of synergistic outcomes from sustainable intensification of agriculture need to include smallholder livelihoods with food production and ecosystem services. *Current Opinion in Environmental Sustainability*, *32*, 53-59.

- Lindsjö, K., Mulwafu, W., Andersson Djurfeldt, A., Joshua, M.K. 2021. Generational dynamics of agricultural intensification in Malawi: Challenges for the youth and elderly smallholder farmers. Int. J. Agric. Sustain., 19, 423–436. https://doi.org/10.1080/14735903.2020.1721237

- Lunt, T., Ellis-Jones, J., Mekonnen, K., Schulz, S., Thorne, P., Schulte-Geldermann, E., Sharma, K. 2018. Participatory community analysis: Identifying and addressing challenges to Ethiopian smallholder livelihoods. Dev. Pract., 28, 208–226. https://doi.org/10.1080/09614524.2018.1417354

- Mahon, N., Crute, I., Simmons, E., & Islam, M. M. 2017. Sustainable intensification–"oxymoron" or "third-way"? A systematic review. *Ecological Indicators*, 74, 73-97.

- Martin, A., Coolsaet, B., Corbera, E., Dawson, N., Fisher, J., Franks, P., Mertz, O., Pascual, U., Rasmussen, L.V., Ryan, C. 2018. Land use intensification: The promise of sustainability and the reality of trade-offs, in: Schreckenberg, K., Mace, G., Poudyal, M. (Eds.), *Ecosystem Services and Poverty Alleviation: Trade-Offs and Governance*. Routledge, London, England and New York, New York, pp. 305–316.

- Masangano, C., Mthinda, C. 2012. *Pluralistic extension system in Malawi (Discussion Paper)*. Eastern and Southern Africa Regional Office, International Food Policy Research Institute, Addis Ababa, Ethiopia.

- Mdee, A., Ofori, A., Chasukwa, M., Manda, S. 2021. Neither sustainable nor inclusive: A political economy of agricultural policy and livelihoods in Malawi, Tanzania and Zambia. *Journal of Peasant Studies*, 48, 1260–1283. https://doi.org/10.1080/03066150.2019.1708724

- Me-Nsope, N., Larkins, M. 2014. *Gender analysis of the pigeon pea value chain: Case study of Malawi (No. 5), Center Report Series*. Global Center for Food Systems Innovation, Michigan State University, East Lansing, Michigan.

- Meyer, R.L. 2015. *Financing agriculture and rural areas in sub-Saharan Africa: Progress, challenges and the way forward (Working Paper)*. International Institute for Environment and Development (IIED), London, England.

- Mhango, W.G., Snapp, S.S., Phiri, G.Y.K. 2013. Opportunities and constraints to legume diversification for sustainable maize production on smallholder farms in Malawi. Renew. *Agric. Food Syst*., 28, 234–244. https://doi.org/10.1017/S1742170512000178

- Montt, G., & Luu, T. 2020. Does Conservation Agriculture Change Labour Requirements? Evidence of Sustainable Intensification in Sub-Saharan Africa. *Journal of Agricultural Economics*, 71(2), 556-580.

- Moseley, W.G., Pessereau, E.J. 2022. Mother's little helper: A feminist political ecology of West Africa's herbicide revolution, in: Barcus, H., Jones, R., Schmitz, S. (Eds.), *Rural Transformations: Globalization and Its Implications for Rural People, Land, and Economies*. Routledge, Oxfordshire, England.

- Mulema, A.A., Jogo, W., Damtew, E., Mekonnen, K., Thorne, P. 2019. Women farmers' participation in the agricultural research process: Implications for agricultural sustainability in Ethiopia. *Int. J. Agric. Sustain*., 17, 127–145. https://doi.org/10.1080/14735903.2019.1569578

- Mungai, L., S. Snapp, J.P. Messina, R. Chikowo, A. Smith, E. Anders, R.B. Richardson, and G. Li. 2017. Smallholder farms and the potential for Sustainable Intensification. *Frontiers in Plant Science*. doi: 10.3389/fpls.2016.01720

- Mutenje, M., Kankwamba, H., Mangisonib, J., & Kassie, M. 2016. Agricultural innovations and food security in Malawi: Gender dynamics, institutions and market implications. *Technological Forecasting and Social Change*, 103, 240-248.

- Mutyasira, V., Hoag, D., Pendell, D. L., & Manning, D. T. 2018. Is sustainable intensification possible? Evidence from Ethiopia. *Sustainability*, 10(11), 4174.

- Muyanga, Milu, Zephania Nyirenda, Yanjanani Lifeyo, and William J. Burke. 2020. *The future of smallholder farming in Malawi. No. 2371-2022-460.*

- Msigwa, R. E. and G. Mofulu. 2013. The Value and Time Allocation in Rural Tanzania. *Journal of Economics and Sustainable Development*, 4(10): 150–60.

- Mwambi, M., Bijman, J., Mshenga, P. 2020. Which type of producer organization is (more) inclusive? Dynamics of farmers' membership and participation in the decision-making process. *Ann. Public Coop. Econ.*, 91, 213–236. https://doi.org/10.1111/apce.12269

- Nath, T.K., Jashimuddin, M., Kamrul Hasan, Md., Shahjahan, Md., Pretty, J. 2016. The sustainable intensification of agroforestry in shifting cultivation areas of Bangladesh. *Agroforestry Systems*, 90, 405–416. https://doi.org/10.1007/s10457-015-9863-1

- Ndiritu, S.W., Kassie, M., Shiferaw, B. 2014. Are there systematic gender differences in the adoption of sustainable agricultural intensification practices? Evidence from Kenya. Food Policy, 49, 117–127. https://doi.org/10.1016/j.foodpol.2014.06.010

- Newby, J.C., Manivong, V., Cramb, R.A. (Eds.). 2013. *Intensification of lowland rice-based farming systems in Laos in the context of diversified rural livelihoods*. Presented at the 57th AARES Annual Conference, Australian Agricultural and Resource Economics Society, Sydney, Australia, pp. 1–27. https://doi.org/10.22004/ag.econ.152172

- Olum, S., Gellynck, X., Juvinal, J., Ongeng, D., & De Steur, H. 2020. Farmers' adoption of agricultural innovations: A systematic review on willingness to pay studies. *Outlook on Agriculture*, 49(3), 187-203.

- Omotesho, K.F., Akinrinde, A.F., Komolafe, S.E., Aluko, O.E., 2019. Analysis of women participation in farmer group activities in Kwara State, Nigeria. *Agric. Trop. Subtrop.*, 52, 121–128. https://doi.org/10.2478/ats-2019-0014

- Onyiriuba, L., Okoro, E.U.O., Ibe, G.I. 2020. Strategic government policies on agricultural financing in African emerging markets. *Agric. Finance Rev.*, 80, 563–588. https://doi.org/10.1108/AFR-01-2020-0013

- Ortega, D. L., Waldman, K. B., Richardson, R. B., Clay, D. C., & Snapp, S. 2016. Sustainable intensification and farmer preferences for crop system attributes: evidence from Malawi's central and southern regions. *World Development*, 87, 139-151.

- Osabohien, R., Adeleye, N., Alwis, T.D. 2020. Agro-financing and food production in Nigeria. *Heliyon* 6, 1–8. https://doi.org/10.1016/j.heliyon.2020.e04001

- Oumer, A.M., Burton, M., Hailu, A., Mugera, A. 2020. Sustainable agricultural intensification practices and cost efficiency in smallholder maize farms: Evidence from Ethiopia. *Agric. Econ.*, 51, 841–856. https://doi.org/10.1111/agec.12595

- Paudel, G. P., Kc, D. B., Justice, S. E., & McDonald, A. J. 2019. Scale-appropriate mechanization impacts on productivity among smallholders: Evidence from rice systems in the mid-hills of Nepal. *Land Use Policy*, 85, 104-113.

- Paul, B.K., Epper, C.A., Tschopp, D.J., Long, C.T.M., Tungani, V., Burra, D., Hok, L., Phengsavanh, P., Douxchamps, S. 2022. Crop-livestock integration provides opportunities to mitigate environmental trade-offs in transitioning smallholder agricultural systems of the Greater Mekong Subregion. *Agricultural Systems*, 195, 1–14. https://doi.org/10.1016/j.agsy.2021.103285

- Petersen, I., Kruss, G., Gastrow, M., Nalivata, P.C. 2018. Innovation capacity-building and inclusive development in informal settings: A comparative analysis of two interactive learning spaces in South Africa and Malawi. *Journal of International Development*, 30, 865–885. https://doi.org/10.1002/jid.3232

- Porciello, J. Bourne, T. Lipper, L., Lin, S., and Langleben, S. 2021. *Mining the Gaps: Using Machine-Learning to Map a Million Data Points on Agricultural Research from the Global South*. Colombo, Sri Lanka: Commission on Sustainable Agriculture Intensification.

- Pretty, J., Benton, T.G., Bharucha, Z.P., Dicks, L.V., Flora, C.B., Godfray, H.C.J., Goulson, D., Hartley, S., Lampkin, N., Morris, C., Pierzynski, G., Prasad, P.V.V., Reganold, J., Rockstrom, J., Smith, P., Thorne, P., Wratten, S. 2018. Global assessment of agricultural system redesign for sustainable intensification. *Nature Sustainability*, 1, 441–446. https://doi.org/10.1038/s41893-018-0114-0.

- Raut, N., Sitaula, B. K., & Bajracharya, R. M. 2010. Agricultural intensification: linking with livelihood improvement and environmental degradation in mid-hills of Nepal. *Journal of Agriculture and Environment*, 11, 83-94.

- Rahman, S.A., Paras, F.D., Khan, S.R., Imtiaj, A., Farhana, K.M., Toy, M.M., Akhand, M.B., Sunderland, T.C.H. 2011. Initiatives of tropical agroforestry to sustainable agriculture: A case study of Capasia Village, Northern Bangladesh. *J. Hortic. For.*, 3, 115–121. https://doi.org/10.35648/20.500.12413/11781/ii277.

- Ragasa, C., Sengupta, D., Osorio, M., Ourabah Haddad, N. and Mathieson, K. 2014. *Gender-specific approaches and rural institutions for improving access to and adoption of technological innovations.* Food and Agriculture Organization of the United Nations, Rome, Italy.

- Ramcilovic-Suominen, S., Kotilainen, J. 2020. Power relations in community resilience and politics of shifting cultivation in Laos. *For. Policy Econ.*, 115, 1–11. https://doi.org/10.1016/j.forpol.2020.102159

- Reich, J., Paul, S. S., & Snapp, S. S. 2021. Highly variable performance of sustainable intensification on smallholder farms: A systematic review. *Global Food Security*, 30, 100553.

- Ripoll, S., Andersson, J., Badstue, L., Büttner, M., Chamberlin, J., Erenstein, O., & Sumberg, J. 2017. Rural transformation, cereals and youth in Africa: What role for international agricultural research?. *Outlook on Agriculture*, 46(3), 168-177.

- Sartas, M., Schut, M., Proietti, C., Thiele, G., Leeuwis, C. 2020. Scaling readiness: Science and practice of an approach to enhance impact of research for development. *Agricultural Systems,* 183, 1–12. https://doi.org/10.1016/j.agsy.2020.102874

- Shew, A.M., Durand-Morat, A., Putman, B., Nalley, L.L., Ghosh, A. 2019. Rice intensification in Bangladesh improves economic and environmental welfare. *Environ. Sci. Policy*, 95, 46–57. https://doi.org/10.1016/j.envsci.2019.02.004

- Shilomboleni, H., Owaygen, M., De Plaen, R., Manchur, W., Husak, L. 2019. Scaling up innovations in smallholder agriculture: Lessons from the Canadian international food security research fund. *Agricultural Systems*, 175, 58–65. https://doi.org/10.1016/j.agsy.2019.05.012

- Snapp, S.S., DeDecker, J., Davis, A.S. 2019. Farmer participatory research advances sustainable agriculture: lessons from Michigan and Malawi. *Agronomy Journal*, 111, 2681–2691. https://doi.org/10.2134/agronj2018.12.0769.

- Snapp, S.S., Grabowski, P., Chikowo, R., Smith, A., Anders, E., Sirrine, D., Chimonyo, V., Bekunda, M. 2018. Maize yield and profitability tradeoffs with social, human and environmental performance: Is sustainable intensification feasible? *Agricultural Systems*, 162, 77–88. https://doi.org/10.1016/j.agsy.2018.01.012

- Snapp, S.S., Grabowski, P., Musumba, M., Palm, C.A., Chikowo, R., Bekunda, M.A. 2016. *Development of a sustainable intensification indicators framework: Reports from the frontline in Mali and Malawi.* Presented at the Conference on Solidarity in a Competing World—Fair Use of Resources, Michigan State University, Vienna, Austria.

- Sørensen, P. 1996. Commercialisation of food crops in Busoga, Uganda, and the renegotiation of gender. *Gender & Society*, 10(5): 608–28.

- Spielman, D.J., Ward, P.S., Kolady, D.E., Ar-Rashid, H. 2017. Public incentives, private investment, and outlooks for hybrid rice in Bangladesh and India. *Appl. Econ. Perspect. Policy*, 39, 154–176. https://doi.org/10.1093/aepp/ppw001

- Sugden, F., L. Nigussie, L. Debevec & R. Nijbroek. 2021. Migration, environmental change and agrarian transition in upland regions: learning from Ethiopia, Kenya and Nepal, *The Journal of Peasant Studies*, DOI: 10.1080/03066150.2021.1894552

- Sugden, F., Maskey, N., Clement, F., Ramesh, V., Philip, A., & Rai, A. 2014. Agrarian stress and climate change in the Eastern Gangetic Plains: Gendered vulnerability in a stratified social formation. *Global Environmental Change*, 29, 258-269.

- Sugden, F. 2009. Neo-liberalism, markets and class structures on the Nepali lowlands: The political economy of agrarian change. *Geoforum*, 40(4), 634-644.

- Suhardiman, D., Giordano, M., Leebouapao, L., Keovilignavong, O. 2016. Farmers' strategies as building block for rethinking sustainable intensification. *Agriculture and Human Values,* 33, 563–574. https://doi.org/10.1007/s10460-015-9638-3

- Suhardiman, D., Pavelic, P., Keovilignavong, O., Giordano, M. 2020. Putting farmers' strategies in the centre of agricultural groundwater use in the Vientiane Plain, Laos. *Int. J. Water Resour. Dev.*, 36, 149–169. https://doi.org/10.1080/07900627.2018.1543116

- Theriault, V., Smale, M., & Haider, H. (2017). How does gender affect sustainable intensification of cereal production in the West African Sahel? Evidence from Burkina Faso. *World Development*, 92, 177-191.

- Thierfelder, C., Chisui, J.L., Gama, M., Cheesman, S., Jere, Z.D., Trent Bunderson, W., Eash, N.S., Rusinamhodzi, L. 2013. Maize-based conservation agriculture systems in Malawi: long-term trends in productivity. *Field Crop. Res.*, 142, 47–57. https://doi. org/10.1016/j.fcr.2012.11.010.

- Urfels, A., McDonald, A. J., Krupnik, T. J., & van Oel, P. R. 2020. Drivers of groundwater utilization in water-limited rice production systems in Nepal. *Water international,* 45(1), 39-59.

- Von Braun, J. and Kennedy, E.T. 1994. *Agricultural Commercialisation, Economic Development, and Nutrition*. Washington: International Food Policy Research Institute [by] Johns Hopkins University Press.

- Wade, L. 2014. Rapporteur's synopsis, in: Robins, L. (Ed.), *Proceedings of a Dialogue Held in Phnom Penh, Cambodia, ACIAR Proceedings Series*. Presented at the A policy dialogue on rice futures: Rice-based farming systems research in the Mekong region, Australian Centre for International Agricultural Research (ACIAR), Canberra, Australia, pp. 3–158.

- Ward, P.S., Pede, V.O. 2015. Capturing social network effects in technology adoption: The spatial diffusion of hybrid rice in Bangladesh. *Aust. J. Agric. Resour. Econ.*, 59, 225–241. https://doi.org/10.1111/1467-8489.12058

- Weltin, M., Zasada, I., Piorr, A., Debolini, M., Geniaux, G., Perez, O. M., ... & Schulp, C. J. 2018. Conceptualising fields of action for sustainable intensification–A

systematic literature review and application to regional case studies. *Agriculture, Ecosystems & Environment*, 257, 68-80.

- Yahaya, I., Pokharel, K.P., Alidu, A.-F., Yamoah, F.A. 2018. Sustainable agricultural intensification practices and rural food security: The case of Northwestern Ghana. Br. *Food J.* 120, 468–482. https://doi.org/10.1108/BFJ-01-2017-0021

- Zulu, L. C., Djenontin, I. N., Darkwah, A., Kamoto, J., Kampanje-Phiri, J., Fischer, G., ... & Egyir, I. 2021. Realizing Inclusive SAI: contextualizing indicators to better evaluate gender and intergenerational inequity in SAI processes and outcomes–cases from Southern and Western Africa. *International Journal of Agricultural Sustainability*, 19(5-6), 376-402.

- Zulu, L. C., Djenontin, I. N., & Grabowski, P. 2021. From diagnosis to action: Understanding youth strengths and hurdles and using decision-making tools to foster youth-inclusive sustainable agriculture intensification. *Journal of Rural Studies*, 82, 196-209.

- Zulu, L. C., Djenontin, I. N., Kamoto, J. F., Kampanje-Phiri, J. M., & Fischer, G. 2022. Do youth conceptualizations influence the inclusion of young people in sustainable agriculture intensification? Insights from Ghana and Malawi. *Environment, Development and Sustainability,* 1-27.

https://www.cgiar.org/initiative/19-sustainable-intensification-of-mixed-farming-systems/