Strengthening agricultural biodiversity for smallholder livelihoods

— What knowledge is needed to overcome constraints and release potentials?

Report to Hivos and Oxfam Novib
Background document for the development of a Knowledge Programme

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SUMMARY

Agricultural biodiversity has a great potential to contribute to positive change and strengthening of smallholder farmers' livelihoods. This report aims to identify existing constraints to release this potential. The Dutch development NGOs Hivos and Oxfam Novib commissioned the report as a starting point for discussion, with the specific aim to provide a background for the further development of a Knowledge Programme. The overall goal of the intended Knowledge Programme is to contribute to reducing risks and improving the livelihoods of rural people living in poverty.[1]

Initially, a theoretical framework based on resilience thinking was developed, focussing on factors crucial for positive adaptation and transformation in the social-ecological systems of agricultural landscapes. Consultations with key actors were carried out through a written survey and interviews. Information and feedback were incorporated and analysed in the context of the framework. Relevant literature was identified, consulted, and listed throughout the process. The survey revealed a broad range of successful cases showing how agricultural biodiversity in different ways – through the actions and management of smallholder farmers and their organisations – has contributed to increased wellbeing and strengthened livelihoods as well as more resilient ecosystems. In addition, the survey pointed out key factors behind less successful interventions. A sample of survey cases is presented in the report.

An important observation is that knowledge constraints stressed by respondents refer only to a limited extent to the lack of technical knowledge. Main constraints refer instead to observations that farmers' knowledge and experiences related to agricultural biodiversity have not (yet) been translated sufficiently into policies and strategies relevant to development organisations working in the South. A related constraint is that existing policies are often perceived as inadequate or even conflicting. We argue that it would be possible to address some of these constraints by focussing on the windows of opportunity for positive change, and promoting knowledge for empowerment and catalysing transformation. Overall, applying social-ecological systems' and resilience thinking as a means of visualising reality can be a useful tool in the context of governance and management of agricultural biodiversity.

Analyses of the factors behind success cases and the various constraints actors have faced show that niches and opportunities for a future Knowledge Programme on Strengthening agricultural biodiversity for smallholder livelihoods can lie in 1) creating enabling environments that allow for experimentation and innovation in social-ecological systems, 2) promoting empowerment through learning and other means, 3) linking local actions to the regional and/or global level, and 4) contributing to systematic documentation of much needed evidence, and to promote the bridging of organisations to support the development of more accurate policies.

An overarching matter seems to be to address power-related issues in all interventions and efforts, to help answer the question: How can power relations be tipped towards equity?

[1] Hivos & Oxfam Novib. 2011. Terms of Reference Mapping study. Sustainable Agriculture, biodiversity management, climate change adaptation and mitigation. A Hivos-Oxfam Novib Knowledge Programme.

1. INTRODUCTION

1.1. Background

The Resilience and Development Programme (SwedBio) at the Stockholm Resilience Centre was assigned by Hivos and Oxfam Novib to identify knowledge constraints related to the role of agricultural biodiversity for smallholder farmers' livelihoods, with the aim to contribute to the development of a new Knowledge Programme. (*See Annex V, Terms of Reference*).

The overall goal of the forthcoming Knowledge Programme is to contribute to reducing risks and improving the livelihoods of rural people living in poverty[2], through focusing on the role of knowledge.

Given the vast topic and the limited amount of time we found it necessary to focus our efforts during the mapping process. The choice was to focus on the flow of knowledge rather than on technical gaps, and this was done by illustrating the role of knowledge in processes for initiating positive change.

We have judged it more appropriate to discuss knowledge *constraints* – e.g. bottlenecks that hinder positive transformations – rather than knowledge *gaps*, to indicate that we identify the core of the matter not so much a lack of knowledge *per se*, but rather that the main issue is to make sure that the right knowledge for a certain context is made available. This is closely linked to empowerment of the people and organisations that will use the knowledge.

The number of hungry people has, in spite of all intentions to counter this problem, been rising rapidly over the past decade. The persistence of hunger and malnourishment and its aggravation during the recent food and economic crises underscore the need for improved global as well as national food-security governance.

The Earth's biodiversity, including the agricultural biodiversity – agricultural landscapes, species, varieties, breeds, crop and livestock wild relatives, pollinators, microorganisms, and genes – is disappearing at an alarming rate, and with it the knowledge embedded in its management and use. Despite the urgency, we have not been able to slow down the rate of the loss, nor to spread and make use of the knowledge societies already possess. At the same time, interest in the commercial use of genetic resources has increased, followed by demands on intellectual property rights. Many studies show that the millions of smallholder farmers, and livestock keepers worldwide, who are the custodians of diversity and holders of traditional and indigenous knowledge related to biodiversity, have limited possibilities to benefit from this development.[3,4,5]

1.2. Methodology

The knowledge mapping was carried out in a three-step approach: 1) a theoretical framework was developed, based on resilience thinking; 2) consultations were carried out to capture views and perspectives from actors in the field; and 3) results and suggestions were analysed in the light of the framework, and a draft report produced.

Relevant literature was identified, consulted, and listed, throughout the whole process (*see Annex I, References*).

In this report, the use of the term "farmer" is intended to reflect the diversity of cultures and human societies that have created and managed the agricultural diversity, including livestock keepers,

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[2] Hivos & Oxfam Novib. 2011. Terms of Reference Mapping study. Sustainable Agriculture, biodiversity management, climate change adaptation and mitigation. A Hivos-Oxfam Novib Knowledge Programme.

[3] Commission on Intellectual Property Rights. 2002. Integrating Intellectual Property Rights and Development Policy.

[4] R. Andersen. 2008. Governing Agrobiodiversity. Plant genetics and developing countries. Ashgate.

[5] G. Tansey and G. Rajotte 2008. The Future Control of Food. A Guide to International Negotiations and Rules on Intellectual Property, Biodiversity and Food Security.

pastoralists, fisherfolks, and others. For explanation of some frequently used terms and concepts, see Annex II, Glossary.

1.2.1. Theoretical framework

A theoretical framework, based on *resilience* thinking and visualising a process of *adaptation* and *transformation* in smallholder farmers' agricultural systems, was developed in line with the Terms of Reference, and in consultation with researchers, including Dr Per Olsson and Dr Thomas Hahn of the Stockholm Resilience Centre. The framework focuses on where possible constrains related to knowledge can be expected to occur, and where strengthened knowledge can possibly contribute to positive system transformation.

The aim of this theoretical framework is to assist in understanding the role of agricultural biodiversity for food security, risk reduction and improved livelihoods, and as a means for recognising constraints to and possibilities for positive change in the process of adaptation, exchange, and internalisation of knowledge. The framework was not initially developed to reflect on policy and power issues related to agricultural biodiversity and smallholder farmers, as knowledge *per se* was the specific focus of the Terms of Reference. During the mapping process, however, it became evident that power is viewed as an overarching topic, crucial to address regardless of the nature of the knowledge constraint in question. Survey respondents and participants at the key actors meeting in Kenya all stressed this fact. The theoretical framework was therefore expanded on to the current state; to take into account examples of how resilience theory can address power related issues. This field of research is under development (see sections 2.2.7 and 4.6.6).

1.2.2. Consultations

Consultations were carried out to capture views and perspectives from actors in the field, including representatives from NGOs, CSOs, international organisations, and academic institutions. Information was gathered through a questionnaire and live interviews, as well as from seminars and other information sharing events.

A strategic aim was to identify areas in which key civil society actors can act as bridging organisations to link different knowledge paradigms and levels of interventions, and to identify constraints to positive transformation. In doing this, potential opportunities for a Knowledge Programme based on an interface between practice, policy, and science, can be detected. Organisations and institutions were selected on recognized expertise in fields related to agricultural biodiversity, smallholder farmers' livelihoods, food security, and development. Coverage is not exhaustive, but rather focuses on addressing a broad range of aspects and organisations.

Taking departure in the theoretical framework, the process of consultation with key actors was carried out through 1) a survey questionnaire (Annex III); 2) semi-structured interviews; 3) participation in selected international network meetings and workshops arranged by civil society organisations (Kenya, May; Sweden, June; Philippines, August)[6] and 4) participation in international meetings arranged by UN agencies (the Convention on Biological Diversity: expert meeting on customary sustainable use in Montreal in June, and the Thirteenth Regular Session of the Commission on Genetic Resources for Food and Agriculture, in Rome in July). In formulating questions for the written survey, we focused on finding ways of seizing information related to the processes of transformation and learning, defining key factors behind success stories, and also understanding the bottlenecks, the barriers to change. Questions were deliberately formulated in an open-ended way.

In all, survey responses and interviews cover 39 organisations, including 14 from Africa, 9 from Asia, 1 from Latin America and 15 with a global scope. 28 respondents are civil society organisations, 3 academic institutions, 4 UN Agencies, and 4 national governments. Given the limited timeframe for this

[6] Meetings arranged by 1) in Kenya: Ecoagriculture partners, COMESA, TerrAfrica, SwedBio; 2) in Sweden: Indigenous Terra Madre; 3) in the Philippines: SEARICE Programme Inception and Monitoring and Evaluation Workshop.

mapping study, we believe that the coverage was reasonable and fairly representative. More time and resources would of course have allowed for a more extensive coverage, including more interviews and individual follow-up. Latin America is represented by only one respondent, a fact that constitutes a regrettable limitation in the context of this mapping study.

Additional consultations were made and background information collected during workshops, seminars, side events, and plenary sessions of the mentioned meetings, and through regular seminars at the Stockholm Resilience Centre. The process of consulting key actors was followed by further refinement of the theoretical framework, and knowledge constraints and windows of opportunity were identified and categorised in line with this.

The draft report was presented at a peer assist session at the second Global AgriKnowledge Share Fair at IFAD, Rome in September 2011. An actors' meeting was held in Thika, Kenya in October 2011, where the draft report and its conclusions were presented and the way forward was discussed (see separate Workshop report, forthcoming). The draft report was also circulated through Bioversity International's Platform for Agricultural Biodiversity Research (PAR), leading to additional valuable feedback from various actors.

1.2.3. Literature

The selection of literature was guided by feedback from Hivos and Oxfam Novib partners, other respondents, and resilience researchers' view of strategic cutting-edge publications. Focus lies on literature with an interdisciplinary approach to agricultural biodiversity, and publications after the year 2000. However, a collection of classic literature – older publications on agricultural biodiversity that have remained valid as basic references, and which has been repeatedly identified during this work – has also been included. Given the extensive scope and interdisciplinary approach of this mapping study, and the vast number of publications available, the list of publications does not claim to cover the field in a comprehensive way. The mapping of knowledge and the selection of literature has rather focussed on providing entrance points for where actors will have most potential to contribute to the sustainable conservation, development, use and sharing of benefits from agricultural biodiversity, and point to possible catalysts for successful interventions for a Knowledge Programme, making maximal use of these organisations' respective skills.

1.4. A new Knowledge Programme

Based on this report, the results from the actors' meeting in Kenya in October 2011 (*report forthcoming, see www.hivos.net*), and additional consultations, Hivos and Oxfam Novib will develop the outline of the proposed Knowledge Programme on "Strengthening agricultural biodiversity for smallholder livelihoods".

2. AGRICULTURAL ADAPTATION AND TRANSFORMATION – A THEORETICAL CONTEXT

2.1. Background

There is a vast amount of knowledge embedded in the management of agricultural biodiversity and agricultural systems. Farmers around the world show impressive skills in adapting agricultural systems to their local conditions, and have over time created the enormous variation in cultivated plants, livestock breeds, and agricultural landscapes upon which we all depend. Farmers are now facing new and additional challenges in adapting to the changing global conditions. Climate change; social and ecological regime shifts (*see 4.2.2*); together with market-related changes, peaking or volatile prices, reduced availability of inputs (e.g. oil and phosphorous), and more, are only some of the issues that will require new coping strategies.

In addition, the world at large is looking with increasing interest at agriculture. There is increasing pressure on agricultural lands, with new and altered demands from consumers. Feed and fuel crops have increased in demand on the global market, while sufficient production of food crops is crucial to feeding a growing world population.

Generating new knowledge on agricultural practises and biodiversity management of particular relevance for smallholder farmers is important. However, exchanging knowledge and transferring knowledge over generations or between systems, as well as adapting existing knowledge to altered conditions, will be equally important. Processes that lead to internalisation of knowledge (learning) ought to have greater chances to succeed.

2.1.1. Agricultural biodiversity

Agricultural biodiversity is a broad term that includes all components of biological diversity of relevance to food and agriculture, and all components of biological diversity that constitute the agricultural ecosystems: the variety and variability of animals, plants and micro-organisms, at the genetic, species and ecosystem levels, which are necessary to sustain key functions of the agro-ecosystem, its structure and processes.[7]

Crop and livestock diversity have been developed by humankind during at least the last 10,000 years. Through thousands of years, farmers and livestock keepers have shown impressive skills in adapting agricultural systems to local conditions. The variation in cultivated plants and livestock breeds, as well as the agricultural landscapes on Earth, is impressive. Out of the around 30,000 known edible plant species,[8] about 7,000 have been used in agriculture for food and fodder. Today, less than 2 per cent of these are recognized as economically relevant at the national and global levels.[9] Currently, 30 cultivated plant species provide 90 per cent of all the human food derived from plants, and 12 plant and five animal species together provide 70 per cent of the human diet.[10] Such a narrow nutritional basis puts sustainable food security at risk.

In the context of crops and domestic animals, diversity within species is as important as diversity between species. This intra-species diversity has greatly expanded through agricultural practises and management. However, with current trends in agriculture, two major concerns have been raised with regard to crop and livestock genetic diversity: increasing levels of genetic vulnerability, and genetic erosion.

Vulnerability occurs where a widely used and genetically similar crop variety develops susceptibility to a pest or pathogen that threatens to create widespread crop losses. This is a common tradeoff from

[7] Convention on Biological Diversity. COP decision V5, annex.

[8] FAO 1998. The state of the world's plant genetic resources for food and agriculture. FAO. Rome.

[9] Bioversity International, http://www.bioversityinternational.org/

[10] FAO 2010. The Second Report on the State of the World's Plant Genetic Resources for Food and Agriculture. FAO. Rome.

agricultural production systems based on large-scale monocultures. With regards to livestock, a more genetically uniform livestock population may be more vulnerable to severe epidemics. Another aspect is when high-output livestock breeds are moved into production systems in which they are challenged by diseases to which they lack genetic resistance.[11]

Crop varieties are always being abandoned, lost and changed, even in farming communities that rely on traditional varieties. This does not necessarily lead to genetic erosion. However, loss of diversity through genetic erosion is an on-going and very relevant concern. This implies loss of genetic variability by means of extinction of a crop cultivar or livestock breed, or by loss of genes within a cultivar or a breed that is not extinct but has a narrow breeding base. Without proper management and maintenance of a broad diversity of species, cultivars, and breeds within crops and livestock in the agricultural systems, key functions of the agricultural ecosystem may be lost. To add to this picture, there is also a strong concern globally about genetic erosion of crop wild relatives caused by habitat loss, fragmentation, pollution, and other human-induced pressures on wild populations.

2.1.2. Resilience theory

It has become more important, and accepted, to understand that we live in a highly interconnected world, and that everything we do has an effect downstream, or on related systems. It is therefore crucial to take a holistic approach, i.e. addressing social-ecological systems – of which indeed agricultural systems are great examples – as what they truly are: interconnected and interdependent, inseparable in their ecological and social components. Resilience theory can provide a framework and tools for addressing and enhancing households' capacity to deal with changes, slow or abrupt, i.e. building resilience in a positive sense.

Resilience has increasingly been acknowledged as an important factor in determining ecosystems' capacity to continue generating ecosystem services in a world increasingly influenced by global environmental change. Resilience can be defined as the capacity of a social-ecological system to withstand perturbations from e.g. climate or economic shocks and to rebuild and renew itself afterwards, without shifting into a qualitatively different state. There is a strong correlation between biodiversity and an ecosystem's resilience, and its ability to deliver ecosystem services.[12]

KEY TERMS (*see also Annex II, Glossary*)

ADAPTABILITY is the capacity of the actors in the system to manage resilience in order to stay within a desired state during periods of change.
REGIME refers to a set of state in which a system exists while having the same basic structure and function. Most social ecological systems can have more than one regime in which they can exist.
A REGIME SHIFT happens when a social-ecological system crosses a threshold to another regime, with a different structure and function. A resilient system has a greater capacity to avoid unwelcome surprises such as regime shifts.
RESILIENCE can be defined as the capacity of a social-ecological system to withstand perturbations from e.g. climate or economic shocks and to rebuild and renew itself afterwards, without shifting into a qualitatively different state.
Ecosystem resilience is a measure of how much disturbance (like storms, fire or pollutants) an ecosystem can handle without shifting into a qualitatively different state. It is the capacity of a system to both withstand shocks and surprises and to rebuild itself if damaged.
Social resilience is the ability of human communities to withstand and recover from stresses, such as environmental change or social, economic or political upheaval. Resilience in societies and their life-supporting ecosystems is crucial in maintaining options for future human development.
SOCIAL-ECOLOGICAL SYSTEMS are linked systems of people and nature. The term emphasises that humans are a part of, not apart from, nature — and that the delineation between social and ecological systems is artificial and arbitrary.
TRANSFORMABILITY refers to the interaction of the social and natural realm and is the capacity of people in a social-ecological system to transform that social-ecological system into a different kind of system.
TRANSFORMATION - A change that results in a fundamentally new system.
VULNERABILITY refers to the propensity of social and ecological systems to suffer harm from exposure to external stresses and shocks.

[11] FAO 2007. The state of the world's animal genetic resources for food and agriculture. FAO. Rome.
[12] Adapted from Resilience and Sustainable Development: Building adaptive capacity in a world of transformations. (Skriftserie 2002:1)

Resilience research focuses to a large extent on the dynamics and feedbacks between people and nature in the so-called social-ecological systems that they make up. Social-ecological systems are linked systems of people and nature. The term emphasises that humans are a part of, not apart from, nature — and that the delineation between social and ecological systems is artificial and arbitrary. One important element in resilience theory is the concept that social-ecological systems can have multiple regimes, separated by thresholds. Crossing a threshold means entering a new regime with a different structure and function (regime shift).[13]

Examples of regime shifts include a coral dominated system in clear water, which following eutrophication and overfishing shifts into a system with turbid water and algae dominance, with a new set of functions and feedbacks, e.g. no longer providing the environment that many fish require to reproduce successfully. Another example is when a grassland system turns into shrub-bushland through a combination of grazing pressure effects and the lack of fire, leading to a qualitatively different state that may no longer provide the same possibilities to feed livestock populations.[14] Both examples of course have implications for individuals and communities dependent on resources from the systems, in these cases e.g. fish catch and grazing grounds for livestock.

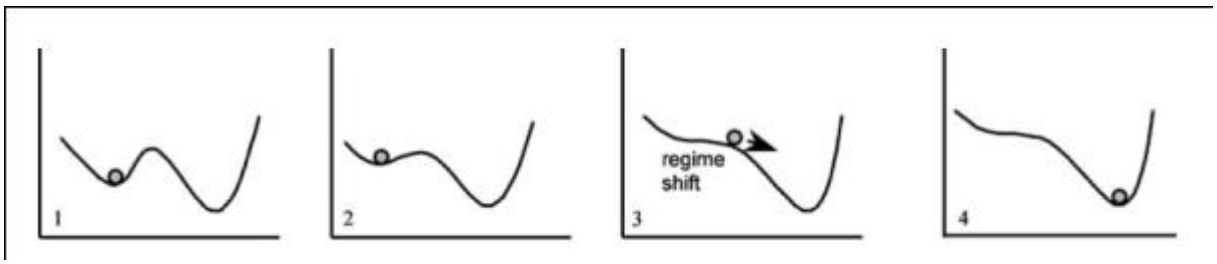

Figure 1. The »ball and cup« model illustrates resilience loss followed by phase shifts. 1: Original system state. 2: The »stability domain« is affected by various changes in the environment and/or in management practices that reduce the resilience of the system (the cup becomes shallower). 3: A disturbance that previously could be absorbed moves the system into an undesirable state with a loss of ecosystem services. 4: The system is essentially locked in an undesirable state generating fewer ecosystem services to society. The ball resembles the state of the ecological community and the cup is referred to as the »stability domain« or »basin of attraction«. The stable state of the system is at the bottom of the cup but can be moved up along the side of the cup by a disturbance. The shift from one stability domain to another involves passing a threshold (adapted from Deutsch et al. 2003, Folke et al. 2004).[15]

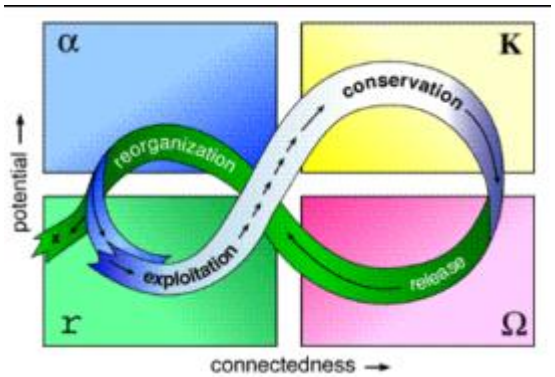

Figure 2.The adaptive cycle (from Gunderson and Holling 2002).[16]

Another important element in resilience theory is the *adaptive cycle*, which describes how social-ecological systems behave over time – going through cycles of growth and conservation, followed by release and renewal. These adaptive cycles operate at different scales (from the micro- to the global level). The links between these different scales are crucial since whatever happens at one scale can influence or even drive what happens at other scales.

[13] C. Folke et al. 2004. Regime Shifts, Resilience, and Biodiversity in Ecosystem Management. Annual Review of Ecology, Evolution and Systematics

[14] Ibid..

[15] M. Huitric (Ed.) 2009. Biodiversity, Ecosystem Services and Resilience – Governance for a Future with Global Changes. Background report for the scientific workshop »Biodiversity, ecosystem services and governance – targets beyond 2010« on Tjärnö, Sweden, 4-6 September 2009.

[16] C.S. Hollings. 2004. From Complex Regions to Complex Worlds. Ecology and Society.

A simplified adaptive cycle, showing the different phases of a forest. The growth and conservation phases are commonly described as forest succession. Fires can be viewed as disturbances, or as an agent of creative destruction by which accumulated structure is released. Fires are quickly followed by a renewal or reorganization phase in which seeds, remnant vegetation and other mechanisms lead to a new growth phase.

Figure 3. The Adaptive Cycle and forest renewal through fire and succession. From RAWorkbook: Community Portal, http://wiki.resalliance.org/index.php/Forest_fires_-_an_ecological_example_of_the_adaptive_cycle

It should be noted that resilience in itself is not necessarily desirable. A social-ecological system in an undesirable state (such as a depleted fishery, a salinized landscape, or a poverty trap) can be described as highly resilient in the sense that it resists all efforts to move the system out of that state.[17] This use of the term resilience relates mainly to the interpretation that resilience is the capacity to bounce back to a "normal" condition or "equilibrium" state after disturbance. However, resilience can also be described as the long-term capacity of a system to deal with change and continue to develop. This report emphasises the resilience framework in the latter sense: the long-term capacity of a system to deal with change and continue to develop.

One major challenge lies in changing the current development paradigm where we have increased human wellbeing at the cost of ecosystem degradation, to instead promote and apply a landscape perspective approach that allows for the development of parallel increases in wellbeing and status of the ecosystems on which we all depend.[18]

2.2. Resilience theory and agricultural biodiversity management – towards a system approach for catalysing desired change

Over time, social-ecological systems, including the people and nature they consist of, shape and reshape landscapes, seascapes, plant and animal populations, and genetic resources. Farmers are strongly influential in shaping their landscape, and are at the same time affected by changes at all levels. They have been, and are constantly, developing coping strategies to address changes in their surroundings, leading to further adaptation or transformation of their systems. We will attempt to illustrate the process of possible adaptation and/or transformation of farmers' management of agricultural biodiversity to changing conditions, such as an altered climate or changes in policy. In the different phases of change, we aim to identify knowledge constraints –noted as bottlenecks in the adaptation or transformation process towards positive change *(see chapter 4, Results and analysis)*. In the context of these constraints, our ambition is to identify potential strategic interventions for a Knowledge Programme. The mapping of current knowledge focuses on the potential for maintaining and improving biodiversity, ecosystem services, and food security, and for strengthening the resilience of the social-ecological systems of smallholder farmers, their organisations and their surrounding environments, in the sense of their long-term capacity to deal with changes and continue to develop.

[17] B. Walker and D. Salt. 2006. Resilience Thinking. Sustaining Ecosystems and People in a Changing World. Island Press.

[18] C. Raudsepp-Hearne et al. 2010. Untangling the Environmentalist's Paradox: Why Is Human Well-being Increasing as Ecosystem Services Degrade? BioScience.

Using a resilience theory approach can contribute to improvements in the way actors address changes in agricultural landscapes. It is also a relevant tool for enhanced understanding and action related to present concerns regarding food security, in particular when analysing systems' transformations, and questions such as how and why changes take place. The following section highlights some key elements of change in coupled social-ecological systems.

2.2.1. System transformation

When internal or external factors lead to major changes in the system, adaptation may not be enough or even possible, leading to *transformation* of the social-ecological system. System transformations take place across the world, some positive for sustainable development and poverty alleviation, and some quite the contrary. One of the biggest challenges lies in catalysing change to achieve positive transformation.

Large-scale changes have been, and continue to be, initiated without sufficient knowledge on what they will entail. One example is the Green Revolution in Asia, where the positive outcome was quite obvious; namely the capacity of the systems to pull societies out of hunger by means of more productive agricultural systems and therefore higher yields. What we know now is that this came at a very high, but not as apparent, cost in terms of undesired side effects. Examples include ecosystem degradation and biodiversity loss, e.g. coral reef degradation due to nitrogen runoff from chemical fertilizers on agricultural land.[19]

Human-induced large-scale transformations have often resulted in loss of ecosystems' capacity to provide the ecosystem services they used to,[20] naturally a loss also for the human population. People who are more directly dependent on ecosystem services, such as smallholder farmers, livestock keepers and fisherfolk, can face more severe and direct impacts than others. A few ecosystem services can be replaced by technical innovation (water purification), some by labour intense interventions (pollination, only true for some crops) – but a number of ecosystem services, if lost, can be irreplaceable (food production, the recreational value of a landscape, and more).

2.2.2. How do transformations take place?

In relation to transformation, the big question lies in the "*how*". How do transformations take place in linked social-ecological systems? How can change for positive transformation be initiated?
There is currently no clear framework for studying the "how" in transformations related research on coupled systems.[21] Scientists are working on developing a functioning structure, merging views from research on social innovation, transformation management, and resilience theory addressing social-ecological systems.

Of relevance in this context is the tendency that research often focuses on describing bad cases; this is what can happen if an ecosystem gets degraded, this is what can happen if we use a lot of pesticides, this is what can take place if we over-harvest our lakes or our oceans; but not as much bring forward the positive cases. The negative examples tend to drown known success stories and optimistic scenarios. Scientists sometimes also show reluctance in being normative or prescriptive, despite consensus around some issues like minimizing the use of pesticides, using the correct amount of fertilizer to enhance yield with minimum runoff, to name but a few.

2.2.3. Knowledge transfer and upscaling

[19] P. B. R. Hazell. 2010. Asia's Green Revolution: past achievements and future challenges. In Sushil Pandey et al. (Eds.) Rice in the Global Economy: Strategic Research and Policy Issues for Food Security.
[20] B. Walker and D. Salt. 2006. Resilience Thinking. Sustaining Ecosystems and People in a Changing World.
[21] F. Westley et al. 2011. Tipping Toward Sustainability: Emerging Pathways of Transformation. Ambio.

The mechanisms of how learning takes place are still somewhat poorly understood.[22] This is an area where more research is needed, especially in the light of upscaling of existing and successful projects. The concept of *social learning*, when people engage with one another, share diverse perspectives and experiences to develop a common framework of understanding and basis for joint action, may come in particularly useful in the context of strengthening smallholders and their farming systems.

2.2.4. Identifying champions

Current research indicates that institutional entrepreneurs, in literature often referred to as champions,[23, 24] connected to each other in social networks, are crucial for successful change.[25] Many times it boils down to something that sounds simple enough in theory but is something quite hard to achieve in real life: having the right people in the right place at the right time. Taking advantage of the windows of opportunity. Persistence. Innovation theory in sociology and other research refers to micro agency and macro structure to describe the importance of individuals who are able to see and act on these golden moments.[26]

Resilience theory can help us understand the source and role of change in systems, particularly the kinds of changes that are transforming and take place in systems that are adaptive. Such changes are evolutionary and comprise economic, ecological, and social systems. They concern rapidly unfolding processes and slowly changing ones; gradual change and episodic change; and they take place and interact at all scales, from local to global. Linkages across scale are still poorly understood and acted upon, and remain a focus of current research.

2.2.5. Causal loop analysis

Understanding the dynamics of coupled systems is key for understanding the question "how" in relation to system transformation.

Below is an example of recent SRC research exploring feedback mechanisms by carrying out causal loop analyses. Understanding these feedback mechanisms may help in guiding towards more successful interventions, to lead to transformation of a system and to allow people to escape from poverty traps. Field studies for this research project were carried out in the Makanya catchment in Tanzania.

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[22] D. Armitage et al. 2007. Adaptive co-management and the paradox of learning. Global Environmental Change.

[23] H. Reid et al. 2010. Community Champions: Adapting to Climate Changes. IIED.

[24] S. L. Yaffee et al. 1997. Factors that promote and constrain bridging: A summary and analysis of the literature.

[25] Dr P. Olsson, SRC. Pers. ref.

[26] P. Olsson et al. 2004. Social-Ecological Transformation for Ecosystem Management: the Development of Adaptive Co-management of a Wetland Landscape in Southern Sweden. Ecology and Society.

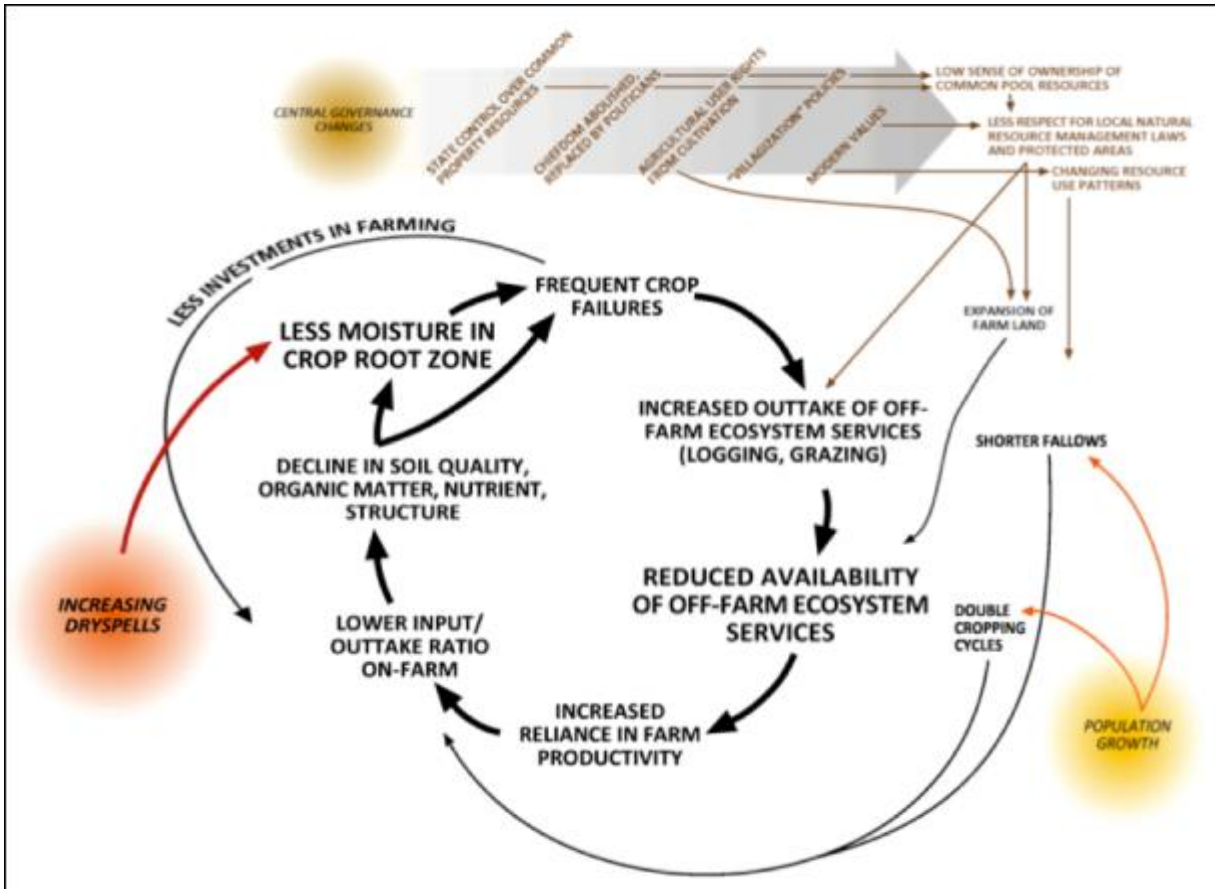

Figure 44. Illustrating how 3 drivers for change (population growth, increasing dryspells, and central governance changes) have interacted with a set of key system variables in a process that over time has reduced the productive potential in the agricultural system. The figure can also illustrate how external forces (e.g. improper policies, and unclear tenure rights) can dominate and impede on communities' efforts to improve their systems. (Illustration from E. Enfors. 2009. Traps and Transformations. Exploring the Potential of Water System Innovations in dryland sub-Saharan Africa)[27]

Once this kind of feedback mapping, or causal loop analysis, has been carried out – preferably in a setting including local stakeholders – and barriers to system improvement/transformation identified, it becomes more straightforward to find ways of influencing development towards a more positive state of the system. A barrier can be something as simple or easy to understand as the lack of rainfall, or lack of human resources to carry out a certain task, or lack of appropriate seed. But it can also be lack of ideas, or a system where innovations are not promoted but instead impeded. In many cases, however, it becomes apparent that barriers lie far beyond the local system, e.g. in governance structures, the policy environment, with trade/market actors, or in unequal access to resources and power. The example above illustrates one way of how current research addresses the challenge of understanding complex social-ecological systems and processes. Mapping of social-ecological systems, including feedback loop analyses, can be a useful method for societies or organisations to better understand their local systems. Identifying the key factors that drive change can in turn improve the base for action.[28]

2.2.6. Multi-level transformation

Great initiatives leading to success can be found all over the world, but they do not seem to change things at a larger scale.[29] Why is that? Why don't they make a bigger difference? How can we make sure that they have greater impact?

[27] E. Enfors. 2009. Traps and Transformations. Exploring the Potential of Water System Innovations in dryland sub-Saharan Africa.

[28] Resilience Alliance. 2010. Addressing resilience in social-ecological systems: Workbook for practitioners. Version 2.0.

[29] L.D. Danny Harvey. 2000. Upscaling in Global Change Research. Climatic Change.

When identifying the barriers to change by creating a feedback map of the local system, it is not uncommon to end up with the answer that transition to a better system is hindered by barriers out of reach for the scope of the local situation.[30] This illustrates a notion we frequently came across during the mapping process; even when valuable knowledge and possible solutions exist, efforts to change an existing system can easily be overruled by e.g. power structures and dysfunctional policies (*see figure 4 above*).

Bridging organisations could play an important role to overcome this kind of constraints in the struggle to achieve positive transformations.[31]

2.2.7. Analysing power relations

Critique has been raised that the concept of power has not yet been sufficiently addressed in resilience theory. However, power relations can be identified as a crucial constraint in realising potentials for positive change for smallholder farmers and the agricultural landscapes they are managing.

As G. Peterson (2000) argues, ecological and social dynamics operate across a variety of scales and so does political power. Scientists have defined three dimensions of political power: overt, covert, and structural.[32] These three dimensions of power illustrate three scales at which power operates.

Overt power is the direct wielding of power through force, incentives, or intimidation to influence people's decisions. Overt power operates in the here and now because it requires mobilized people, and by necessity, it occurs over brief periods at specific locations.[33] This could be a smallholder farmer facing charges for 'illegally' selling a variety of their saved seed in a nearby village. Although the custom of selling farmer saved seed has a long tradition, a new seed certification act has prohibited this action, as the seed is not legally certified.

Covert power removes the opportunity for people to behave in specific ways by controlling what type of decisions can be made. Covert power operates by controlling whether issues are discussed or addressed by an institution. For example, when a dam building agency ignores native treaty rights and destroys native fishing areas.[34]

Structural power is the slowest and broadest scale type of power. Structural power is the ability of the institutions of a society to restrict the set of issues about which people think they can make decisions. Structural power involves manipulating culture, which is slow to change, and likely operates over a broader area than an individual institution. Because it determines what concepts are even considered, and therefore requires a group that is relatively insulated from external ideas.[35] An example of structural power can be when pesticide companies ignore informing the public about necessary precautions for protection of public health and the environment – or even sell prohibited substances – and no one questions this structural set-up. Communities may not be aware that they have rights or that things could be different, and local authorities may neglect controlling and holding the companies accountable.

This kind of reasoning might be helpful in understanding and formulating why, for example, it can be difficult to implement internationally agreed decisions on national and local levels.

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[30] Resilience Alliance. 2010. Assessing Resilience in Social-Ecological Systems: Workbook for Practitioners.

[31] M. Huitric (Ed.) 2009. Biodiversity, Ecosystem Services and Resilience – Governance for a Future with Global Changes. Background report for the scientific workshop »Biodiversity, ecosystem services and governance – targets beyond 2010« on Tjärnö, Sweden, 4-6 September 2009.

[32] S. Lukes, 1973. Power: A Radical View. Macmillan, London.

[33] G. Peterson. 2000. Political ecology and ecological resilience: An integration of human and ecological dynamics. Ecological Economics.

[34] Ibid.

[35] Ibid.

3. CURRENT DEBATE FOCUS – HOW TO FEED THE WORLD

Food security for all is a key goal for the global society at large. The World Food Summit in 1996 set as the main target to reduce the number of undernourished people to half no later than 2015. In addition, the first of the Millennium Development Goals is to eradicate extreme poverty and hunger.

The number of hungry people has, in spite of all intentions to counter this problem, been rising rapidly over the past decade. The persistence of hunger and malnourishment and its aggravation during the recent food and economic crises underscore the need for improved global as well as national food-security governance.

Some issues of the current debate have been identified as central for the focus of this mapping study:

- What agricultural systems may be capable to feed the world by the year 2050?
- Sustainable agricultural intensification is often referred to as part of the solution to the above question. But what does this concept entail?
- How does a rights-based approach to food security and food sovereignty impact on the possibilities to feed the world and support smallholder farmers development?

An increasing world population will put further pressure on agriculture through rapidly rising food demand – expected to increase by 70 per cent by 2050 – in order to eradicate hunger in a world population of 9 billion people by 2050.[36] This expected increase is to a large extent attributed to a change in diets, with the global population consuming food with a higher proportion of meat and other animal based food than before. The planetary boundaries analysis[37, 38] suggests that the degrees of freedom are limited for future expansion of crop land, freshwater use and extraction of phosphorus for food production; while extraction of nitrogen from the atmosphere (for fertilizers) and loss of biodiversity rates need to come down very rapidly. Food for a growing world population within the planetary boundaries will require a new 'planetary food revolution' that meets several challenges:[39]

- On aggregate, contributes to remain within the safe operating space of the planetary boundaries, particularly with regards to the rate of loss of biodiversity, land-use change, freshwater use, interference with the global nitrogen and phosphorus cycles, and climate change.

- Increased efficiency and productivity of a broad spectra of ecosystem services, including – but not limited to – food, in the agricultural landscapes through the integration of innovative ways of managing land, water, crops, livestock, and nutrients, while strengthening the resilience of agricultural landscapes by simultaneously increasing biodiversity.

- Optimising efficiency in the food chain, from harvest through processing to consumption and recycling, food supply can increase with much less damage to the environment, similar to improvements in efficiency in the traditional energy sector.[40]

- Increased attention to consumption patterns for reaching efficiency in resources use and to consider distribution, equity and rights aspects including the link between 'development' and the possibility of a growth in consumption by the world's poor majority.[41]

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[36] FAO 2006. World agriculture towards 2030/2050: Interim Report. FAO. Rome.

[37] J. Rockström et al. 2009 a. A safe operating space for humanity. Nature.

[38] J. Rockström et al. 2009 b. Planetary Boundaries: Exploring the Safe Operating Space for Humanity. Ecology and Society.

[39] J. Rockström and M. Schultz. 2011. Contributing to Resilience. Chapter in Djoghlaf, A. and F. Dodds. 2011. Biodiversity and Ecosystem Insecurity: A Planet in Peril.

[40] C. Nellemann et al, 2009. The Environmental Food Crisis – The Environment's Role in Averting Future Food Crises: A UNEP Rapid Response Assessment.

[41] J. Rockström and M. Schultz. 2011. Contributing to Resilience. Chapter in Djoghlaf, A. and F. Dodds. 2011. Biodiversity and Ecosystem Insecurity: A Planet in Peril.

There is a risk that, in a context dominated by the fear of food shortage, and thus in the name of increasing production, the need for both social and environmental sustainability of the solutions devised will be underestimated. As de Schutter writes: "One indicator of the reality of the risk is the almost complete silence in international discussions about the conclusions of the International Assessment of Agricultural Knowledge, Science and Technology for Development[42,43], sponsored by the FAO and the World Bank that concludes the way the world grows its food will have to change radically to better serve the poor and hungry if the world is to cope with a growing population and climate change while avoiding social breakdown and environmental collapse".

Feeding the world will remain not only a challenge of production, but also an issue of distribution, consumption patterns and equality. Sufficient food production does not guarantee food security by itself. Chapell and LaValle (2011) highlight the disproportionate research focus on "*availability*", and the lack of focus on the other aspects of food security,[44] such as access, stability, and quality/nutritious values.

3.1. The right to food concept

In the context of the current debate several approaches have been developed that put a stronger emphasis and focus on what could be referred to as the "agency" component of the food security concept. Important elements include food sovereignty, right to food and food justice. These approaches aim to focus on strengthening peoples' livelihoods in a broader sense, and view food production and consumption as intimately linked. They also take into account the cultural identities of food producers in a broad sense (farmers, pastoralists, livestock keepers, fisherfolk, hunters and gatherers, urban producers), and value that these same people are the managers and custodians of the world heritage of agricultural biodiversity.[45] These rights-based approaches to food security are based on the recognition that poverty, social exclusion, and a lack of participation in political decision-making processes are the main causes of food insecurity worldwide.[46]

Efforts to define and strengthen the rights of small-scale food producers, who are often also among the poorest people, include promoting the concept of Farmers' Rights. In an agricultural perspective, rights issues encompass a broad range of aspects, where secure tenure rights to land, water and other natural resources, and control over what the agricultural system produces, are the most critical aspects for women, men and youth dependent on farming for their livelihoods. An especially important aspect for smallholder farmers is the right to agricultural biodiversity, and to save, reuse, and sell seed and other plant material. This right also encompasses rights to their traditional knowledge, to take part in decision-making and rights related to the use and sharing of benefits from their seeds and their knowledge, including in a research context.

The concept of Farmers' Rights is acknowledged in the International Treaty on Plant Genetic Resources for Food and Agriculture, which entered into force in 2004. The Treaty recognizes the enormous contribution that the local and indigenous communities and farmers of all regions of the world, particularly those in the centres of origin of crop diversity, have made and will continue to make for the conservation and development of plant genetic resources which constitute the basis of food and agriculture production throughout the world. It gives governments the responsibility for implementing Farmers' Rights and Livestock Keepers' Rights, and lists measures that could be taken to protect and promote these rights.[47]

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[42] IAASTD. 2007. International Assessment of Agricultural knowledge, science and technology for development

[43] UN Human Rights Council. 2008. Building resilience : a human rights framework for world food and nutrition security : report of the Special Rapporteur on the Right to Food, Olivier De Schutter.

[44] M. J. Chappell and L. A. LaValle. 2011. Food security and biodiversity: can we have both? An agroecological analysis. Agric Hum Values

[45] M. Pimbert. 2008. Towards Food Sovereignty. Reclaiming Autonomous Food Systems.

[46] European Commission. 2010. Communication from the commission to the council and the European parliament. An EU policy framework to assist developing countries in addressing food security challenges

[47] International Treaty on Plant Genetic Resources for Food and Agriculture. http://www.seedtreaty.org

The right to freely organise, e.g. in farmers organisations and cooperatives, is crucial for positive developments in terms of markets and wealth, but also in terms of women and men farmers' voices being heard in a democratic development process, and in formulating agricultural and other policies for individual nations.

Strengthening women's rights and access to resources such as biodiversity and land are not only human rights issues, but also critical factors for food security. Rural women and men have different roles, responsibilities, and knowledge in managing agricultural biodiversity, resulting in different needs, priorities, and concerns. Generally – but not always – men are more involved in agriculture for commercial purposes, whereas women often work with subsistence crops, vegetable gardens, and small livestock. Women are often crucial for local seed systems, and women collect plants and animals to feed and cure their families. Women, therefore, play an important role in maintaining biodiversity and the related local and traditional knowledge. Women's close relation and dependence on local biodiversity, domesticated as well as wild, also implies that loss of biodiversity, for example due to climate change, or species extinction, often affects women more than men.[48]

3.2. Agriculture and climate change

Climate change is already seriously changing the conditions for farmers, livestock keepers, pastoralists, fisherfolks, and agriculture at large, all over the world. Melting glaciers, rising sea levels, changing rainfall patterns and higher frequency of extreme weather incidents, such as storms, hurricanes, droughts, and floods have made many poor people around the world more vulnerable. The combined effects of ecosystem degradation and other environmental risks, with climate change serving as a multiplier to already serious degradation processes, affect poor communities and nations proportionally more adversely, thereby undermining the possibilities to achieve the Millennium Development Goals.[49, 50]

Important to note in the context of agriculture and climate change, is the fact that agriculture is itself a major driver and cause of climate change.[51,52] The question is, what type of agriculture is more likely to reduce carbon emissions and what type of agriculture is better placed to mitigate, cope, and adapt to the effects of climate change.

In the light of on-going and anticipated climate change, agricultural biodiversity has rightly received attention as an indispensable resource in developing coping strategies for farmers and livestock keepers. There is considerable evidence that smallholder farmers in traditional farming environments are adapting to climate change, particularly through the use of traditional varieties and the adaptation of traditional farming practices.[53] At the ecosystem or landscape level, adaptation activities can reduce the impacts of climate change and buffer their effects, reducing the negative impacts on humans and the environment.

The resilience of local food systems and their possibilities to adapt to change and stresses can be enhanced through a strategy of diversification within the landscape and agricultural system or farm. This may be achieved using a range of different approaches including agroforestry, maintenance of inter- and intra-species diversity, and increased use of agro-ecosystem-associated biodiversity and is equally appropriate in dryland, mountain, humid tropic, and coastal environments. Adaptation activities include the maintenance and reintroduction of traditional varieties, the adoption of new species and varieties to

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[48] Gender in agriculture sourcebook. 2009. The World Bank, Food and Agriculture Organization, and International Fund for Agricultural Development.

[49] MA 2005. Millennium Ecosystem Assessment: Ecosystems and Human Well-being: Synthesis.

[50] World Bank 2009a. World Development Report 2010. Development and Climate Change.

[51] IPCC Fourth Assessment Report: Climate change 2007. Chapter 8. Agriculture.

[52] GRAIN. 2011. Food and climate change: The forgotten link

[53] Platform for Agrobiodiversity Research (PAR)/FAO. 2011. Biodiversity for Food and Agriculture. Contributing to food security and sustainability in a changing world

meet newly developed production niches, and the development of ways of ensuring that materials remain available (e.g. community seed banks) and adapted (e.g. participatory plant breeding).

Resilience and adaptability also seem to be enhanced by the use of sustainable agricultural practices.[54] Furthermore, ecosystem protection and restoration, landscape rehabilitation and reforestation can reduce the adverse effects of climate change on local food systems. They reduce the vulnerability to extreme weather events, drought, excessive rainfall and seawater intrusion, and help ensure ecosystem services such as pollination, pest regulation and erosion control.

The areas with climates that are now suitable to a particular set of crops, forages, livestock, trees, microbes, and aquaculture are expected to shift in ways that are more favourable to a minority of countries, and less favourable to the majority.[55] Agricultural production in tropical areas is likely to be most at risk. At the local level, farmers will need to take on the challenge to adapt their cropping patterns and livestock strategies, and in this context a diversified mix of crops, varieties, and breeds will be crucial as a base for enhancing resilience. Three principal climatic risks related to agriculture can be defined:[56] novel climates; changes in averages, and increases in variability; and increased maximum temperatures above and beyond those experienced today.

According to recent research, most countries will become more similar to one another under the predictions of climate change.[57] This will lead to a greater interdependence between nations, but also holds out the hope that countries will be able to adapt their agriculture by looking to other countries with a similar climate. Perhaps contradictory at a first glance, 30% of the farming systems will be located in areas with a completely novel climate, i.e. with a combination of climatic factors never before experienced on Earth,[58] emphasising the importance of increased efforts to make use of and developing the diversity of both old and new varieties of crops and livestock breeds. It also stresses the importance of experimentation, innovation, and learning within and between different knowledge systems and cultures.

3.3. The dilemma of optimisation

Efforts to increase agricultural production are often based on a philosophy of optimising the delivery of yield per hectare of a specific crop. It may entail planting all available land with a single high-yielding variety and then maximising growth with chemical fertilisers and pest control, and using large-scale cropping machinery. Initially, this kind of optimisation may work. Indeed, it has resulted in enormous advances in resource productivity and human welfare. Now, however, those initial successes are bedevilled by a variety of emerging secondary and highly problematic effects on all continents and in all oceans.[59]

An optimisation approach aims to get the system into some particular "optimum state", and then hold it there. This is sometimes referred to as a maximum sustainable yield or optimal sustainable yield paradigm. These models generally assume that changes will be incremental and linear (cause-and effect-changes). They ignore implications of what might be happening at higher scales, however, and frequently fail to take full account of changes at lower scales.

Another problem with optimisation is that the systems we live in and depend on are usually configured and reconfigured by extreme events, not average conditions. The linkages between scales and sectors

[54] Platform for Agrobiodiversity Research. 2011. The use of agrobiodiversity by indigenous and traditional agricultural communities in adapting to climate change.
[55] FAO 2009a. Commission on Genetic Resources for Food and Agriculture. The Impact on Countries Interdependence on Genetic Resources for Food and Agriculture.
[56] http://www.slideshare.net/ciatdapa/climate-change-and-plant-genetic-resources-for-food-and-agriculture-fao-july-2011?from=ss_embed
[57] Ibid..
[58] J.W. Williams et al. 2007. Projected distributions of novel and disappearing climates by 2100 AD. PNAS.
[59] B. Walker and D. Salt. 2006. Resilience Thinking. Sustaining Ecosystems and People in a Changing World.

(agriculture, industry, conservation, energy, forestry, etc.) often drive changes in the particular system that is being managed. And importantly, while minor changes are often incremental and linear, the really significant ones are usually lurching and nonlinear – like the sudden change from a clean, clear lake to one dominated by an algal bloom.

Being efficient, in a narrow sense, leads to elimination of redundancies – keeping only those things that are directly and immediately beneficial. This kind of efficiency leads to drastic losses in resilience,[60] which negatively affects smallholder systems' capacity to cope with shocks and stresses.

3.4. Sustainable agricultural intensification

Sustainable agricultural intensification is commonly referred to in the debate as a coping strategy for increasing food production. Although the intention with the term is to stress the ambition to produce more on the same amount of land, it is somewhat unclear what this implies. Whereas the traditional way of agricultural intensification is a package of chemical fertilizers, hybrid seeds, high energy input and pesticides, sustainable agricultural intensification should be expected to use an ecosystem approach and deal with the landscape level, as well as to integrate social-ecological systems thinking.[61]

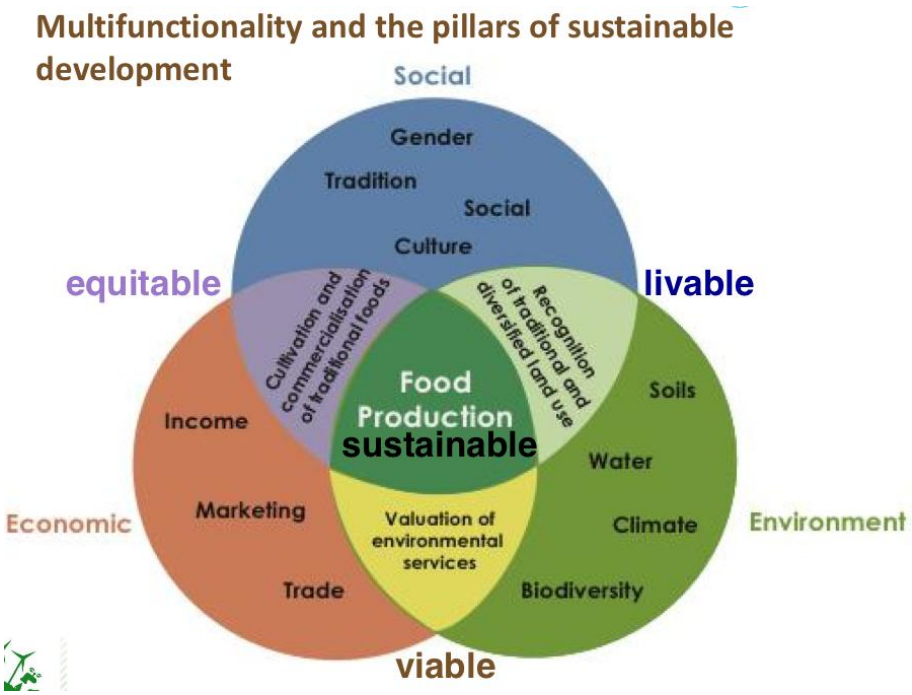

Figure 6. Illustration showing the complexity of food production.[62] (From IAASTD, adapted in H.R. Herren presentation)

Future food production systems will not only depend on, but must contribute positively to, healthy social-ecological systems where resilient communities are an integral part.[63] Approaches in this context include *climate-smart agriculture*, which is described as "agriculture that sustainably increases productivity, resilience (adaptation), reduces/removes greenhouse gases (mitigation), and enhances achievement of national food security and development goals"[64], and the *triple-win* concept which promotes agriculture's role as part of the climate change solution, through its role in capturing carbon,

[60] Ibid..

[61] IAASTD 2008. Adapted in presentation by H.R. Herrren. Can be found at: http://www.unep.fr/scp/business/dialogue/2011/presentations/Day_1/Session_4/Session4_3_Herren_MI.pdf

[62] Ibid..

[63] UNEP. 2009. The Natural Fix? The role of ecosystems in climate mitigation.

[64] http://www.fao.org/climatechange/climatesmart/en/

leading to increased production as well as increased resilience of production systems.[65] Sustainable crop production intensification has been put forward as FAO's first strategic objective. The FAO definition of this concept is an approach that uses inputs such as land, water, seed and fertilizer, to complement the natural processes that support plant growth, including pollination, natural predation for pest control, and the action of soil biota that allows plants to access nutrients.[66]

3.5. Power and food security

Analyses of power relations are crucial in the context of food security and smallholder farming (*see also sections 2.2.7 and 4.6*). The definition of *Food Security,* agreed upon at the 1996 World Food Summit, states that: 'Food security exists when all people, at all times, have physical and economic access to safe and nutritious food which meets their dietary needs and food preferences for an active and healthy life'. The term has however been interpreted very broadly, and sometimes been used more as a definition of a goal.[67]

Food security is not limited to *availability,* i.e. the sufficiency of a food supply to meet people's needs, but also entails *accessibility,* i.e. people's economic and physical ability to acquire food; *acceptability,* i.e. the cultural and nutritional suitability of the available food; *appropriateness*, i.e. the ecological sustainability and the safety of a food supply; and *agency,* i.e. access to accurate information on food supply, quality, and safety in order to make informed market choices, including the rights to such information and to the other aspects of food security, and a socio-political system that guarantees these rights.[68]

The human right to adequate food is recognized in several instruments under international law, including the Universal Declaration on Human Rights and the International Covenant on Economic, Social, and Cultural Rights. The rights-based approach to food security starts from the recognition that poverty, social exclusion, and a lack of participation in political decision-making processes are the main causes of food insecurity.

Power relations is also a central component in the concept of *food sovereignty*, initially coined by the international agricultural movement La Via Campesina, a notion that takes the food security issue one step further. The definition of food sovereignty has evolved over time. Important elements include: the right of individuals, peoples, communities, and countries, to safe, nutritious and culturally appropriate food, and to food producing resources; the right to define their own agricultural, labour, fishing, food, land and water management policies, which are ecologically, economically and culturally appropriate to their unique circumstances. Along the same lines, proponents of the food sovereignty concept consider it a right for farmers to control their own seeds and livestock breeds, unrestricted by intellectual property rights and free from genetically modified organisms. Another important element for the social movements referring to food sovereignty is the right to choose the level of self-reliance in food, and the right to develop autonomous food systems that reduce communities' dependence on global markets and corporations.[69, 70]

[65] http://go.worldbank.org/8J7X0ICLI0
[66] FAO. 2011. Save and grow. A policymaker´s guide to the sustainable intensification of smallholder crop production.
[67] M. Windfuhr and J. Jonsén. 2005. Food Sovereignty. Towards democracy in localized food systems.
[68] C. Rocha. 2007. Food insecurity as market failure: A contribution from economics. J. of Hunger and Environmental Nutrition..
[69] M. Pimbert. 2009 Towards food sovereignty: reclaiming autonomous food systems. IIED, London
[70] M. Windfuhr and J. Jonsén. 2005 Food Sovereignty. Towards democracy in localized food systems. ITDG

4. RESULTS AND ANALYSIS

The previous chapters focused on resilience theory and on issues of current debate around smallholder farming, agricultural biodiversity and climate change. In this chapter we will use this framing to present and analyse the collected information. Six key knowledge constraints related to the elements of change have been identified through the process of developing the theoretical framework for this study, in combination with analysing the results from the actors' consultation, discussions with researchers, and literature. The knowledge constraints will be further elaborated upon below, with examples from the actors' consultations as illustrations.

4.1. First knowledge constraint: *How do transformations take place?*

As mentioned in section 2.2.2, there is currently no clear framework for studying the "how" in transformations related research on coupled systems.[71]

One example of current research of relevance for this question focuses on the re-greening in the Sahel. Scientists from various academic institutions, including universities in Burkina Faso and Niger, as well as the SRC, work together in an interdisciplinary project to analyse transformation at the systems level. Initial results show that farmers appear to have actively managed their land in ways that contribute to re-greening, and also enhanced productivity.

The re-greening of Sahel
This project draws comparisons between sites in the Sahel that have responded to climatic variability in contrasting ways to understand why change happens in some regions while not in others.
The West African Sahel is as a region of particular interest in the context of environment and development. Here, poverty and food insecurity are widespread, rainfed farming dominates the livelihood strategies, and population growth rates are among the highest in the world. People in this region are directly dependent on provisioning ecosystem services, such as yield of staple crops, availability of grazing land, and firewood, for their livelihood security. They are also highly vulnerable to degradation of regulating ecosystem services such as nutrient cycling and erosion control. Over the past decades the Sahel has often been portrayed as a region undergoing desertification; thus as a region plagued by recurring droughts and widespread land degradation, with severe famine as the outcome.
Recent analysis of satellite data suggests, however, that this view of the Sahel may not be entirely accurate. In contrast, and to the surprise of many scientists and policy-makers, these studies reveal that large areas of the Sahel have in fact become increasingly green over the past 20 years. While the causes behind the re-greening are debated, it seems that the trend is not just a result of returning rainfall, but instead that farmers have actively managed their land in ways that have enhanced its productivity.
The Sahelian re-greening thus presents a unique opportunity to identify lessons for how to adapt and cope in challenging environments characterized by high climatic variability. In a three-step analysis inspired by resilience thinking we will compare local development trajectories of linked social-ecological systems across the different sites.

http://stockholmresilience.org/research/researchthemes/freshwaterfoodandecosystemservices/

Interaction between researchers and local communities play a crucial role in understanding how this kind of large-scale landscape transformations take place. Scientists can contribute with, among other things, models for analysing collected data, aggregations, and technological support. Communities naturally have deeper knowledge and understanding of local conditions, including experience of historical events that have contributed to shaping the system of today. Outcomes from this type of research may contribute to strengthening greening approaches in other areas of the world. In addition, it can contribute to increased attention to smallholder farmers' and livestock keepers' crucial role in strengthening biodiversity and ecosystem functions by nurturing the agricultural landscape.

4.2. Second knowledge constraint: *Transfer of knowledge, and the process of learning*

[71] F. Westley et al. 2011. Tipping Toward Sustainability: Emerging Pathways of Transformation. Ambio.

Consultations confirm the initial hypothesis that understanding the processes of knowledge transfer and learning is central for successful upscaling of interventions related to agricultural biodiversity management and enhancing livelihoods. Respondents highlight that fora for knowledge sharing, where knowledge can be expressed and turned into action, are crucial.

Knowledge sharing in participatory processes
Joko Learning Center, which implements the DARE (former CBDC-BUCAP) programme in Nan province in Thailand, separate between tacit and explicit knowledge in their work. The tacit knowledge being the unspoken knowledge that everyone has within, which becomes explicit, and effective, only when shared with others for example when transformed to written, documented knowledge. Joko Learning Centre applies this idea in the work with participatory learning processes, in which they encourage farmers (and their families) to share their tacit knowledge. Farmers teach and learn from each other through Farmer Field Schools (FFS), Farmer Field Days (where farmers report the result of FFS) on participatory plant breeding, participatory variety selection and organic farming.

Interview, Joko Learning Centre representative

4.2.1. Loss of knowledge

Knowledge is not static, and it is never gained forever. It has to be recovered, adapted, and internalised into society over and over again. A common concern among respondents is the loss of traditional, local, and indigenous knowledge. This concern is shared by civil society representatives and scientists from different disciplines. Communities have lost, and continue to lose, their knowledge and understanding of local agricultural biodiversity. Examples raised include cases where there is no system in place for elders who possess this knowledge to transfer it before they die. Several organisations have developed tools to regenerate and recover traditional knowledge, and to strengthen contacts between generations in order to reverse this trend. Examples include encouraging traditional knowledge in formal education systems, and transferring knowledge through the development and use of ecological calendars, eco-mapping, and seed fairs. A crucial aspect that needs to be taken into account is how to overcome illiteracy difficulties.

African Biodiversity Network – Climate Seeds and Knowledge process
ABN has been implementing a process called Climate, Seeds and Knowledge (CSK), in different countries in Africa. The process involves engaging local people in dialogues about food situations at local and national levels, contribution of the people in assuring their own food security, how to grow the food, and what to constitute the food. Through this process they start recuperating their indigenous crops and the knowledge about them, and doing this within the context of ecological farming. This project brings together men and women who have different but complementary knowledge, to address household food security using their indigenous biodiversity.

Quote actors survey, African Biodiversity Network

Encouragingly, there is increasing recognition that different knowledge systems and well-rooted local observations described with local wordings are important to fully understand how social-ecological systems function.[72] This perception is building momentum in various contexts, such as the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES). Another example is a current initiative where IPCC together with the CBD, UNU, UNESCO, and UNDP, address issues related to Indigenous Peoples, Marginalized Populations and Climate Change, where contributions from individuals and communities in developing countries and/or marginalized regions are encouraged.

Knowledge-related issues are however quite political and sometimes very sensitive. Respondents note that there have been cases of exploitation of indigenous and traditional knowledge, leading to situations in which knowledge holders end up restrictive in what type of knowledge they want to share. One conclusion is that it is important to recognize the right to Free, Prior, and Informed Consent[73] in all efforts and projects dealing with exchange and documentation of traditional knowledge and practices related to indigenous and local communities.

[72] M. Tengö. 2011. How to deal with exchange between knowledge systems – a way forward. Background paper for meeting in Jokkmokk, June 22, 2011.
[73] United Nations Declaration on the Right for Indigenous Peoples. UNGAS 2007.

4.2.2. Local adaption of knowledge

Respondents stress the need for concrete and practical information, adapted to local conditions and understandable by the end users, e.g. the farmers, fisherfolk, or livestock keepers. Extension systems need to be efficient and effective, and able to translate knowledge into field activities. Importantly, survey results highlight that extension systems should recognise and respect the knowledge already held by farmers and livestock keepers.

Respondents highlight that communities often lack strategies to cope with the impacts of climate change at the local level. Events like droughts and erratic rainfalls are simply too unpredictable. Coping strategies for other stresses such as pest infestation are more often in place, e.g. where farmers have developed strategies based on noticing early signs of infestation. Nonetheless, there are examples of interventions that have equipped farmers with tools for adaptation to changed local conditions, often due to climate change. Participatory plant breeding is a strategy included in this category, where for example farmers in Vietnam have been able to develop rice varieties with an increased tolerance to saline conditions, much needed because of increased salt intrusion in rice paddies due to sea level rise.[74]

4.2.3. Innovative learning

Awareness of and ability to respond to uncertainty and surprise is a necessity to cope and adapt in times of global change. This includes the opportunity and will to experiment, innovate, and learn within and between different knowledge systems and cultures.[75] In this context, various respondents have noted the usefulness of the concept of *participatory action research*.[76, 77, 78]

Learning by doing – Participatory Action Research
Methods include engaging multidisciplinary teams of researchers and local knowledge holders for livelihood analysis, agro-ecosystem and landscape analysis, market relations, organisational assessments, and impact analysis. Historical analysis, the use of complementary methods from the social and natural sciences, and the knowledge of local resource users are used in combination with extended peer review processes to co-validate the knowledge and policy recommendations generated. Cycles of learning, reflection, and action *by, with,* and *for* farmers are designed to produce knowledge and positive change for social-ecological resilience, empowering local communities.

Quote actors survey, International Institute for Environment and Development (IIED)

Respondents also suggest that it would be useful to experiment with technological and institutional innovations to strengthen local voices and actors. This includes exploring the potential of citizen-controlled media like participatory video and community radio, as well as methods for citizen deliberation and inclusion in policy making.

"The Organic Farmer" – Practical advice for farmers
The Organic Farmer is an information magazine for Kenyan small-scale farmers who until recently have had only scarce access to information on sustainable agriculture. With this application-oriented periodical: The Organic Farmer (TOF), Biovision provides them with information on possible ways out of the poverty trap. The farmer magazine is distributed every month free of charge to interested farmers' groups in Kenya and selected neighbouring countries. Via Website http://www.organicfarmermagazine.org the Organic Farmer reaches its readers worldwide. TOF readers receive concrete guidance and practical tips on how they can increase their harvests using simple, environmentally friendly methods. This information is disseminated via radio also "Radio Kiswahili Service", KBC (the weekly TOF radio programme in Swahili is received in Kenya and Tanzania and has up to 3 million listeners) as well as through flyers and brochures. Farmers particularly often use the opportunity to pose questions to the newspaper and receive feedback via SMS and readers' letters. Advisory services have been largely unavailable so far. The iTOF Centres close this gap. To improve access to training services, iTOF advisors travel to the villages and carry out the farmer group trainings on site. This service is

[74] Interview with SEARICE representative. August 2011.
[75] R. Costanza. 2010. The Search for Real, Integrative Solutions. Solutions Journal.
[76] P. Kristjanson et al. 2009. Linking international agricultural research knowledge with action for sustainable development
[77] M. Bruges and W. Smith. 2008. Participatory approaches for sustainable agriculture: A contradiction in terms?
[78] F. Baum et al. 2006. Participatory Action Research. Journal of Epidemiology and health.

particularly valued, as shown by the high demand.

Through cooperation between the Biovision farmer communication projects "Infonet", the farmers' newspaper "TOF", "TOF Radio", and the iTOF centres, synergies can be utilised and a wide target group can be reached.

Case from the Millennium Institute/Biovision

Strong local organisations of farmers, as well as other stewards of land and aquatic environments, are – according to respondents – crucial elements in empowering communities to express their demands for knowledge.

4.2.4 Empowerment and education – key factors to make informed choices

A clear majority of respondents are in agreement that empowerment is key. Making sure that people have the possibilities to make their own informed choices is a necessity for development and learning. Many respondents note structural reasons for why this seems so hard to achieve:

"The most important barrier is the mindsets of people. A lot of people still hold to the colonial teaching that everything indigenous is backward. So growing and eating indigenous crops is backward. We have been investing much time during dialogues to discuss the importance of indigenous biodiversity and knowledge, working on a process of decolonizing the minds of the people through the dialogues so that they accept themselves and their local biodiversity"

Another respondent state that academic knowledge is often seen as more valuable than local/practical knowledge. Concern is also raised around the fact that general poverty disempowers farmers; lack of education and good health implies that they cannot engage properly in innovation and development of their farming systems.

It is stressed that gender sensitive interventions and empowerment of women is crucial in an agricultural context.

Respondents raise concerns regarding different aspects of education. On the one hand, education is considered absolutely crucial for development. On the other, voices are raised that education should entail disseminating the "right kind" of knowledge, promoting sustainable agricultural use and practices rather than large-scale, high-input practices. Curricula do not always integrate knowledge relevant for children and youth from agricultural communities, and do not consider their cultural contexts well enough. Concerns are also raised that local communities often lack the knowledge, information, and sharing of experiences to effectively counter harmful impacts to local diverse agricultural systems created by large-scale interventions and processes, e.g. agriculture industrialisation, GMOs, and landgrabbing. This highlights other dimensions, addressing validation and acceptance of knowledge, and conflicts between different knowledge paradigms. One respondent also stresses inequality issues, and highlights the fact that means for advertisements and propaganda are unequally distributed between actors. Farmers and livestock keepers need to have sufficient knowledge to make their own informed choices.

4.3. Third knowledge constraint: *Identification of factors that initiate processes towards positive change*

Research indicates that so called champions,[79,80] are crucial for successful change. Several respondents confirm this and emphasize that transformations most often do not start at the institutional level, but rather with key individuals. Respondents' experiences highlight that individual connections are crucial, and that individual communication is needed to influence the institutional level. The importance of endorsing a multi-stakeholder approach already from the start – including in the planning stages of an intervention – has been stressed as key for successful upscaling.

[79] H. Reid et al. 2010. Community Champions: Adapting to Climate Changes. IIED.

[80] S. L. Yaffee et al. 1997. Factors that promote and constrain bridging: A summary and analysis of the literature.

4.3.1 Upscaling and sustainability of interventions

One conclusion that can be drawn from analysing the consultations' information, is that under the right circumstances and in an enabling environment, successful cases can "automatically" scale up. The case of ISD below illustrates how collaboration with government actors allowed successful upscaling. Individuals supported by evidence managed to convince the local government to get involved. Farmers' positive experiences in increased productivity and food security encouraged more people to adopt the promoted agroecology practises.

The Tigray Project

'The Tigray Project' has been implemented with local communities in the drought prone areas of Central, Eastern and Southern Tigray starting from 1996.

The project has successfully demonstrated that ecological agricultural practices such as composting, harvesting of water and soil, and crop diversification, can succeed and bring benefits to poor farmers and communities, particularly to women-headed families. Among the benefits demonstrated are increased yields and productivity of crops, improved hydrology with raised water tables and permanent springs, improved soil fertility, rehabilitation of degraded lands and increased incomes. The successes of the project have led to its expansion to include many more communities in Tigray and in other parts of the country. The government has now adopted the approach used by the project as its main strategy for combating land degradation and poverty in Ethiopia. Factors behind the success were: Farmers leading the project and opportunities for farmers to learn from each other e.g. via cross-visits; this led to successful uptake of the ecological agriculture practices, as well as because the project based the interventions on farmers' knowledge and technologies.Strong support from the local and regional government; from the start the project was co-run by the Bureau of Agriculture and Rural Development and local development agents also promoted the ecological agriculture practices. Ability to be flexible and accommodate community wishes and participation.

The making and use of compost by farmers has enabled many of them to avoid taking chemical fertilizer on credit while improving the productivity of their land.

- Raising and transplanting seedlings of long season crops such as maize and sorghum has enabled farmers to keep these in their crop mix.
- A focus on women-headed households to identify high value crops (particularly spices), providing sheep or goats, and techniques for raising seedlings of multipurpose and fruit trees has given them an important source of income.
- Linking environment clubs in local elementary schools with knowledgeable farmers and establishing vegetable gardens using compost.

The three most important factors for success in the project have been:

1. Farmers experiencing real change in their productivity (food security) using their own varieties without relying on expensive external inputs.
2. Enabling an open dialogue between farmers and their local agricultural experts for a better understanding of each others knowledge base (traditional for farmers, and modern for experts).
3. Good documentation of the processes through open discussions and reports from training and follow-up meetings as well as collecting and compiling yield data from farmers' fields.

Quote actors survey, Institute for Sustainable Development

Another example from the actors survey is shown below, where actors' collaboration, income diversification and a well-designed intervention created possibilities for self-renewal as well as reaching more households than the ones targeted initially.

Income generation by diversification backed up by cross-sectoral intervention: Montanosa Research Development Center

The objective of the project has been to enhancing traditional agriculture through increased diversity; and increased production of selected crops for cash and for household savings. Coffee Arabica is one of the crop with high price and was identified as the one-town-one product of Sagada. A tripartite (NGO, LGU and community/farmers) convergence was formed to develop the coffee industry for the town. MRDC intentionally joined the tripartite to make program intervention to re-direct the idea of establishing coffee plantations to enriching whatever crops and developing agro-forestries with coffee as the main crop to be inserted to whatever is existing. The project also identified wild useful trees and herbs and incorporated these in the agro-forestry sites.... and presently sugar cane is also being incorporated with the aim of reviving village-based sugar processing which stopped more than 60 years ago. The project started in mid 2008, with a start off fund from foreign donor for 1.5 year but now people are continuing the work on their own.

Household savings have already been experienced by the few households who are now producing their own sugar. Coffee trees increased significantly and most of these will bear berries this coming coffee season (2011).

Quote actors survey, Montanosa Research Development Center

To add to the complexity, cases that initially scale-up successfully can be hampered by conflicting policies at a later stage (*as shown in the example below*), thus hindering further progress.

MASIPAG – scaling up rice diversity and diverse farming systems
MASIPAG is a Philippine nation-wide farmer-led network of people's (farmers) organizations, non-government organizations and scientists working towards farmers' empowerment through farmers' control and sustainable use of genetic and biological resources, agricultural production and associated knowledge. Since 1986, MASIPAG has been in the forefront of biodiversity conservation, which started in the reclaiming the control over the seeds of traditional rice varieties back into the hands of the small and resource-poor Filipino farmers. From the initial farmer-based rice genetic conservation and improvement in 1986, it progressed into corn genetic conservation and improvement, and the scaling up including native animal genetic conservation and improvement. MASIPAG is known for its expertise in farmer-led biodiversity conservation and diversified integrated farming system which build farmers' resilience to climate changes. As of now, 35 000 farmers are part of the MASIPAG network.
While implementing sustainable agriculture the MASIPAG way, there are external factors that greatly affect the implementation of its programs and advocacies. These include government programs which are not appropriate and responsive to the needs of the farmers and farming communities. Philippines is an agricultural country and its economy is dependent on agriculture, but where 7 out of 10 farmers do not own the land they till. Strong and appropriate Government support to this major sector and backbone of the economy is lacking. Agriculture programs apparently contradict the goal of local self-sufficiency and security, and the agrobiodiversity conservation initiatives of the small and resource poor farmers, to mention the GMO commercialization and contamination, lacking political will to implement genuine agrarian reform program, among others. This is further worsened by the unpredictability of climate changes and occurrences of natural calamities.

Quote actors survey, MASIPAG

4.4. Fourth knowledge constraint: *Lack of understanding of processes for feedback in integrated social-ecological systems*

Overall, respondents put more emphasis on obstacles and restrictions at the policy level and other external barriers, than on internal knowledge constraints such as maladapted agricultural practices, e.g. lack of knowledge on composting techniques or pesticide alternatives. The feedback loop (*figure 4*) highlights that external factors can impact strongly on an intervention's general success, whether or not the intervention as such is appropriate. This reflects a notion highlighted by many respondents: sometimes it seems impossible to change a local system, regardless of what you do. By carrying out a system feedback mapping exercise, some of the external barriers can be identified. Once these barriers to system improvement/transformation have been identified, it can become more straightforward to find ways of influencing development towards a more positive state of the system. This is reflected both in survey responses and in literature.[81]

Promoting green manure for small-holder farmers in sub-Saharan Africa
There are numerous examples of interventions that promote technologies with great potential, but where a widespread acceptance by farmers is not achieved. One such example is the poor adoption of legumes by smallholder farmers in sub-Saharan Africa.[82] The modest success of legumes has partly been explained by a lack of appropriate methodologies and tools to stimulate adoption, and a need for new and more innovative approaches to identify potential niches for legumes and to facilitate the integration of legumes into complex smallholder farming systems´. The research approach has been focused on promoting legumes as a way of improving soil fertility, whereas the overriding criteria for farmers when selecting varieties were related to marketability, early harvest, yield, and ease of production (low labour demand).[83] A

[81] E. Enfors. 2009. Traps and Transformations. Exploring the Potential of Water System Innovations in dryland sub-Saharan Africa.
[82] J.O. Ojiem et al. 2006. Socio-ecological niche: a conceptual framework for integration of legumes in smallholder farming systems.
[83] S. Adjei-Nsiah et al. 2008. Farmers' agronomic and social evaluation of productivity, yield and N2-fixation in different cowpea varieties and their subsequent residual N effects on a succeeding maize crop.

lesson learned is that that soil fertility benefits of legumes must be considered as an 'additional benefit' rather than a primary criterion, and that it is only when addressing a wide range of biophysical (e.g. climate, soil fertility, etc.) and socio-economic variables (e.g. preferences, price, production objectives etc.) together with smallholder farmers themselves that more sustainable cropping systems including the use of legumes in smallholder systems can be designed.

Example from Seminar on Future Farming, Swedish University of Agricultural Sciences 2011

4.4.1. Landscape-wide approaches

The concept of landscape literacy is referred to by respondents, and in literature[84], to describe what can be viewed as the capacity to identify and understand feedback loops at the landscape level. Respondents also note the importance of social factors that affect interactions at the system's landscape level. There is a need to find more information on what type of landscapes are generally managed by smallholders in different ecosystems and food systems. This would underpin actions on sustainable intensification and conservation of agricultural biodiversity, adaptive capacity, and resilience, one respondent argues.

Landscape-wide processes and planning
One notable barrier that we have encountered is that individuals and groups working in different sectors have very different perception and understanding of landscape-wide processes, e.g. how agricultural uses broader natural resources beyond the farm, the role that farms play in hydrological cycles or in wild species territorial land use. We are working to develop visual teaching tools to facilitate shared understanding of the landscape, which is foundational for multi-stakeholder negotiation and planning.

Quote actors survey, Ecoagriculture partners

Knowledge on how agricultural landscapes function and understanding landscape-wide processes is raised by many respondents as areas in need of more attention. Specifically, they ask for more information related to interactions and performance of different combinations of crops/livestock; and knowledge on bundles of ecosystem services provided by agricultural landscapes, as well as interactions between the agricultural sector practices and other ecological functions. A landscape approach can show the mosaic of small biodiverse farms as part of a system at a larger scale, and acknowledges the green corridors and refuges they form between protected areas. This is becoming increasingly important in the context of adaptation to climate change, and in a sustainable land management perspective.

KENVO and the Kijabe landscape: an ecoagriculture approach
KENVO (a CBO) in the Kijabe/Kikuyu Forest Escarpment landscape in Kenya about 30 kms NW of Nairobi, EcoAgriculture Partners have worked to pilot test concepts and methods for integrated landscape analysis and management. The collaboration has helped KENVO develop a variety of agroforestry production practices to conserve agrobiodiversity, linked small-scale commercial agricultural developments with forest conservation strategies, identified wild species' use of agricultural lands, as well as assessment, planning and management, and monitoring and evaluation tools for landscape scale action.

Quote from survey response, EcoAgriculture Partners

4.5. Fifth knowledge constraint: *How can local actions and initiatives be (better/more efficiently) linked to regional and/or global processes?*

Respondents present several reasons to promote learning intensification and knowledge exchange across scales. Knowledge – given it is the right knowledge in the right place – can enhance farmers' livelihoods and their capacity to make informed and independent decisions. This could be related to selecting crops and varieties for next year's sowing, analysing pesticide advertisement in local radio

[84] H. Palang and G. Fry (Eds.) 2003. Landscape interfaces: Cultural Heritage in Changing Landscapes.

broadcasting, or marketing of farm produce. Secondly, evidence and documentation of knowledge and experiences are crucial tools in changing perceptions and promoting policy development. Evidence alone will not change policies, but it will be almost impossible to change policies without it.

Smallholder farmers' experiences on positive transformations of their social-ecological systems need to be better documented, understood, and linked across scale. We argue that connecting individuals and organisations across levels and fields of expertise play an important role in the struggle to achieve multi-level transformation. Along the same lines, there is a need for practical knowledge on how to link issues and translate them into field activities with farmers through efficient and effective extension systems.

4.5.1. National/regional policy level constraints

As mentioned earlier, survey results point to policy constraints as the most significant bottleneck to set the stage for positive change. One respondent wrote:
"agricultural biodiversity is often treated as an 'add-on' or entirely separate activity from the main process of agricultural development and land management, rather than incorporated into the core of such programs. Agricultural biodiversity needs to become part of mainstream policy."
Several respondents note directly conflicting policies originating in different government departments, leading to a lot of confusion. Examples include promoting eucalyptus plantations, introducing GMOs in national agriculture, and promoting hybrid rice.

Conflicting development paradigms
Agriculture and biodiversity conservation are at odds or in conflict with each other in many of the current food production systems the world over. However, the expansion of GM crops in Africa, and the reach of the corporate seed industry is a huge constraint. Coupled with this, is the increasing consolidation of the agrochemical industry in Africa; as well as the vertical integration of large grain exports with smaller grain handlers in a bid to control the oil seed market in Africa for instance. We have generally speaking, found it extremely difficult to convince policy makers and regulators to adopt agro-ecological approaches to food production and agrobiodiversity conservation for small holder emerging farmers. It does appear as if there is some political will and space for government to intervene where there is no strong multinational seed and agro-chemical company present.

Quote actors survey, African Centre for Biosafety

More specifically, respondents note that the interplay between land administration, biodiversity protection, and climate change policies is often not well reflected in national policies, strategies, and development programs. This fact is also reflected in literature.[85] A recent survey of national climate policies in Southeast Asia found that national policy frameworks and plans on climate change adapted or crafted by the surveyed countries were mainly influenced by global forums and discussions, and less by local actions and initiatives.[86]

Climate adaptation in national planning
In terms of climate change adaptation, there is still lack of knowledge as to what specific adaptation practices could be adopted by farmers and encouraged by governments through policy and fiscal incentives. There needs to be further exploration of incorporating ecological agriculture practices in national adaptation plans. There also needs to be consideration of synergistic, slow onset, etc. impacts of climate change on smallholder farmers and the resilience benefits that agrobiodiversity and ecological agriculture practices can bring.

Quote actors survey, Third World Network

According to respondents in this survey, it is absolutely crucial to adapt to local conditions not only knowledge and practices, crop varieties and livestock breeds, but also that policies are developed in a way that make them suitable for and adaptable to different contexts.

Participatory Plant Breeding

[85] A. Sharma. 2009. Planning to Deliver: Making the Rio Conventions more Effective on the Ground. Climate Change, Biodiversity, Desertification. GTZ.
[86] SEARICE 2011. Country level policies and programs and international policies.

Through Participatory Plant Breeding (PPB), SEARICE and the CBDC-BUCAP network in Southeast Asia have been able to promote farmers' knowledge and innovations and to raise farmers concern in national and global policy processes.

At the local level, Farmer Field Schools (FFS) and evidence in the field provide proof that farmers have the capacity to do plant breeding. Researchers and local government staff are convinced when they visit FFS and see this for themselves. The mindset that academic knowledge is "higher" than farmers' knowledge changes. Vice versa, farmers need to become aware of the policies that affect them, and SEARICE produces simplified information on relevant law writings. They ask for farmers' feedback and concerns related to the laws, and raise farmers' opinions to the policy level.

At the national level, SEARICE organises presentations of results from annual assessments of the field work, and sees this as a strategic time to try to influence politicians. The presence of farmers to present their work and their concerns to politicians is now possible thanks to the programme. This is also seen as a key strategy; to bring forward the farmers to present their work and raise their own concerns. This is how they get support at both national and international levels, and it constitutes a very good model for bridging knowledge gaps.

From SEARICE's experience, the key to success is to have a multi-stakeholder approach. If different categories of stakeholders are involved from the beginning, that goes through a mutual process of learning together, this will facilitate upscaling of interventions.

Interview, SEARICE representative

Survey results stress a general notion that policies generally favour what one respondent described as a: *"…modernity that sees no future for food providers and decent life in the countryside. Much of the international community and governments embrace a linear view of development in which people move to cities/urban slums to get wage work in the secondary or tertiary sectors of the economy."*
This once again highlights that conflicts between different knowledge and development paradigms can be perceived as highly relevant constraints, and as valid as gaps in knowledge *per se*.

4.5.2. International policies and intellectual property rights

Even in cases where international policy instruments are in place, e.g. the ITPGRFA[87], implementation does not always reach the national and/or local levels. One respondent writes:
"Despite the fact that the plant variety protection and farmers' rights act has been passed it has not seriously addressed the International Treaty's emphasis on article 6 (sustainable use) and 9 (Farmers' Rights)."

Several respondents raise concern regarding issues related to Intellectual Property Rights (IPR) and international trade negotiations' impact on agricultural biodiversity, a vast and immensely important area impacting on e.g. diversified seed systems and plant breeding. IPR is highlighted as a policy area in need of urgent revision in order to safeguard agricultural biodiversity and farmers' rights. A few respondents also raise concern regarding the current trend of developing "climate-ready" crops, with specific focus on environmental stress tolerance in plants (tolerance to drought, heat, flood, cold, saline conditions etc.), and stress the need to develop relevant policies, since:
"Corporations are filing hundreds of sweeping, multi-genome patents in a bid to control the world's plant biomass. "[88]

In the context of landscape management policies, one of the major challenges respondents note is the lack of farmers and local communities' influence on the design of strategies related to agriculture, rural development, conservation, and investments. Mechanisms are needed to address this gap, and to strengthen local and farmer organisations' possibilities to engage in multi-stakeholder landscape-scale planning processes.

4.5.3. Food sovereignty

[87] International Treaty on Plant Genetic Resources for Food and Agriculture, http://www.planttreaty.org/
[88] ETC Group. 2010. Capturing Climate Genes. Gene Giants Stockpile "Climate-Ready" Patents.

Voices are raised among respondents that significant funding and active support of actors working within a food sovereignty paradigm is necessary to generate new knowledge and action for positive social and ecological change. As one respondent argues:
"An altered knowledge paradigm is needed, with more emphasis on issues like agricultural biodiversity management, food security, and climate change. In this regard, the 'food sovereignty' concept offers a potentially useful alternative framework to pose novel research questions as well as to identify technical and institutional innovations needed to sustain biodiversity rich food systems for equity and social-ecological resilience."

We interpret this as an interest in exploring a transdisciplinary and holistic research approach, integrating power relation aspects.

4.6. Sixth knowledge constraint: Dealing with knowledge and power

In discussions, a majority of respondents highlight the issues of power and power relations as forces that pose more limitations than any other knowledge constraint experienced. As previously mentioned, (*see 4.2.6 and 4.2.7*) the integration of power theory and power relations into resilience theory is under development. However, there are examples of how the resilience theory lens can be used, taking into account the concept of power.

Equity is key to convert tradeoff between agriculture and biodiversity to win-win
Efforts must now be urgently directed at the agrobiodiversity that still form the basis the food security and livelihood security of millions of Africans. Agriculture and biodiversity conservation are at odds or in conflict with each other in many of the current food production systems the world over. Ways have to be found to overcome these conflicts in agriculture policies and institutions. Historical evidence and current studies show that biodiversity conservation strategies must be integrated with agricultural practices that are also socially just and ecologically sustainable not only to ensure food security and sustainable livelihoods but also to ensure ecosystem health. These strategies can have a knock on effect on social stability, easing rural to urban migration, and debt relief and dependence.

However, the expansion of GM crops in Africa, and the reach of the corporate seed industry is a huge constraint. Coupled with this, is the increasing consolidation of the agrochemical industry in Africa; as well as the vertical integration of large grain exports with smaller grain handlers in a bid to control the oil seed market in Africa for instance.

Quote from survey, African Centre for Biosafety

The example above can illustrate a case of *Structural power*, the slowest and broadest scale type of power. As discussed in 4.2.7, structural power is the ability of the institutions of a society to restrict the set of issues about which people think they can make decisions. Structural power involves manipulating culture, which is slow to change, and likely operates over a broader area than an individual institution. It determines what concepts are considered, and therefore requires a group that is relatively insulated from external ideas for starting a process of change.

If power relations are analysed in the context of the feedback loop, it may articulate and visualise that degradation and biodiversity loss can be attributed to outside forces. Several respondents express this concern, and stress that external factors make it hard to realise the potentials of smallholder agricultural systems.

Respondents also argue that more knowledge is needed on institutions and policies that affect and often restrict smallholders' access to seeds, land, water, and wild biodiversity, which are at the heart of their ability to cope with change and maintain resilient systems. Landgrabbing, privatisation and centralisation of water sources, concentration of seed companies and unequal competitiveness of global, national and local markets are affecting the ability of smallholders to maintain resilient agricultural systems.

Some civil society organisations and networks have been inspired to develop the resilience thinking further, to help them understand their own situations. One example is the African Biodiversity Network, which has adapted its own definition of resilience at the community level:

Resilience at the community level
The ABN defines resilience as 'the ability of a community to withstand negative internal and external pressures and threats. Resilience enables adaptation and strength, coherence and intergenerational learning. Communities can be resilient when they are empowered and clear about their future and can act together to protect their rights'.
The route to resilience is developed through intergenerational learning to revive indigenous ecological knowledge; the creation and use of eco-maps and calendars to facilitate agreement of land and biodiversity governance and control, first within communities, and then with local government; and community dialogues to analyse and strengthen relevant traditional ecological knowledge and practices, and build community ecological governance capacity. All of these methods promote dialogue, analysis, and negotiation to identify, agree, and implement local solutions that increase local control and protection of ecosystems and community rights and responsibilities.

Quote from African Biodiversity Network webpage: www.africanbiodiversity.org

Initiatives, including addressing individuals', communities' and organisations' knowledge, may have little or no impact in themselves if power structures – including aspects of control over the world's food systems and its associated agricultural biodiversity – hamper their implementation. Nevertheless, knowledge is an indispensable component when arguing for change, in particular for those that have few other resources on hand.

In summary, when addressing and promoting knowledge related to agricultural biodiversity for positive transformations in agricultural landscapes, and strengthening of smallholders' livelihoods and resilience, it is crucial to also make sure that power aspects are taken into account.

4.7. Issues of other current debate

The survey has confirmed the initial general hypothesis that the main constraints do not seem to be the technical knowledge gaps, but rather the transfer of knowledge and other elements of a change process, as outlined in the theoretical framework. However, the survey also identified a limited number of additional important and more technical constraints and dimensions that do not fit naturally in the change process framework. We believe these dimensions are worth including in the report, seeing their value as technical knowledge gaps, and have gathered them in this chapter. The topics are: Market aspects; Payment for ecosystem services/stewardship; Agroecology; Basic scientific data and Genetic resources conservation strategies.

4.6.1. Market aspects

Several respondents stress the sensitivity of market-related issues. In many cases, farmers have been encouraged to grow exotic crops for export, turning farming into an agri-business instead of an agri-cultural practice. When it comes to markets, respondents raise policy aspects and related frustration as a more apparent constraint than tangible knowledge gaps. This constraint may be more apparent here than with any other technical aspect on agricultural biodiversity.

Access to markets
Small farmers need access to markets. Especially local and regional markets. Access to (fair and sustainable) global markets may open the door to a sub-category of small farmers, not to all. And it comes at a price. Versatility of global commodity markets implies risks for small farmers, sometimes putting them into desperate situations. Strengthening regional markets, with enhanced links between rural and urban producers and consumers, is an area requiring attention.

Quote actors survey, ILEIA

Marketing and/or seed trade policies and legislation limit for example farmers' options to sell seeds, a practice that is often allowed only within local communities. One respondent notes that to gain access to the market to sell seeds, farmers need to go through a seed certification process. This is a lengthy and

costly process – and once the process is completed the farmer may no longer be growing that specific variety. However, it is also stressed that well-informed and evidence-based cases can influence policy change.

Production, marketing, and distribution of indigenous seed varieties to farmers
A large number of indigenous varieties of seeds were in use till a few decades back. They were protected, nurtured and cultivated for varied properties such as – agronomic, suitability to various soil types, pest and disease resistance, drought and flood resistance, their utility to make specific items of food etc. Seeds are now produced and distributed by the official seed supplies system of the Department of Agriculture or by the Private seed industries in which the indigenous seed varieties receive very poor attention. Our effort is to help farmers to cultivate these seeds for exchange with farmers and to market them. The objective was to ensure a good income for farmers and also supplies of good quality seeds as inputs for sustainable organic farming. Formal trade is possible only in the case of seeds that are "notified" by the agriculture systems. Currently there are very few indigenous seed varieties that are thus notified and this means all the seeds produced cannot be labelled and sold as certified seeds but only as "truthfully labelled seeds". This limits their commercial potential and they are not eligible for any support or subsidy for seed production.

Quote actors survey Centre for Indian Knowledge Systems

Respondents also raise concern that markets may limit biodiversity, in the sense that market demands have a strong influence on production: what kind of crops/varieties/breeds are favourable if aiming for the market? It is stressed that market demands should not be allowed to decide what kind of diversity should be conserved.

Communities are not always familiar with joint marketing and management practises, affecting both smallholder farmers' development options and possibilities for promoting biodiversity. One respondent writes:
"Marketing structures and systems are not well defined, market dynamics are least understood by the small scale farmers. Different market chain actors are focused on specific activities rather than looking at marketing as a whole chain with different players that add value at each stage of the commodity that go towards meeting the consumer needs. The value chains links are also weak, there are poor marketing strategies and very limited add-value processes. Thus, the small scale farmers get little for their efforts."

In terms of adding value and opening up for marketing opportunities of local produce, the case below is highlighted.

League for Pastoral People, and Natural Justice: Bio-cultural Community Protocols
One way to address multiple dimensions of agricultural biodiversity, including market aspects, is illustrated by the work of Natural Justice together with the League for Pastoral People. In enabling a process for the development of Bio-cultural Community Protocols, people are not only documenting the knowledge and the resources their communities possess, but they have also in many cases been empowered in the process, and shown possibilities and options for value-adding and marketing of local products. Synergistic effects have included being given back a sense of pride in what they have and do, identification of areas for value-adding and marketing of local products, together with highlighting options and possibilities, and in many cases also discovery of "new" (not previously documented) breeds with potentially valuable traits, such as heat or drought tolerance.

Interview, League for Pastoral People representative

Agricultural biodiversity as niche markets is noted as an area with potential in various aspects. Biodiverse agricultural systems could increase income, drawing on the potential higher price on a variety of underutilized crops, as well as semi-domesticated and wild biodiversity.

Centro Ecologico, Brazil: Alternative to external certification increases confidence of local communitites
Initially, there was no certification at all for organically produced goods since it was not considered necessary when producers and consumers had such a close relationship. However, the feeling gradually developed that a certification system was necessary to deal with the claim that certification was lacking because the goods were of lower quality. The Participatory Guarantee System (PGS) that was then established by local consumers and producers is based on trust

instead of the international certification system model with expensive external controls. A particular aim is to stimulate self-determination and to build up a sense of pride in local producers. The network Ecovida, where Centro Ecologico is one of the driving parties, coordinates the work on PGS. Ecovida bases its work on a high level of confidence between producer and consumer, and now covers the three states Parana, Rio Grande do Sul and Santa Catarina. The network consists of 24 nodes that all work both regionally and locally through consumer and producer groups and through environmental groups and other voluntary organisations. In dialogue with the Ministry of Agriculture, PGS has today spread throughout Brazil. Similar systems have been developed in e.g. Chile, Bolivia and Costa Rica.

Quote from Organic Farming in Brazil – Participatory certification and local markets for sustainable agricultural development[89]

4.6.2. Payment for ecosystem services/stewardship (PES)

Some respondents highlight incentives promoting PES as important for further development. Some argue that the concept should be Payment for Ecosystem Stewardship, instead of Services, emphasising that farmers would be paid for his or her stewardship of the land – and the system's ability to provide ecosystem services – rather than for the services *per se*. Respondents also note that more basic research is needed to explore the implications of this kind of economic incentives.

CEDECO, Costa Rica: Payment for Ecosystem Services

CEDECO started in 2011 implementing the Cam(Bio)2 methodology in Talamanca region, Costa Rica. Environmental services were evaluated and negotiations started with local and European companies to create relations to invest in local development trough payments for specific Carbon reductions/sequestrations. We expect to include concrete values of biodiversity conservation from these alliances, like an integral scheme to support rural development and environmental conservation.

The farmers are organics around local organization APPTA (http://www.appta.org). APPTA includes 1200 families and 1000 organic certified farms, of which 80% is indigenous Bribri or Cabécar and 20% is black or white. Women consist 38% of the members of the association. Agroforestry systems of cocoa and bananas have high capacity to reduce/sequester carbon and conserve biodiversity, respecting other land uses in the region (Conventional bananas). However, is necessary that the intervention in the business approach support small farmers' organization to improve ecological management (i.e. trough composting plants, additional products from on farm biodiversity (tropical fruits), training, etc.

Quote from actors survey, CEDECO

The concept of PES and similar market-based approaches is however seen as quite a sensitive field, and views differ between respondents. Concerns have been raised that this would be another way of commodification of nature. Many actors oppose to such interventions on the notion that biodiversity itself has intrinsic values and should not be reduced to instrumental values.[90] Proponents to the concept claim that PES could be an approach to support farmers in less favourable areas, and to raise awareness of the less known goods and services provided by agricultural landscapes. It is important to note that PES interventions can also be funded by public means as support to biodiversity and ecological functions, and that all action in this area is not market-based. It is necessary to establish clarity on land rights and natural resources rights before initiation of a PES scheme, as this would increase the value of the land and possibly also competition. In a gender perspective, this is even more important in areas where women have less formal access to land. An additional constraint is that PES programs may favour some people more than others, with implications for overall poverty reduction. Operational costs of reaching small-scale producers in a PES scheme are generally high. This is true in particular where beneficiaries do not constitute a homogenous and well-organised group, which is often the case of poor and marginalized peoples.[91]

[89] J. Lundberg and F. Moberg. 2009. Organic farming in Brazil – Participatory certification and local markets for sustainable agricultural development

[90] Swedish Biodiversity Centre. 2008. Contributing to Resilience. Results and experiences from the SwedBio Collaborative Programme 2003 – 2008.

[91] FAO. 2007. State of Food and Agriculture 2007. Paying Farmers for Environmental Services.

Overall, practices related to sustainable farming often end up as win-win solutions with adaptation to and mitigation of climate change. Carbon trading in the context of agriculture is a specific case of PES, and an area that is expanding rapidly. How to design truly pro-poor schemes for PES will be even more important in the context of increasing funding options for climate adaptation and mitigation work, e.g. through carbon credit mechanisms.

4.6.3. Agroecology

Respondents identify agroecology, the concept of perceiving the crops, the farm and the landscape as a system, as a promising approach that could bring benefits to smallholder farmers if adopted more widely. The core principles of agroecology include recycling nutrients and energy on the farm, rather than introducing external inputs; integrating crops and livestock; diversifying species and genetic resources in agroecosystems over time and space; and focusing on interactions and productivity across the agricultural system, rather than focusing on individual species.[92] Agroecology is highly knowledge-intensive and based on techniques that are not delivered top-down but developed on the basis of farmers' knowledge and experimentation.[93]

One critical point that many raise is the need for local adaptation, taking into account the diversity of ecological zones and their agricultural systems. Concern is also raised that there is not enough basic data available on how agroecological systems really work, feeding into the case for further research with a systems level approach.

One respondent writes:
"There is an urgent need to explore directly the ways in which the contribution of agricultural biodiversity can be optimized in support of agro-ecosystem functionality and the livelihoods of small-scale farmers. This is not just basic scientific knowledge (although that is certainly part of it) it involves the linked exploration by farmers, communities and scientists of diversity per se *in ways that cover scales, components, agro-ecological systems and take account of resilience, trade offs, transformations and can be translated into meaningful knowledge products. It is essential that this exploration is inter-disciplinary and covers all aspects of agricultural biodiversity."*

4.6.4. Basic scientific data on all components and aspects of agricultural biodiversity

Respondents, in particular those from academia and international organisations, stress the need to carry out proper inventories and quantification of agricultural biodiversity – including crop varieties, crop wild relatives, pollinators, livestock breeds, aquatic genetic resources, and microorganisms– as a large proportion of the existing diversity remains undocumented. Scientific evidence and data related to the productivity of agroecological, organic, and agricultural biodiversity-based systems build largely on isolated cases. Options as well as outcomes differ between regions and ecological zones, and depend on local social-ecological contexts.

A need for more information on the size, location, and contribution of smallholder agriculture to food security at a global and regional level and within specific areas of the food economy has also been identified. Emerging data suggests that the smallholder sector is larger and more significant for food security and food systems than is commonly accounted for in agriculture and food policy.[94]

In addition, there is a need to address the gap in our knowledge of the institutional contexts that affect the ability of smallholders to adapt and cope with shocks and change. More information is needed on the types of organisations that smallholders establish and manage to exchange knowledge and gain access to essential resources.

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[92] M. A. Altieri et al.1998. The potential of Agroecology to combat hunger in the development world. 2020 brief 55.

[93] O. de Schutter. 2011. Agroecology and the Right to Food. Report presented at the 16th Session of the United Nations Human Rights Council, by the Special Rapporteur on the right to food, Olivier De Schutter.

[94] Dr. P. Eyzaguirre, Bioversity International. Pers. ref.

3.6.5 Genetic resources conservation strategies

Some respondents also stress the complementarity of *in situ* and *ex situ* approaches to conservation of genetic resources, to create the best possible environment for addressing risks and enabling responses: *"This is a race against time as this diversity, along with its associated knowledge, is disappearing at an alarming rate."*

The Pavlovsk station, Russia

Founded by Nikolai Vavilov himself in 1926, the Pavlovsk Station, where the struggle to conserve crop diversity really began, houses Europe's largest collection of fruits and berries. 600 different apple varieties. A thousand strawberries. More than a thousand black and red currants, and hundreds of varieties of other fruits and berries. 5700 varieties in all, 90% of which are conserved nowhere else.

This station today faces its most serious threat, from real estate developers. The developers have argued that because the collection is "priceless" it is also "worthless." Even the "minor crop" collections housed at the Station, however, can be credited with generating gigantic, recurring economic returns. Some 60% of the black currant varieties grown in Russia, the world's largest producer, were developed at Pavlovsk. It is a crop that generates more than $400 million in farm sales annually in Russia.

The struggle to save this biodiversity from extinction has entered the political arena. Citing a new law that allows the takeover of public lands not "efficiently" used, a court some time ago turned over the land to developers. Unless the President or Prime Minister overturn the ruling, the developers will rip out the collection. Never before in history will so much crop diversity be lost intentionally and avoidably as if estate development starts in Pavlovsk. One can only hope that the Russian leadership will reverse the court if and when the Russian leadership actually hears about the threat to the Pavlovsk Station and realizes its importance.

Adapted from Cary Fowler, Crop Topics. The Global Crop Diversity Trust[95]

The case above is only one of many examples of crop collections at risk of extinction.[96,97] The mapping process has reconfirmed that biodiversity is being lost at alarming rates under both *ex situ* and *in situ* conditions. This again stresses the need for an intersectoral approach to conservation, development, and use of genetic resources, built on the opportunity and will to experiment, innovate, and learn within and between different knowledge systems.

[95] http://www.croptrust.org/documents/newsletter/newsletter_croptrust_v23.htm
[96] http://agro.biodiver.se/2010/10/a-threatened-genebanks-roundup/
[97] http://agro.biodiver.se/2010/10/fruit-tree-genebank-faces-the-chop/

5. CONCLUSIONS AND RECOMMENDATIONS

Resilience theory, which has formed the framework for this mapping of current knowledge, can be helpful in understanding how system changes take place, and where intensified knowledge and improved means of handling the same could enhance the situation for smallholder farmers. This can be exemplified by assessing which phase in the adaptive cycle the local system currently is, and adapting interventions in accordance with the findings, e.g. the likelihood for innovation and experimentation impact increases when a system is in the reorganisation phase (*see figures 2 and 3*). Another possibility is to carry out a feedback loop analysis (*see figure 4*) to understand how internal and external factors interplay, with the aim to again guide interventions. Important in this context would be to take in views and perspectives from different fields of expertise, i.e. make sure that researchers, practitioners, and farmers all collaborate.

5.1 The six knowledge constraints

Scientists addressing research on social-ecological systems, and associated literature, point out that there is not sufficient understanding of system transformations, or of processes for feedback in integrated social-ecological systems. An additional constraint in scientific knowledge generation, which has been mentioned by researchers, is the frequent lack of links between different areas of agricultural biodiversity research, and the tendency of researchers to work in isolation from each other. It is of major importance to overcome the barriers or separation between disciplines. There is also an urgent need to further address power aspects and influence. More knowledge available in these fields could indeed be supportive for policymaking and for addressing smallholder farmers', livestock keepers' and respondents' observations of constraints and bottlenecks. Of particular interest is to understand the combined effects of ecosystem degradation and other environmental risks, with climate change serving as a multiplier to already serious degradation processes. We identify these constraints – at least partly – as scientific research gaps, and argue that they may perhaps not constitute a particular focus for a Knowledge Programme. However, we do believe that researchers need to collaborate closely with smallholder farmers and local communities for true advancement of our common understanding of the complex adaptive systems that agricultural systems form.

Actors who have been part in the process of developing this report take departure in their respective fields of expertise. They all have strong experiences and continuous engagement for biodiversity and smallholder farmers, livestock keepers, and/or other custodians of diversity and knowledge. As they have differing entry points, their suggestions and views cover a range of different perspectives.

The six knowledge constraints identified in this mapping study are listed in the table below. The constraints are categorized into different types, depending on what kind of intervention would be needed to address the constraints. This in turn leads to the conclusions on possibilities for a Knowledge Programme in the right hand column.

Constraint	Type of constraint	Possibility for a Knowledge Programme
1. How do transformations take place?	Scientific research gap	Less so, however crucial to link researchers to the field and create space for sharing between scientists and communities
2. Transfer of knowledge, and the process of learning (internalisation of knowledge)	Implementation/policy constraint	Yes, through documentation; facilitated exchange between knowledge systems; and innovative methods for learning
3. Identification of factors that initiate processes towards positive change	Implementation/policy constraint	Yes, through concerted upscaling efforts, and enabling innovation

4. Lack of understanding of processes for feedback in social-ecological systems	Scientific research gap. Resilience assessment however a possibility to improved understanding of the situation on community and other scale levels.	Guidance from the *Assessing Resilience in Social Ecological Systems: Workbook for Practitioners*
5. How can local actions and initiatives be (better/more efficiently) linked to regional and/or global processes?	Implementation/policy constraint	Yes, through enabling cross-scale interaction and systematising evidence from the ground. Bridging organisations have a crucial role to play.
6. How can power relations be tipped towards equity?	Implementation/policy constraint, and scientific gap	Attention to power issues should be mainstreamed in all topics

The sixth constraint was elaborated upon and added following the key actors meeting in Thika, Kenya, acknowledging the fact that an overwhelming majority of participants stressed the need to address power related aspects in all efforts and interventions. For more on this, see the forthcoming workshop report and concept note for the development of the Knowledge Programme (*www.hivos.net*).

5.2 Possibilities for a Knowledge Programme

We can visualise a Knowledge Programme that concentrates on integrating social-ecological aspects into the goal of enhancing biodiversity management and improving peoples' livelihoods, and where empowerment of individuals and communities plays a key role. Identifying ways to implement innovative methods for knowledge sharing, for documentation, and for intersectoral collaboration to develop new knowledge (evidence and insights) could come in quite useful. The aim could be to find ways – through solid gathering of evidence from local levels – to be able to overcome barriers to change towards what should be seen as true "sustainable intensification".[98] We highlight some possible approaches below, and list the knowledge constraints they would address.

5.2.1. Experimenting with landscape approaches, social-ecological systems, and payment for ecosystem stewardship

A group of organisations working in this field have been identified among respondents, opening up for possible collaboration, interaction, and contribution to the building of new knowledge, and as a means to connect landscape approaches for agricultural biodiversity and sustainable livelihoods, with policy development.

This kind of intervention would address knowledge constraint numbers 4 and 5.

5.2.2. Exchange between knowledge systems – traditional, practitioners', and scientific knowledge

Traditional and local knowledge on agricultural biodiversity is of great significance for resilient social-ecological systems. This knowledge is, however, disappearing at an alarming rate.

One main question is: Driven by the urgency of the issues at stake, how can we explore synergies between knowledge systems to move towards more sustainable futures with secured and enhanced human wellbeing, while also respecting the interests of all knowledge holders? [99]

[98] J. Pretty et al. 2011. Sustainable Intensification. Increasing Productivity in African Food and Agricultural Systems.

[99] M. Tengö. 2011. How to deal with exchange between knowledge systems – a way forward. Background paper for meeting in Jokkmokk, June 22, 2011.

Efforts to promote and conserve local and traditional knowledge, and to enhance the exchange between different knowledge systems would address knowledge constraint number 2.

5.2.3. Local seed supply systems and participatory plant breeding

Many development interventions use participatory approaches to empower communities and to facilitate learning. The participatory plant breeding and selection approach combines this with targeting on-farm conservation, development, and use of plant genetic resources. This approach promotes the role of traditional and improved farmer varieties – which are adapted to local conditions – for risk reduction and adaptation to changes, such as climate change. Tools like these often have the added value of building knowledge and empowering communities, including building relations and facilitating exchange between different knowledge systems.

A cluster of responding organisations have used participatory methods for plant variety selection and plant breeding, and in some cases addressing livestock breeds as well. This approach also includes concrete observations and actions regarding climate change adaptation, and options for building evidence for enhanced policy and legal systems for seed certification, Intellectual Property Rights, and Plant Variety Protection.

Efforts in this regard would address several of the above mentioned knowledge constraints, including numbers 2, 5 and 6.

5.2.4. Assessing systems' resilience

Mapping and analysing a social-ecological systems' feedback loops in order to identify barriers to change can be a useful way of moving forward. The Resilience Alliance publication Assessing Resilience in Social Ecological Systems: Workbook for Practitioners (*see www.resalliance.org*), can act as a starting point for integrating the resilience-thinking concept in the knowledge networks.

Carrying out this kind of analyses would address knowledge constraint number 4.

5.2.5. Policy and power

As previously noted, the knowledge constraints stressed by respondents refer only to a limited extent to the lack of technical knowledge. Main constraints refer instead to observations that farmers' knowledge and experiences related to agricultural biodiversity have not (yet) been translated sufficiently into policies and strategies relevant to development organisations working in the South. In this lies an opportunity for a Knowledge Programme: to contribute to systematic documentation of much needed evidence, and to promote the bridging of organisations to support the development of more accurate policies. This kind of intervention could entail a coupling of constraint 2: internalisation of knowledge); and constraint 5: How can we (better/more efficiently) link local actions and initiatives to regional and/or global processes?

Initiatives, including addressing individuals', communities' and organisations' knowledge, may have little or no impact in themselves if power structures – including aspects of control over the world's food systems and its associated agricultural biodiversity – hamper their implementation. Nevertheless, knowledge is an indispensable component when arguing for change, in particular for those that have few other resources on hand.

We note that knowledge related to influencing the practice and policy levels is important, but understand that interventions targeting the policy arena *per se* may fall out of the scope of the intended Knowledge Programme. A Knowledge Programme can however be important for supporting evidence-building, to catalyse change and influence policy interaction, and to enhance the links between practice, policy, and science.

An overarching matter is to address power related issues in all interventions and efforts, to help answer the question: How can power relations be tipped towards equity?

5.3 Way forward

The information and ideas presented in this report were intended as a starting point for discussion, with the specific aim to provide a background for the further development of a Knowledge Programme on the topic of Strengthening agricultural biodiversity for smallholder livelihoods. We have incorporated feedback from actors in this field and visualised the various perspectives we have encountered during the process of work. It is our recommendation and hope that Hivos and Oxfam Novib find a way to develop a Knowledge Programme on this important and engaging topic, in consultation and collaboration with relevant actors. We also hope that this document can provide a background and provoke further thoughts and inspiration for individuals and organisations working in this field, and be relevant beyond the Knowledge Programme.

Given the limited timeframe and the vast topic of the study, the draft recommendations are by no means intended to be exhaustive, or final. While some knowledge constraints have been identified, and suggestions of ways to address them put forward, other issues have surfaced that fall out of the scope of this study but nevertheless constitute interesting topics for further elaboration or research. One way to further improve and elaborate on the reasoning in this report could be to invite more in-depth feedback from additional researchers and practitioners from various fields. This could be addressed as part of the Knowledge Programme, or as a separate task before the finalisation of the outline of the same.

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