Agroecology

Making Ecosystem-based Adaptation
Work in Agricultural Landscapes

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List of Abbreviations

APCNF	Andhra Pradesh Community Managed Natural Farming
ASOCUCH	Asociación de Organizaciones de los Cuchumatanes (Engl.: Association of Organizations of the Cuchumatanes)
CBD	Convention on Biological Diversity
CFS	Committee on World Food Security
COP	Conference of Parties
ELD	Economics of Land Degradation
EU	European Union
EbA	Ecosystem-based Adaptation
GDP	Gross Domestic Product
FAO	Food and Agriculture Organization of the United Nations
GHG	Global Greenhouse Gases
HLPE	High-Level Panel of Experts on Food Security and Nutrition
ICUZONDEHUE	Asociación de Desarrollo Integral Comunitario de la Región Norte de Huehuetenango (Engl.: Association of Integrated Community Development of the Northern Huehuetenango Region)
IFAD	International Fund for Agricultural Development
IPCC	Intergovernmental Panel on Climate Change
MAM	March-April-May
NbS	Nature-based solutions
NDCs	Nationally Determined Contributions
NGOs	Non-Governmental Organizations
OND	October-November-December
OxC	Options-by-Context
RySS	Rythu Sadhikara Samstha (Engl.: Farmers Empowerment Organization)
SDGs	Sustainable Development Goals
SMPOB	Sistema Milpa+Papa+Ovinos+Bosque (Engl.: Milpa+Potato+Sheep+Forest system)
TCA	True Cost Accounting
TEEBAgriFood	The Economics of Ecosystems and Biodiversity for Agriculture and Food Programme
UN	United Nations
UNCCD	United Nations Convention to Combat Desertification
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
USD	United States Dollar

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1. An Introduction to the Challenges and Chances of Building Climate-Resilient Food Systems

Challenge of interlinked and systemic crises

The aim of this report is to encourage the agriculture and climate communities to find common, integrated, and systemic responses to one of the most urgent questions for humanity: How to develop climate-resilient and sustainable food systems in times of multiple crises that are threatening global food security?

Today's planet is facing a number of systemic crises that are closely interlinked with each other. One of the most dramatic examples is the interdependency between the global food system and the drastic change of the global climate. The climate crisis exacerbates hunger,[1] biodiversity loss,[2] and the degradation of land and water resources.[3] Thus, climate change threatens agriculture and disrupts the global food system,[4] thereby multiplying existing risks in the system. For example, changing rainfall patterns cause higher frequency and severity of droughts and floods, posing immense challenges to farmers in all world regions. This makes the agricultural sector extremely vulnerable to the immense threats posed by changing global climate conditions. The global Covid-19 pandemic has further exposed the vulnerability of the world's food systems and deepened social inequality. The Food and Agriculture Organization of the United Nations (FAO) estimates for 2020 that around 768 million people, or 9.9 percent of the global population, suffered from hunger. Compared to 2019, this is an increase of nearly 118 million and 153 million compared to 2015.[5] In cynical contrast to this, 1.3 billion tons of food are wasted every year.[6]

At the same time, agriculture itself is a major contributor to climate change, land, and water degradation, as well as biodiversity loss.[7] The Intergovernmental Panel on Climate Change (IPCC) estimates that the agricultural sector is responsible for around 21 to 37 percent of overall anthropogenic emissions of global greenhouse gases (GHG), while other estimations even suggest an average of 34 percent of GHG emissions (ranging from 25 to 42 percent) for the year 2015.[8] Regarding the destruction of forests, the FAO Remote Sensing Survey suggests that almost 90 percent of global deforestation is driven by agricultural expansion,[9] making the agricultural sector a key factor for the global loss of trees as valuable carbon stores. Whether crop land expansion or livestock grazing dominates deforestation varies between regions and sub-regions: livestock grazing lead to 70 percent of forest loss in South America, 52 percent in Oceania, and 44 percent in North and Central America, while crop land expansion was responsible for a share of more than 75 percent forest cover loss in Africa and Asia.[10] Today around 40 percent of the global land area is occupied by agriculture,[11] from which another 60 percent are estimated to be at risk of pesticide contamination. Agrochemical contamination results in pollinator loss – which is in turn again posing higher risks of crop production loss.

What becomes visible are multiple and interlinked crises covering the challenges of climate change, land and water degradation, biodiversity loss and a disruptive global food system. The mutual influence of all four dimensions even amplifies the effects of the individual crises, as visualized in Figure 1.

Need for systemic solutions

Against this background, systemic responses are required to adapt agricultural and food systems to the interrelated challenges posed by climate change, biodiversity loss and land and water degradation. Such responses need to enhance the resilience of agriculture and food systems instead of focusing on selected components in isolation, such as the drought tolerance of plants grown in monocultures. Thus, a transformation is needed that enhances the resilience of entire food systems and protects ecosystems and the services they provide. Solutions need to not only enable climate change adaptation and create sustainable rural livelihoods, but also curb the environmental damage associated with unsustainable agricultural production and food consumption, which effectively would backlash onto any type of production system and onto society as a whole.

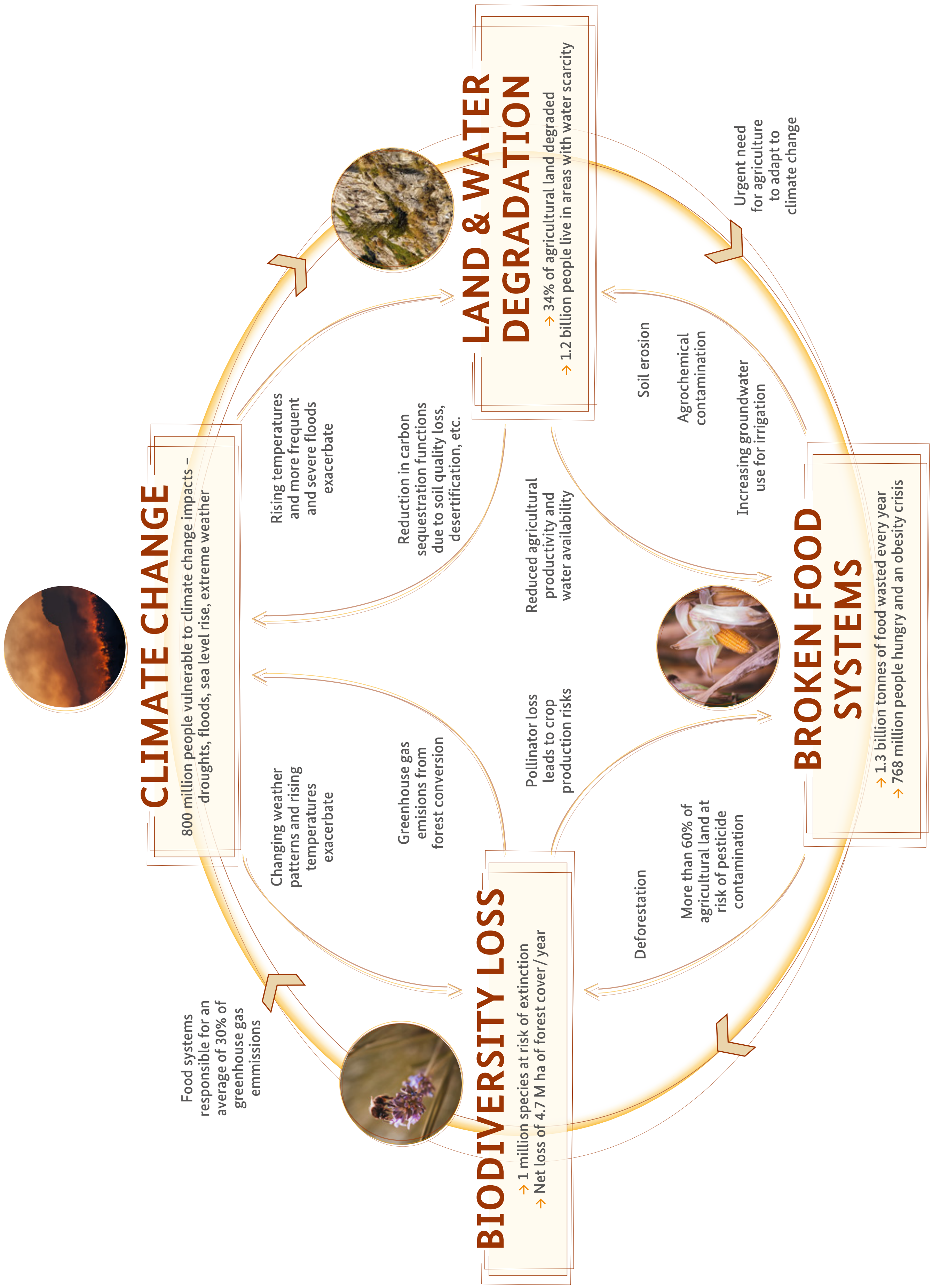

Figure 1: The interlinked crises of climate change and disruptive food systems.

Segregated policy and knowledge communities and the missing middle

While in general the need for such systemic responses seems to be recognized by the global community, so far policies and programs on food security and climate change adaptation too often remain in silos, creating a "missing middle" between aspirations formulated in international policy dialogues and practical achievements in landscapes on the ground. However, addressing this missing middle will be critical for succeeding in transforming the global food system in a climate-friendly and nature-friendly way.

One reason for this gap is that climate and agriculture policies and programs are often developed in isolation of each other, as evident in the separate international conventions and platforms on climate change (United Nations Framework Convention on Climate Change, UNFCCC), biodiversity (Convention on Biological Diversity, CBD), land degradation (United Nations Convention to Combat Desertification, UNCCD), and food security (United Nations Committee on World Food Security, CFS). The three so-called Rio Conventions (UNFCC, CBD and UNCCD) are increasingly recognized as interlinked in achieving their ambition and consequently a Joint Liaison Group was established in 2001.[12] However, in general the workings of these bodies largely involve different groups of people from different governmental institutions, forming knowledge communities that work too often in isolation from each other. What becomes visible is the need to build bridges between different existing conventions and fora at the international level.

This segregation is also reflected at the national level, where national programs to achieve food security as well as to implement the three Rio Conventions often have separate policy frameworks, measurement approaches and national development plans that may constrain resources available for each (such as National Adaptation Plans, National Biodiversity Strategies and Action Plans, and Land Degradation Neutrality Targets).[13]

A second reason for the missing middle is that there are often limited capacities to systematically support local transformation processes on the ground. Hence, an implementation gap often exists between national-level commitments and implementation capacities as well as available resources at the local level.

As a result, segregated policy and knowledge communities often persist between the different policy fields and related sectors (missing horizontal integration) as well as at regional, national, and sub-national levels (missing vertical integration). This missing integration contributes to global responses that are siloed, disconnected and even antagonistic to one another.[14]

Creating synergies

The central idea of this report is that the blending of Ecosystem-based Adaptation (EbA) with agroecological approaches can increase the organizational capacity and resources devoted to translating national commitments on food security, climate, biodiversity conservation and sustainable land management into action on the ground. In contrast to the current reality of siloed approaches, there are huge opportunities for synergies where efforts are combined across sectors and levels for creating resilient food systems that actively address the multiple crises and support the realization of the United Nations (UN) Sustainable Development Goals (SDGs). This is increasingly important when traversing from international aspirations to the local contexts where land use change occurs. Thus, there is an urgent imperative to connect policy design and implementation across sectors and levels. Complementarities between national programs mean more efficient resource use and higher implementation capacity. This is key as critical implementation gaps often exist at the local landscape scale.

To address climate change in agricultural landscapes, this report suggests aligning the knowledge and actions of EbA on the one hand with the agricultural approach of agroecology on the other hand. Although conferring adaptation benefits, so far agroecology does not have explicitly considered projected climate risks and impacts. This creates a clear opportunity to employ agroecological practices within an EbA framework so that both approaches are explicitly combined to address specific adverse effects of climate change. Such combined approach could also contribute to the overall resilience of agri-food systems and rural livelihoods and address in parallel the related crises of biodiversity loss as well as land and water degradation.

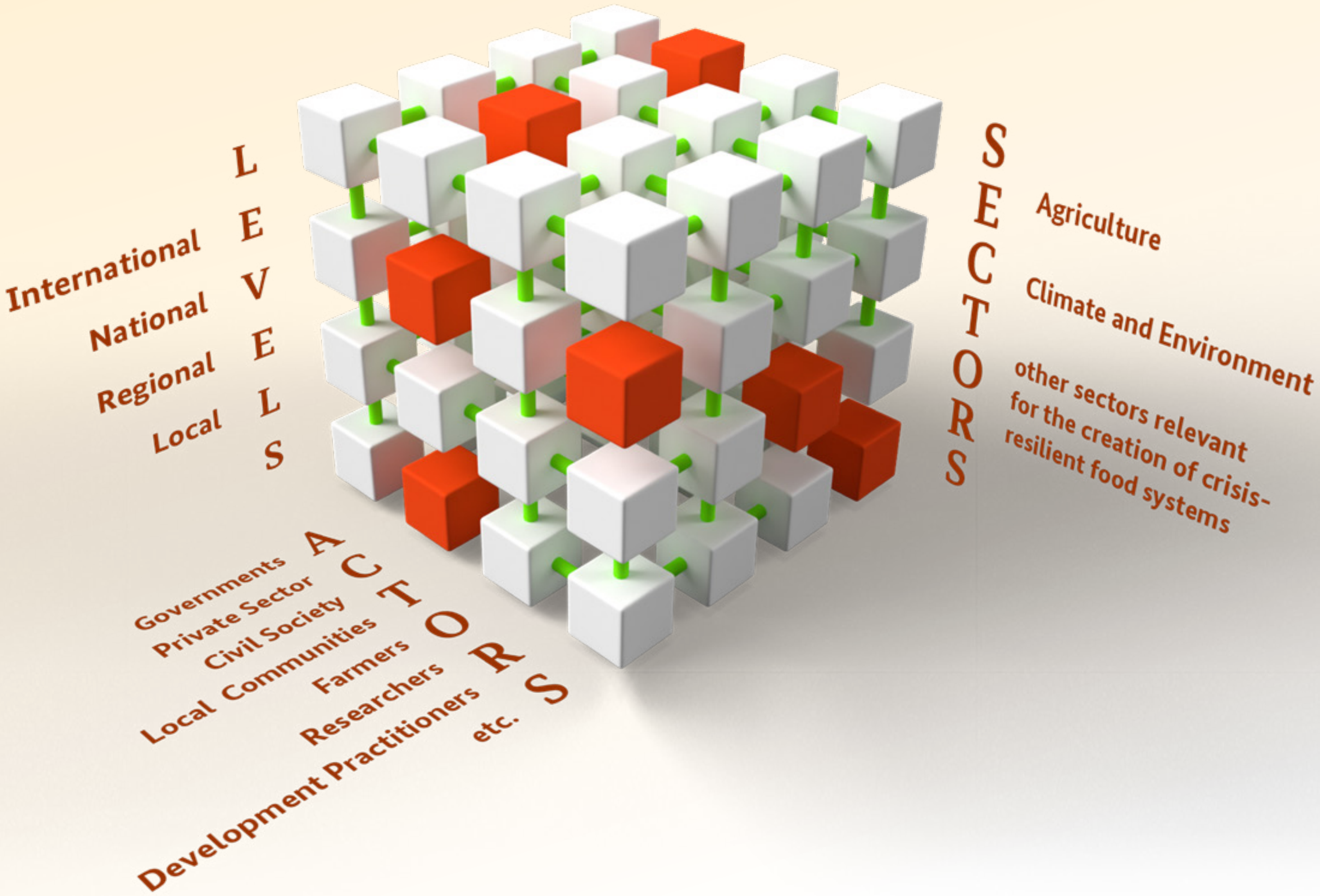

Figure 2: **Missing vertical and horizontal integration** between relevant actors and sectors that apply agroecology and Ecosystem-based adaptation in their specific activities at different levels – **the "missing middle"**.

Methodological procedure

By focusing on these potential synergies, Chapter 2 of this report presents agroecology as an EbA approach in agricultural landscapes and discusses potential contributions to the SDGs. The chapter explains why employing agroecology as an EbA approach requires innovation to incorporate projected climatic change risks and related impacts regarding land degradation and biodiversity loss. Here, the focus is not only on generating agroecological solutions in terms of practices in the fields but also regarding social adaptation via knowledge transfer.

Chapter 3 will present such agroecological solutions and innovations via three different case studies from India, Kenya, and Guatemala. Based on the lessons learned from the case studies, Chapter 4 suggests practical steps required to merge agroecology and EbA at the national policy level as well as landscape level. The chapter also discusses the components of an enabling environment necessary to promote the up-scaling of these complementary approaches.

By presenting a Five-Step-Approach in form of an "hourglass procedure", the report offers a solution on how to address the missing middle. It is shown that when agroecology is implemented as EbA, it not only contributes to the achievement of diverse SDGs and multilateral environmental agreements, but also to emerging food system transformation pathways at the local and national level.

Chapter 5 gives an outlook on how the alignment of the agroecology and EbA policy and knowledge communities leverages a strategic opportunity for joint action in developing climate-resilient and socio-economically viable food systems that protect biodiversity and land and water while contributing to climate change adaptation and mitigation.

2. Agroecology and Ecosystem-based Adaptation: Two Sides of the Same Coin

Agroecology and Ecosystem-based Adaptation: What is in the terms?

Agroecology is a systemic approach promoting agriculture that systematically uses and supports ecological processes. It proactively addresses the various linkages between producers, consumers, and the range of other elements constituting a food system.

Agroecology is based on a set of clearly articulated socio-economic and ecological principles.[15] Advocates of agroecology aim to achieve transitions in agricultural production schemes, ranging from more "incremental" changes at the level of the agroecosystem up to more "transformational" shifts at the level of the food system as a whole (see Info Box 1).[16]

At the farm level, agroecology aims at enhancing biodiversity and ecosystem services – i.e. the benefits that ecosystems provide to human wellbeing – through context-specific, environmentally friendly practices.[17] At the level of food systems, agroecology is guided by principles such as fairness, social justice, participation and good governance of land and other natural resources,[18] thereby aiming at contributing to the progressive realization of the right to food.[19] It builds on transdisciplinary science and the traditional knowledge held by farmers to co-generate innovations. Agroecology benefits from social movements that advocate for holistic food system changes.[20] Agroecological methods are context-specific and can include techniques like agroforestry, integrated water resource management and soil conservation.[21] Agroecology provides climate adaptation and mitigation benefits like higher and diversified incomes, ecosystem protection and carbon storage – however, so far it has not been specifically designed to address projected climate change effects.

Food System and Agroecosystem

Food System

According to the High-Level Panel of Experts on Food Security and Nutrition (HLPE), a food system gathers all the elements (e.g. environment, people, inputs, processes, infrastructure and institutions) and activities related to the production, processing, distribution, preparation and consumption of food, and the outputs of these activities, including socio-economic and environmental outcomes. Sustainable food systems ensure food security and nutrition for all in such a way, that the economic, social, and environmental bases to generate food security and nutrition of future generations are not compromised.

Three core elements constitute a food system:

1. Food supply chains (production, storage, distribution, processing, packaging, retailing, and marketing)
2. Food environment
3. Consumer behavior

Agroecosystem

An agroecosystem is described in literature as a cultivated, human-managed ecosystem. A well-known example of a traditional agroecosystem is the rice-fish-duck system in Hani terraces in Southwest China, that focuses on the integration of crops and animals based on a circular economy: Rice provides food, shelter and shade for the fish and ducks. At the same time, the fish and ducks eat weeds and pests and loosen the soil to improve the growing environment for rice.

As highlighted by the High-Level Panel of Experts on Food Security and Nutrition (HLPE), there is no single, consensual definition of agroecology and the precise aspects that are embedded in the concept.[22] Still, there is a clear consensus in literature stressing that agroecology embraces three different dimensions: a transdisciplinary science, a set of practices and a social movement.[23] A number of international organizations and actors recognize that agroecology has the potential to make a significant contribution to the food system transformation, even though further research is needed regarding the increase of yield by agroecological practices. The clear promise of agroecology is that it works with and not against nature, thereby contributing to a sustainable food system that adapts to a warming world, minimizes environmental impacts, eliminates hunger, and improves human health. [24] From this perspective, it can be argued that agroecology is a Nature-based Solution (NbS).[25]

Also EbA, which is equivalent to NbS for adaptation, has emerged from the climate and biodiversity communities as a systemic adaptation response. The concept was first introduced by the UNFCCC in 2008 and was officially defined by the CBD in 2009 as the use of biodiversity and ecosystem services (ecological dimension) as part of an overall adaptation strategy (institutional dimension) to help people to adapt to the adverse effects of climate change (socio-economic dimension). To be acknowledged as an EbA activity, initiative, project, approach, or strategy, all three dimensions must be clearly addressed. Hence, EbA clearly acknowledges that human resilience critically depends on the integrity of ecosystems. At the same time, EbA is people-centric in its focus because it does not depict ecosystem health alone as a guarantee for human resilience.[26]

Much more, EbA should be seen as one integrated part of a broader adaptation strategy referring as well to sustainable and community-based natural resource management and community-based adaptation. What makes EbA different from conservative adaptation strategies is, thus, to explicitly include local stakeholders and rights-bearers by linking traditional biodiversity and ecosystem conservation approaches with sustainable socio-economic developments. EbA-practices are diverse and can include for example integrated watershed management, sustainable land management, or coastal zone management. Also, EbA is a flexible approach: The “green” infrastructure applied in EbA approaches can be combined with “grey” infrastructural measures like dikes, dams, river stabilization structures or man-made reservoirs.[27]

Five criteria have been identified in literature that stress the systemic or holistic nature of EbA. First, EbA reduces social and environmental vulnerabilities. Such vulnerability assessment must focus on the hazards and risks to people and be based on a combination of climate information from the scientific as well as local communities. The second criterion suggests that EbA generates societal benefits in the context of climate change adaptation. Such benefits must be shared in a fair and equitable manner and be based on the use of biodiversity and ecosystem services. Thirdly, EbA restores, maintains, and improves the ecosystem health by addressing the challenges and trade-offs resulting from climate change. Fourth, EbA must be supported by policies at multiple levels (local, national, regional, landscape) and can support sectoral adaptation as well as multi-sectoral approaches. Lastly, EbA supports equitable governance and enhances capacities by following a community-centered, participatory and gender-sensitive approach.[28]

Ecosystem-based Adaptation and Agroecology: Shared Principles and Ambitions

While agroecology and EbA originate in different policy and knowledge communities – agroecology from the sustainable agriculture community and EbA from the climate and biodiversity spheres –, they share common principles and key characteristics, that could support joint policies, programs, and strategies.

1. Both EbA and agroecology are **NbS** with the aim of **strengthening and maintaining ecosystem services** for sustainable livelihoods and ecological, economic, and social sustainability.
2. They are **systemic in nature**, moving beyond interventions that target only selected aspects of a given system, be it a food system or an ecosystem.
3. Both address pressing societal challenges by **speaking to a range of policy priorities and SDGs**.

Combining the two approaches has the potential to make faster and larger impacts in the fight against climate change and food insecurity by bringing together complementary perspectives, expertise, and resources.

Especially with a focus on the SDGs, the FAO stresses the inherent adaptation and resilience potential of agroecology to climate change due to the core principles on which agroecological practices build (i.e. diversity, efficient use of natural resources, nutrient recycling, natural regulation and synergies).[29] The following (not exhaustive) list highlights some potential synergies and contributions by applying EbA-sensitive agroecology with regard to different SDGs:[30]

Landscape Approaches

In the context of development cooperation, landscape approaches cover a set of concepts, tools, methods, and approaches deployed in landscapes with the aim to achieve multiple economic, social, environmental objectives (multi-functionality) through multi-stakeholder processes that recognize, reconcile and synergies interests, attitudes, and actions of involved actors.

As explained by GIZ (2019, p. 2): *"Different forms of land use such as forestry, agriculture, conservation areas and settlements are interdependent. Policy and administrative measures and guidelines that focus exclusively on the protection or use of forests on the one hand or agriculture on the other hand can give only an incomplete perspective of landscapes with all their uses and stakeholders. A comprehensive approach, however, is the foundation for sustainable management of landscapes that enables compromises between the various interests. Against this background, strategies for the integrated management of landscapes – known as landscape approaches – are gaining importance."*

Potential Synergies and Contributions of EbA and Agroecology to the SDGs

SDG	Potential synergies and contributions of EbA and agroecology
1 NO POVERTY	Food production through EbA-sensitive agroecological approaches can reduce production costs through an efficient use of resources and the selling of excess crops. This bears huge potential for poverty reduction in large parts of the rural population through better income, economic stability and resilience.
2 ZERO HUNGER	The application of EbA-sensitive agroecological practices reduces vulnerabilities and climate-based risks for achieving food-security in local communities through the optimized use of local and renewable resources and ecosystem benefits.
4 QUALITY EDUCATION	Since agroecology naturally includes local and indigenous knowledge into its practices and couples peer-to-peer learning systems with knowledge from formal scientists, food producers can develop relevant knowledge and skills regarding adaptation techniques in their given local context.
5 GENDER EQUALITY	Equitable and gender-responsive access and governance of natural resources and ecosystem services along the whole food system are actively supported by EbA-sensitive agroecological approaches.
6 CLEAN WATER AND SANITATION	EbA-sensitive agroecological practices conduct water-saving irrigation measures, promote locally adopted crops requiring less water and prevent the pollution of surface and groundwater.
12 RESPONSIBLE CONSUMPTION AND PRODUCTION	High-quality nutrition, diversified diets and nature-friendly food production patterns are a central objective of EbA-sensitive agroecological food systems. Less food loss and waste are supported by shorter value chains, leading to more sustainable production and consumption.
13 CLIMATE ACTION	EbA-sensitive agroecological approaches support adaptation and mitigation in agriculture by building integrated production systems utilizing less energy from fossil fuels and contributing to the storage and fixing of carbon in soils.
15 LIFE ON LAND	Restoration of degraded land areas can be improved by bringing together local communities and food producers to actively include ecosystem services into their agroecological activities.
17 PARTNERSHIPS FOR THE GOALS	Bringing together the communities of EbA and agroecology can guide the climate-sensitive transformation of the food system at all levels via cross-sectoral knowledge sharing, the creation of policy coherence and innovative cooperation on the ground.

Capitalizing on Complementarity and Shared Practices

The shared principles and ambitions on the theoretical level can directly be translated to integrative practices on the farm and landscape level. Farm-level evidence shows that agroecology enhances climate resilience. There is increasing evidence that agroecology improves the resilience of both smallholder farmers and farming systems to climate-related risks and shocks.[31] Observed adaptation outcomes are mostly related to livelihoods, like enhanced food security[32] and incomes, due to lower input costs and potentially higher productivity.[33] By promoting agro-biodiversity, soil and water conservation practices, natural pest management, product diversification, and locally adapted crop and livestock varieties, agroecological practices reduce the impacts of extreme weather events on harvests, animals and soils, thereby stabilizing economic returns.[34] Due to its proven benefits in reducing soil erosion and improving soil organic matter, agroecology further enhances ecosystem services that benefit climate mitigation, like carbon sequestration in agricultural soils.[35]

Thus, agroecological practices and approaches can contribute to EbA in agricultural landscapes. Since many ecosystem services (i.e. pollination, quantity and quality of water provision or habitat provision for biodiversity conservation) only manifest at landscape scale, where a number of different landscape users conduct their different activities, EbA is often implemented in agricultural landscapes due to the large amount of land used for agriculture. Also, what a farmer does at a specific location may have an impact on people and their use of ecosystem services kilometers away. For example, the impact of farmers' activities on water flows (contaminated water supply, flooding etc.) or on soil erosion does not stop at the farm gate nor at national or administrative borders. Therefore, the trade-offs and synergies of activities from different landscape users on ecosystem services (like water regulation or pollination) can only be managed and evaluated on local landscape units. These units can range from around 10 to 1.000 km2, depending on the ecosystem under management (rivers, lakes, forests etc.).[36]

In this context, agroecology offers a range of options to respond to the impact of climate change, biodiversity loss as well as water and land degradation at the agroecosystem as well as landscape level. For example, agroecological strategies like diversification and crop-livestock-tree integration increase resource-use efficiency and resilience to climate change in agricultural landscapes. With the aim to provide systemic responses, some agroecological practices even provide options for balancing tradeoffs between adaptation and mitigation: For example, agroforestry maintains and improves the capacity of soils to sequester carbon in a given landscape parcel, thereby not only contributing to the adaption but also mitigation of climate change.[37]

Creating an Enabling Environment and Alliances for Change

The discussion above shows that there is huge potential to create synergistic effects between policies and knowledge communities of EbA and agroecology from the national level down to the farm plot. The key question is: What will be needed to profit from such synergies in the future and to overcome the missing middle created by the missing horizontal as well as vertical integration between the different sectors and levels of implementation?

First, this implementation gap needs to be addressed by creating an enabling environment for linking EbA with agroecological approaches. An enabling environment for an EbA-sensitive agroecological approach is understood as the relevant conditions that support local communities to adopt and sustain climate-resilient agroecological practices. Structural barriers that hinder such implementation can entail limited access to funding and knowledge, or insecure land tenure. An enabling environment supports people to overcome such barriers, thereby making long-term investments in EbA-sensitive agriculture profitable.[38] This entails: responsible land and natural resource governance, responsive rural service delivery, market access, access to financial services and inclusive knowledge systems for innovating responses for climate-resilient food systems.[39] Such factors need to be addressed by a multi-level governance approach which initiates relevant changes in national, regional as well as local policies, strategies, and programs.

Second, for the creation of an enabling environment at the institutional level the cross-sectoral collaboration between EbA and agroecology needs to be strengthened by building relevant multistakeholder networks – or what has been called "alliances for change". Policy makers, researchers and practitioners working on nature-based solutions like ecosystem-based adaptation, land degradation neutrality, and agroecology need to focus much more on the striking conceptual and programmatic overlaps in their fields of competence:

"It is therefore important to encourage these different communities to explore opportunities to align their agendas and identify potential synergies to help create an enabling environment for climate-resilient agriculture, and food security."[40]

Innovation

This report relies on the definition of the term "innovation" by the HLPE (2019), which states that an innovation can be understood as "the process by which individuals, communities or organizations generate changes in the design, production or recycling of goods and services, as well as changes in the surrounding institutional environment. Innovation also refers to the changes generated by this process. Innovation includes changes in practices, norms, markets and institutional arrangements, which may foster new networks of food production, processing, distribution and consumption that may challenge the status quo."

Different forms of innovation are relevant for the implementation of EbA-sensitive agroecology. Next to technical innovations related to agroecological practices on the field, social and institutional innovations play a key role in encouraging agroecological production and consumption, as stressed by the FAO (2018a): *"Examples of innovations that help link producers and consumers include participatory guarantee schemes, local producers' markets, denomination of origin labelling, community-supported agriculture and e-commerce schemes."*

Combining the policy agendas of EbA and agroecology can create consolidated incentives and capacity for the necessary cross-sectoral cooperation required for an enabling environment to emerge.[41] Studies show that many Nationally Determined Contributions (NDCs) by UNFCCC member states highlight the role of the agricultural sector and the strong adaptation and mitigation benefits and synergies. Also, more than ten percent of NDCs mention and consider agroecology explicitly as a valid approach to address climate change.[42] By strengthening policy coherence between their different fields of action, EbA and agroecological alliances can strongly profit from each other's knowledge resources and capacities.

Policy coherence will be key for an effective and efficient transformation of food systems. Therefore, it will be essential that these alliances work at all levels towards relevant reforms of policies and programs while at the same time ensuring that these changes are taken into action at the landscape level, changing the current status quo on the ground.[43] Thus, alliances for change must be more than a general multi-stakeholder partnership: For achieving a meaningful transition of the food system towards strong climate-resilience, relevant actors must be well-positioned within decision-making processes at all levels.[44] To address political and practical realities from the national to the local level, this report suggests the following, rather practical, Options-by-Context (OxC) approach, that allows alliances to choose a practical way to scale combined EbA and agroecology approaches alongside the horizontal as well as vertical dimensions.

Options-by-Context approach

A big challenge for implementing EbA-sensitive agroecological practices and approaches is that ecological, economic, social, and institutional contexts differ between locations, communities, and even individual households. No one-size-fits-all-approach exists, since a single technology, intervention or practice will not suit all situations. What is needed for an effective and efficient implementation of EbA-sensitive agroecology are locally relevant options working for different farmers and communities in varying contexts.[45]

By matching and tailoring existing EbA-sensitive agroecological solutions to local conditions, the so-called OxC approach[46] responds exactly to this need for local adaptation to agroecological conditions and farmers circumstances. This entails having a precise and comprehensive understanding of which EbA-sensitive agroecological solution suits best the very diverse local farming conditions and household circumstances. The needs, opportunities, and constraints of smallholder farmers and the agroecosystems they operate in are varying to a large extent.[47]

If the diversity of farmers' situations is ignored and only a limited number of non-tailored practices across a large area is presented, the likelihood that farmers will adopt new practices decreases. Thus, understanding the potentials as well as existing barriers in the different local agricultural sectors is key for developing a portfolio of suitable agroecological practices for farmers to choose from. Such context-based understanding is also a key prerequisite for the scaling of suitable practices and approaches to other contexts, scales, and regions.[48]

Options and Context

Options refers to 'things that farmers and farm communities can do differently'. Options may include actors at multiple scales (e.g., NGOs, local and national governments), and are not just technological but can include innovations aiming at improving the enabling environment for change (e.g., market interventions, extension systems and policies).

Context is the ecological, economic, and social situation in which options are used. Options interact with context to determine their performance. Context includes the characteristics of a location such as soils, climate, household characteristics, policies, markets, and more.

Options	**Contextual factors**						
(for restoration, climate adaptation, etc.)	Agroecology	Labour availability	Land size & tenure	Access to equipment / market	Livestock ownership & management	Production orientation	Cultural & social norms
Option 1							
Option 2							
Option 3							
…							

Options-by-Context Matrix.

The identification of suitable options is a multi-stakeholder process based on collaboration and co-learning between multiple actors (i.e. farmers, community groups, extension actors and local government officers, researchers). Testing what technical, social, or governance-related innovations do address best an agroecological context is thus part of a broader paradigm not only to conduct 'research for development' but much more to do 'research in development'. The following table provides an example of an OxC matrix, which can be applied in relevant project settings.[49]

For scaling up context-based solutions knowledge of co-creation and dissemination via advisory services and farmer-to-farmer approaches is essential for supporting the development, improvement, and uptake of agroecological practices. Hence, establishing and strengthening a functional knowledge and innovation system is one of the central ideas behind the application of the OxC approach for supporting agroecology and fostering climate resilience and local food systems. In the following, several case studies are presented that give an answer to the question of how to reach out to the broader farm population and bring such knowledge-intensive production systems to scale.[50]

Economic Evaluation of Climate Resilient Agroecological Practices

Agroecology as an approach to Ecosystem-based Adaptation delivers benefits beyond yield and monetary returns. Different economic assessment techniques do exist to measure related benefits as well as costs that go beyond pure agricultural productivity.

One of such techniques is the so-called True Cost Accounting (TCA). The method addresses externalities that are often left unconsidered and unaccounted for in monetary terms. For example, agricultural investments often focus on single characteristics of a food system, such as yield per hectare, disregarding potentially negative environmental and social externalities. The application of true cost accounting valuation methods accounts for externalities and shows that agroecological approaches and EbA create value in terms of human, social, physical, and natural capital.

Since comprehensive quantitative evaluations of climate-resilient agroecological practices are not only context-specific but also time-consuming as well as resource and knowledge-intense, such methods should only be applied in a project-setting with sufficient resources and a clearly defined need for such comprehensive analysis.

3. Agroecology as an EbA Approach in Agricultural Landscapes: Three Case Studies

Exemplary cases are presented in the following that have one common denominator: responding to the systemic challenges posed by climate change requires governance and policy innovations to scale up plot-level agroecological practices and innovations. This report includes three case studies from Africa (Kenya), Asia (India), and Central America (Guatemala). They have very different origins and are implemented in different agroecological zones. This diversity underlines the suitability of agroecology as an approach to EbA. Despite their diversity, the three case studies emphasize common design elements of landscape-level programs: at the farm level they invest in changing agronomic practices. To achieve impact at the landscape level, these programs invest in governance innovations to upscale farm-level innovations. This approach mirrors agroecological principles that foresee transformation from the plot level to the level of whole food systems (see figure 3). To return to an expression introduced earlier, it requires systemic responses to respond to the systemic challenges posed by climate change.

Scaling-Up

The term "Scaling-up" can be described as the process used to achieve the desired goal of broad impact. Scaling-up strategies distinguish between three different forms:

- Vertical (replication of an approach through institutionalization at different levels),
- Horizontal (gradual rollout of activities to cover a wider geographical area; also called: scaling out), and
- Functional (transfer of successful approaches to another context or service)

Scaling an innovation can be understood as the process of expanding the use of beneficial technologies or practices over geographies and across organizations to impact a larger number of people.

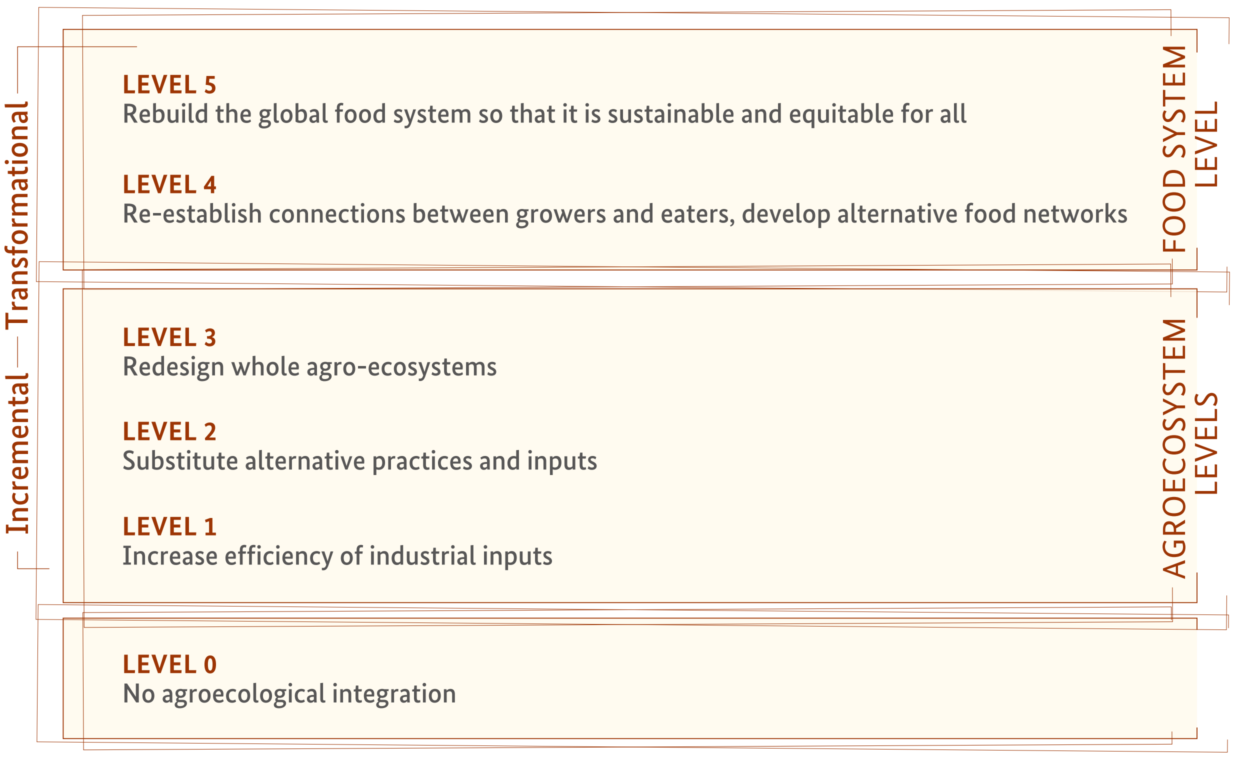

Figure 3: The FAO 10 Elements of Agroecology and Gliessman's (2014) levels of transition towards sustainable food systems.

Figure 4: Map of Andhra Pradesh state in India.

3.1 India: Scaling Out Community-Managed Natural Farming

Climate vulnerability and agriculture in the case study area

India is one of the world's most vulnerable countries to the impacts of climate change, ranking 20 out of 180 countries with Andhra Pradesh being among the five most vulnerable states in the country.[51] Extreme weather events and climate risks such as flooding, sea-level rise, tropical cyclones, heatwaves and droughts threaten India's ecosystems and people's livelihoods.[52] It is projected that India may lose 3–10 percent of its gross domestic product (GDP) annually until 2100 due to climate change, while its poverty rate may rise by 3.5 percent by 2040 due to declining agricultural productivity and rising cereal prices. Such rise of the poverty rate would be equal to around 50 million more poor people by 2040.[53]

As a consequence, the pressure on India's water and food security might progressively increase, disrupting rainfed agricultural food production and having a negative impact on crop yields. Projections for impacts on yields differ between regions: Some regions, like southeastern, western and northern India, might be able to maintain or even increase rice yields due to adaptation, while parts of southwest and central India could also benefit from higher rainfall patterns. In contrast, even with adaptation measures it is expected that parts of southwest, central and northern India could suffer from lower rice yields. Regarding rice, estimations range from around 7 percent of yield reduction up to 10 percent in 2080. A yield decline of around 22 percent is estimated for wheat.[54] Such decrease in the availability and affordability of food and water due to changing climate patterns is expected to reduce the nutritional intake especially among the economically weaker parts of the population[55] Around 70 percent of Indian households still depend substantially on agriculture[56] – this explains why adaptation strategies in the agricultural sector will form the future prosperity basis for large parts of the Indian population.

The state of Andhra Pradesh is in the southeast of India within a fertile coastal belt and a semi-arid, rain-fed inland region.[57] It is called the "rice bowl" of India because of the expansive irrigated paddy cultivation within the state. About 62 percent of the state's population depends on agriculture as a main livelihood strategy. Agriculture contributes over a quarter of Andhra Pradesh`s GDP.[58] The state's smallholder farming sector faces a number of challenges. High costs of agricultural inputs, such as synthetic pesticides, and the reliance of farming models on their use, low crop prices and the effects of environmental degradation, like falling groundwater tables, have led to high levels of indebtedness,[59] causing a social crisis marked by farmer suicides and distress migration.[60] In response, emerging grassroots social movements advocate for alternative natural farming practices that eliminate synthetic inputs.

Case study description

Sustainable agricultural transition efforts include the Andhra Pradesh state government 2016 adoption of agroecological programming to implement the so-called Community Managed Natural Farming approach. The objective of the programming is to make agriculture and farmers' livelihoods economically viable, profitable and climate-resilient. The program targets smallholder and marginal farmers, who account for 89 percent of the farmers in Andhra Pradesh.[61] The non-profit organization Rythu Sadhikara Samstha (RySS, Farmers Empowerment Organization) was designated by the government to implement and coordinate the program and all related farmers empowerment activities, including capacity building and financial support. From an initial 40,000 farmers in 2016, there are now 700,000 smallholder farmers involved in the Andhra Pradesh Community Managed Natural Farming (APCNF) program. The state government aims at rolling out the program to all the 6 million farmers in the state by 2024.[62] APCNF is possibly the largest agroecology program in the world[63] and as such presents an interesting example of scaling up agroecology through government support.

Agroecological approach and adaptation measures

APCNF is both an agroecological program and a pathway to ecosystem-based adaptation. It aims at enhancing smallholder farmers' food security and climate resilience as well as ecosystem integrity. The program adheres to agroecological practices and principles by relying on natural inputs, beneficial ecological processes such as biological nitrogen fixation and other soil microbial functions, and social capital as well as communities' indigenous knowledge. APCNF was developed as an alternative to conventional, chemical-based, and capital-intensive agriculture. The agricultural concept is based on four core farming practices:

1. **Beejamrutham** (microbial inoculation of seeds),
2. **Jeevamrutham** (incorporation of microorganisms into soils through periodic application of inoculum),
3. **Achadana** (mulching), and
4. **Waaphasa** (soil aeration).

Natural fungicides and pesticides made from locally available ingredients such as neem leaves, chilies and garlic are used to protect the crops from pests and diseases.[64] Another key feature is the diversification of cropping patterns, including crop rotation, mixed cropping, or multi-tiered cropping with different varieties of vegetables, fruit trees and seasonal crops grown on the same plot. These farming practices help manage soil fertility and enhance food diversity.

Socio-economic and environmental outcomes

Since project inception, results have been evaluated by different actors. Crop-cutting data collected by RySS show that APCNF farmers have higher disposable income than non-APCNF farmers, mainly due to reduced production costs, without yield penalties.[65] The conversion from conventional to natural farming without reducing yields in the first year has been confirmed during on-farm trials with better yield performance of natural farming over conventional agriculture in drier parts of the state, indicating the importance of water retention through mulching.[66] A preliminary survey by the National Academy of Agricultural Research Management also suggests a net income increase for farmers practicing APCNF.[67] Furthermore, farmer testimonies collected by RySS in 2018 suggest improved plant health and greater crop resilience to cyclone damages and dry spells.[68]

In addition, different studies evaluated the effects of APCNF on input and output variables of the production scheme, like water use, electricity consumption and emission. A 2019 study estimated greenhouse gas emissions from APCNF and conventional farming practices for six cropping systems (paddy rice, groundnut, maize, chilies, cotton, Bengal gram) from 1,467 farmers. Their estimates indicate that APCNF techniques reduce emissions per acre by an average of 46 percent across the six crops.[69] Furthermore, a comparative life cycle assessment by an Indian think tank, the Center for Study in Science, Technology and Policy (CSTEP),[70] suggested that APCNF practices required 50–60 percent less water and consequently less electricity than non-APCNF farming for all selected study crops. For irrigated crops, APCNF required 45–70 percent less energy (12–50 GJ/acre) and resulted in 55–85 percent lower emissions (1.4–6.6 Mt CO_{2eq}) than non-APCNF. For rain-fed crops, APCNF harnessed 42–90 percent less input energy (1.1–16 GJ/acre) what resulted in 85–99 percent lower emissions (0.5–11 Mt CO_{2eq}).

Governance interventions

The rapid growth of the program, despite being entirely voluntary, is premised on the mobilization of social capital, particularly the solidarity and support of women's self-help groups as well as farmer-to-farmer advocacy and local capacity building. Studies suggest that around 69 percent of farmers involved in the program received training from the agricultural department. The promotion of such community-managed sustainable agriculture has been undertaken since the last 15 years, stressing the long-term commitment of the state government.[71] APCNF created decentralized farmer networks to encourage peer-to-peer learning for trust-building and knowledge dissemination. Around 6,000 APCNF local lead farmers advise and guide their peers through farmer-to-farmer systems. Farmer field schools, facilitated by trained conveners, present 'best practices' and support a knowledge-intense transition towards APCNF.[72] Almost 7 million women forming 652,440 self-help groups are organized in 26,753 village groups. Local women community groups provide incomparable access to communication and social networks and help embed natural farming in local society and culture.

The political support for a sustainable transformation of food systems on behalf of the government was also expressed during the 14th Conference of Parties (COP) to the UNCCD, where the Indian Prime Minister mentioned agroecological practices as the way forward to sustainable agriculture.[73] This political commitment was well-recognized at the international level: According to the United Nations Environmental Program (UNEP), the Indian program is an "unprecedented transformation towards sustainable agriculture on a massive scale".[74] It would be a contribution for reaching the UN SDGs, focusing on 'No Poverty', 'Clean Water and Sanitation', 'Responsible Consumption and Production', and 'Life on Land'. Furthermore, the UNEP stresses that the program marks an unprecedented commitment by the Indian state to promote the scaling-out of climate-resilient, regenerative agriculture with the ambition to transform and protect local food systems and long-term well-being of farmers. Finally, the support of the Indian government is also expressed in financial numbers: The scaling-out process will be financed by the Sustainable India Finance Facility with investments amounting to US$ 2.3 billion over 6 years.[75]

Figure 5: Map of Machakos, Makueni and Kitui counties and their sub-county locations in eastern Kenia where agroecological adaptation of soil and water conservation measures by local farmers was assessed.

3.2 Kenya: Matching Agroecological Adaptation and Social Context

Climate vulnerability and agriculture in the case study area

Like many other states in sub-Saharan Africa, the whole area of Kenya is heavily impacted by climate change.[76] However, for this case study only a specific part of eastern Kenya is in the focus of project investigation. Machakos, Makueni and Kitui counties in eastern Kenya (Figure 5) are semi-arid and characterized by small-scale, rain-fed mixed farming subject to frequent drought and crop failures caused by increasingly unreliable rainfall. In general, rainfall distribution is bimodal with two seasons per year: the long rains typically falling over March-April-May (MAM) and the short rains falling over October-November-December (OND). In addition to the growing uncertainty of the rainy seasons, agricultural productivity is limited by extensive land degradation. Consequently, many rural households experience food insecurity. Maize is the main food crop grown by households for home consumption followed by various legumes, fruits, and vegetables. The more reliable OND season is the main growing season for maize in the study area. Consequently, increasingly changing and unreliable rainfall patterns have a lasting negative impact on the main staple food, threating the livelihood of many households in the case study region.[77]

The locations of the case study, consisting of six sub-counties, cover a range of different socio-ecological conditions. The sub-counties vary in average annual precipitation and temperatures as well as regarding their proximity to urban centers. As a result, the six project sites face differences regarding their agricultural potential, their connectivity to markets, and off-farm employment opportunities. Mwala and Yatta (Machakos County), being generally the wettest counties and located at higher altitudes, present more favorable agroecological conditions than other sites. Also, their connection to urban centers like Nairobi and growing towns like Matuu is well established. In contrast to that, Mwingi East and Kitui Rural (Kitui County) are more remote, especially Mwingi East. These sub-counties profit only from fewer off-farm employment opportunities and have comparatively high poverty rates. However, the driest climate can be found in Kibwezi East and Mbooni East (Makueni County). Kibwezi East, in particular, has to deal with high levels of soil erosion. Here, many project households farm on rocky soils with low soil organic carbon. At the same time, the site is close to a main highway connecting Mombasa and Nairobi. Consequently, off-farm employment and labor migration are common phenomena in the district, where especially adult male household members use such opportunities for additional income generation. Recognizing these diverse landscapes and conditions for farming families to gain income through agricultural practices as well as through off-farm activities was key for the identification of suitable agroecological practices in the project area.[78]

Case study description

The research project “Restoration of degraded land for food security and poverty reduction in Eastern Africa and the Sahel: taking success in land restoration to scale (2015–2020)” focused not only on eastern Kenya, but also on farmers piloting a range of agroecological practices (i.e. tree planting) across different countries in sub-Saharan Africa, like Ethiopia, Mali, and Niger.[79] The Dryland Restoration Project, funded by the European Union (EU) and the International Fund for Agricultural Development (IFAD), was run by ICRAF World Agroforestry and local partners with the ambition to facilitate farmers to form communities of practice.[80] Farmers chose which restoration options they wanted to try out and were encouraged to adapt them to their local circumstances. However, this case study focuses on the impact of planting basins in the above depicted case study area in eastern Kenia.

Farmers in Kitui, Makueni and Machakos counties implemented on-farm planned comparisons to assess various land restoration options including planting basins with and without farmyard manure and tree planting/agroforestry practices with a selection of tree species. The project was implemented with a focus on the so-called ‘research in development’ approach, combining the activities of researchers with key development partners like IFAD Country Loan Programs, Non-Governmental Organizations (NGOs), European Commission Country Programs, government, universities, and the private sector. By choosing such participatory approach the project aimed at supporting researchers and development actors to better understand each other’s needs and expectations. Thus, the project objective is to develop innovative ways to achieve the scaling of successful agroecological practices by adopting a co-learning approach that can support the identification of suitable agroecological practices in different local contexts.[81]

Agroecological approach and adaptation measures

Planting basins are a simple agroecological practice to conserve soil and water to help farmers adapt to increasingly unreliable rainfall. They involve digging small pits, usually in a grid formation, and planting crops within them (Figure 6). Their use increases crop yield through capturing surface water run-off, thereby reducing soil erosion and concentrating water at the crop root zone, prolonging moisture availability and helping bridge intra-seasonal dry spells during crop development. In areas where soils have become compacted, the process of excavating basins breaks through soil crusts and plough pans, increasing infiltration. Additionally, compost or farmyard manure added to the pits improves soil texture and nutrient availability. The basins combine longer term land restoration with the need to address immediate food security imperatives.[82]

At the same time, a profound agroecological evaluation is needed regarding biophysical conditions in the given landscapes: rainfall and soil texture influence the performance of planting basins. Arid and semi-arid conditions are best suited for the basins, especially in sites with well-draining medium-textured soils (e.g., sandy loams) receiving 300–800 mm of rainfall per annum and on gently sloping land with gradients between 1–15 percent. The digging and maintaining of basins are very difficult in rocky or extremely shallow soils, where the method is not very well suited. Also, using basins can result in waterlogging and depressed crop yields in case of heavy rain and poorly draining soils. Consequently, farmers may need to remove excess water following heavy rain, divert surface run-off from basins using additional trenches, and back-fill basins with soil. Such modifications lead to additional labor and the need for timely action following heavy rainfall.[83] Depending on these biophysical factors in the different counties of the case study, the suitability of planting basis differs.

Socio-economic and environmental outcomes

Planting basins were established during a dissertation project that involved 1,743 farm households and their performance was assessed in six sub-county locations over three years between 2017 and 2019 through interaction with collaborating farmer groups.[84] What makes the case study specifically interesting are the different impacts of planting basins – as a technical agroecological innovation – on different aspects within the households under observation.

Regarding the direct effects on food security and climate resilience of the cultivation process on the field, a number of interesting results can be summarized. First, the basins increased average maize yields across locations by 0.33 to 3.07 t/ha depending on year and basin size, but with large variations amongst farmers. Whether yield differences translated into higher food security depended, thus, not only on yield but also on how many basins households adopted in relation to their family size. In 2019, the median extra number of days when food was available through the use of basins was 18 days, with 50 percent of households having more than 16 extra days and 25 percent of households reporting more than 30 extra days of food. On average, it requires 216 medium-sized basins to achieve an extra month of food availability. While some farmers maintained large numbers (over 2,000) of basins, the median number of basins per farm in 2019 was only 49.

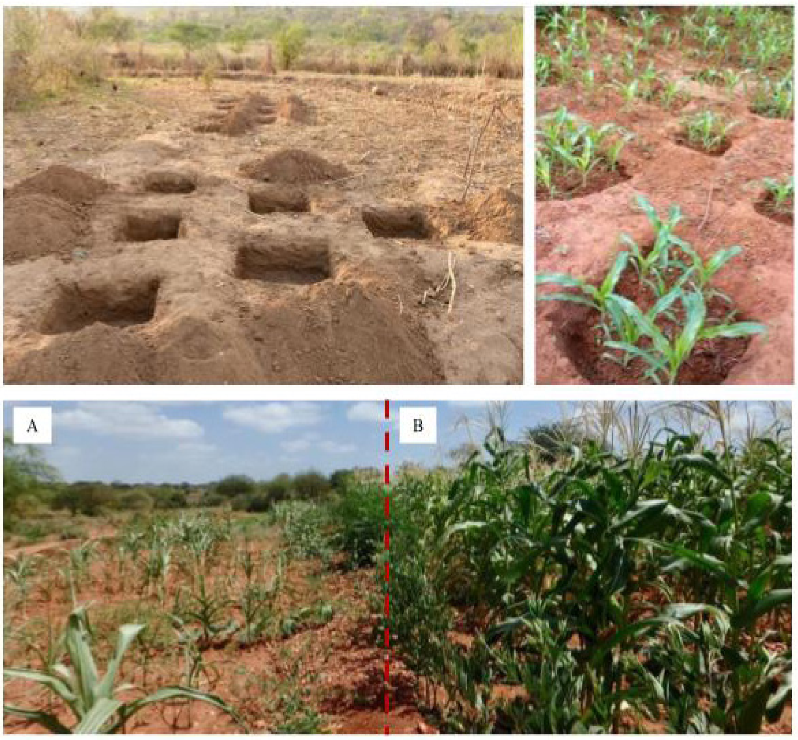

Figure 6: Top panel: examples of planting basin design and arrangement (photos: ICRAF/Ake Mamo); bottom panel: on-farm comparison between farmers' usual tillage practices (A) and planting basins (B) for growing maize (photos: Mary Crossland).

The effects of the basins also differ depending on the social context of a given household. It appears that especially vulnerable households may have been more interested in maintaining a small number of basins as 'safety net' against complete crop failure of subsistence crops like maize in low rainfall years than using basins as a means to increase overall productivity. However, households with higher food security and more market orientation might decide to use the basins for higher-value crops, like vegetables.[85] On average, across all years, crop failure occurred in only 5 percent of cases with basins (compared to 14 percent failure in cases without basins) and, in the driest year (2017), the use of basins reduced crop failure from 30 percent to 11 percent of cases. These observations show that the basins play an additional role to buffer households against climate shocks. Thus, their contribution goes beyond the traditional evaluation of performance like maximizing yields and income per hectare, to being essential for maintenance of livelihoods during times of climate change.[86]

In terms of economic gain and returns on labor, adoption of large basins in a sample of 845 farming households resulted in a median increase of 0.51–1.27 USD/person/day, with 75 percent of the farmers reporting profits from this adoption (50 percent by more than 1 USD/person/day and 25 percent by more than 2 USD/person/day). Some farmers indicated that while labor for land preparation increased by labor-intense digging of basins, overall workload was similar to conventional cultivation because of lower labor requirements for weeding.[87] Still, one of the key lessons learned from the project was that one main barrier for adoption is the lack of labor for the digging. Again, different social contexts of individual households matter: Households with additional off-farm income might be less willing to invest in such labor-intense options like planting basins – at the same time, such households might have access to cash for hiring labor to dig basins, thereby potentially contributing to local employment.[88]

Another interesting effect regarding labor has been observed during project implementation: The traditional division of labor between men and women may be altered by the planting basins. Monitoring revealed a higher incidence of female-only labor for the digging of basins when compared to the typical planting practices utilizing an oxen and plough. This potential shift in labor between men and women through the application of planting basins can lead to risks as well as opportunities for women empowerment. Since the digging of basins is knowledge, time and labor-intensive, such shift in labor distribution bears the risk of increasing women's already high workloads, leading to negative effects for gender equality in a given household. At the same time, the project could show that the decision-making power of women was encouraged by the 'planned comparisons' approach, since the on-farm experimentation was coupled with capacity building measures, actively including women or both partners from household couples. Also, it was observed by the project that especially women, amongst a number of farmers, have chosen to form labor exchange groups to help each other dig basins and overcome labor constraints, thereby increasing women's agency and participation in decision-making at household as well as community level.[89]

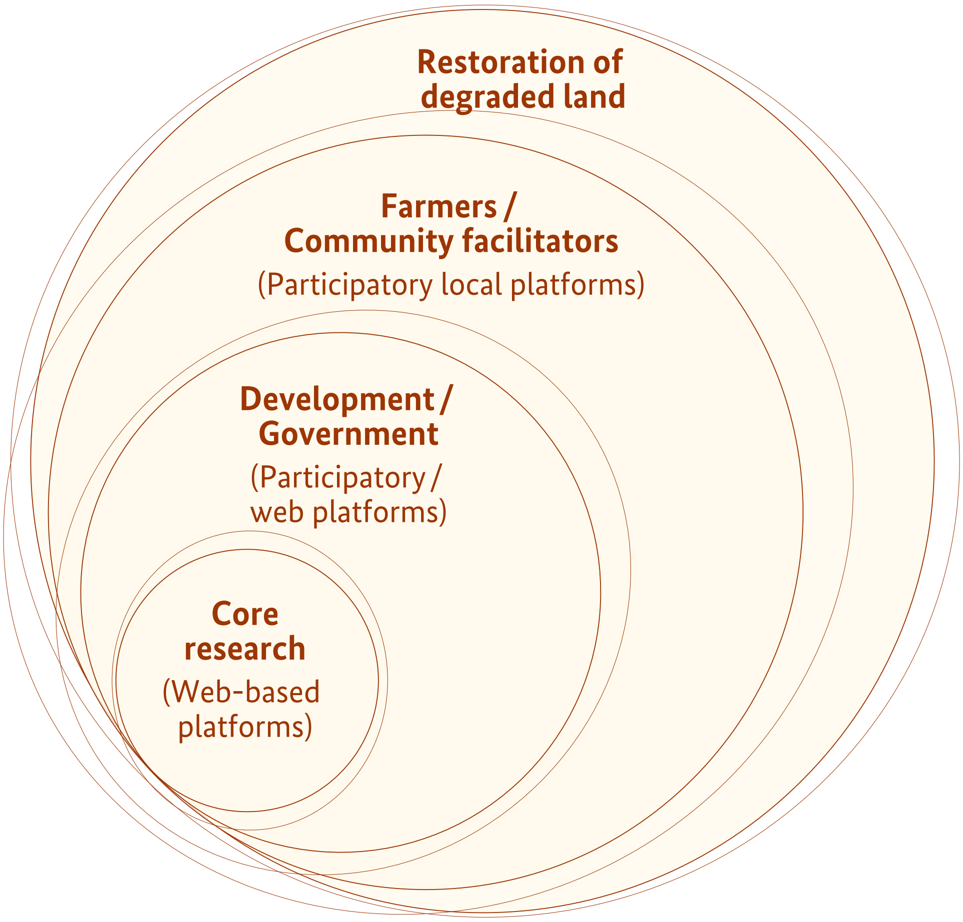

Figure 7: Nested communities of practice, facilitated and documented, with refined tools, methods, and guidelines for taking land restoration for scale.

Governance interventions

Farmers' experiences with innovations in agroecological practices for climate change adaptation revealed the extent to which different practices and adaptations suited farming households in various ecological and socio-economic circumstances. The findings related to the application of planting basins underline the relevance to adopt an Options by Context (OxC) approach and the need for a comprehensive evaluation of environmental, economic as well as social effects of a given agroecological innovation.[90] By applying the OxC approach as well as participatory research approach during the case study, farmers co-created innovations and knowledge about the applicability of planting basins. One important governance innovation presented by the case study are the so-called Communities of Practice, bringing together key partners and stakeholders from research, development, extension, farmers, facilitators and governance institutions to interact in co-learning cycles (see figure 7).[91]

The case study furthermore shows that the dissemination of EbA-sensitive agroecological innovations is not gender-neutral but does have a potential social impact on households and communities. This impact needs to be monitored by collecting data disaggregated by sex and other relevant social differentiation factors (e.g., age, ethnic group) during project implementation. In addition, Communities of Practice – which can be understood as alliances for change – need to actively incorporate social innovations, for example regarding participatory decision-making processes, open dialogues amongst all stakeholders and rights bearers as well as proactive capacity building of the most vulnerable groups at household and community level. The coupling of such social innovations with technological ones will be crucial for sustainable scaling of EbA-sensitive agroecological practices that are ensuring climate-resilient as well as gender-equitable outcomes.[92]

Figure 8: Map of Guatemala and project sites.

3.3 Guatemala: Blending Community-led Governance and Innovation with National Payments for Ecosystem Services

Climate vulnerability and agriculture in the case study area

Guatemala means "place of many trees" in the local language of Guatemala, Nahuatl, and alludes to the country's inherent biological abundance. Its ecosystems are, however, highly threatened by deforestation and climate change. According to the Global Climate Risk Index 2000–2019, Guatemala is among the countries most vulnerable to extreme weather events, ranking 16 out of 180 countries.[93] By 2050, crop yields are expected to drop due to climate change by 35 to 40 percent in coffee and sugar cane and 15 percent in maize and beans.[94] The population's climate vulnerability is exacerbated by a fragile social and economic situation. Poverty, vulnerability, and exposure to damages related to climate events are highest in rural areas, where 67 percent of the population affected by poverty lives.[95] The prevalence of undernourishment in the total population during the time span 2017–2019 was estimated to be around 16 percent, stressing the urgent need to address food insecurity for large parts of the population. At the same time, around 31 percent of total employment in 2019 was directly linked to the agricultural sector, what shows the high interdependence between the sector's productivity and the livelihood of large numbers of people.

Huehuetenango is located in the watershed of San Francisco, in the western highlands near the Mexican border (figure 8). The area is characterized by high poverty rates and extreme and unpredictable weather events such as droughts, excessive rains, hail, and frosts as well as resulting pests.[96] These climate-related hazards do have an impact on livelihoods, e.g., through losses in agricultural yields and destruction of homes and infrastructure. Furthermore, the montane rainforests in the study area, located 1,800 meters above the sea level, are likely to suffer a drastic reduction due to rising temperatures and changes in precipitation patterns, undermining water supply and other ecosystem services.

Case study description

In 1997, ASOCUCH[97] and its local member ICUZONDEHUE[98] developed integrated rural development projects with the aim of enhancing farm production, income, and empowerment, while also promoting social inclusion and institutional capacities. The interventions were later expanded to include forest, soil, and water resource conservation, referred to as SMPOB[99] approach. This integrated farming approach, which was introduced to strengthen resilience to climate change, has been characterized as a form of EbA and includes agroecological practices and principles such as agroforestry, crop diversification, seed sovereignty, local ownership and co-creation of knowledge and exchange. In accordance with the three dimensions of EbA (socio-economic, ecological, institutional), the project analyzed the effectiveness of the SMPOB approach over a long-term project phase in terms of its impacts on food security, income, biodiversity and ecosystem services and local governance.

Agroecological approach and adaptation measures

The SMPOB is a holistic approach with an ecosystem perspective which takes into account the various interactions between humans and their environment in the case study region. It combines sustainable farming techniques, sheep breeding, forest conservation, farmer training and community organization. At the farm level, staple crops such as maize and potatoes are intercropped with diverse species such as beans, squashes, and other vegetables. Through the introduction of organic fertilizers, agroforestry and agro-silvo-pastoral practices and the establishment of community seed reserves, sustainable and agroecological productive systems are strengthened.

Socio-economic and environmental outcomes

Monitoring data collected by ASOCUCH from 2009–2020 showed adoption of new agroforestry practices by 69 percent of households contributing to crop diversification and more frequent harvests. In conjunction with other EbA measures, this led to significant improvement in yields of staple food such as maize, potatoes and beans, with improved food and nutrition security for 87 percent of families. Annual food availability from subsistence farming increased from four to ten months on average during this period. The project actively improved market access and income opportunities in the case study region, which has helped reduce seasonal distress migration to coastal plantations. Around one-third of respondents report that they no longer migrate for economic purposes. More than half of the respondents found that the quality of soils and of the river water improved over the 20-year period. Activities related to forest protection and sustainable management led to increased forest cover by close to 50 percent between 2001 and 2016.[100]

Governance interventions

One of the key governance interventions becomes visible in form of clear financial commitments on behalf of the national government. Payments for community-managed conservation and restoration activities introduced by the state-funded National Forest Incentives Program underline the holistic approach of the SMPOB system beyond the farm level. The Program was set up in 2007 and entails financial compensations for reforestation, sustainable use, and conservation activities such as communal forest monitoring. The network of community-led organizations, ASOCUCH, has played an important role in inclusive participatory governance and local ownership over these funds.

The access to funds of the Program is given to ASOCUCH and its network organizations as a technical and administrative facilitator, who can directly support smallholders in registering with the Program. Decisions about technologies, funding, collaboration, and other development questions addressing farmers' needs are taken jointly and from a demand-driven perspective. As a result, these community-based organizations are less dependent on donor funding, thereby benefiting from greater autonomy in their decision-making and project planning.[101] In that regard, the case study presents a successful example of blending community-led governance and agroecological innovation with national payments for ecosystem services.

Also other positive socio-economic effects are visible. In the case study area of San Francisco over 191 hectares have been covered by the Program since 2010. Thereby, the Program has significantly increased participating households' income: Annual compensations between 642 and 7,700 USD have been reported by participants depending on relevant land area. Furthermore, the creation of alternative employment has been fostered by the Program, for example through the establishment of tree nurseries.

Social governance interventions have also facilitated the scaling-out of the project's Eba-sensitive agroecological approach. The strong collaboration developed among the SMPOB group members has strengthened community cohesion and led to high adoption rates of sustainable agricultural techniques. ASOCUCH also supports institutional strengthening by establishing municipal forest offices and developing local climate adaptation plans. Local peer networks have facilitated information exchange that supports the uptake of agroecological technologies and practices that build on traditional knowledge as supplemented by technical expertise provided by ASOCUCH.

Regarding equal access to plant genetic resources for strengthening climate resilience, community-run seed banks have helped to mitigate climate vulnerabilities and contributed to seed sovereignty. They store a broad range of maize, bean, and potato varieties, including drought-tolerant native varieties that are well adapted to local conditions. Trust and community cohesion has empowered farmers to collaborate in participatory seed breeding and post-harvest storage, allowing them to store, exchange and distribute seeds. More than 75 percent of the interviewed farmers confirmed better yields when using these locally selected seeds. The seed reserve thus helps increase resilience and food security in the face of climate hazards and biodiversity loss.

3.4 Lessons Learned

What broader lessons learned can be drawn from the case studies and the different circumstances under which they have unfold their potential as EbA-sensitive agroecological projects?

India

The Indian case study stresses the fact that government action in form of clear policy directives, accompanied by adequate financing and institutional support is a crucial catalysator for successfully scaling up climate-resilient agroecological approaches to other landscapes.[102] Next to the relevance of strong government commitments, the Indian case study stresses the importance of the OxC approach for a successful and sustainable scaling-up as well as scaling-out process.

Considering the governmental ambition to scale-out the approach of APCNF to all farmers in India, this lesson is not a minor one. Taking into account the very diverse landscape and varying climatic conditions in different parts of the country will be important for a successful application of EbA-sensitive agroecological practices on the ground. Literature suggests that climate change impacts will widely differ across India, depending on local context such as geography (e.g. coastal, inland or mountains) and climate (e.g. arid or wet) among others. Therefore, inclusion of detailed, regional-scale climate change risk assessments will be key to develop landscape-specific mitigation and adaptation measures to reduce vulnerability to climate change within the different agroecosystems over the country.[103]

Kenya

The Kenyan case study has made clear that the introduction of EbA-sensitive agroecological technical innovations needs to be accompanied by social and governance innovations that ensure gender equality and equal access to benefits resulting from such innovations. In the case of digging planting basins in eastern Kenya, it could be shown that this agroecological technology presents both opportunities as well as risks for women empowerment. To ensure that adaptation and land restauration efforts advance gender equality rather than perpetuate existing inequalities, it is crucial that agroecological projects assess not only potential synergies regarding climate adaptation but also trade-offs in a given social landscape of an agroecosystem.[104]

The involvement of both man and women in the design of project activities for scaling climate-resilient agroecological innovations forms the base for formulating not only climate-resilient but also gender-responsive agroecological approaches. Furthermore, the Kenyan example shows that landscape and household-adapted solutions are essential for a sustainable application, since the biophysical as well as social variables differ a lot between different landscapes and farms. Therefore, an OxC approach is an important tool for a targeted scaling of relevant agroecological innovations to other landscapes and agroecosystems.

Guatemala

The case study in Guatemala is a positive example for bringing together nature conservation and human development in an agricultural landscape while closely aligning the agroecological project approach with national payments for ecosystem services. The case study highlights the importance of community-based adaptation as well as funding as core components of a climate-resilient transformation of local food systems. Besides, the case study points out some of the enabling conditions under which EbA can be effectively implemented yielding multiple benefits beyond a specific project lifetime.

Regarding community-based funding, the project demonstrates that supporting farmers with national payments for ecosystem-services is not only a financial incentive for starting community adaptation in the first place, but it is also an important variable for the upscaling of an effective approach alongside geographical as well as time-based scales. Second, climate-resilient agroecological initiatives do not only need to offer economic incentives to local communities but much more make them accessible and manageable to local actors for ensuring that the use of financial resources is adapted to local needs and diverse ecological conditions on the ground.

Considering the project's lessons learned on community-based adaptation, community-led governance and the empowerment of local communities was key for strengthening community cohesion and resulting high adoption rates of EbA-sensitive agroecological practices. Civil society organizations can be an important catalyst and "knowledge broker" in such processes, thereby also managing trade-offs among different interests. Furthermore, it could be shown that connecting knowledge and experience from long-standing EbA-initiatives at local farm and community level with state and policy processes at national level is an important step for overcoming the missing middle. Thus, more attention should be paid in the future to "bottom-up learning processes" to ensure that valuable local knowledge is not ignored but instead applied to create synergies and knowledge cycles between different levels and sectors.[105]

Common observations

Three key commonalities can be identified between the case studies. First, **all case studies stress the importance of applying an OxC approach for scaling-up** successful agroecological approaches that address climate change, biodiversity loss as well as land and water degradation in a systemic manner. While the interlinked systemic crisis of climate change, biodiversity loss, as well as land and water degradation certainly ask for systemic solutions, a top-down approach in form of a silver bullet does not exist for sustainably transforming food systems. Environmental, economic, and social conditions widely differ between various contexts and landscapes. Therefore, existing common as well as traditional and local knowledge on climate-resilient agroecological principles and practices in agriculture must be adopted to these individual conditions in farms and fields.

The second key lesson builds on the first one, as it stresses the **relevance of creating linkages between farmers** by farmer-led and farmer-focused knowledge exchanges. Farmers are the custodians of ecosystem services to be found in the manifold agroecosystems of planet Earth. As such, they must be set at the forefront of transforming the global food system in its whole. Convincing people of a long-term implementation of climate-resilience agroecological practices by participatory planning and governance, inclusive capacity building and the inclusion of local and traditional knowledge is an important pre-condition for a sustainable transformation of local food systems.

A third and final common lesson is the **effectiveness of so-called alliances for change** that cross sectors and scales. In all three case studies, innovative and strategical multistakeholder groups have been formed between farmers, local community actors, stakeholders from the private sector, and relevant governmental agents and institutions as well as experts from agricultural research and ecosystem-focused sciences. The creation of circular learning groups connecting local knowledge with international and national expertise from the agriculture and climate communities was a strong success factors in all three case studies. As such, these strategic alliances found practical ways to address the missing middle described in the beginning of this report. To sum up the key lessons learned of the three cases: By **strengthening horizontal as well as vertical integration between sectors and scales**, a systemic and climate-resilient transformation of the food system in a global manner is brought one important step closer.

4. Five Steps for Designing Agroecology as an EbA Approach in Agricultural Landscapes

Addressing the missing middle

This report proposes five steps to guide the country-level implementation of agroecology as an EbA approach in agricultural landscapes. The implementation process should be conducted by specific alliances for change that are consisting of different actors depending on the relevant level of implementation of each step. Thus, a key objective of this approach is to strengthen platforms that facilitate the horizontal integration between climate and agricultural communities as well as vertical integration between the national and local level actors and actions, thereby directly addressing the "missing middle" as described in the beginning of this report.

The hourglass procedure for scaling out

All five steps are referred to as the "hourglass procedure" (see figure 9) because they start with a broad analysis of cross sector and cross scale integration needed to address the missing middle between international conventions, national commitments, and local actions on the ground (Step 1). Then, the approach narrows down to interrelated climate change and food security issues at a specific landscape level and the development of contextually relevant solutions for different agroecosystems, local communities, and social contexts (Step 2–4). Finally, it broadens again to the national level for developing an enabling environment that paves the way for scaling up and out successful EbA-sensitive agroecological solutions to other landscapes and contexts within a given country.

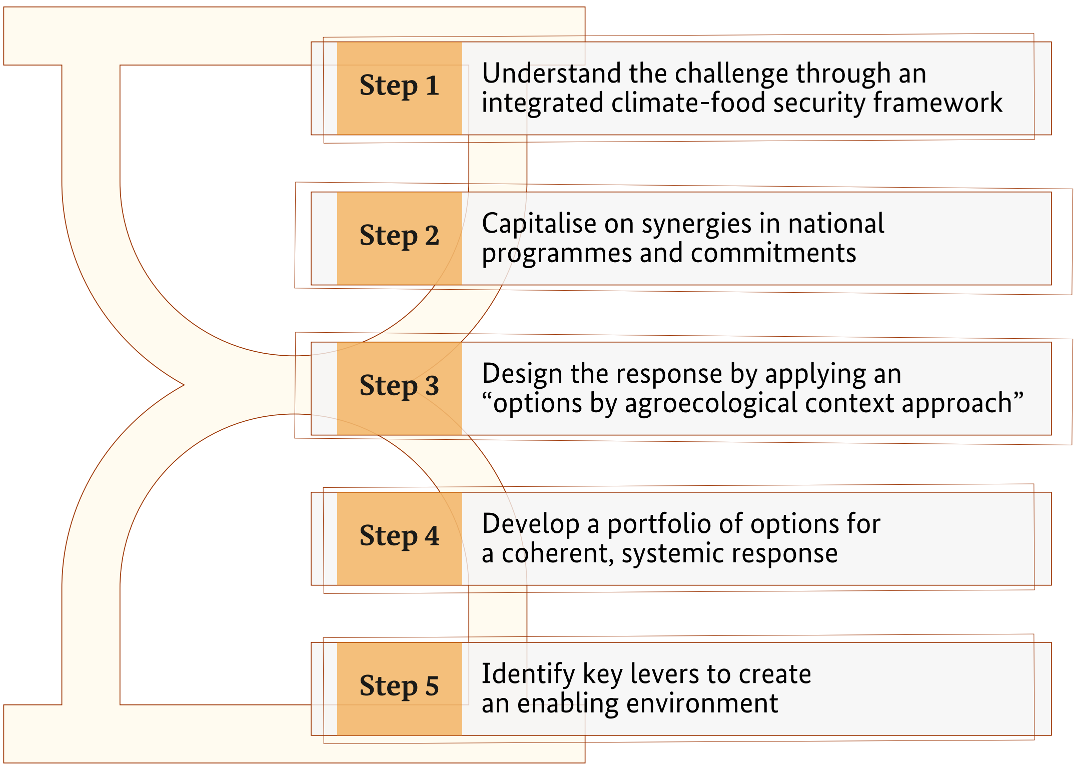

Figure 9: The five-step hourglass procedure for combining EbA and agroecology.

Incremental application depending on existing resources

While the Five-Step-Approach might look complex in the first place, its practicability lies in the incremental application of different steps depending on human and financial resources as well as the "windows of opportunity" for policy change. As demonstrated in chapter 3 by the Kenyan case study, an OxC approach at the landscape level can also be applied without strategic political action at the national level – even though a comprehensive and sustainable transformation of the country-wide food system will certainly depend on national reform processes.

If due to political reasons no such "window of opportunity" for policy change does exist in a certain moment, alliances for change can first focus on local success stories that create best practice examples in a given landscape and pioneer for EbA-sensitive agroecological options that can be scaled-up and out at a point in time when political majorities can be reached for necessary policy change. While a chronological application of the approach is ideal, also a simultaneous or alternating implementation of different steps can thus still lead to incremental transformation of crises-responsive food systems at local as well as national scale of a given country.

Inclusive processes of change for defining systemic responses

Demonstrated by the three case studies in India, Kenya, and Guatemala, building alliances for change between the agriculture/food and climate communities drives the necessary transformation of the food system. Such strategic partnerships are also key for altering the global financial architecture in a way that makes the creation of climate-resilient food systems realistic from a financial point of view. The implementation of systemic approaches will need systematic and adequate funding. While the inclusion of multiple stakeholders does naturally mean more efforts regarding cooperation and coordination in the beginning, such time investment in an inclusive process is thus necessary for the identification of systemic responses that adequately and parallelly address the multiple crises of food insecurity, climate change, biodiversity loss as well as land and water degradation.

The following paragraphs describe each of the five steps in detail with the aim to define processes and mechanisms through which relevant actors can coordinate their actions and resources (including knowledge and expertise as one of the key resources) for creating climate resilient food systems on the ground.

4.1 Capitalizing on Synergies: Analysis of relevant National Commitments

Step 1 of the hourglass procedure is localized at the national level. For overcoming the missing middle and for supporting the horizontal as well as vertical integration of EbA and agroecology at a national scale, first relevant national commitments emerging from international agreements regarding climate, biodiversity and food security need to be outlined. For identifying synergies between corresponding laws, policies, and programs, it is key to strengthen platforms that facilitate co-operation between climate and agriculture communities at national and, later on, local levels.[106] The process at national level involves two stages.

1. **Policy and Legal Analysis:** To overcome siloed approaches to food security, climate resilience, biodiversity conservation as well as land and water restoration at national level, it is important to identify relevant national commitments in form of laws, policies, strategies, and programs in these policy areas and to outline how they interact. Integrated and systemic responses to the multiple crises need to be reflected in systemic and coherent national policies. Thus, a policy and legal analysis should focus on how existing political measures and activities related to the food system as well as ecosystem-based adaptations interact or counteract with one another. Profound policy and legal analyses are prerequisites for developing policy coherence – which forms the base for a crises-responsive food system in the long-run.

2. **Institution Building:** Adapting national and sub-national fora and platforms to create synergies between the different policy and sector-related communities is an important part of the horizontal integration process. Such cross-sectoral institutions are also relevant for promoting integrated responses to the creation of crises-responsive food systems alongside the policy agenda setting process. To the extent possible, developing integrated solutions should build on existing institutional arrangements by connecting relevant fora and actors, rather than creating entirely new structures. Their precise nature of institution building will depend on national circumstances. Inter-ministerial working groups are one example of this. An important part of institution building is to create linkages to the local level to facilitate vertical integration between existing programs and projects and to unite top-down and bottom-up efforts.

4.2 Understanding the Landscape: Developing a Rational on Crises-Related Challenges

Often there is only sparse information on how contextual conditions influence the suitability of agroecological practices. Hence, there is a need to understand local social and biophysical conditions influencing the choice of agroecological practices to be able to validate their suitability. Step 2 is to understand the current and projected climate change impacts and the contextual factors relevant for developing adapted agroecological responses in a specific landscape. This step should not only consider current adaptation needs but also the projected changes in climate patterns to ensure that the practices to be identified are also suitable for future climatic conditions.[107]

As has been demonstrated in the case studies, climate patterns and scenarios can widely vary within the jurisdictional boundaries of a given country. Thus, the development of EbA-sensitive agroecological solutions must be adapted to landscapes, not to national or administrative boundaries. However, next to the ecological conditions in the targeted area, the social conditions that influence the suitability of agroecological and EbA practices must be clarified for developing a comprehensive understanding of the nexus between climate, biodiversity, land and water conditions on the one hand, and food security for communities in the area on the other hand.

Step 2 comprises three stages, each of them at the level of a selected agricultural landscape:

1. **Climate Risk Analysis:** This stage involves analyzing the challenges posed by different climate change scenarios in the specific landscape. This includes an assessment of current and projected climate risks and related impacts on the ecosystem regarding biodiversity loss and land and water degradation. Resulting adaptation needs of existing agroecosystems should be formulated.

2. **Stakeholder Mapping:** To target agroecological responses that address the needs of all relevant stakeholders in the specific landscape, a comprehensive stakeholder mapping should outline all resources, users and other relevant actors that effect the local food system and relevant ecosystem services. A particular focus should be given to actors' specific function within the local food system and to their potential to influence the ecological and social context of existing agroecosystems.

3. **Vulnerability Assessment:** Outlining patterns and structural reasons for food insecurity and vulnerability due to ecosystem-based risks is the third stage of Step 2. There is an emerging consensus that the same structural drivers are responsible for food insecurity and vulnerability to climate change, namely inequalities in terms of capacities, access to assets and resources, and power asymmetries within relevant decision-making processes. It is therefore important to create conditions where all actors within a food system have sufficient agency to determine production and consumption patterns in line with their aspirations and needs. Therefore, an assessment of existing vulnerabilities and adaptative capacities of those actors identified during the stakeholder mapping aims at ensuring that agroecological innovations are not just responsive to the ecological but also social context of a given landscape.

Such comprehensive assessment of the relationship between climate scenarios and actors of the food system at landscape level is key to identifying the necessary changes in policies and institutions required to ensure that agroecological responses are inclusive and targeted as well as sustainable and scalable. Therefore, the structural analysis of Step 2 is also used later to inform the development of strategies at national level to facilitate the enabling environment for linked EbA- agroecology solutions (see Step 5 below).

4.3 Designing the Response: Applying an Options-by-Context Approach

Step 3 aims at adjusting different EbA-sensitive agroecological practices (options) to the social and ecological circumstances that prevail in any given landscape (context) and that have been identified in Step 2. An options-by-context approach allows mapping adaptation needs to agroecological practices and ecosystem services that can deliver appropriate adaptation responses in different contexts. It is key that those options are locally refined by linking local, traditional knowledge to state-of-the-art science, as described by the following three stages of Step 3.[108]

1. **Defining Communities of Practice**: Finding agroecological practices and approaches that match the complex ecological and social circumstances of a given landscape requires co-creating agroecological innovations by linking local and traditional to scientific knowledge. As demonstrated in the Kenyan case study, Communities of Practice – consisting of all relevant stakeholders in a given landscape – offer the opportunity to bring all relevant needs, perspectives and interests to the table. Such communities embrace a transdisciplinary approach to research and extension ("research in development" instead of "research for development"), which entails being participatory, problem-focused, situation-sensitive, and solution-oriented. The process of defining and activating a Community of Practice requires time in the first place but is necessary for delivering sustainable EbA-sensitive agroecological approaches that suit the people on the ground and the ecological purpose they are intended for. Also, potential trade-offs and conflicts between different landscape users should be actively moderated within the Community of Practice to find compromise.

2. **Participatory Mapping of Ecosystem Services**: One key challenge for designing an OxC matrix for EbA-sensitive practices in the field is based on the lack of congruity between ecosystem and jurisdictional or farm plot boundaries. Regarding the farm plot, farmers need to understand the effects and interlinkages of their management decisions on ecosystem services that go even beyond the agroecosystem they are operating in. Regarding jurisdictional boundaries, it is crucial to take into account that different agencies quite often have responsibility for different land uses (e.g. forestry and agriculture) and ecosystem services (e.g. water regulation, biodiversity conservation and production). Thus, cross-sector and cross-scale collaboration between these different agencies is required for joined-up decision-making at the range of scales necessary to administer ecosystem provision in the different agroecosystems of a given landscape. Thus, mapping of ecosystem services can provide an intuitive, visual means of communicating information amongst stakeholders and raising awareness on how their actions are interlinked. As such, the mapping can support land users and administrators to take into consideration the broad spectrum of ecosystem services potentially affected by their management decisions, as well as for guiding the implementation of agri-environmental policy at the scale at which land use change occurs.[109]

3. **Options-by-Context Matrix:**[110] Developing an OxC matrix is the third stage for selecting agroecological practices that contribute to climate adaptation and biodiversity conservation in line with prevailing socio-ecological contexts in a target area. Farmers' circumstances are generally highly heterogeneous in terms of both ecological and social conditions, as demonstrated in the case studies in chapter 3. Different agroecological practices can have different impacts on men and women as well as on different households depending on their level of vulnerability. Thus, it is necessary to match agroecological adaptation options with the social context in a given agroecosystem and to design relevant innovations considering diverse resource users' needs in the targeted landscape. Consequently, the information conducted by the Climate Risk Analysis, the Stakeholder Mapping, and the Vulnerability Assessment of Step 2 should be actively applied when formulating options.

4.4 Including Complexity: Developing a Solution Portfolio

Step 4 is to bundle agroecological practices identified through the options-by-context approach to address the systemic challenges posed by climate change. Given the complexity and ever-changing nature of agroecosystems and climate challenges in different contexts, it is necessary to offer a mix of solutions that can be adapted to changing circumstances.[111]

1. **Bundling Innovations:** The first stage is to identify most suitable agroecological practices for the agroecosystem for achieving multiple production benefits. A recent corporate-level evaluation of IFAD's support to innovations for inclusive and sustainable smallholder agriculture highlighted the importance of bundling different actions to lift farmers out of poverty. Combining different innovative practices – like climate-resilient farming technologies with new forms of organizing farmers and modernizing access to finance – supports smallholder farmers in tackling the different challenges simultaneously. Such innovation packages can unfold a transformative dimension by not only lifting vulnerable farm households out of poverty but also making them resilient to parallel occurring shocks (e.g. concurrency of drought and price collapses). Especially in times of multiple crises a stand-alone innovation might not adequately respond to the complex economic, social and environmental contexts where today's farmers operate in.[112]

2. **Inclusive Selection Processes:** Bundling compatible options that, together, can make transformative change, requires ensuring that the additive effect of a suite of options is large enough to generate transformative outcomes and that options are not counteracting one another. As elaborated above, next to t ecological innovations, social innovations play a key role in transformation processes. Agricultural production patterns are not socially, economically, or culturally neutral and their long-term adoption often requires changes in behaviors, attitudes and institutions – from the household level all the way up to relevant authorities that administer resource use and ecosystem services in relevant landscapes. Here, social solutions need to be anchored in local contexts that address common problems, like power asymmetries between gender or the ignorance of local knowledge systems, in new ways. This means that the implementation of EbA-sensitive agroecological solutions should not only be concerned with what is to be achieved (outcome) but specifically how the solutions are developed (process).[113] Underlined by the key lessons from the case studies, the selection and evaluation of innovation bundles must be conducted in an inclusive process. This also entails the gender-sensitive review of innovations and make potential negative impacts visible and thereby adjustable. As made visible in the case studies, especially with a focus on the inclusion of women and other disadvantaged groups, combining agroecological practices on the field with access to resources, capacity building and other social measures can have a positive impact on the resilience of local food systems and the people depending on it.[114] Again, information collected during Step 2 via the Climate Risk Analysis, the Stakeholder Mapping, and the Vulnerability Assessment should be applied to ensure that all relevant stakeholders and their needs are taken into account.

4.5 Creating an Enabling Environment: Identifying Key Components for Scaling Up

Step 5 is to analyze the necessary actions to address the missing middle in order to create an enabling environment that allows for the scaling up of agroecology as EbA. For reaching the SDGs, it will be essential to bring EbA-sensitive agroecological practices to scale, ensuring that successful initiatives do not remain unnoticed at the local or landscape level. Thus, the options identified in previous Steps 2–4 require an enabling environment to make agroecological practices suitable for other landscapes and communities.

However, upscaling cannot only be understood to simply mean the replication of a successful project elsewhere. Such a view fails to see the policy environment that often prohibits its upscaling due to existing institutional barriers or contradictory policies. Hence, the ambition of upscaling is not simply a technical question of replication of EbA-sensitive agroecological practices but much more a highly political endeavor.[115] Therefore, Step 5 might require more resources in terms of time, investment, and strategy than those steps taking place at the landscape level. An enabling environment that is existing of a broader institutional framework only changes slowly. Hence, the creation of such environment cannot be an afterthought but must be part and parcel of interventions right from the beginning.[116]

When relevant bundles of agroecological practices and innovations are identified at landscape level, it is the logical next step to look at what changes to policies, institutions, markets, research, and extension services are necessary for these practices to be widely adopted. In short, it is necessary to look at the components of an enabling environment. The following components should be analyzed and addressed by strategic stakeholder groups at the national level:

1. **Strengthening Alliances for Change**: Change is based on actions and actions are based on actors. Creating an enabling environment necessitates in the first place to bring the relevant heads together at the national level. The strengthening of transformative alliances combining EbA and agroecology is thus a precondition for any future change. Addressing the existing systemic crises by transforming the food system requires political leverage and continued strategic effort over extended periods of time. Therefore, creating an enabling environment is more likely where pressure, capacity and resources are leveraged across alliances between EbA and agroecology communities.

   Thus, capacity building of and knowledge exchange between relevant actors from government, private sector, farmers' associations, community representatives and researchers from the EbA and agroecology science must be institutionalized. Therefore, this first stage of Step 5 builds on relevant institutions identified and strengthened in Step 1. As has been demonstrated in the case studies, civil society organizations often perform as knowledge brokers between the different sectors and levels – as such, their inclusion, training, and financial support should be actively accounted for.

2. **Promoting Policy Coherence**: An enabling environment relies on an appropriate institutional and policy framework at the national level. Local initiatives will only have limited impact without such framework.[117] Based on the policy analysis in Step 1, reformative action needs to be initiated where, for example, climate-related policies do not sufficiently include systemic, ecological farming approaches.

   However, where policies already selectively address agroecological elements, like soil and water conservation practices, these connecting factors should actively be applied to demonstrate the synergistic effects between EbA and agroecology and to embed these synergies more broadly into existing policies. This can also entail active policy guidance for relevant policy makers in relevant national forums and platforms. As stressed by the FAO: "The lack of understanding of agroecology amongst policymakers may be the greatest barrier to its inclusion in climate change policies and strategies."[118]

3. **Facilitating Multiple-Level Governance**: As stressed by the FAO, agroecology but also EbA are best supported by responsible governance mechanisms at different scales.[119] National level legislation as well as policies and programs rewarding agricultural management that contributes to biodiversity conservation and the provision of ecosystem services have already been formulated by a number of different states. However, territorial, landscape and community level governance, such as traditional and customary governance models, are not less relevant for fostering cooperation between stakeholders, maximizing synergies and reducing or managing trade-offs.[120]

Decision-making on ecosystem services often takes place at different scales: Ground level decisions about changes in land use are mainly conducted by local-level actors, like farmers, forest managers and other land users. However, many policy decisions regarding the provision of ecosystem services – like for example clean water – are often made at landscape or regional scale through responsible administrations, especially in federal government systems. More strategic decisions on ecosystem services are more likely to be taken at a national scale, especially when they encompass transboundary perspective in cases of major lakes or protected area networks that cross national frontiers.[121] Thus, the diffusion of responsible governance of land, fisheries and forests and their ecosystems need to be actively supported by all levels of government in a given state. Strengthening and coordinating such processes should be initiated at the national level.

4. **Raising Public Awareness:** The transformation of the food system towards more climate resilience and responsiveness towards biodiversity loss, land and water degradation and food insecurity can only be successful if sufficient public awareness about relevant measures and potential options exists. One tool can be public awareness campaigns addressing the broader public, consumers, and other actors of the food system. However, also more targeted campaigns for sensitizing politics and other decision-making actors are an option, depending on the already existing knowledge of the potential role of EbA-sensitive agroecology amongst relevant stakeholders.

   Furthermore, the education system and extension services that train current and future farmers and other actors within the food system should include relevant content in their curricula about the implementation of crises-responsive agroecological solutions. To strengthen bottom-up efforts, also locally adapted indigenous knowledge should be actively included in the formulation and dissemination of information and knowledge.

5. **Investing in Agroecological Solutions**: The financial support for EbA-sensitive agroecological approaches can be achieved through different means. The FAO[122] lists successful examples of school meals and other public procurement programs, the creation of market regulations allowing for branding of agroecological products or subsidies and incentives for ecosystem services.

   Access to rural finance and strategic funding for EbA-sensitive agroecology can be provided for by the national level through rural development programs. The case study in Guatemala demonstrated that state support in form of a payment scheme for ecosystem services contributed successfully to the scaling of EbA-sensitive agroecological practices in the rural project area. Hence, shifting the public support towards more diversified and climate-resilient farming systems must also be expressed by monetary streams in the national budgeting.

6. **Creating a Level Playing Field**: The creation of an economic level playing field between different agricultural production patterns is another key condition for making agroecology economically sustainable in the long run. This could entail removing subsidies for synthetic inputs and providing incentives for sustainable food production methods that account for the value of nature.

   As the HLPE puts it: "A substantial barrier to premium pricing for sustainably produced food is that market prices usually do not include the cost of negative externalities of production, nor reward the positive benefits of systems with positive ecological impact."[123] The following excursus explains in more detail how the making of an economic case for EbA-sensitive agroecological practices can contribute to such level playing field amongst different agricultural production systems.

Excursus: Making an Economic Case for EbA-sensitive Agroecology

Still today, agricultural systems are often evaluated against very narrow performance measures focusing on productivity and monetary returns. Environmental and social impacts are considered as externalities and, hence, not accounted for. This distorts a comprehensive evaluation of the sustainability of agricultural production systems and leads to perverse decisions about how to manage agricultural land and related ecosystem services. Against this background, economic evaluation methods show the hidden costs of presumably more efficient conventional production schemes that, however, in fact undermine the long-term resilience of agroecosystems and environmental and social landscapes they are embedded in.

1. **Economic Evaluation at the National Level:** Building an economic case for EbA-sensitive agroecological practices at the national level can be relevant for countries where sufficient political majorities for the transformation of the food system do not yet exist. EbA and agroecology are systemic and, as such, complex approaches including multiple variables to respond to the challenges of climate change, biodiversity loss, land and water degradation as well as food insecurity. Given this complexity, decision makers might need support to evaluate synergies and resource efficiency of adopting agroecology as an EbA-sensitive approach in relevant policies and national strategies (like National Adaptation Plans, National Biodiversity Strategies and Action Plans, and Land Degradation Neutrality Targets).

   Economic evaluations can depict the true costs of non-systemic conservative agricultural practices and the benefits of existing alternatives. Such economic data can be vital for policy makers to reach evidence-based decisions that evaluate not only short-term economic effects of agricultural production schemes, but much more resulting environmental and social consequences. For example, True Cost Accounting (TCA) measures evaluate all important dimensions of human wellbeing and environmental impact. Such comprehensive economic evaluation can contribute to evidence-based policy making for ensuring coherence of relevant policy fields at the national level.

   Such economic evaluation at the national level can be conducted during Step 1 or 5 of the Five-Step-Approach, if a political necessity exists and sufficient time and resources are available.

2. **Economic Evaluation at the Landscape Level:** The use of economic metrics to assess true costs and benefits of different agricultural practices can also be undertaken at the local level for a given landscape to convince relevant stakeholders to conduct relevant investment in agroecological practices. It is critical that the assessment of the true value of EbA-sensitive agriculture is conducted in an inclusive way to ensure that options match and reflect local priorities and experiences of all stakeholders. Therefore, a participatory approach is key to economically evaluate the performance of different EbA-sensitive agroecological options since costs and benefits must be assessed for a broad range of resource users in a given landscape.

   Such economic evaluation at the landscape level can be conducted during Step 3 of the Five-Step-Approach, if a societal necessity exists and sufficient time and resources are available.

Approaches Supporting Economic Evaluations

Approaches and methods for such economic evaluations at the national as well as landscape level do not need to be invented from scratch –several approaches with a proven track record do already exist.

The Economics of Ecosystems and Biodiversity for the Agriculture and Food program (TEEBAgriFood)[124] recognizes and accounts for all significant “externalities” along the value chains of the eco-agri-food systems.

The Economics of Land Degradation (ELD) Initiative[125] uses economic metrics to value and account for ecosystem goods and services provided for by healthy soils and land. Thereby, the approach shows the true value of land to stakeholders from all sectors and makes an economic case for investing in sustainable land management.

Overview of the Five-Step-Approach

Step	Intended Outcome	Activities / Analysis needed	Level of Intervention
STEP 1 Analysis of relevant National Commitments	Capitalizing on Synergies	**(1) Policy and Legal Analysis:** Identify relevant national policies, laws and strategies influencing the eco-system as well as food system(s) and describe how they (do not) interact. **(2) Institution Building:** Adapt national and sub-national institutions, fora, and platforms to create synergies between policy and sector-related communities.	National
STEP 2 Developing a Rational on Crises-Related Challenges	Understan-ding the Landscape	**(1) Climate Risk Analysis:** Map current and projected climate change risks and related eco-system-based impacts. **(2) Stakeholder Mapping:** Describe the stakeholders and their resource access as well as needs in a given landscape (with a focus on agricultural practices). **(3) Vulnerability Assessment:** Outline patterns and structural reasons for food insecurity and vulnerability due to ecosystem-based risks.	Landscape
STEP 3 Applying an Options-by-Context Approach	Designing the Response	**(1) Defining Communities of Practice:** Create strategic stakeholder groups for developing EbA-sensitive agroecological solutions that include transdisciplinary knowledge from all relevant sectors and scales. **(2) Participatory Mapping of Ecosystem Services:** Map existing ecosystem services in a given landscape together with all stakeholders that influence, use and manage those services to create a common understanding on interlinked actions. **(3) Options-by-Context Matrix:** Define eco-sensitive agroecological practices and innovations in line with stakeholder needs and knowledge in the given landscape.	Landscape
STEP 4 Developing a Solution Portfolio	Including Complexity	**(1) Bundling Innovations:** Bundle innovations identified through the OxC matrix for an eco-sensitive and systemic response in the given landscape. **(2) Inclusive Selection Process**: Select bundles of innovation in an inclusive process that considers not only technical but also social innovations for ensuring gender-responsive as well as generally inclusive outcomes and the avoidance of non-intended negative effects.	Landscape
STEP 5 Identifying Key Components for Scaling-Up	Creating an Enabling Environment	**(1) Strengthening Alliances for Change:** Build and enforce strategic multistakeholder groups that support horizontal and vertical coordination between sectors and levels for scaling diversified and climate-resilient agricultural systems. **(2) Promoting Policy Coherence:** Based on the policy and legal analysis, guide policy makers on how to strengthen synergies between relevant policies on climate, biodiversity, land and water conservation as well as food security. **(3) Facilitate Multiple-Level Governance:** Include all levels of governance into the scaling up and out of EbA-sensitive agroecological solutions and strengthen coordination processes between them where necessary. **(4) Raising Public Awareness:** Sensitize the broader public as well as decision-makers for EbA-sensitive agro-ecology and mainstream relevant knowledge and information in the education system and extension services. **(5) Investing in Agroecological Solutions:** Encourage financial support for agroecological approaches in rural development programs and national budgeting. **(6) Create a Level Playing Field:** Develop an economic level playing field, i.e. by removing negative subsidies for synthetic inputs and providing incentives for sustainable food production. **(7) Make an Economic Case** (optional)**:** Conduct an economic evaluation of EbA-sensitive agroecological practices that depicts the true costs and benefits related to the provision of ecosystem services in agri-cultural production patterns.	National

5. Conclusions

→ Encouraging action

This report has demonstrated that agroecology is an effective, but still insufficiently utilized EbA approach in agricultural landscapes. There are significant similarities in terms of principles and practices across the two approaches and their combination provides direct synergistic effects for reaching the SDGs. Yet, given the long-standing separation of communities concerned with agriculture and food on the one hand and those dealing with climate and nature conservation on the other hand, it first of all requires joint planning, common strategic efforts, and financial investments to make use of the broad portfolio of possible synergies. However, the key message of this report is: While certain investments in time, finance and networking need to be made in the first place, these investments will clearly pay off in the mid-term to long-term by creating crises-responsive and resilient food systems that are able to address the multiple crises the global community is facing today.

→ Learning from pioneers

As discussed on a theoretical level in chapter 2 of this report, EbA can accommodate agroecology as an adaptation approach, and agroecology offers opportunities for implementing EbA in agricultural landscapes. For this rather natural fusion to happen, it is key that agroecology more systematically reflects projected climate change risks and impacts. The case studies presented in chapter 3 demonstrate the practical feasibility of using agroecology as an EbA approach in agricultural landscapes. The case studies presented in very diverse landscapes of India, Kenya and Guatemala demonstrate that communities and program practitioners have already found practical ways to implement systemic agroecological approaches on the ground, thereby contributing to the health of human-made agroecosystems and natural ecosystems alike. Also, the case studies underline that practical experience does already exist to make agroecology work as a means to implement EbA in agricultural landscapes. Putting it simple: The fusion of these two approaches is already unfolding. In this regard, a growing body of programs from around the globe offers valuable lessons learned for policy makers and practitioners alike. The future common task of the two communities from EbA and agroecology is to make these success stories available and scalable.

→ Bringing together sectors and scales

To scale up successful programs and projects, the Five-Step-Approach in form of the hourglass procedure stresses the relevance of actions at the national as well as at the landscape level alike. Thereby, the approach contributes to the vertical as well horizontal integration for successfully governing the transition towards crises-responsive food systems across sectors and scales. While the national level is responsible for defining and strengthening synergies between EbA and agroecology in relevant policies, laws, strategies and programs, the landscape level forms the base for designing EbA-sensitive agroecological innovation bundles that are context-sensitive and responsive to the diverse faces of climate change. The application of an OxC approach accepts the given variety of agricultural landscapes and the diverse needs and interest of their resource users. This diversity must also be expressed by the constellation of Communities of Practice that synergize local and global knowledge on how to achieve food security in a sustainable and nature-friendly way.

→ Closing the financing gap

While the story is old, the moral is more acute then ever: Ignoring the impact of agricultural or any other human-made system on climate change might seem cheap in the first place – however, the long-term payment will not be bearable for future generations. There is an urgent need to significantly increase mitigation and adaptation funding for any kind of sustainable agricultural practices as well as for the saving of ecosystem-based services. Systemic responses like those embraced by agroecology and EbA will not only save valuable resources for future generations but will also lead to a saving of scarce human and financial resources within public and private governance structures at all levels. It is important that multilateral institutions, national governments, private sector entities and research agencies reflect the potential of agroecology to deliver EbA in agricultural landscapes in their funding allocations. By calculating synergetic effects and resulting benefits as well as costs of non-adaptation through economic evaluations, the EbA and agroecological communities can make a strong economic case for efficient and effective agricultural solutions that actively incorporate climate resilience and support local livelihoods on fields and farms.

→ Planting the future

To conclude, building alliances for change amongst the agriculture and climate communities will be the motor to drive food system transformation and to achieve the SDGs as well as the objectives of the Rio Conventions. Agroecology offers substantial opportunities to scale EbA in agricultural landscapes – however, this requires a significantly higher level of awareness between the two communities, alongside their openness to further explore common synergies. As this report suggests, these alliances for change are not only possible but rather critically needed. The global questions whether humanity will find a way of transforming today's societies into climate-neutral and nature-friendly systems is far from being answered. Regarding the agricultural sector, the combination of EbA approaches with agroecological solutions provides one important response to this very urgent matter of our time.

Annex 1: Example of an Options-by-Context Matrix for Planting Basins in Eastern Kenya

Land restoration options	Contextual factors						
	Agroecology	Labour availability	Land size and tenure	Access to equipment/market	Livestock ownership and management	Production orientation	Cultural and social norms
Planting basin	Rainfall, soil texture and slope are key biophysical factors influencing basin performance. Basins are best suited to arid/semi-arid conditions, in sites with well-draining medium textured soils (e.g., sandy loams) receiving 300-800 mm of rainfall per annum and on gently sloping land (gradients of 1-15%). Under more humid conditions and on poorly draining soils, basins can result in waterlogging and depressed yields. Farmer adaptations can reduce risk of flooding under high rainfall. These include removing excess water, diverting run-off from basins using additional trenches and refilling basins with soil. Rocky or extremely shallow soils can make digging and maintaining basins difficult.	Basins are typically dug by hand and are labour-intensive. Lack of labour and suitable tools for digging basins are one of the main barriers to adoption. The initial labour cost of digging large numbers of basins is likely prohibitive for many households. Even when returns justify hiring of external labour, lack of cash upfront to pay labourers and lack of labourers to hire may be challenging for some households and in certain locations. Uptake of basins can lead to a shift in labour burden from men to women, with women becoming more involved in land preparation – an activity traditionally carried out by men. Nevertheless, women may gain greater autonomy over land preparation. Although basins increase time taken for land preparation, they have been reported to reduce the time needed for weeding. Basins also help spread labour demand throughout the year since they can be dug throughout the dry season. Farmers, especially women, have formed labour exchange groups to help each other dig basins.	Planting basins are temporary structures thus suitable both for those who own land and those who rent land. Nevertheless, insecure tenure agreements may deter farmers from investing in digging basins. Households with limited farm sizes maybe more likely to invest in and benefit from the use of planting basins. Using planting basins intensifies maize production and allows farmers to maximise the use of their land. Households with small farms may also have lower land-to-labour ratios and greater labour availability for digging and maintaining basins. Land is typically acquired by men through inheritance upon marriage. Women's land rights are often restricted by customary practices whereby women rarely inherit land and typically attain secondary use rights through their husband. Young people often lack access to and control over land, reducing their opportunities to engage and invest in agriculture.	Farmers may lack access to appropriate tools for digging basins. Capital may be needed to purchase or hire such tools. However, using planting basins may reduce farmers' reliance on the use of borrowed or rented ploughing equipment. This may be beneficial especially for women farmers since they typically have lower access to resources oxen and ploughing equipment. From our analysis we see that households where only women were involved in ploughing often relied on the use of borrowed equipment and had the lowest rates of plough ownership. Using basins could benefit women in these households by reducing their dependence on borrowed equipment and helping avoid planting delays.	Households with livestock may need to protect basin structures from damage from free-grazing livestock during the dry season.	Basins can reduce the chance of crop failure in low rainfall conditions, providing a safety net in terms of food security. Maintaining a small area of basins could help buffer vulnerable households against climatic shocks and yield failures. Households who are more food secure and market orientated, however, may be less interested in using basins for subsistence crops such as maize. Households who have alternative livelihood activities may be less interested or have less time to invest in farming. Similarly, households or farmers with aspirations to move out of farming may be less interested in labour intensive options such as planting basins. Households with sources of off-farm income (e.g., members who earn off-farm income, remittances) may have access to cash for hiring labour to dig basins. Young people may not see farming as a desirable livelihood.	Men typically have greater authority over land and agricultural enterprises that generate high revenues. Despite women's increased involvement in workshops and uptake decisions, it is evident that asymmetries in decision-making authority persist. Women's ability to implement innovations across the farm largely depended on some form of pro forma consultation with their husbands and even women with absent husbands were often still obligated to consult their spouse. Older women likely better able to negotiate access to land, influence decisions and have more free time to attend agricultural workshops than younger women living with their in-laws. Young people may also not see farming as a desirable livelihood. However, conversely, households who have alternative livelihood activities may be less interested or have less time to invest in farming. Similarly, households or farmers with aspirations to move out of farming may be less interested in labour intensive options such as planting basins. Households with sources of off-farm income (e.g., members who earn off-farm income, remittances) may have access to cash for hiring labour to dig basins.

Land restoration options	Contextual factors						
	Agroecology	Labour availability	Land size and tenure	Access to equipment/market	Livestock ownership and management	Production orientation	Cultural and social norms
Different planting basin dimensions	Given their role in capturing run-off, basin design influences performance under different agroecologies. Some evidence suggests larger sized basins (e.g., 90x90cm) are better suited to higher rainfall conditions. Small basins (e.g., 30x30cm) perform poorly in comparison to larger basin (60x60cm, 90x90cm). Smaller basins are prone to backfilling with sediment following heavy rains and quickly lose their ability to capture surface water run-off.	Small basins (i.e., 30x30cm) can be difficult to dig and fill in with sediment quickly following high rainfall. Larger basins (i.e., 60x60cm and 90x90cm) are thought to be less labour intensive to dig and maintain.					
Combining planting with farmyard manure	Using basins in combination with farmyard manure improves their efficacy, especially when rainfall is adequate. However, use of soil amendments such as mulch and manure can attract termites. Addition of manure is particularly important in heavily degraded sites with soils low in organic matter and soil organic carbon.	Additional labour may be required for collecting and applying manure.			Households without livestock may lack access to farmyard manure for use with basins.		
On-tree farm planting	Local agroecological conditional will influence the suitability of different tree species. Rainfall, altitude, soil type are all important factors to	Tree planting can be labour intensive (although less so compared to other options such as planting basins). Trees require weeding during establishment and	Farm size can influence the suitability of different arrangements. Woodlots are better suited to those with large farms. Boundary planting and planting	Lack of access to seedling through nurseries and good quality germplasm can be challenging. Suitable tools for planting and tree care are also needed. Cash	Tree seedlings require protection from free-grazing livestock. Species that can be used as tree fodder may be preferable to those with	Species preference may vary with production orientation. Higher value species such as mango and Melia may be better suited for market orientated	Tree growing, especially fruit trees practices, are likely to have strong gender dimensions to their uptake, management, and benefits. Men tend to exercise greater control over
Reseeding pastureland	Soil texture and depth are important factors. Reseeding steeply sloping land may be challenging. Challenges also include termite destruction by grasses and fire.	Lack of participation by youth and men		Storage facility Tools and equipment Financial capital Market availability			
Aforestation and reforestation	Water availability and climate variability is important for tree seeding survival and tree species selection. Soil texture and fertility will also influence species suitability.	Large scale tree planting can be labour intensive. Less labour-intensive options might include natural regeneration but requires that there are sufficient seed/stumps to regenerate. High labour cost Inadequate skilled labour for tree planting may also be a challenge.		Proper tools Source of capital	Protection where free grazing	Land restoration Increased tree cover Food security water availability (farm and household) Increased household income	Leadership Capacity Policies and regulations Monitoring

Annex 2: Sources

Figures and Info Boxes

Figure 1 (p.5): Weigelt, J, Sinclair, F., Lossack, H., Mikulcak, F. (2022). Resilient Agriculture: Five key messages on how to implement agroecology as a systemic adaptation response. Berlin, TMG Research.

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Info Box "Food System and Agroecosystem" (p. 8): HLPE (2017). Nutrition and food systems. A report by the High-Level Panel of Experts on Food Security and Nutrition of the Committee on World Food Security. Rome: HLPE.

Info Box "Landscape Approaches" (p. 10): GIZ (2019). Landscape Approaches. Background Paper. Available at https://www.giz.de/en/downloads/giz2020-0174en-landscape-approaches-background-paper.pdf (last access on 10.10.2022).

Info Box "Potential synergies and contributions of EbA and agroecology to the SDGs" (p.11): The list has been conducted based on statements from the following two sources: FAO (2020); FEBA (Friends of Ecosystem-based Adaptation) (2022). Ecosystem-based Adaptation and the successful implementation and achievement of the Sustainable Development Goals. IUCS, Gland, Switzerland. Available at https://zenodo.org/record/6789086#.Yx9u8bTP2Uk (last access on 10.10.2022).

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Info Box "Options and Context" (p. 13): Crossland, M., Chesterman, S., Magaju, C., Maithya, S., Mbuvi, C., Muendo, S., Musyoki, M., Muthuri, C., Muthuri, S., Mutua, F., Njoki, C., Sinclair, F., Winowiecki, L. (2022). Supporting farmer innovation to restore: An illustrated five step guide to applying the Options by Context approach to land restoration. Nairobi, World Agroforestry. Available at https://apps.worldagroforestry.org/downloads/Publications/PDFS/TN22019.pdf (last access on 10.10.2022).

Info Box "Options-by-Context Matrix" (p. 14): template from Crossland et al. (2022), see above.

Info Box "Economic Evaluation of Climate Resilient Agroecological Practices" (p. 14): own depiction.

Info Box "Scaling-Up" (p. 15): GIZ (2016). Guidelines on scaling-up for programme managers and planning officers. Available at https://snrd-asia.org/download/giz2017-en-scaling-up-guidelines.pdf (last access on 10.10.2022); Jacobs, F., Ubels, J., Woltering, L., Boa-Alvarado, M. (2021). The Scaling Scan – A practical tool to determine the strengths and weaknesses of your scaling ambition. (2nd Edition). Published by the PPPlab and CIMMYT. Available at https://ppplab.org/wp/wp-content/uploads/2018/11/PPPLap-Scaling-Final-19022019.pdf (last access on 10.10.2022).

Figure 3 (p. 15)**:** inspired by FAO (n.d.). The ten elements of agroecology. Guiding the transition to sustainable food and agricultural systems. Available at https://www.fao.org/3/I9037EN/i9037en.pdf (last access on 25.10.2022).

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Figure 6 (p. 21)**:** Crossland, M. (2022). see above, p. 18.

Figure 7 (p. 22)**:** World Agroforestry Centre, IFAD, ICARDA, ICRISAT, ILRI, CGIAR. Communities of Practice. Creating and Sharing Knowledge. Available at https://www.worldagroforestry.org/sites/default/files/Communitites%20of%20Practice%20updated%20brief%20March%202017.pdf (last access on 25.10.2022), p.1.

Figure 8 (p. 23): Stiem-Bhatia, L., El Fassi, M., de Condappa, D., Weigelt, J., Benavides, L., Mwangi, W., Selvin Pérez Pérez, E., Coj Sajvin, A., De León, R., D'Souza, M., Srinidhi, A., Amalia Porta, M., Rodríguez, A (2021). Ecosystems for resilience. Enabling community-led adaptation: Five key insights from Guatemala and India. TMG Research, Berlin; September 2021. Available at https://doi.org/10.35435/2.2021.2 (last access on 10.10.2022), p. 11.

Figure 9 (p. 27): Weigelt, J., Sinclair, F., Mikulcak, F., Lossack, H. (2021): Ecosystem-based Adaptation in Agriculture. How Agroecology Can Contribute to Tackling Climate Change. White Paper. Available at https://www.globallandscapesforum.org/wp-content/uploads/2021/11/6-White-Paper_GLF-Climate-Ecosystem-based-adaptation-in-agriculture_En.pdf (last access on 10.10.2022), p. 5.

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