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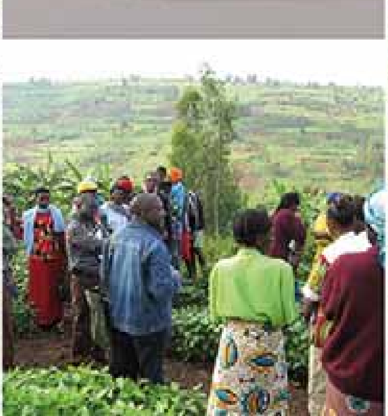
# Sustainable Intensification in Smallholder Agriculture

## An integrated systems research approach








# 1 Integrated systems research for sustainable intensification of smallholder agriculture

*Ingrid Öborn, Bernard Vanlauwe, Kwesi Atta-Krah, Richard Thomas, Michael Phillips and Marc Schut*

## Sustainable development goals and smallholder agriculture

The Sustainable Development Goals (SDGs) 2030, endorsed by the Heads of States in the United Nations (UN) 2015, and the national discussions and implementation plans that followed, have put light on how intertwined and interdependent the various aspects of sustainability and sustainable development are (UN, 2015; van Noordwijk et al., 2015). This book on sustainable intensification of smallholder agriculture is relevant for many of the SDGs and in particular for achieving the following goals: reducing poverty (#1), achieving food security, improved nutrition and sustainable agriculture (#2), gender equity and empowering women (#5), conserving and sustainably using aquatic resources (#6, #14), and promoting sustainable use of terrestrial ecosystems and reversing land degradation (#15). There are trade-offs and synergies between the SDGs and there is a need to balance the economic, social and environmental dimensions of sustainable development. The scale at which the SDGs are implemented also matters for agricultural development: global (e.g. climate agreement), regional (e.g. trade pacts), national (e.g. policies and incentives) or local level (e.g. innovation platforms and networks).

Building on experiences from research in sub-Saharan Africa, South and Southeast Asia and Latin America, this book elaborates on different aspects of sustainable intensification and diversification of smallholder agriculture and livelihood systems leading to *systems intensification*. The aim is to illustrate different aspects and dimensions of integrated agricultural systems research where the focus is moving from farming systems to livelihood systems and institutional innovation. Sustainable systems intensification includes ecological, economic and social dimensions where food, income and nutrition security and reduced natural resources degradation are the main focuses of agricultural interventions. Combined with supporting innovation systems and capacity to innovate that are vehicles for stakeholder engagement and partnerships, they are the basis to achieve development outcomes inclusive of gender and equity improvements. This chapter provides a summary and synthesis of the other chapters, putting the methods, approaches, analyses, experiences and research and development findings in different contexts (Figure 1.1).

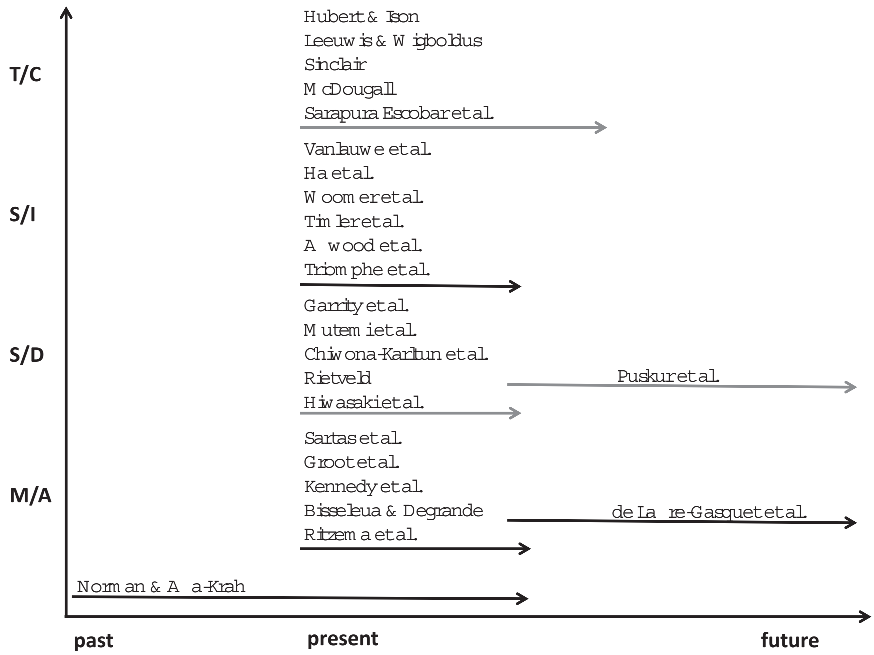



*Figure 1.1* The chapters of the book are covering different aspects of integrated systems research ($y$-axis): methods and approaches (M/A), situation analysis and diagnosis (S/D), systems improvement (S/I), and transformation and change (T/C). They deal with past experiences and trends, recent research achievements and work directed towards understanding the future, i.e. foresight ($x$-axis). The author names are indicated.

## What is integrated systems research?

Integrated systems research involves the management and improvement of the system based on the holistic analysis of its components within a defined agro-ecological space, their interactions, trade-offs and synergies aimed at livelihoods enhancement for farmers and communities and agro-ecological sustainability. This adds a level of complexity similar to what many farmers face daily. They manage farms that have multiple crops, livestock, soil and water management challenges and make frequent decisions to minimize trade-offs and optimize synergies. Farmers, for example, decide on utilization of their labour, income and savings considering on- and off-farm needs such as fertilizer; improved breeds, seed and education; and opportunities for short-term cash income and longer term food and income security. Agricultural research needs to support farmers managing their farming and livelihood system with all its complexity and complications and therefore adopts a systems approach aiming at systems improvement and rural transformation.

The focus on production of agricultural commodities that characterizes much of the agricultural research over the last 40–50 years paid insufficient attention to the need to co-develop the social, economic, environmental, cultural, technological, infrastructural and institutional contexts including impacts on gender and generations. In addition investment opportunities, externalities and trade-offs, non-linearity and tipping points in the relationships among the social, natural, economic and production environments were often insufficiently studied (van Ginkel et al., 2013). This has repeatedly led to poor adoption rates of innovations, particularly among the poor and vulnerable. It also challenges scaling-up and scaling-out and neglects other income-generating opportunities the system potentially provides. A comparison between the systems and more 'conventional' approaches is provided in Table 1.1.

A value proposition to guide systems research (Thomas, 2015) was presented at the conclusion of the international conference on 'Integrated Systems Research for Sustainable Intensification in Smallholder Agriculture' in Ibadan, Nigeria, 3–6 March 2015. The conference was organized by Humidtropics, a CGIAR Research Programme (CRP) on integrated systems for the humid tropics in collaboration with the Dryland Systems and Aquatic Agricultural Systems CRPs and brought together biological and social scientists to present and discuss their research that is reflected in this book. It provides a solid basis to advance the scientific base and skills in agricultural systems research and its contribution to the SDGs.

*Table 1.1* Conventional and systems approaches to smallholder farming

| *Conventional approach* | *Systems approach* |
|---|---|
| Focus on single commodity and single livelihood component | Focus on multiple commodities and livelihood components |
| Aimed at improving productivity and closing yield gaps, regardless of risk | Aimed at improving whole farm productivity with explicit consideration of trade-offs and social, economic and environmental sustainability. Targets multiple wins where possible; balances trade-offs where not |
| Focus on discrete value chains, overlooking externalities | Attention to interactions between value chains, explicitly considering externalities |
| Focus on innovations and investments responding to specific drivers of change within sectors at discrete scales | Focus on interactions between multiple drivers of change and innovation and investment within options across sectors and scales |
| Linear approaches | Dynamic iterative approaches |
| Discrete research disciplines | Blended biological with social research |
| Scientific knowledge transferred to stakeholders | Local and scientific knowledge combined, co-generated and embedded in the broader community |
| Gender equality and social justice as isolated outcomes of the research process | Disadvantaged groups involved and empowered throughout |

Source: Adapted from Dryland Systems Task Force, 2015.

## Value proposition to guide systems research

There is a need for integrated systems research that improves the understanding of place-based social, financial, technical and environmental contexts and provides a knowledge resource to enhance the targeting and relevance of potential systems interventions with an aim to scale these out to similar extrapolation domains (van Ginkel et al., 2013). Integrated systems research then develops and tests, with farming households and development partners, feasible combinations of technical, market, governance and policy options capable of improving livelihood systems. It helps to improve total farm productivity, including closing yield gaps of system components with greatest relevance to smallholder farmers. A fully integrated systems approach requires further development of monitoring and evaluation systems with indicators that can show whether systems approaches are working, for whom, where, to what extent and how, and fast enough to support adaptive management.

To reach scale, systems research has to be better embedded in development where it:

- Fosters partnerships that better target social, institutional and technical options;
- Creates hybrid knowledge that builds science onto local knowledge to reduce yield gaps of systems components and enhance multiple value chains;
- Improves capacities of households and institutions to innovate;
- Improves the effectiveness of development spending through enabling research embedded in development programmes;
- Realizes social, economic and environmental co-benefits;
- Creates platforms where outputs of other research programmes can be delivered at scale; and
- Identifies diversification opportunities in agriculture for investments.

A major challenge is to ensure that systems research strengthens the science–policy interface that has prevented governments and international bodies to contribute to transformational change on the ground to rural populations. Without meeting the pre-conditions for change that are often outside the control of the smallholder such as land access, capital, seeds, fertilizer and agro-chemicals (Sumberg, 2005; van Ginkel et al., 2013), the uptake of interventions usually stalls. Identification of diversification opportunities and new combinations of systems components such as cereals with legumes, livestock and trees can act as a magnet for the agricultural sector and draw in diverse parties and increase investments in rural areas.

The prospect for using new science, big data and information, ease of access to geographic information systems, better understanding and application of the 'options by context' concept and heterogeneity in both biophysical and socio-economic factors (Sinclair, *this volume*) will also allow systems researchers to deal with 'wicked' problems, productivity trade-offs and synergies, climate change, land degradation, gender inequities and youth unemployment at the expected scale of impact, that is with millions of farmers across millions of hectares. At the same time, systems research may directly improve the effectiveness of development spending at local scales, produce generalizable knowledge and forge new partnerships to improve livelihoods and human well-being.

## Methods and approaches for integrated systems research

Agricultural systems research started in the late 1960s and 1970s with farming systems research that had a focus on looking into the farms to better understand limited resourced smallholder farmers. Norman and Atta-Krah (*this volume*) provide the historical perspective and experiences of systems research during 40–50 years characterized by farmer participatory approaches and inter-disciplinarity. Focus shifted towards on- and off-farm dimensions (livelihoods), interactions and trade-offs, and involved multi-stakeholders in the research–development continuum. Systems science at the scale of impact is discussed further by Sinclair (*this volume*), reconciling bottom up participation with the production of widely applicable research outputs. This requires moving away from a notion that there is a dichotomy between participatory bottom up approaches and comparisons of options across locations and different contexts being a prerequisite for large scale adoption and impact at scale. The FAO farming systems classification (Dixon et al., 2001) has been updated and taken forward for sub-Saharan Africa by Garrity and co-authors (*this volume*). The five major farming systems in sub-Saharan Africa provide the principal livelihoods of more than two-thirds of Africa's poor. Garrity et al. (*this volume*) conclude that bold initiatives are needed to drive sustainable intensification in African farming systems, underpinned by new ways of organizing and governing the innovation process.

Innovation and its role for transformation (change) is the topic of the chapter by Hubert and Ison (*this volume*) who have developed a theoretical framework for systems thinking and innovation in praxis and situations. Foresight, systems thinking and institutional change is the theme of the chapter by de Lattre-Gasquet and co-authors (*this volume*) where they examine three examples of foresight exercises and their contribution to institutional innovation and policy making, including (1) the direction of the cocoa and rubber sectors and related research (Cirad), (2) scenarios and challenges for feeding the world in 2050 (Agrimonde), and (3) agriculture in the face of climate change (CCAFS).

The Systems CRPs implemented from 2012 to 2016 are examples of integrated systems research in practice. Humidtropics is used as example by Bisseleua and Degrande (*this volume*) who describe approaches to operationalizing integrated systems research. Figure 1.2 illustrates the backbone of the programme with systems analysis and synthesis, integrated systems improvement, and institutional innovation and scaling as three pillars (strategic research themes) interlinked through the research cycle and cross-cutting activities on gender, nutrition and capacity development.

Although most chapters focus on terrestrial agricultural systems, some attention is given to aquatic systems. 'Does sustainable intensification offer a pathway

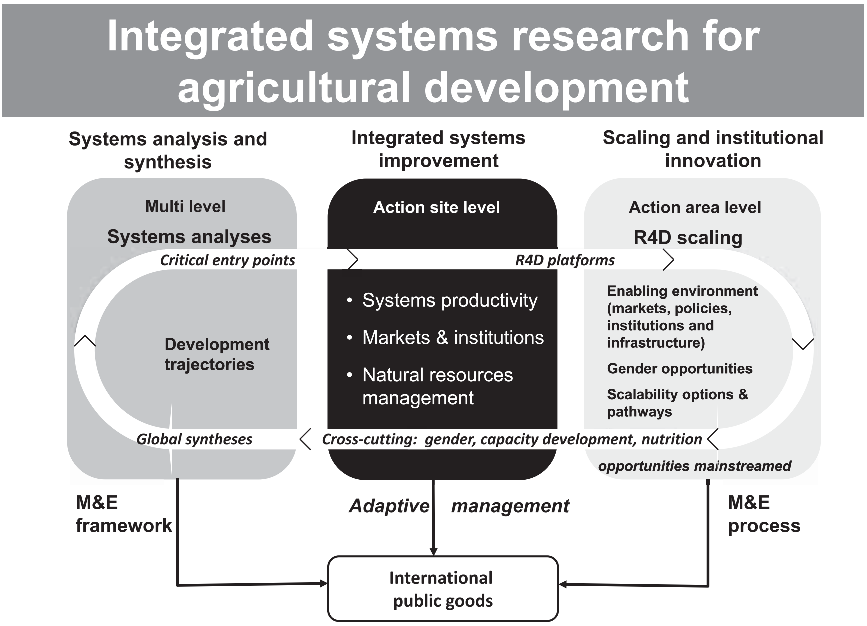



*Figure 1.2* Conceptual framework for the agricultural systems research programme on integrated systems for the humid tropics (Humidtropics) funded through the CGIAR research programmes 2012–2016

Source: Humidtropics.

to improved food security for aquatic agricultural system-dependent communities?' – is the question Attwood and co-authors (*this volume*) pose. They share experiences from the aquatic systems research in sub-Saharan Africa and Asia, using examples from Bangladesh, Cambodia and Zambia, and define and discuss the difference between 'intensification' and 'sustainable intensification'. The futures of aquatic agricultural food systems in Southern Africa (Madagascar, Malawi, Mozambique and Zambia) are explored by Puskur et al. (*this volume*) and the drivers to future-smart research and policy options are discussed, including multi-stakeholder involvement and empowerment of local communities.

There is a need to experiment with different sets of entry points for different farmer typologies to enhance the targeting and relevance of potential systems interventions for sustainable intensification. This is exemplified by Ritzema et al. (*this volume*) who describe a quantitative approach for characterizing livelihoods and assessing potential wide-scale impact of interventions that complements detailed household modelling in informing intervention strategies.

## Sustainable intensification in practice

Conceptualization and building frameworks are important to help understand the factors that need to be considered to implement integrated systems research, but are insufficient to create positive change at the level of fields, farms, farming communities and landscapes. Traditionally, after clearing natural fallows, nutrient mining is the first degradation process kick-starting a number of other degradation processes. Declining soil fertility generates declining crop yields and triggers a mutually reinforcing vicious cycle of resource degradation. Enhancing farm-level productivity while improving the natural resource base is essential for smallholder farmers' livelihoods. Sustainable intensification encompasses the need to enhance productivity whilst maintaining or improving ecosystem services and system resilience to shocks.

However, Vanlauwe et al. (*this volume*) recognize that increased system productivity and improvement in natural resource integrity do not necessarily go hand-in-hand. Pathways need to be identified to move from current smallholder farming systems with low productivity and degraded natural resources towards productive systems with the provision of soil-based ecosystem services preserved. Various intensification paradigms are evaluated through an analysis of the dynamics of crop yields (proxy for system productivity) and soil carbon contents (proxy for natural resource integrity) in long-term trials. External nutrient inputs are clearly needed to trigger farming systems productivity and break the downward spiral of soil degradation, especially when land is in short supply. Extra crop residues need to be recycled to maintain soil carbon stocks, thus gradually moving up the path towards sustainable intensification. Such paths are intersected by trade-offs between investments in space and time by smallholder farming families who most often lack the necessary resources to simultaneously obtain short-term crop productivity increases and maintain favourable production and ecosystem conditions for the longer term.

Mutemi et al. (*this volume*) used participatory approaches to understand fine-scale variation and entry points for sustainable intensification in Western Kenya. Knowledge about agro-ecological interactions in mixed farming systems was elicited from smallholders across four villages in two counties using a knowledge-based systems approach. The study revealed common challenges across the four villages related to land scarcity, decreased soil fertility and pests and diseases in staple crops and fruit trees. However, each village had its own natural resources management constraints and dynamics requiring customized approaches to intensification of mixed crop-tree-livestock systems. Farmers had detailed knowledge of the challenges faced in crop production, but had significant knowledge gaps in terms of pest and disease identification and control. The study demonstrates the importance of integrating local knowledge with scientific knowledge to better understand fine-scale variation in farming contexts and the need of farmers to identify locally relevant entry points for sustainable intensification.

The research by Timler et al. (*this volume*) in Eastern Zambia further explores the entry points for sustainable intensification. The entry points in their study focussed on legume interventions, identified *ex ante* for various farmer typologies, as defined by the presence of legumes and livestock, labour use and off-farm income, through the use of the bio-economic model FarmDESIGN. Taking into account farmers' structural constraints and their objectives to (1) maximize operating profit and organic matter added and (2) to minimize labour requirements, this model revealed different trade-offs and synergies between objectives and confirmed that specific interventions were more suitable for different farm types. For instance, soybeans were found beneficial to low resource-endowed households that spent most labour on land preparation, to medium-to-high resource-endowed households with substantial off-farm income, and to high resource-endowed households with high crop and animal income. Only medium-to-high resource-endowed households with substantial off-farm income could benefit from maize–cowpea intercropping.

In their chapter, Ha et al. (*this volume*) give examples of diversification of mono-cropping with vegetable production as a means of sustainable systems intensification. Because land use is dominated by monocultures of starchy staple crops in Northwest Vietnam, agricultural diversification could improve the livelihoods of farmers in the region. Vegetable production in particular could offer the opportunity to increase household incomes and nutrition from relatively small plots of land and from integration with livestock and agroforestry systems. However, basic production constraints will need to be addressed, including the supply of quality seed of a diverse range of vegetable varieties and integrated pest management. Providing training while addressing production constraints could have a large impact on rural livelihoods in Northwest Vietnam.

While the authors of the chapters mentioned above used various arguments and approaches to define entry points towards sustainable intensification, Woomer et al. (*this volume*) used the legumes soybean and climbing bean as entry points in Western Kenya and evaluated them for their yield, biological nitrogen (N) fixation and potential benefits to farming livelihoods. They identified the following elements to include in future on-farm trials: (1) comparing short- and long-rains performance, (2) evaluating additional new, rust-tolerant soybean varieties, (3) examining different rates of legume-specific fertilizer, and (4) comparing standard and experimental formulations of legume inoculants. Stakeholder-identified issues such as Striga weed elimination, crop diversification (away from maize) and animal enterprise intensification were also found to be key to understanding how improvements in legume enterprise interact with other components of the small-scale maize-based farming and livelihood systems in Western Kenya.

Although authors in general agree that sustainable intensification requires the right entry points, various approaches were used to determine these, varying from open-ended, over classes of entry points (legumes, vegetables), to specific crops (soybean, climbing beans). Recognition that not all entry points will suit all farming families in a specific environment was explicitly addressed in one chapter (Timler et al., *this volume*). The need for varying approaches to experiment with different sets of entry points for different farmer typologies is highlighted by the fact that only two chapters include applied research to validate entry points and just for specific crops. Entry points in all chapters focussed – rightfully, one could argue – on increasing and diversifying farm productivity to address food and nutrition insecurity, but natural resource integrity dimensions were absent from most of the chapters, or implicitly present at best. Pathways towards sustainable intensification will also require investments in natural resources management. Long-term trials are one of the few options to validate the nature (productivity, natural resource status, resilience) of interventions claiming to deliver sustainably intensified smallholder farming systems.

## Nutrition as element in food security

Food security is important for livelihoods improvement and includes nutritional security. Food must reflect the essential elements, nutrients and vitamins that are needed for healthy living. In the case of smallholders, such dietary balance can begin from the diversity in crops, trees and livestock that are managed as part of the integrated agricultural landscape. Farm production must not only be seen in terms of major staples like maize, cassava or rice, but also in the mix of nutritional diversity options it provides. Chiwona-Karltun et al. (*this volume*) addresses the importance of balancing agri-food systems for optimal global nutrition transition, including the importance of nutrition of women and children. The shift towards agri-food systems is in line with integrated agricultural systems thinking, and incorporates food value chain dimensions, with an increasing focus on health and nutrition through agriculture. Chiwona-Karltun et al. (*this volume*) look at the priority of nutritional needs and the specific roles that each group of nutrients have within this context. This is followed by an examination of the evidence around the issues of food security and food safety. The authors emphasize that malnutrition is no longer limited to under-nutrition, but also includes over-nutrition in energy intake leading to obesity and concomitant non-communicable diseases.

At the heart of systems orientation is an emphasis on understanding relationships between changing factors. This necessity has led to the emergence of the nutrition-sensitive landscape approach, which addresses the relationship between nutrition, agriculture and the environment, and aims to identify, quantify and tackle unsustainable trade-offs while generating synergies. This subject is addressed by Kennedy et al. (*this volume*), relating to the conceptual underpinnings, and followed with an overview of approach and methods to assess food availability and diversification of diets. Further analysis of use of the nutrition-sensitive landscape approach for exploring trade-offs and synergies between food and nutrition security, agricultural production, market interactions and natural resources management across temporal (seasons) and spatial (farm to landscape) scales is provided by Groot et al. (*this volume*). It entails multi-disciplinary analyses of how choices of women and men regarding land

and farm management and their food acquisition and consumption patterns affect the food system, nutrition adequacy and ecosystem services.

## The gender and equity dimensions in systems research

Growing acknowledgement among some scholars and practitioners that both agriculture and gender are embedded in how societies and their institutions function provide openings for advancing a more complex, systemic understanding of gender within agriculture. This includes understanding of the relationships and interface between gender and nutrition, and the dynamics embedded in their interactions across varied agro-ethno-ecological zones. This is particularly vital given the differential roles of women and men in relation to addressing nutrition issues in the household and farm systems. Improving household nutrition and health requires a multi-faceted approach dealing with nutrition, income and social aspects such as gender dynamics. Overall developments in economic circumstances and transformational changes in the form of improvements in social inclusion and changes in gender norms and agency require further analysis and study.

There are two levels at which gender analysis is reported in this book. The first level relates to understanding gender norms and agency and involvement of women and men in agricultural research and development, as influenced by traditions, cultures and social regulations. The second level involves the mainstreaming and incorporation of gender dimensions in systems research and technology development, such as in nutrition-based research, through gender-linked treatments or the collection of sex-disaggregated data. Such incorporation and analysis is aimed at better targeting technology development and ensuring that women's and men's roles and benefits are built into the conduct of the research. Aspects and examples of both levels of gender research and analysis are addressed in this book.

A case study that analyzes two cases in gender norms and agency in Uganda out of a large-scale global study is reported in Rietveld (*this volume*). The analysis addresses the question "how do gender norms shape poor men's and women's abilities to adopt and benefit from agricultural and natural resources management (NRM) innovations?" A second analysis of gender research is provided by McDougall (*this volume*), who makes the point that understanding the role of gender in agricultural development research offers much needed new insights for making significant increases in productivity, food security and livelihoods. The chapter by McDougall explores the significance of gender in agricultural systems research for achieving global sustainable development outcomes, including poverty reduction, and increased food and nutrition security. It also focuses on a 'more novel role' for gender as a leverage point for innovations in systems research.

Further analysis and examples linking gender to agricultural systems research are analyzed in other chapters. For example, Sarapura Escobar and co-authors (*this volume*) present the Papa Andina Initiative in Peru as illustrating the role of gender transformative approaches in agricultural innovation. The case suggests that gender transformative outcomes occur when a gender neutral programme design is abandoned in favour of gender responsive processes achieved through participatory and applied methodologies that foster collective work, communication and individual and group learning among diverse groups of stakeholders. All of these processes influence changes in gender norms, perceptions and relations entrenched within social systems, in this case the Central Andes of Peru.

## Systems and institutional innovation

Systems research and development approaches to sustainable agricultural intensification require integrated technological and institutional innovations (Schut van Asten et al., 2016). Examples of technological innovations are new or improved crop varieties, animal breeds, appropriate mechanization, information and communication technology (ICT) and new (farm) management practices. The effective development and uptake of such technological innovations require institutional innovations, for example new forms of stakeholder collaboration and novel policy, business or development strategies. Furthermore, lifting technological and institutional barriers will reveal new limitations (e.g. capacity of the market to absorb increased produce) and unintended consequences (e.g. herbicide resistance of crops), which require further technological and institutional progress. This shows the importance of iterative innovation processes of continuous reflection, learning and adaptation, which is exactly how systems have evolved historically (Geels, 2002). It is therefore no surprise that the performance of an agricultural innovation system – one of the more integrated and holistic systems approaches – is often expressed in the capacity of the system to continuously identify and overcome challenges and proactively explore new opportunities (Foran et al., 2014).

In agriculture, the concept of 'systems' and 'systems research' has different meaning for different people. Leeuwis and Wigboldus (*this volume*) have positioned this query at the centre of their chapter. They argue that the type of systems thinking (e.g. hard versus soft systems; functionalist versus political systems) to a large extent determines what types of research questions, intervention or change strategies, monitoring and evaluation frameworks, and scaling pathways are deemed credible, legitimate and effective. Rather than favouring one systems research approach over another, the authors propose enhancing the leverage and 'actionability' of 'systems research' through the participatory experimentation and systemic evaluation of combined technological and institutional options. This is in line with scientific theories on how change in complex configurations happens, and leaves sufficient space for different conceptualizations of systems research and systems boundaries.

The broadening of systems boundaries and the challenges that creates for measuring the effectiveness of system innovation and multi-stakeholder innovation processes form the starting point of the contribution by Sartas et al. (*this volume*). The authors problematize the lack of generalizable evidence on the effectiveness of multi-stakeholder processes to systems research and development, and present results of the development and testing of a "Learning System for Agricultural Research for Development (LESARD)". LESARD uses online open access tools and data repositories to document and analyze – amongst others – divergence or convergence of stakeholder perspectives; representation of different stakeholder, gender and age groups; and the 'actionability' in the multi-stakeholder process. It provides short-term feedback to facilitators and researchers on whether the multi-stakeholder innovation process is contributing to achieving a diverse range of development outcomes and impacts that allows for critical reflection and increased effectiveness.

Multi-stakeholder platforms are a popular vehicle for supporting multi-stakeholder innovation processes. Especially, so-called 'innovation platforms' are increasingly used in the implementation of agricultural research for development programmes (Dror et al., 2016; Schut, Klerkx et al., 2016). Hiwasaki et al. (*this volume*) reflect on the constraints and opportunities of using interlinked local and subnational multi-stakeholder platforms by presenting experiences from the East and Central Africa, West Africa, Central America and Central Mekong regions. They identify common objectives, appropriate representation of stakeholders and stakeholder engagement building on existing partnerships, secured resources and capable facilitation as success factors. Challenges include: demonstrating 'quick wins' for stakeholders in subnational platforms, strong focus on research over hands-on business and development approaches, limited ability of platforms to steer research for development agendas and resource allocation, limited practical support to implement the platforms, ensuring local ownership and sustainability beyond donor funded projects, and the tailoring of key platform concepts to specific social, political and institutional contexts.

The chapter by Triomphe and colleagues (*this volume*) illustrates the dichotomy between local 'organically-evolving innovation processes' and 'externally-induced innovation interventions' by building on the Joint Learning in and about Innovation Systems in African Agriculture (JOLISAA) programme experience. The chapter concludes that 'externally-induced innovation interventions' through public agricultural research and development organizations dominate the African innovation landscape. However, many farmers actively innovate individually and collectively in 'the social wild', without support through the agricultural research and development systems and often under the radar of researchers, policy or development actors. Rather than institutionalizing specific types of local innovations, the authors propose to strengthen agricultural innovation systems and – in doing so – the capacity to innovate for stakeholders across different systems levels. In that sense, Triomphe and colleagues (*this volume*) provide empirical support to the claim made by Leeuwis and Wigboldus (*this volume*) that understanding the nature and features of 'real' innovation processes can provide an important basis for strengthening innovation systems.

## Lessons learnt and ways forward

Integrated agricultural systems research has gone through progressive steps from its early days as farming systems research to recent studies and analysis of sustainable intensification and diversification of livelihood systems taking into account the variability in context such as farmer typology (resources), bio-physical (soil, climate, etc.), socio-economic and institutional aspects, as well as the nested scales where interventions and change will have to take place (field, farm, community, district/landscape, national, etc.). Farmers are natural experimenters and farmer empowerment emerges across the many examples in this book as a guiding principle. This suggests the need for alignment with national and regional development agendas and policy frameworks. Systems research for impact requires multi-stakeholder engagement and capacity development with the systems researchers well embedded within development processes towards co-learning. The examples also suggest the need for appropriate methods and approaches to identify entry points for interventions aimed at sustainable systems intensification and diversification. Special attention is required on identifying leverage points for change for social equity and gender.

Integrated systems research has an important role in agricultural research for achieving development outcomes and impact based particularly around the goals of food and nutrition security, sustainable intensification and diversification of livelihood systems, gender and social inclusion and enhancing the natural resource base (e.g. soil health, water quality and availability, biodiversity) forming parts of the SDGs towards 2030 and the strategy and results framework of the CGIAR 2016–2030 (CGIAR, 2015). Whilst traditionally the focus has been on productivity enhancement or natural resources management approaches, a wider integrated systems perspective is required. This includes the need for trade-off analysis, working across scales from field-farm-household to socio-economic (institutions, markets, policy), human nutrition and biophysical landscapes (ecosystem services, soil and water management).

The following chapters provide a rich set of approaches to systems research operating at various scales from household to landscape to global scales. These approaches aim at delivering research and development outcomes and impacts. The challenge is now to move forward with the wider application of such approaches. One crucial aspect to successfully implement integrated systems research is further development of monitoring and evaluation systems with indicators that can show what is working, for whom, where, to what extent and how, and with feedback that is fast enough to support co-learning, adaptive management and development of options for specific contexts.

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