Food and Agriculture Organization of the United Nations

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The Potential of Agroecology to Hedge against Climate Change

and Build Resilient and Sustainable Livelihoods and Food Systems

- DRAFT TECHNICAL REPORT -

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Executive Summary

The transformation of agriculture and food systems in a broader sense to address the challenges of a changing climate will only happen through coordination and collaboration between various disciplines and across all levels, bringing together technical and policy-related evidence as well as the various actors of the food system.
Our project follows this logic and is therefore designed as a multi-stakeholder collaboration between research institutions (Research Institute of Organic Agriculture - FIBL, Institut Senegalais de Recherches Agricoles-ISRA, Bioversity International Kenya), civil society organizations (Biovision- Foundation for ecological development, Enda Pronat, Institute for Culture and Ecology – Institute for culture and ecology-ICE), and UN agencies (FAO).
Three analysis lenses were applied to provide a robust evidence-base for the following question:

"What role for agroecology in strengthening climate change resilience?"

We looked for evidence on that question in:
1) the international policy arenas, in particular in UNFCCC and Koronivia process
2) peer reviewed studies on agroecology through a meta-analysis
3) two case studies in Kenya and Senegal
 -from a policy potential point of view, assessing institutional frameworks in terms of the potential to incorporate agroecology to hedge against climate change
 -from a technical potential point of view, through farm-community level analysis on resilience

The study at a glance

- Solid evidence demonstrates that agroecology increases resilience, especially by strengthening a) ecological principles, in particular biodiversity, overall diversity and healthy soils (*Meta-analysis & case studies resutls*); and b) social aspects, in particular co-creation and sharing of knowledge and building on traditions (*case study results*)
- The interdisciplinary and systemic nature of agroecology is key for its true transformational power but challenging, both for research and policy processes: the majority of existing scientific evidence and current policy processes focus only on the productive dimension, mostly with sectorial view, focusing on crop production.
- Agroecology is proposed as one of the approaches to hedge against climate change by countries, with more than ten percent of the national determined contributions (NDCs) mentioning Agroecology.
- Also in the United Nations Framework Convention on Climate Change (UNFCCC) related processes, agroecology is strongly supported by the findings and recommendations of the 2019 International Panel on Climate Change (IPCC) Special Report on Land and the 2019 CFS High Level Panel of Experts (HLPE) report.

Key recommendations

- The current knowledge base is robust enough to argue for supporting agroecology as a climate change adaptation strategy.
- Further comparative research on the multidimensional impacts of agroecology is needed.
- Barriers to the scaling-up of agroecology need to be addressed, such as knowledge intensity and complexity, enabling integration and creating a level playing field for Agroecology.
- Agroecology's transformative resilience building potential depends on its holistic and systemic nature which goes beyond a set of practices and includes: a social movement, for producers' empowerment and a multidisciplinary scientific paradigm.

1 Introduction

1.1 Rationale: bringing agroecology into climate change discussions

Climate change has severe negative impacts on livelihoods and food systems worldwide, with adverse future projections, seriously undermining current efforts to improve the state of food security and nutrition, especially in Sub-Sahara Africa (SSA) (FAO 2016). The 2018 report on the State of Food Insecurity raised an urgent appeal to accelerate and scale-up actions to strengthen resilience and enhance adaptive capacity in agricultural sectors.
As recently highlighted by the Intergovernmental Panel on Climate Change special report on Global Warming of 1.5°C and special report on land (IPCC, 2018; IPCC, 2019), also by the State of the world's Biodiversity for Food and Agriculture (FAO, 2019) and various other recent key publications on issues related to climate change, there is an urgent need for a transformational change of our food systems towards more sustainability and resilience.
At the 21. conference of the parties of the UNFCCC (COP 21), the 2015 Paris Agreement finally recognized "the fundamental priority of safeguarding food security and ending hunger, and the particular vulnerabilities of food production systems to the adverse impacts of climate change". As a response, in 2017, at COP23 in Bonn, the international community adopted a decision to have a work stream on agriculture through a three-year Koronivia Joint Work on Agriculture (KJWA). Ecological and sustainable agriculture and food systems, through their potential for adaptation, mitigation and building resilience, are a fundamental part of the solution to tackle climate change. They are uniquely placed to help countries to deliver on climate goals and the 2030 Agenda for Sustainable Development.
The entry-point and focus of this study is on climate change, as both agroecology and climate change have complex potentially intimate relationships, often insufficiently disseminated to and acknowledged by a broad audience, hindering it to be seen as an effective path to follow to set-up national climate targets (Côte et al., 2018).
Since the very first international symposium on agroecology in 2014, organized by the Food and Agriculture Organization of the UN (FAO), followed by regional conferences and a second international symposium on agroecology in 2018, agroecology is featuring well on the global Agenda. FAO's governing bodies highlighted the importance of agroecology, and called at the 26th Committee on Agriculture and at the 40th Conference in 2018 for the need to: strengthen normative and evidence-based work foster research and increase the collection of evidence and qualitative data on agroecology.

The launch of a global initiative aiming at scaling up agroecological production systems in support of the sustainable development goals (SDGs) (the scaling-up agroecology Initiative[1]) in 2018 and this year's CFS (Committee on World Food Security) HLPE report on "Agroecological and other innovative approaches for sustainable agriculture and food systems that enhance food security and nutrition"[2] further illustrate the multi-level momentum on agroecology: from the field, to the regional, national and international levels.

Agroecology has an important role to play in transforming agriculture and food systems and is often cited as a promising systemic approach to unlock adaptation and mitigation potentials in agriculture and food systems and build resilience for a sustainable development.
Many experiences, data, evidence and results exist in the field, in different countries, led by farmers, civil society organizations, research and some supported by governments, which support this

[1] http://www.fao.org/3/I9049EN/i9049en.pdf
[2] See: http://www.fao.org/3/ca5602en/ca5602en.pdf

affirmation. Indeed, numerous reports from research organizations, civil society and grassroot organizations, present agroecology as a promising systemic approach to address the climate issue by unlocking adaptation and mitigation potentials and building resilience (see for an overwiew e.g. Baker et al 2019).

Despite this increased visibility in public debates and the claimed good performance of agroecology for transforming agriculture towards increased sustainability, it is not yet widely adopted by farmers. This is traced back to various reasons, such as lack of enabling institutional and policy environments and the strong pressure from ongoing industrialization and commercialization, or lack of funds for research and education (Nicholls and Altieri 2018).

Agroecology has been existing long before climate change was seen as a major threat for agriculture sectors and is therefore not an approach specifically designed to address climate change. Thus its climate resilience qualities which are examinated in this study are rather an outcome of its of its systemic apporache and natur, mimicking natural, complex ecosystems. However there is still insufficient comprehensive and structured evidence supporting the claim of its climate change adaptation potential as well as too little information made available on the broader political and political-economic challenges and constraints that need to be considered and addressed when building on the agroecology approach to hedge against climate change. Unlike in the more food system focused fora, such as the 46th session of the Committee on World Food Security (CFS 46), with the endorsement of the High Level Panel of Experts report (HLPE, 2019), which are increasingly highlighting the essential role of agroecology in food systems transformations, agroecology does not yet get the same recognition and visibility in the climate change discussions.

Just recently Sinclair et. al (2019) published a background report on "the contribution of agroecological approaches to realizing climate resilient agriculture" for the Global Commission on Adaptation (GCA) (GCA, 2019), which includes recommendations to use agroecological practices to build resilience of smallholder farms and a commitment in the action track on agriculture and food security to enable access to agroecological practices for 60 million smallholders. It proposes adaptation and mitigation benefits of agroecological approaches at four scales - field; farm / livelihood; landscape / community; food system derived from all 13 agroecological principles identified in HLPE, 2019.

1.2 Overall objective and set-up

Responding to FAO's governing bodies' call for increased evidence-based work on agroecology, this study aims at highlighting the linkages between agroecology and climate change, by providing evidence on the technical (I.e. ecological and socio-economic) and policy potential of agroecology to build resilient food systems.

The evidence compiled in this study aims to bring elements from various backgrounds and perspectives together and feed UNFCCC processes, as well as national climate-related discussions.

This has already been achieved while compiling this study, with specific submissions on 2b, 2c and 2d of the Koronivia process (see Chapter 2.2) that build on insights from this work.

This study's results are presented throughout several events in country pavillons (EU-Pavillon, Senegal, France) and a specifically for that purpose designed roundtable during COP 25 in Madrid in December 2019.

This report has the objective to provide evidence to the question:

How can agroecology contribute to climate change adaptation, mitigation[3] and build resilience, both in terms of practices and policies?

Inspired by the idea that transformation will only happen through a coordinated articulation between all levels which are key for innovation (considering the local level of action and implementation, the national level defining the governance framework and the policies and the international agenda of the global level), this study brings together different levels of analysis:

1. At the international level:
- **A technical potential analysis through a meta-analysis**: which provides a scientific evidence from peer reviewed articles of the performance of agroecology in relation to climate resilience building (adaptation and mitigation)
- **A policy potential analysis**: which assesses the potential for agroecology to be considered and recommended as a relevant adaptation / mitigation approach in the agriculture-climate discussions.

2. At the national level: **Two country case studies** (Senegal and Kenya), each of which includes:
- **A technical potential analysis** which provides a better understanding of the ecological and socio-economic performance of agroecology, based on a rigorous comparative analysis answering to the question "are and if so why agro-ecological agroecosystems are more resilient than non-agroecological ones?"
- **A policy potential analysis** which provides a better understanding of the current political context as well as the enabling environment and the obstacles for agroecology to be considered in the decision-making process and out-scaling.

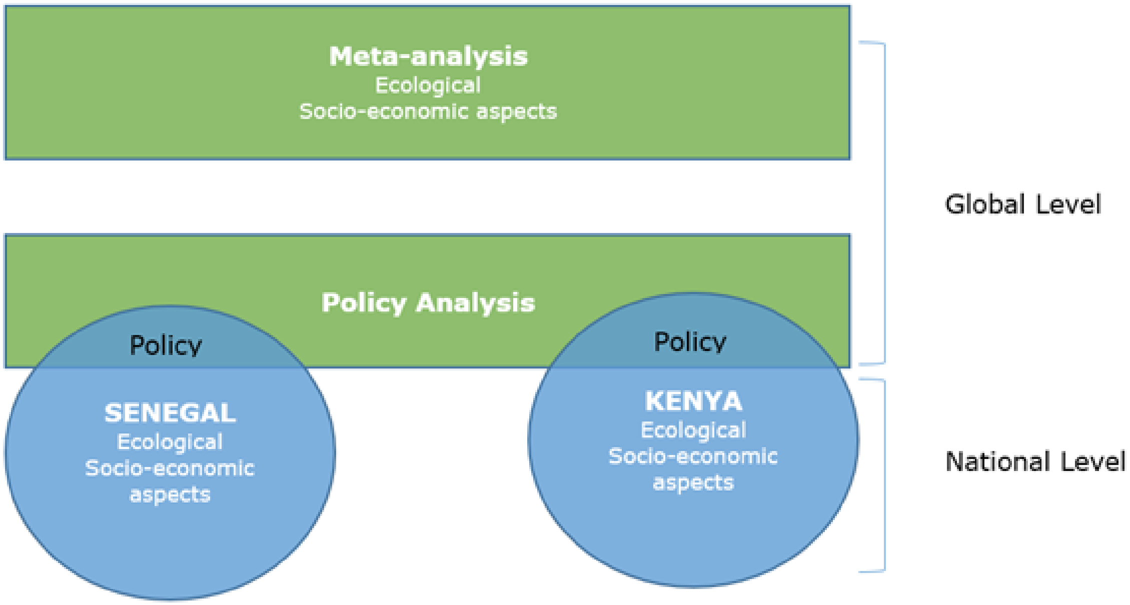

Figure 1: Illustration of the two levels (international and national) of analysis and the four components (Meta-analysis/International analysis of the policy potential/ national analysis of the policy potential/ local/national analysis of the technical potential). It also indicates content-wise overlaps.

[3] Mitigation co-benefits and trade-offs are also considered, wherever possible.

The results of this study also aim to promote discussions around agroecology in national and international climate fora.

This study was carried out in 10 months (from March 2019 to December 2019), through a close multi-level (FAO Headquarters and Country Offices), inter-divisional (Plant Production and Protection - AGP, animal health - AGA, and climate change and environment - CBC) and multistakehoder collaboration, combining research (Research Institute of Organic Agriculture – FIBL[4], the Senegalese Institute for Agricultural Research[5] and Bioversity International in Kenya) and civil society organizations (Biovision Foundation for Ecological Development - Biovision[6], Enda Pronat[7] in Senegal). It was also open to external experts (who met twice during an advisory group meeting) and which members were part of the peer-review process. This interdisciplinary and multiscale study set-up reflects and respects the complex nature of agroecology and climate change.

Synergies with ongoing work

- Building on FAO's 10 elements[8] characterizing agroecology, part of the implementation of the Scaling-up Initiative on agroecology, this study has, as a co-benefit, also been pilot-testing the first draft of the the multidimensional assessment framework for agroecology (tool for agroecology performance evaluation - TAPE), developed by FAO in close collaboration with experts (see 1.3.1).
- Another synergy is achieved by building on the 13 agroecosystem resilience indicators from Cabell and Oelofse (2012) mobilized in the FAO SHARP tool[9]. The SHARP tool is the basis for the country case studies on the technical potential of agroecology in on-going field projects (see 1.3.2) .
- As mentioned above, the study by Sinclair et al. (2019) is on the same questions. The authors came to the conclusion that "Agroecological approaches have proven ability to simultaneously address specific climate hazards, enhance the resilience off farming systems to climate change and to improve the flow of a range of ecosystem services". The 13 HLPE Agroecology principles the report is based upon, have been developed in parallel to this study. As a consequence we do not refer to them explicitly here, but understand them as complementary as also highlighted by the authors of the HLPE report. Principles however might in some situations be better suited for analyitical purposes, in particular if rather qualitative questions are examinated. The policy recommendations from Sinclair et al to enable rational decision making about and adoption of agroecological approaches have been considered and integrated into the recommendations of this report (in particular Chapter 5).
- Finally, this study relates to a number of recent reports, such as the 2019 High Level Panel of Experts on Food Security and Nutrition report on agroecology (HLPE, 2019), the Global Center on Adaptation (GCA) Study (Sinclair et al., 2019) and the Swiss-National FAO committee discussion paper.

[4] see: https://www.fibl.org/en/it/homepage.html
[5] see: https://www.isra.sn/
[6] see: https://www.biovision.ch/en/home/
[7] see: http://www.endapronat.org/
[8] see: http://www.fao.org/agroecology/database/detail/en/c/1128220/
[9] see: http://www.fao.org/in-action/sharp/en/

1.3 Definitions and Concepts

1.3.1 Agroecology framework: how to understand agroecology in this study

Complexity, context-specific and based on bottom-up and territorial processes being at the heart of agroecology, there is not one universal definition for it. Indeed, recent years have seen the multiplication of definitions of agroecology, nuances depending on the authors, institutions or civil society organizations (CSO), highlighting its dynamic concept (HLPE, 2019). Nonetheless, there is a consensus that agroecology embraces three dimensions: a transdisciplinary science, a set of practices and a social movement (Wezel et al., 2009; Wezel and Silva, 2017; Agroecology Europe, 2017)

Defined by the IPCC as one of the options of sustainable land management, including agroforestry (IPCC, 2019), agroecology is the application of ecological sciences to the study, design and management of agriculture (Altieri, 1995). Integrated land-use systems that maintain species diversity, agrobiodiversity, the improvement of ecological processes and delivery of ecosystem service, the strengthening of local communities and recognition of the role and value of indigenous and local knowledge are core elements of agroecology (IPCC, 2019).
The HLPE report defines agroecological approaches to sustainable food systems for food security and nutrition as follows:

Agroecological approaches favour the use of natural processes, limit the use of purchased inputs, promote closed cycles with minimal negative externalities and stress the importance of local knowledge and participatory processes that develop knowledge and practice through experience, as well as more conventional scientific methods, and address social inequalities. Agroecological approaches recognize that agrifood systems are coupled social–ecological systems from food production to consumption and involve science, practice and a social movement, as well as their holistic integration, to address FSN (HLPE, 2019, p. 39).

Agroecology thus provides possible transition pathways towards more sustainable food systems, based on a holistic and systemic approach (IPES-Food, 2016). During its historical evolution, the focus of agroecology went from the field, farm and agroecosystem scales to encompass, over the last decade, the whole food system.

Bridging ecological and social dimensions, people-centered, knowledge-intensive and rooted in sustainability, agroecological approaches aim at transforming food and agriculture systems, addressing the root causes of problems and providing holistic and long-term solutions, as expected by the 2030 Agenda (FAO, 2018). Agroecology particularly contributes to no poverty (SDG1), zero hunger (SDG2), good health and wellbeing (SDG3), decent work and economic growth (SDG8), responsible consumption and production (SDG12), climate action (SDG 13) and life on land (SDG 15) (CNS-FAO, 2019). Also, the core principles on which agroecological practices build (I.e.: diversity, efficient use of natural resources, nutrient recycling natural regulation and synergies) characterize their inherent adaptation and resilience potential to climate change (Côte et al., 2018).

Encompassing aspects related to the three pillars of sustainable development (environment, social and economic), several sets of agroecological principles were developed by different actors so as to characterize inherent properties of agroecology and to ensure a common understanding.

Stemming from FAO regional seminars[10], seen as an analytical tool, the FAO 10 elements of agroecology aim at helping countries to operationalize agroecology. They provide an overall framing of important properties of agroecological systems and approaches, as well as key considerations in developing an enabling environment for agroecology.

- Six elements relate to the description of common characteristics of agroecological systems, foundational practices and innovation approaches: **Diversity; synergies; efficiency; resilience; recycling; co-creation and sharing of knowledge**
- Two relate to context features: **Human and social values; culture and food traditions**
- And two relate to the enabling environment: **Responsible governance; circular and solidarity economy**[11]

As illustrated below, these 10 elements reflect elements encompassing different scales (agroecosystem and food system), different levels of transitions towards sustainable food systems (as defined by Gliessman, 2007). When levels 1 and 2 are incremental, levels 3 to 5 are transformational.

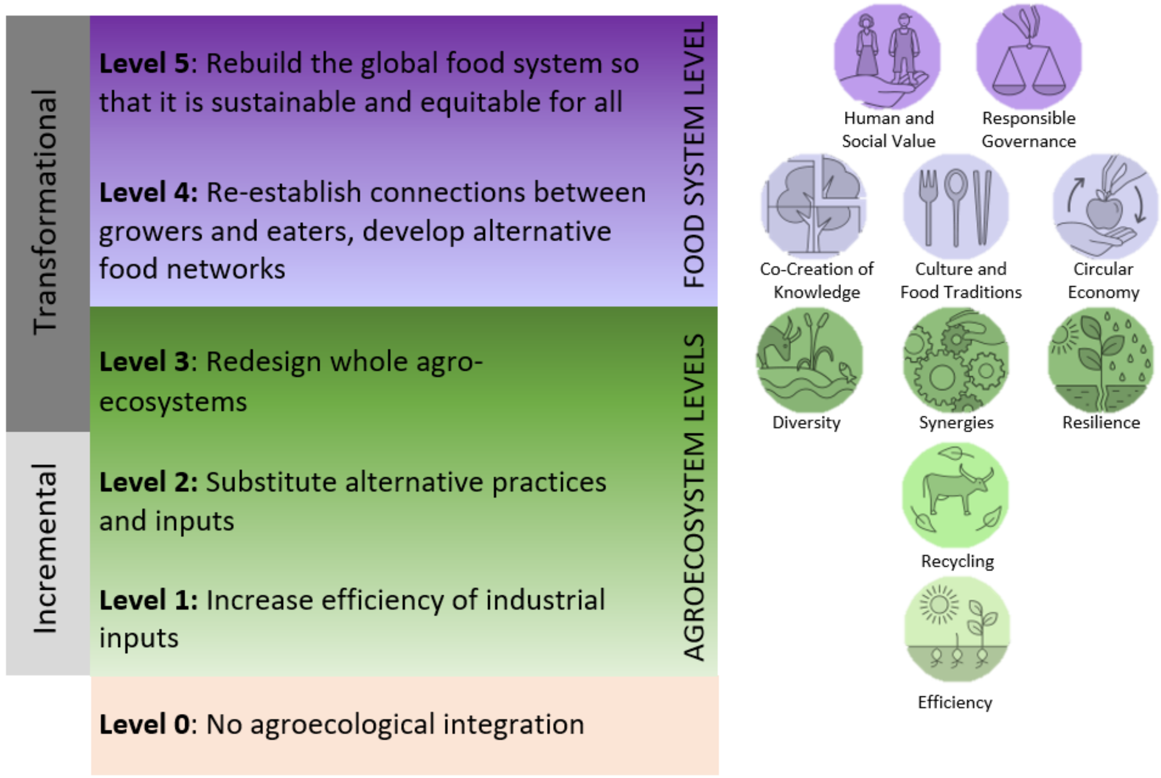

Figure 2: The 10 elements of agroecology understood according to: the levels of transition towards SFSs (Gliessman, 2007). Source: Biovision (n.d.), inspired by (HLPE, 2019)

This study builds on these 10 elements, as analytical lenses, framing what is understood by agroecology. It therefore adopts a systemic approach of agroecological agroecosystems, considering the entire food system (from production to consumption, considering the enabling environment).

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[10] The 10 Elements of Agroecology were developed through a synthesis process. They are based on the seminal scientific literature on agroecology – in particular, Altieri's (1995) five principles of agroecology and Gliessman's (2015) five levels of agroecological transitions. This scientific foundation was complemented by discussions held in workshop settings during FAO's multi-actor regional meetings on agroecology from 2015 to 2017, which incorporated civil society values on agroecology, and subsequently, several rounds of revision by international and FAO experts.

[11] see: http://www.fao.org/3/I9037EN/i9037en.pdf

1.3.2 Climate Resilience

Climate change is expected to affect agriculture and food security in various ways and the effects will be sector and region specific. Taking crop production in Africa for example, climate change will result with yield reduction in majoar cereals but with some regional differeces. Southern Africa region is expected to experience 18% decline in maize yield while the aggregate for Sub-Saharan Africa as whole will be 22% reduction (Lobell et al. 2008).

With regard to livestock, there is a risk of loss due to expected prolonged droughts and rangeland degradation especially in northern and southern Africa which are expected to become drier as a result of increased surface temperatures and reduced precipitation (Masike & Urich, 2009). Crop production is mainly rainfed and livestock systems are often unsheltered or unprotected, thus making these production systems highly sensitve. These, together with high intra-and inter- seasonal climate variability, high frequency of droughts and floods make African agriculture the most vulnerable (IPCC, 2014). There is therefore a need to reduce this vulnerability and to adapt agricultural systems to climate change and to enhance their resilience.

Vulnerability is the degree to which a system coulda dversely be affected by shock and stress (climatic change and variability) depending on its adaptive capacity (IPCC 2012). The potential impact of climate change upon a system is determined by its level of exposure and sensitivity. A system's level of exposure in turn is determined by climate drivers and risks and depends on the character, magnitude and timing of climate change and variation, while the level of sensitivity determines the extend to which a system could be affected by a given climate change exposure (Fritzche et al. 2014). Thus, the resulting impact (risk) would be the function of threat to the system, vunerability and depending on its adaptive capacity (Alteri et al. 2015). Adaptive capacity consists of two dimensions: recovery from shocks and response to change. If the system experiences a shock and it fails to recover, it shows that it is vulnerable but if it can moderate the risk it shows that it is able to respond to change and thus it is resilient (figure 3) (Gitz and Meybeck, 2012; FAO, 2017).

Resilience on the contrary is defined as the ability of a system to absorb the shock, maintain its function during the shock or ability to return to its functional state prior to the shock (IPCC, 2012). According to (Gitz and Meyback, 2012), resilience goes further than shock absorption or return to previous state but rather about adapting and learning to cope with changes and uncertainties. To achieve this, systems, including agriculture, will need a certain degree of capacities, such as: absorptive capacity, which is the ability to cope with and absorb effects of shocks and stress; adaptive capacity – ability of systems including the components of a system to adjust and adapt to shocks and stresses while functioning in accordance with the objective of the system, and transformative capacity which is the ability to drastically change in order to assume the new function.

Through this lens, resilience is understood to constitute adaptation to climate change, in that the more adaptive the system is, the more resilient it is (or vice and versa). Climate change adaptation is the adjustment of processes, practices and structures to moderate potential risks from climate change (IPCC, 2014). Within agricultural systems, adaptation implies adjusting biophysical (ecological) and socioeconomic (including institutional) processes in attempt to respond and or prepare for the impacts of expected climate change and variability (FAO, 2017).

According to Altieri et al. (2015), vulnerability of agricultural systems could be reduced by increasing response capacity (a component of adaptive capacity) which is embedded within the agroecological characteristics of the farm and by adoption of adaptation strategies that can moderate risks. Possible adaptation actions vary and depend on the context. In the context of resource constraint farmers such as in Africa, integrated–agricultural systems could be crucial for adaptation (Gil et al.2017). These are inclusive of diversified systems, mixed systems, agroforestry and collectively regarded as agroecological. In most cases, these systems have been found to be more resilient than those that are specialized with a single produce. In Kenya, Indiso et al. (2017) found cowpea-maize intercropping to result with higher soil moisture content than single maize and in Mexico, the use of agroforestry in the coffee production was able to maintain high levels of soil moisture compared to a single crop (Lin 2007). In both cases, the use of these integrated systems resulted with higher yields. Furthermore, in a survey conducted after Hurricane Mitch in Central America, it was found that farmers who were practicing diversification experienced less damage and economic loss in their farms than their specialized neighbouring farms (Holt-Gimenez, 2002).

The value of integrated and diversified agricultural activities within the farming systems, in particular also Agroecology and diversity in reducing vulnerability against climate variability and extreme weather events is also recognized in the IPCC special report on land (IPCC, 2019). According to this report, diversification of different aspects of food systems is a crucial element for enhancing performance and efficiency that could manifest into increased resilience, reduced risks and maintained stability of food production in the wake of shocks and stresses. Since agroecology promotes diversification, synergistic relationship between farm components and links all elements of food systems, Miles et al. (2018) suggested that adoption of agroecological approaches could be an entry point for enhancing resilience for future climatic shocks while at same time providing a buffer against current shocks such as droughts and floods.

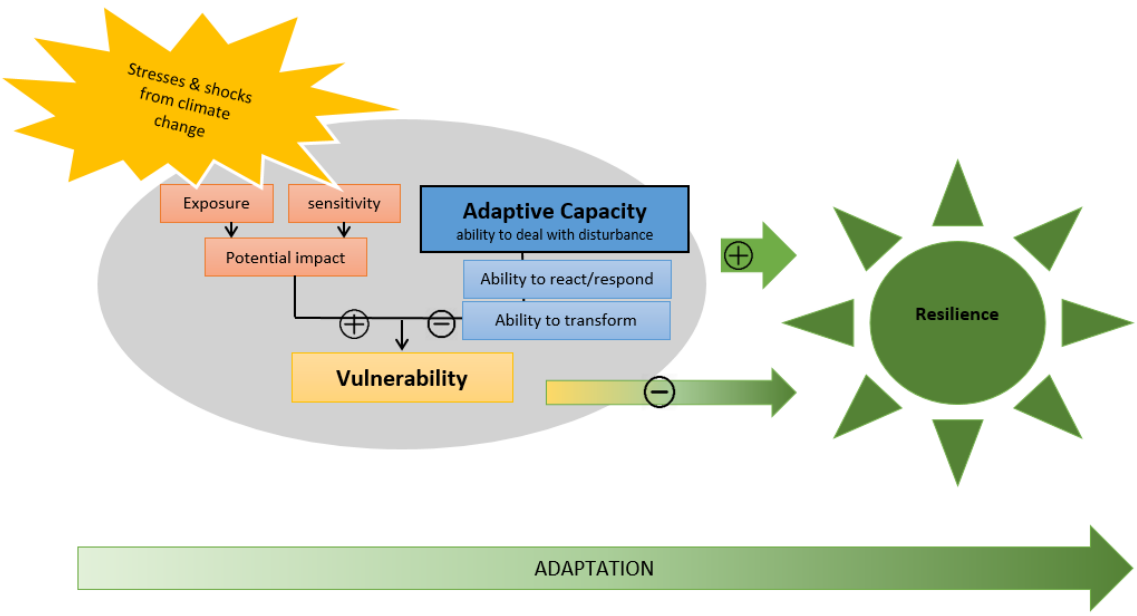


Figure 3: Resilience framework depicting a generic adaptation process and how the elements of adaptation interact to achieve resilience (adapted from FAO, 2017, DFID Disaster Resilience Framework (2011), TANGO Livelihoods Framework (2007), DFID Sustainable Livelihoods Framework (1999), Fraser, et al. (2011)).
Building stronger resilience to climate change and resilient livelihoods requires increasing adaptive capacity and reducing vulnerability of agro ecological systems and livelihoods. These components of resilience may at the same time provide mitigation co-benefits.

Measuring Resilience

Resilience is a challenging concept to measure and this is due to its abstract and multifaceted nature (Cumming at al. 2005). The claims that some approaches could better enhance the resilience of a system than others are mostly based on variables like yield. This often happens when assessing the response of a system to risks like drought or floods; that is, one system performed better than the other during such events. However, for agroecosystems that are classified as both ecological and social, assessing their resilience on outputs such as yield is not sufficeient. There needs to be identification of some proxies which are reflective of the intertwined nature of ecological and socio-economic components of agroecosystems. This proxies or indicators should be able to provide an indication of the level of resilience achieved within a system (Cabell and Oelsfe, 2012). General rules and principles related to these proxis could then be identified and would be a guide towards translating such proxies into actions in an attempt to increasing resilience (Carpenter et al. 2001).

According to Cabell and Oelsfe (2012), such rules and principles, can be grouped and divided into different indicators which their presence in an agroecosystem may indicate that the system is resilient and that it possesses the capacity to adapt. These indicators need to be consistent with agroecosystems nature which includes both physico-chemical (ecological), and socio-economic (social and economic) characteristics. The goal for assessing resilience should therefore be to understand the drivers of vulnerability in order to identify some intervention options that can improve climate resilience of agroecosystems.

In this study, in order to assess the resilience and or lack thereof of agroecological systems, we adopt the use of resilience indicators, as suggested by Cabell and Oelsfe (2012). In addition, we used the 10 elements of agroecology (FAO, 2018), as a defining framework for agroecology, which puts more emphasis on the connectedness of social and ecological nature of agroecosystems. We looked at how these different elements (or rather princpiles contained therein) contribute to the resilience of agroecological systems (figure 4). These indicators could be broadly grouped under different capitals of sustainability which are, human, natural, social, financial and physical capital. These are the capitals of the sustainable livelihoods. Thus, with the use of the proposed resilience indicators by Cabell and Oelsfe (2012) and as integrated in the SHARP tool (Self-Evaluation and Holistic Assesment of Climate Resilience of Famers and Pastoralist), we assess which livelihood capitals of the agroecological systems (or agroecology) contribute to building their resilience. This overall conceptualization of the study is illustrated in the figure 4 below.

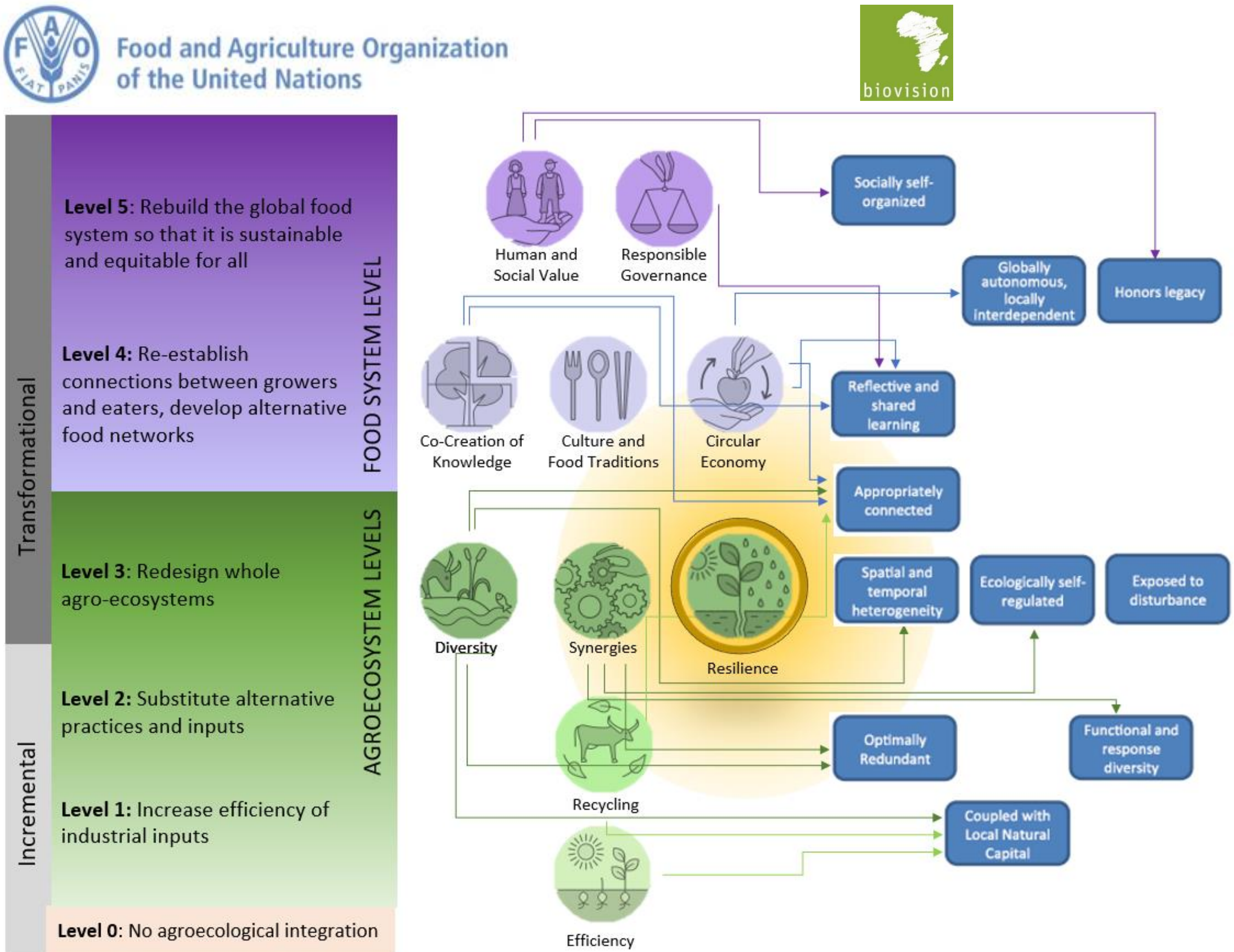


Figure 4: Linking FAO's 10 elements of agroecology & Gliessman's 5 levels of food system transformation (inspired by HLPE report) with the 13 SHARP resilience indicators and the 6 SLF framework dimensions

2 International policy potential

2.1 Approach

In this section, we shortly present how agriculture developed as a topic in the international climate change policy debate and which role agroecology plays in current climate policy. A systematic **literature research** on policy reviews and reports was conducted to line out the historic development (section 2.2.1).

To capture the role of agroecology in international climate change policies, a **mixed methods approach** was applied. In the **quantitative analysis**, the nationally determined contributions (NDCs) of 136 countries (section 2.2.2) and all of the submissions (as well as the official workshop reports) on topics 2(a), 2(b), 2(c), and 2(d) of the Koronivia Joint Work on Agriculture (KJWA, section 2.3) were individually and systematically analysed, from an agroecological perspective. The conceptual framework for this analysis builds on FAO´s ten elements of agroecology (FAO, 2018). In order to determine, whether or not a specific point raised in any one of the submissions can be considered to address one of these ten elements, the indicators of Biovision´s Agroecology Criteria Tool (ACT) were applied (Biovision, n.d.).

These quantitative results are complemented by a **qualitative analysis** of 15 semi-structured interviews led with selected individuals (Annex 7.1) from key positions in governmental, multilateral, civil society, research and farmers' organizations. The objective of the interviews was to gain an in-depth understanding of stakeholders' opinions on and perceptions of the role of agroecology in the international climate change policy debate, particularly within the UNFCCC processes (including the KJWA) from key positions in governmental, multilateral, civil society, research and farmers' organizations. Section 2.3.5 addresses stakeholders' perceptions of the current dynamics and critical points of the debate in the UNFCCC processes in general and specifically regarding the KJWA. The subsequent section (2.4) brings forward opinions regarding the future outlook on the links between agroecology and other sustainable agriculture approaches and climate change.

2.2 Background on agroecology in the UNFCCC climate negotiations

2.2.1 The long road to Koronivia: A brief history of agriculture in the international climate change policy debate

The **intrinsic connection between agriculture and climate change** was already explicitly recognized at the first World Climate Conference in 1979, both in terms of "human activities that affect climate" and in terms of impacts of climate change on agriculture and food security (WMO, 1979). Climate change was "firmly put on the agenda of politicians" (Gupta, 2010) in 1990, following the second World Climate Conference and the establishment of the Intergovernmental Panel on Climate Change (IPCC)[12].

Two years later, **in 1992, the UNFCCC was adopted** in New York during a UN General Assembly and opened for signature at the "Rio Earth Summit". It entered into force in 1994 with a mitigation objective, to "stabilize greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous

[12] Established by the United Nations Environment Programme (UNEP) and the World Meteorological Organization (WMO) in 1998, endorsed by the UN General Assembly the same year.

anthropogenic interference with the climate system" (UN, 1992). The Convention specifies that such a level should be achieved, inter alia, to ensure food production is not threatened[13].

At the early stages of climate change policy discussions, including in the UNFCCC, there was a **marked emphasis on mitigation** (Gupta, 2010). Adaptation and climate resilience of agriculture received little to no attention, but the IPCC response strategies pointed out potential co-benefits (e.g. erosion control, improved water management) of mitigation measures proposed for the agricultural sector (IPCC, 1990). These **proposed mitigation options with potential co-benefits include some practices related to sustainable agriculture and agroecology** such as minimum- or no-till systems, perennial cover crops, reducing nitrogen fertilizer use by applying animal manure, and silvopastoral systems.

The **Kyoto Protocol**, adopted in 1997 and entering into force in 2005, builds on the UNFCCC and does not contain any new long-term objectives or principles. It **specifically mentions sustainable agriculture as a means for mitigation**, yet provides no further details (Gupta, 2010). The Kyoto Protocol defined the Clean Development Mechanism (CDM) – one of the flexibility mechanisms, designed to enable parties to achieve emission reductions most efficiently – in a way that would allow for using climate mitigation funds for the payment for ecosystem services. While improved soil management has a large potential for carbon sequestration and some argued that such payments could provide farmers in developing countries with considerable supplementary income, **soil carbon sequestration was eventually excluded from the international carbon offset markets**. The opposition to its inclusion was partially based on "the argument that soil carbon offsets were a means of putting the mitigation burden on low income developing country farmers and that farmers were unlikely to see any benefit from participating in such markets, but rather could be exposed to losing rights to their land" (Lipper and Zilberman, 2017).

The second decade of the **new Millennium brought an end to the long-standing dichotomy between adaptation and mitigation**, broadened the discussion from agriculture to a more holistic food system approach and led to a proper "climatization of the debate on agriculture"[14]. To a large degree this was due to the **systems perspective** of the 2030 Agenda for Sustainable Development[15] and the Paris Agreement on Climate Change[16], the IPCC's increasing references to food systems in its reports as well as several research initiatives[17] bringing forward "win-win" solutions (**highlighting synergies between adaptation and mitigation**).

Since 2006, the UNFCCC Subsidiary Body for Scientific and Technological Advice (SBSTA) held a number of workshops on issues related to agriculture. **Agriculture was formally incorporated as an agenda item under the SBSTA in 2011**. Between 2013 and 2016, five workshops on issues related to agriculture took place under the SBSTA. Finally, at COP23 in 2017, the two permanent subsidiary bodies (SBs) of the UNFCCC (SBSTA and the SB for Implementation, SBI) were officially requested to jointly address issues related to agriculture[18]. This collaborative process, the **Koronivia Joint Work on Agriculture (KJWA)**, was to include workshops and expert meetings, working with constituted bodies under the Convention and take into consideration the vulnerabilities of agriculture to climate change and approaches to addressing food security. The **decision to establish the KJWA was hailed as a breakthrough**, being the "first substantive outcome and COP decision in the history of the agenda item on agriculture" and giving unprecedented priority to the objective to "develop and implement new strategies for adaptation and mitigation within the agriculture sector"(St-Louis et al., 2018). The establishment of the KJWA was fruit

[13] As stipulated in UNFCCC, art. 2: https://unfccc.int/resource/docs/convkp/conveng.pdf

[14] stakeholder interviews for this report (see Annex 7.1)

[15] adopted at the UN Sustainable Development Summit in New York in September 2015.

[16] adopted at COP 21 in December 2015

[17] such as the Global Research Alliance on Agricultural Greenhouse Gases (launched in December 2009), debate on Climate Smart Agriculture, "4 per 1000" soils for security and climate initiative, a carbon sequestration initiative (launched by France in December 2015 at the COP 21)

[18] adoption of decision 4/CP.23 on the Koronivia Joint Work on Agriculture

of a long negotiation process, **ending the divide between technical knowledge and implementation** by bringing together the SBI and SBSTA.

2.2.2 Analysis of the degree of integration of agroecology into NDCs

Nationally determined contributions (NDCs) are a core component of the Paris Agreement. In the NDCs, each party is requested to outline and communicate their respective mitigation and adaptation goals. A previous analysis of the) NDCs carried out by FAO (2016) showed that **the agriculture sector features prominently in the NDCs**, with many countries highlighting the role of agriculture, forestry, fisheries and aquaculture in their economic development. Many also point to the vulnerabilities of these sectors to climate change. The agriculture sectors are able to deliver considerable adaptation and mitigation benefits and many NDCs recognize these adaptation-mitigation synergies. The systematic analysis presented here intends to identify the extent to which countries include agroecology and related approaches in their NDCs.

Out of 136 NDCs analysed, **17 countries[19] (12.5 percent) explicitly mention agroecology**. **Of these countries, 13 are from Sub-Saharan Africa**, two from Latin America and the Caribbean, one from the Near East and North Africa and one from Asia Pacific. **The emphasis is clearly on adaptation**, as 15 of these 17 countries, see agroecology as an adaptation strategy and only 6 see it as contributing to mitigation, mostly referring specifically to agroforestry.

African countries mention agroecology mostly in the context of soil, land and water management. For example, the Republic of Burundi (2015) aims to develop an agroecology approach for soil fertility management and soil conservation. The Republic of Rwanda (2015) seeks to employ agroecology for nutrient cycling and water conservation in order to maximize sustainable food production, while Cote d'Ivoire (2015) intends to use agroecology for reforestation and restoration of degraded lands.

In addition to the 17 countries explicitly mentioning agroecology, many countries refer to some of the elements of agroecology. **The elements of agroecology highlighted most prominently are related to production aspects** (diversity, efficiency, recycling, resilience and synergies); **elements referring to the socio-economic and political dimension of agroecology** (circular and solidarity economy, co-creation and sharing of knowledge, culture and food tradition, human and social values and responsible governance) **are largely neglected** (fig. 5).

Out of the 136 NDCs analysed, only four countries refer to the co-creation of knowledge, five countries to culture and food tradition and only two countries refer to human and social values. **Countries referring to these socio-economic and political elements are mainly from Latin America and the Caribbean**. For instance, the Republic of Venezuela (2015) aims to mainstream agroecology into school and university curricula from pre-school to diploma level. The Republic of Honduras (2015) aims at promoting the establishment of regional research centres and national outreach programs and development of sustainable systems based on agroecology. Latin American countries, including Guatemala and Bolivia, also stand out for acknowledging the importance of and revitalizing indigenous and ancestral knowledge.

[19] Burundi, Comoros, Ethiopia, Rwanda, Seychelles, Tunisia, Gambia, Togo, Côte d'Ivoire, Nigeria, Central African Republic, Chad, Democratic Republic of Congo, Honduras, Venezuela, Afghanistan.

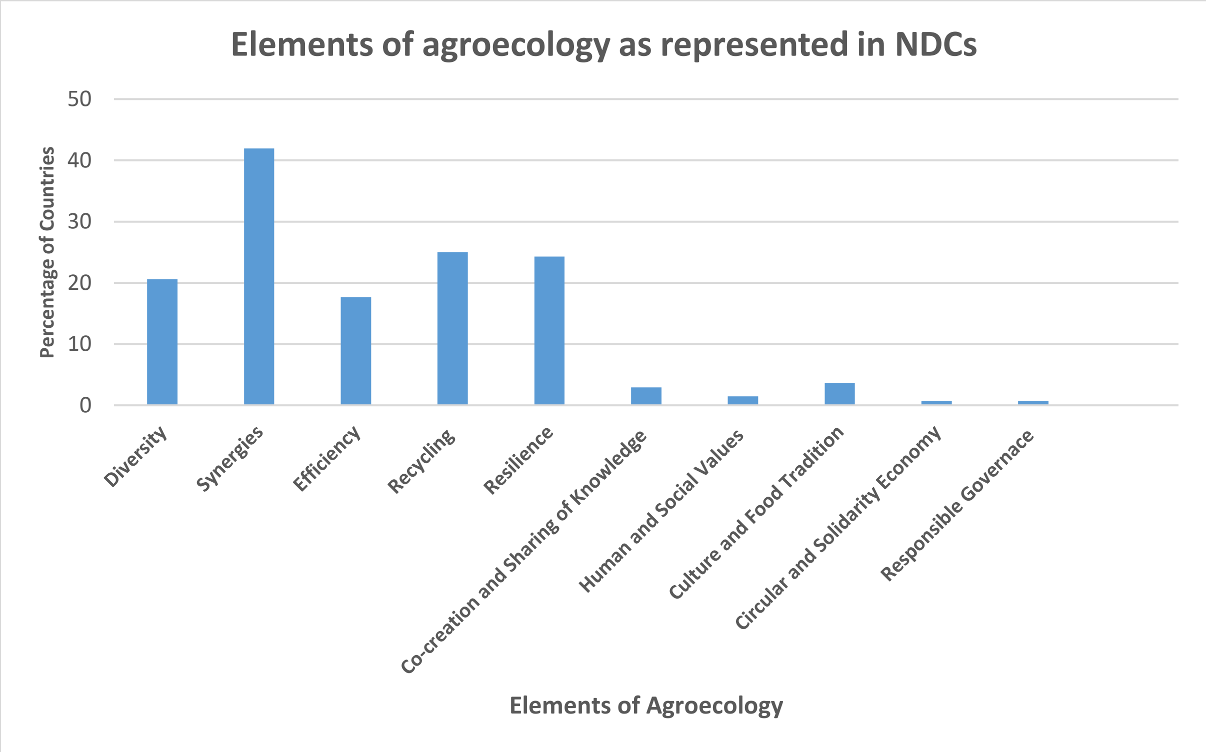


Figure 5: The degree to which countries highlighted different elements of agroecology as options contributing to both adaptation and mitigation in their NDCs. The majority of countries see agroecology mostly as an adaptation strategy. Mitigation is seen mostly through synergies with the use of agroforestry and efficiency in terms of reduced use of fertilizers.

The degree to which the elements of agroecology are reflected in countries NDCs differ by regions (fig. 6). Synergies are very frequently referred to by countries in Sub-Saharan Africa (in 60 percent of the NDCs) and Latin America (41 percent). The same regions also emphasize resilience. In NDCs from the Asia Pacific region, on the other hand, efficiency and recycling figure prominently. In the NDCs from Near East and North Africa region, none of the elements of agroecology play an outstanding role.

Under synergy, which is the most frequently identified agroecology element, the majority of the countries refer to agroforestry, silvopastoral and mixed crop-livestock systems. In regard to diversity, most countries are aiming to employ different crop varieties and livestock breeds with more emphasis on traditional crops and livestock, which are considered more stress tolerant and adapted to local conditions. For efficiency, most countries aim at reducing the use of industrial (synthetic) fertilizers by adopting organic fertilizers and promoting integrated pest management. Recycling is mentioned mostly in reference to composting and crop residue reuse for soil cover and soil organic matter improvement. All of the countries in the Near East and North Africa including the recycling element refer to wastewater reuse in agriculture. Resilience is seen mostly through a diversification perspective; i.e. diversifying agricultural activities as a contribution to enhancing farmers' resilience. In addition to diversification, many countries envision the use of agricultural insurance and establishment of micro-credit financing to increase the resilience of producers.

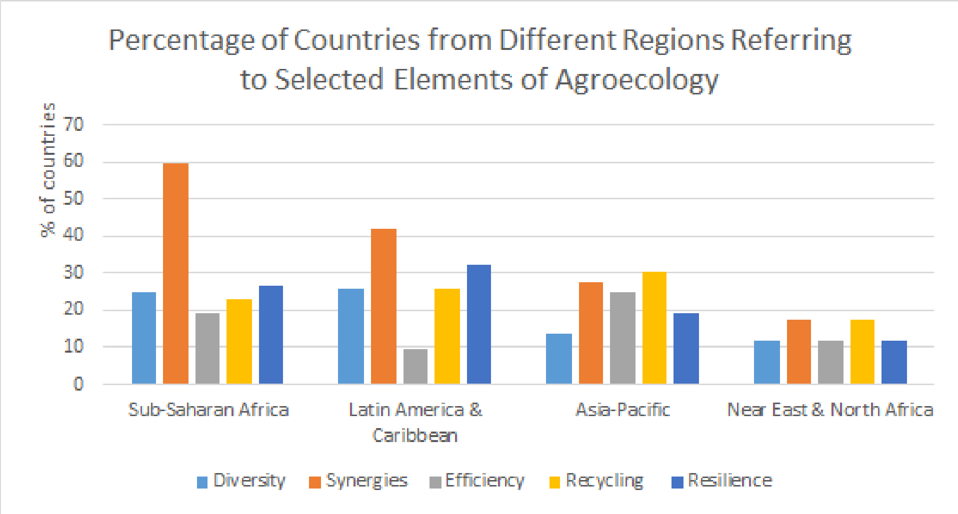


Figure 6: Percentage of countries by regions, referring to different elements of agroecology in their NDCs.

2.3 Current dynamics in the Koronivia negotiations: opportunities and challenges for agroecology to be supported by outcomes and mechanisms of the UNFCCC

2.3.1 The Koronivia Joint Work on Agriculture (KJWA) process and initial submissions of parties and observers

In 2017, at COP23 in Bonn, the international community adopted a decision to have a work stream on agriculture through a three-year Koronivia Joint Work on Agriculture (KJWA). The roadmap of the KJWA foresees in-session workshops on six topics from December 2018 to June 2020 (fig. 7).

Parties as well as observers were invited to submit their views ahead of the adoption of the roadmap in May 2018. FAO provides a detailed analysis of the initial submissions by 21 parties and 27 observers (Chiriacò et al., 2018). Here we first provide a quick overview of this FAO analysis from an agroecology perspective and then review the more recent submissions made under various topics in the KJWA in 2019.

Many of these **initial submissions focussed on the modalities of the KJWA process** and of issues related to assessment, monitoring and evaluation. A number of submissions express the view that the KJWA is, above all, a **great opportunity for sharing knowledge, experiences and best practices**. Thus, a number of submissions include specific showcases, whereas others focus on needs and priorities for advancing on the respective workshop topic.

It is noteworthy that showcases and best practices are mostly included in the submissions of industrialized countries and the West African nation Benin. These "best practices" generally emphasize conventional agriculture, biotechnology and digital solutions but also include some agroecological practices (e.g. cover crops, no-till, recycling of drainage water, rotational grazing). On the other hand, submissions of developing countries (including from the African Group of Negotiators (AGN) the Least Developed Countries (LDC) group, and the African states Benin, Burundi, Kenya and Malawi) usually include a list of priorities and needs to advance on the respective topics. These lists, in a considerable number of cases, make reference to practices or principles related to agroecology. Specific examples include capacity building for women and youth, reduced tillage, cover crops, crop rotation, ecosystem-based grassland management, inclusive property land rights, integrated agro-silvo-zootechnical systems, integrated soil fertility management, optimized management of crop residues, organic fertilizers and organic farming in general, reforestation, restoration of degraded lands, and valorisation of animal waste. Finally, it is important to note that only the LDC group submission highlights the need to integrate traditional knowledge.

Figure 7: Roadmap of the Koronivia Joint Work on Agriculture (KJWA) adopted from Chiriacò et al. (2019b).

Parties and observers to the UNFCCC are invited to submit their views ahead of each of the workshops on the six topics agreed upon in the roadmap of the KJWA.
We present in the following sections, an individual and systematic review of all of the submissions (as well as the official workshop reports) on topics 2(a), 2(b), 2(c), and 2(d) from an agroecological perspective.

2.3.2 Topic 2(a)

Modalities for implementation of the outcomes of the five in-session workshops on issues related to agriculture and other future topics that may arise from this work

As the workshop title suggests, the majority of submissions and discussions focussed on modalities and processes with an emphasis on sharing of knowledge and experiences as well as support for implementation (Chiriacò et al., 2019a; UNFCCC, 2019a). Concrete **practices and technologies received little attention but especially observer submissions called explicitly for systemic and transformational approaches as well as enhanced inclusiveness, equity and participation**.
Agroecology is specifically mentioned only in the submission by the Climate Action Network (CAN). CAN refers to agroecology in three instances, including this statement: “KJWA presentations and discussions should reflect on and direct work towards holistic efforts, including the progressive transition towards agroecology to ensure the long-term viability of agricultural systems within the natural world that they depend upon.” (Climate Action Network International, 2018). Additionally, several submissions mention sustainable agriculture and the need for approaches to adaptation that create co-benefits for sustainable development. Further, **individual elements of agroecology are mentioned in 53%** (9 out of 17) **party submissions and in 54%** (7 out of 13**) observer submissions** (fig. 8). The submission of Vietnam is the most concrete, pointing out good experiences with integrated crop-livestock-aquaculture systems, referring to this as climate smart agriculture (CSA).

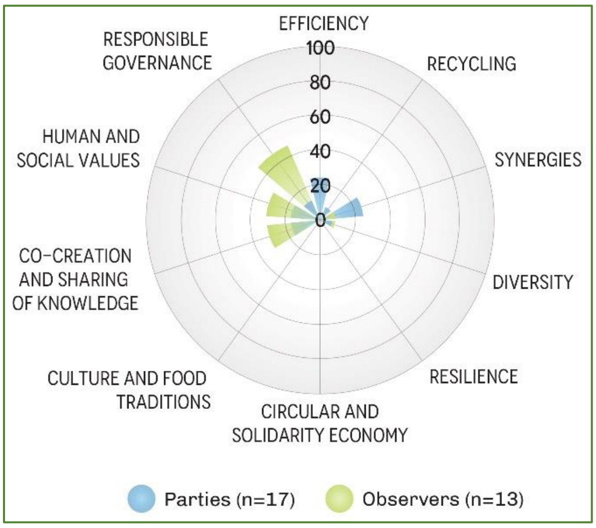


Figure 8: Percentage of party (n=17) and observer (n=13) submissions to the KJWA workshop on topic 2(a) at SB49 making specific reference to any of the 10 elements of agroecology.

2.3.3 Topics 2(b) and (c)

2(b) Methods and approaches for assessing adaptation, adaptation co-benefits and resilience and 2(c): Improved soil carbon, soil health and soil fertility under grassland and cropland as well as integrated systems, including water management

As both topics were addressed at the same session (SB50) and there was a single call for submissions on both topics, a number of submissions do not clearly separate the two topics and are therefore discussed jointly here as well. **Elements of agroecology figure quite prominently in many submissions** to SB50 (fig. 9; see also Chiriacò et al, 2019b). Submissions specifically on topic 2(b) often include references to socio-political aspects of agroecology (e.g. co-creation and sharing of knowledge, human and social values and responsible governance). Views on topic 2(c) often highlight the adaptation and mitigation co-benefit potential of agroecological farm- to landscape level approaches corresponding to the elements efficiency, diversity, recycling, resilience and synergies. Culture and food traditions as well as circular and solidarity economy are the only two elements rarely addressed in party as well as observer submissions, both being mentioned in just a single observer submission each.

While **agroecology is rarely mentioned specifically in party submissions**, some contain **various references to agroecological practices** (e.g. Brazil, Indonesia, Kenya, Uruguay, Vietnam). However, **usually these are mentioned as singular approaches** (especially agroforestry, cover crops, crop rotation, organic fertilizers and reduced tillage) **and not as part of a systemic transformation of production systems**. Two out of 17 party submissions (**Kenya and EU) refer to agroecology by name**. While Kenya describes it as a climate smart agriculture (CSA) measure, the EU mentions agroecology as a transformational approach as well as an example of “sustainable land/soil management practices” (European Union, 2019).

Agroecology is mentioned explicitly in 22% of observer submissions (5 out of 23) on topics 2(b) and (c) (Biovision & FiBL, Climate Action Network, GenderCC, GIZ, YOUNGO). In all of these, agroecology plays a rather **central role and is decisively endorsed**. Additionally, nearly all other observer submissions (all but the World Business Council for Sustainable Development) include at least one element of agroecology, without mentioning it by name.

The **enhanced interest in agroecology and other transformative approaches is also demonstrated by the workshop reports drafted by the UNFCCC secretariat**. The report on topic 2(b) states that “it is generally accepted that successful adaptation to climate change requires transformation and paradigm shifts" and specifically mentions agroecology two times (UNFCCC, 2019b). The report on topic 2(c) even refers eight times explicitly to agroecology, including thrice in the section "Summary of discussions and the way forward" (UNFCCC, 2019c).

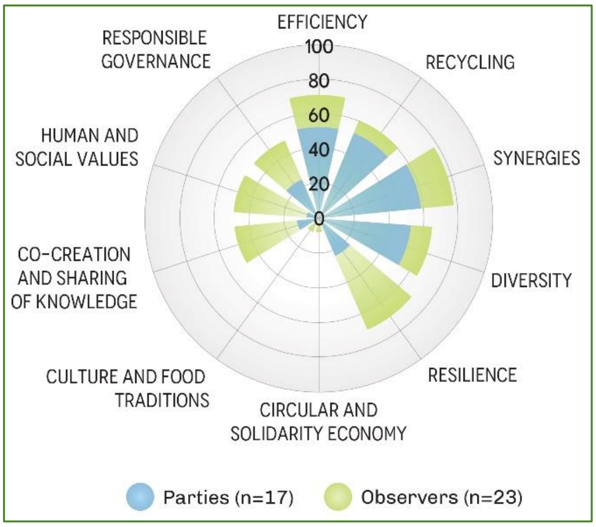


Figure 9: Percentage of party (n=17) and observer (n=23) submissions to the KJWA workshops on topics 2(b) and (c) at SB50 making specific reference to any of the 10 elements of agroecology.

2.3.4 Topic 2(d)

Improved nutrient use and manure management towards sustainable and resilient agricultural systems

As of 15 November 2019, six parties and ten observers submitted their views on topic 2(d). A number of submissions point out **clear thematic overlaps with topic 2(c)**. However, in contrast to the discussion on soil health, **the emphasis in most submissions on topic 2(d) is limited to the agroecology elements efficiency** (increasing efficiency of fertilizer use, especially through precision farming) and **recycling** (substituting synthetic with organic fertilizers, especially manure). Additionally, three parties and three observers see **nutrient management as an entry point for integrated crop-livestock systems and harnessing the resulting synergies**. In this regard, the **EU specifically mentions agroecology**. Apart from this, **most party submissions include rather few references to systemic approaches for nutrient management**. Brazil and the EU are partial exceptions, highlighting the multiple benefits of cover-crops, crop rotation, green manure, intercropping, recycling of organic waste material and reduced tillage for enhancing the resilience and sustainability of the agricultural sector. On the other hand, several parties argue for increasingly integrating discussions on different KJWA topics as well as enhancing synergies with other discussions within and outside of UNFCCC. Further, a number of submissions highlight the need for stronger multi-stakeholder processes, especially the involvement of scientists and farmers. This notwithstanding, **the focus is on the technological components of agroecology and the socio-economic dimensions are mostly neglected** (fig. 10). Again, a partial exception is the EU submission, which includes a specific sub-section on circular economy.

All observer submissions point to the link between soil nutrient management and the agroecology element diversity and synergy (especially crop rotation, intercropping and functional biodiversity). It is noteworthy that actors such as **FAO and the Farmers Constituency highlight the "need for a holistic approach for nutrient use and manure management"**. **FAO also specifically promotes agroecology** and "offers support to countries seeking to undertake transformative changes in agricultural sectors in the face of climate change" (FAO, 2019b). Further, agroecology is specifically endorsed by the Climate Action Network (CAN), IFOAM, Biovision and FiBL, Brighter Green as well as CropLife International, although the respective organizations' definitions of the term differ to a considerable degree. While the former **NGOs highlight the holistic and transformative characteristics of agroecology**, CropLife International reduces the concept to the technological elements and argues for agroecology's compatibility with biotechnology.

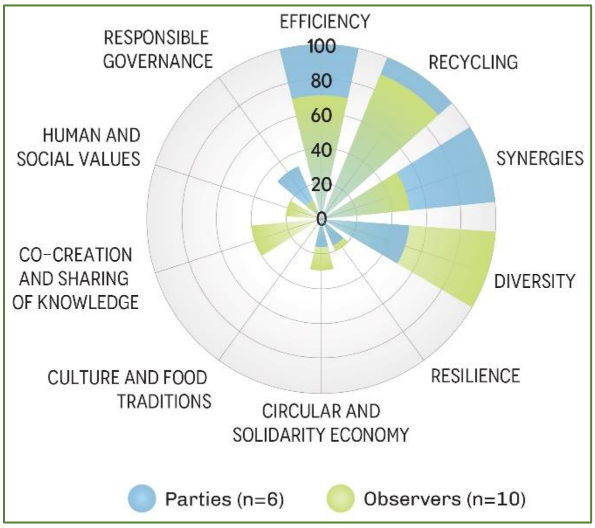


Figure 10: Percentage of party (n=6) and observer (n=10) submissions to the KJWA workshop on topic 2(d) at SB51 making specific reference to any of the 10 elements of agroecology.

2.3.5 Opinions of key stakeholders on the current discussion on the agriculture and climate change nexus in the UNFCCC processes, including the KJWA

All interview partners agree, that the discussion on the agriculture-climate change nexus was delayed for too long and that, even now, discussions at the UNFCCC processes are not yet about which agricultural model to promote. Thus, **neither conventional agriculture nor agroecology or other transformative approaches are emphasized**. The current debate seems to be really on the general modalities of implementation (rather on the "who" and "how": responsibilities and financing) and usually do not go sufficiently in depth and detail regarding concrete approaches (the "what": appropriate technologies). Several interviewees feel that **"discussions in the UNFCCC often remain vague and not precise"**.

Nevertheless, many interviewees perceive that **transformational approaches are becoming increasingly important** for both parties and observers, "at least in the wording although the reality usually remains at essentially a business as usual model". Hence, it seems that ***de facto* most parties still aim for incremental change within conventional agricultural systems**. Interviewees often explained this by the fact that countries strive to protect their own interests and to have a competitive edge on the global market. The majority of interviewees agree that a number of **observers are a lot more demanding regarding the promotion of transformative approaches**, such as agroecology.

A number of interviewees highlight that **agroecology is "clearly gaining momentum"**, although it still **remains a controversial topic**. As a representative of FAO phrases it: agroecology is a "difficult agenda to move forward, with big powerful countries with dominant industrial agricultural systems" opposed to it in principal. Further, a negotiator reflected: "Agroecology is increasingly being mentioned but technological details etc. do not receive sufficient attention and detailed explanations are mostly lacking". Generally, several interviewees mentioned they were **missing a stronger science-policy interface in the KJWA workshops** and feel that capacity-building and awareness raising is often missing for negotiators to be sufficiently equipped to tackle the different topics discussed.

Finally, different interviewees expressed **confusion or even frustration regarding the myriad of concepts and approaches without clear distinction** (e.g. agroecology, climate smart agriculture, conservation agriculture, ecosystem-based adaptation, nature-based solutions, and sustainable land management). Some see it as the mandate of UN institutions, such as FAO, to clarify, show evidence, and showcase different options, thus providing a global framework. On the other hand, speaking from a farmer perspective, an interviewee flags that **"it's not about black or white but rather the diversity of options"** and "the core of the debate should focus on one factor these concepts should all have in common: profitability and the need for improving farmers' wellbeing".

2.4 Outlook: Future potential of agroecology to be backed through UNFCCC or other international processes

"Koronivia gave soul to agriculture in the climate change discussions'', and interviewees all agree that as the only active agenda point focusing solely on agriculture, "the process itself is extremely valuable and important". Yet some regret that "**discussions do not lead to any concrete decisions or actions**". An interviewee highlights that the Koronivia process is currently missing the grasp of transformational change of the agricultural system as it limits itself to food security, not embracing the entire food system. There is a lot of hope for post-COP 25, as this is seen as "a big turning point for KJWA", the "test phase for the KJWA to show it is useful" and make it a "trigger of change".

There are diverging views on the question whether agroecology has a chance to be promoted in the KJWA outcomes. Some (especially negotiators and researchers) feel it as "quite possible". They highlight the numerous interventions on agroecology during workshops and in submissions from the Global North and South (regarding soil related issues for example, as shown in section 2.3.3) as well as the inclusion of agroecology in the IPCC special report on land. **Even though they may not be promoted by name, some interviewees are sure that agroecological practices and principles will play an important role in any conclusions and outcomes**.

A majority, however, express more doubts and see it as "unlikely" for different reasons. A negotiator highlights that **agroecology is "still perceived as being too idealistic and dogmatic and most actors are obliged to balance the opinions and demands of different interest groups**". A researcher mentions not expecting "such a level of detail on technologies and approaches but rather outcomes on modalities and processes", an NGO representative mentions that "agroecology as a solution or system is not very prominent in the debates". Key barriers for an enhanced integration of agroecology in the international climate change policy debates are described in Text box 1.

Nevertheless, it is important to note that many interviewees from different backgrounds insist on the "strong need for the engagement of people advocating on agroecology in this debate". Many highlight that "any effort to have this on the agenda in the discussion is important". Also, some mention that discussions on agroecology will shape and influence agricultural development activities of member states, through the promotion of country experiences and best practices. Examples of what worked in countries being the most convincing argument.

Text box 1: Key issues hindering the scaling-up of agroecology in the climate change discussions

- The wording often being very political
- The absence of a common understanding, the lack of sensibilization, visibility and communication on agroecology, in particular to some key stakeholders (i.e. key investors and donors are currently missing in the climate discussions)
- Doubts prevail regarding scientific evidence for agroecology, highlighting the importance of discussing technological details during side-events
- The difficulty in having a proper spokesperson for agroecology in the climate discussions, due to strong resistance by some influential stakeholders

- There is still a lot of reluctance to consider the entire food system in its globality
- The absence of international trade from the debate on climate change and agriculture (only addressing "non-market approaches") and the dogma to not question the current role and form of trade
- The lack of a common understanding of the boundaries between the multiplicity of different concepts (agroecology, climate smart agriculture, conservation agriculture, ecosystem-based adaptation, nature-based solutions etc.)
- The focus on farm-level carbon and methane emissions in the climate change discussions, when a key entry-point for agroecology is land-use at a territorial scale.

All interviewees agree that the UNFCCC framework (including KJWA) is one of the right places to push for a more sustainable food system, including to scale up agroecology, but not the only one. It is key to seize the opportunity of the climate change momentum to open discussions on the transformation of the agricultural model to achieve improved environmental performance and to bring back complexity within agricultural systems. But, "climate alone is not enough, or else it will not be truly transformational". It is also key to focus on other related issues, and therefore other arenas and fora as well, such as biodiversity and food security. This highlights the issue of the compartmentalization of the different topics and the need to build bridges between different existing conventions and fora (e.g. UNFCCC, Committee on World Food Security (CFS), Convention on Biological Diversity (CBD), Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES)).

Currently, there is a lot of hope for the scaling-up of agroecology. This promising turning point is partially enabled by the IPCC special report on land, advocating for a transformation of the food system. This report provides a clear understanding of the convergence of different options, highlighting their co-benefits. It particularly focuses on solutions concerning soils and forests, for which agroecology integrates many of the solutions and tackles many of the challenges exposed. The IPCC special report on land "clearly promotes agroecological practices, and shows how it can contribute on enhancing farmer's resilience. Many interviewees highlight that this report is a very positive basis for scaling-up agroecology within the climate change discussions, as these reports have an outstanding weight in the climate change debates.

A combination of other elements brought forward by the interviewees show a promising road towards the scaling-up of agroecology. For instance, the accelerating **convergence between scientific evidence and civil society mobilization** was mentioned as key to making change happen. Further, it was pointed out that there is an increasing **convergence between the three "Rio Conventions"** (CBD, United Nations Convention to Combat Desertification (UNCCD) and UNFCCC) **creating momentum for integrative and systemic approaches**. Finally, there is a **growing emphasis on nature-based solutions** as highlighted in the IPCC land report, the UNCCD-SPI report on carbon benefits of SLM (Chotte et al., 2019) and the global assessment report of IPBES (IPBES, 2019).

2.5 Conclusions on the potential to integrate agroecology in international climate change policies

Only recently the link between agriculture and climate change began to be properly articulated on the international policy level and **finally the dichotomy between climate change mitigation and adaptation seems to have been largely overcome**. The establishment of the KJWA was a breakthrough as it brought unprecedented emphasis on the climate change – agriculture nexus and the **potential of agriculture to contribute to both mitigation and adaptation simultaneously**.

A detailed analysis of 136 NDCs and all submissions to the first four KJWA workshops demonstrate that a considerable number of **countries and stakeholders from different backgrounds see agroecology and related approaches as a promising means for reaching adaptation and mitigation targets** and at the same time increase the resilience of the food systems. Individual elements of agroecology, **particularly in regard to soil health and natural resource cycles**, are perceived as auspicious approaches. The systemic nature of agroecology and especially its **socio-economic and political elements receive far less attention**. Submissions by observers to the UNFCCC, especially those of some civil society organizations (**CSOs), are much more demanding and call for fundamental transformation of the food system**. That, such a transformation is necessary, is also acknowledged by the UNFCCC secretariat, stating that "it is generally accepted that successful adaptation to climate change requires transformation and paradigm shifts" and by the European Union (EU) referring to agroecology as a transformational approach as well as an example of "sustainable land/soil management practices". Also, recent reports by the IPCC, the UNCCD-SPI and the IPBES indicate an increasing convergence of the three "Rio Conventions" and demonstrate a shared focus on transformative approaches as well as nature-based solutions.
Based on these findings, it is not surprising that many of our high-level interview partners from diverse institutions highlighted that **agroecology is gaining momentum**. However, given the complex political economy underlying decision-making under the UNFCCC and the still contentious nature of agroecology, **few believe that agroecology will be specifically promoted in an official outcome of the KJWA**. Many believe rather that it is likely **that individual elements or practices of agroecology will be promoted under a different umbrella term**, such as ecosystem-based adaptation, climate smart agriculture or nature-based solutions**. It is key to prevent the risk that an official outcome on agroecology gets stripped of its social, economic and political dimensions and hence of its core holistic, systemic and transformative nature, which is fundamental for its potential to build resilience to climate change**.

3 Meta-Analysis: Evidence on the potential of agroecology to adapt and increase resilience to climate change

3.1 Introduction

In this section, we investigate how robust the knowledge base for the various claims on agroecology as a strategy for climate change adaptation and mitigation co-benefits is. As laid out in the previous chapters, agroecology is increasingly perceived as a promising approach to address climate change. However, the knowledge base for such claims is not always clear and the debate is often dominated by ideological and value-based rather than scientific arguments. While a huge number of case-studies and summarising reports illustrates the potential of agroecology for increased sustainability and climate change adaptation in particular (Côte, Poirier-Magona et al., 2019; Sinclair et. al., 2019, IIASTD 2009), the overall evidence-base lacks systematic scientific syntheses of the key indicators for agroecology as a comprehensive approach. This contrasts with the situation of organic agriculture, for example, where a number of recent meta-analyses on yields, financial performance, soil organic carbon and other environmental aspects is available (Gattinger, Muller et al. 2012; Crowder and Reganold 2015; Seufert and Ramankutty 2017; Sanders and Hess 2019; Seufert 2019). Such robust scientific evidence-base is however central for triggering any significant policy support for agroecology and farmer adoption, when stronger calls are voiced that agricultural policies should become more evidence- and results-based. This chapter aims at closing this knowledge gap on the performance of agroecology with regard to climate change adaptation by compiling and analyzing the scientific evidence from this rich body of existing knowledge on agroecology.

3.2 Methodology

To synthesise this evidence, the analysis draws on two types of results.

First, there is a considerable number of case studies that assess the climate change adaptation potential of production systems, which are judged agroecological by the authors. An extensive literature search on those in English, Spanisch, French, Protuguese and Italian was undertaken, and only the studies that a) were peer-reviewed, b) contained information on an agroecological system in comparison to some baseline system, and c) provided quantitative evidence for the relative performance regarding at least one indicator for climate change adaptation and resilience (Chapter 0) were retained. These studies are referred to as **"Single system comparison studies".**

Second, there is a huge number of case studies that analyze how agricultural production systems, practices and characteristics that strongly relate to agroecology or some of its key elements (but without referring explicitly to this term) correlate with indicators of climate change adaptation and resilience. Examples are comparisons of organic versus conventional production systems with respect to yield stability, comparisons of different levels of species richness in agro-ecosystems with respect to total biomass production, comparisons of systems with organic fertilizers to such with mineral fertilizers with respect to soil fertility, or comparisons of how systems with a special focus on soil fertility perform in the face of extreme events if compared to conventional systems. This second type of case studies have repeatedly been synthesized in a number of meta-analyses and reviews on various topics. The search was thus not targeted at these underlying case studies specifically, but directly draw on the results from the corresponding meta-analyses and reviews. By this, the analysis also covers the knowledge based on case studies that do not explicitly refer to agroecology but to some of its key components as captured in the 10 elements of agroecology (FAO 2018) (for full description of the terms, see Annex 7.2.1).

This analysis employs the notion of agroecology used by the UN Food and Agriculture Organization (FAO), structuring it along the ten elements embracing agronomic, environmental, social, economic and institutional dimensions (FAO 2018) (see Chapter 0 and Figure 2). For the analysis of the performance regarding climate change adaptation, the analysis refers to the indicator framework implemented in the SHARP climate resilience assessment tool (Cabell and Oelofse 2012; FAO 2015) and the ten performance indicators proposed by the global analytical framework for the multi-dimensional assessment of agroecology (FAO 2019).

It is key to highlight that this approach may result in two types of bias. First, the review on the single case-studies does not cover any study that is not self-declared agroecological. The studies without reference to agroeocology are however covered in the meta-analyses and reviewes included, and this bias in the choice of the case studies does thus not result in a bias in the knowledge base covered. Second, the meta-analyses and reviews may cover some of the single agroecological case-studies as well. However, given the low number of the latter compared to the huge number of studies covered in these meta-analyses and reviews, this potential double-count will neither result in any relevant bias. For the detailed methodology, please see Annex 7.2.

3.3 Results

As explained above, we did an extensive literature search on agroecological case studies in various languages. This resulted in the considerable number of 185 studies of potential interest for our review. It then turned out, however, that only few of these agroecological studies met our restrictive inclusion requirements. We emphasize again, that we have chosen to be rather restrictive and apply high standards to the studies included, with the aim to provide a robust knowledge basis that cannot be criticised from being biased in favour of afroecology. Furthermore, the studies retained covered a vast heterogeneity of cases. It has thus not been possible to do any formal synthesis of those in the form of a statistical mate-analysis. However, on the other hand, we found a considerable number of meta-analyses and reviews on production systems, practices and characteristics that closely relate to agroecology and hence decided to base our analysis primarily on those rather than on the agroecological case studies. In the following, we thus present the results from these reviews first, then addressing the single system comparison studies.

3.3.1 Meta analyses and reviews

We identified 34 quantitative meta-analyses and 19 more descriptive reviews . From the meta-analyses, some clear patterns emerge (Figure 11).

First, key practices and characteristics of agroecological production systems, such as use of organic fertilizers, higher crop diversity, low-input systems, organic farming or agroforestry significantly correlate with good performance regarding a number of soil characteristics and biodiversity aspects (e.g. soil organic carbon content, soil biodiversity, soil microbial biomass and activity, nematode and earthworm abundance, and species richness), which are key central aspects of climate change adaptation (FAO 2015, IPCC 2019) (see also Figure 3)

Second, most of the evidence relates to the performance of organic agriculture, agroforestry and practices related to increased crop diversity and organic fertilizer use. Not much evidence is provided on the performance of societal and social aspects of agroecology regarding indicators related to climate change adaptation. One exception is (Crowder and Reganold 2015) reporting on the profitability of organic agriculture, measured via gross returns, benefit/cost ratio and net present values.

Third, clear results can also be seen on mitigation co-benefits of the key practices and characteristics of agroecological production systems, which consistently report positive significant effects on soil carbon contents.

Fourth, yields often tend to be lower in low-input systems than in the conventional reference systems they are compared to. This is the case for organic agriculture, for example, which is an exemplary production system that in many agronomic aspects shows close similarities to agroecology, and for which more scientific evidence is available due to its clear definition. For organic agriculture, also yield stability is lower than in the conventional baseline. This can be traced back to overall lower nitrogen fertilization levels in organic than in conventional agriculture. Comparing studies with similar fertilization levels only, yield stability does not any longer differ significantly, while yields are still lower in organic production (albeit less so than with common conventional average, i.e. higher, fertilization levels) (Knapp and van der Heijden 2018). On the other hand, certain key characteristics of agroecology such as the different diversity aspects (e.g. agrobiodiversity; crop diversity in crop rotations, intercropping, grasslands, etc.; and partly also agroforestry, which is often a system with higher diversity) correlate with higher yields and higher yield stability through time. This may indicate that increased diversity in current organic systems cannot fully compensate for reduced nitrogen supply, as far as yields and yield stability are concerned, and diversity in organic agriculture thus should be further supported. It also indicates where agroecology with its much stronger focus on diversity often differs from organic agriculture.

Columns contain indicators addressed; rows contain systems, practices, characteristics analysed.

Values: percent change with respect to baseline; some studies report different sub-indicators with different values, where we then summarize the results into qualitative values and trends, these are reported by "+" and "-"; values from different studies in the same cell are separated by semicolons ";"

Bold print: significantly different, normal print: not significant

green	better performance than the baseline	(light green: not significant)
yellow	worse performance than the baseline	(light yellow: not significant)
grey	no effect	
red	Practices reported in meta-analyses that may not be deemed agroecological in all cases	
blue	Indicators referring to temporal stability/variability	

	Indicators									
	Soil health									
Systems, practices, characteristics	Soil organic carbon contents	Soil organic carbon sequestration rates	Stability of SOC and C sequestration	Total soil N	Soil aggregate stability	Soil dry room density	Infiltration	soil loss	surface runoff	Soil fertility/ Various beneficial physical soil properties
Organic agriculture	**+**[6]	+[6]	0[33]		15[23]	-4[23]	**137**[23]	-22[23]	-26[23]	
Low-input systems										
Agrof. (incl. silvopast.)*								**-**[24]		**+**[24]
No tillage	**5**[1]									**+**[12]
Reduced tillage	**5**[1]**;+**[34]			**+**[34]		**+**[34]				**+**[12]**;+**[34]
Cover crops	**5**[1]**;8**[30]			**13**[30]						
Biochar	**35**[1]									
Org. fert. (incl. residues)*	**+**[34]			**+**[34]						**+**[12]
Crop rot./diversity/intercr.*	**+**[30]	**+**[32]		**+**[30]						
Grassland diversity										
Biodiversity general										

	Indicators (continued)											
	Soil biodiversity											
Systems, practices, characteristics	soil microbial activity	Soil microbial biomass	Soil microbial functional diversity	Soil biodiversity/ microbial diversity/ richness	Soil bacterial diversity	Soil micro, meso and macro diversity	abundance of soil microbial communities	Arbuscular mycorrhizal fungi diversity	Nematode abundance	Nematode community diversity/ stability	Food web indices	Earthworm abundance and biomass
Organic agriculture	**50**[14]	**45**[14]		2[4]			**60**[14]					**85**[23]
Low-input systems			0[4]		5[4]	-5[4]		15[4]	**+**[13]			
Agrof. (incl. silvopast.)*	**+**[20]											
No tillage												
Reduced tillage	**+**[34]	**+**[34]								**+**[29]	**+**[29]	
Cover crops		**+**[30]										
Biochar												
Org. fert. (incl. residues)*			10[4]		**7**[4]	10[4]			**+**[13]	0[29]	0[29]	
Crop rot./diversity/intercr.*		**25**[30]		**3**[25]**; 15**[25]								
Grassland diversity												
Biodiversity general												

	Indicators (continued)							
	General biodiversity				**Plant protection**			
Systems, practices, characteristics	Species richness	Species abundance/diversity	arthropod diversity/ richness	Stability of species richness/ abundance	Natural plant protection	Level of biological control	Animal pest abundance	Weed abundance
Organic agriculture	**+**[22]**; 30**[27]	**+**[27]	**+**[28]	**+**[33]		+[15]	-[15]	**+**[15]
Low-input systems	**9**[2]; +[13]							
Agrof. (incl. silvopast.)*	**50**[20]**; +**[24]	**50**[20]						
No tillage								
Reduced tillage								
Cover crops								
Biochar								
Org. fert. (incl. residues)*	+[13]							
Crop rot./diversity/intercr.*	**15**[25]				**+**[11]			
Grassland diversity								
Biodiversity general								

	Indicators (continued)											
	Productivity										**Employment**	**Health**
Systems, practices, characteristics	Pathogen abundance	Total biomass production	Stability in total production	Yield		Yield stability	Resource use efficiency	Ecosystem services stability	Profitability	Stability of costs and profits	Rural employment	Exposure to pesticides
Organic agriculture	**-**[15]			**-20**[21]		**-15**[9]	0[23]		**+**[26]	0[33]	**+**[22]	**-**[22]
Low-input systems				**-20**[2]								
Agrof. (incl. silvopast.)*		**+**[20]										
No tillage				**-7**[16]		-3[9]						
Reduced tillage		-[34]		+[34]								
Cover crops												
Biochar												
Org. fert. (incl. residues)*		**-**[34]		+[16]	**-**[34]							
Crop rot./diversity/intercr.*			**+**[19]	+[10]; -[11]; +[16];	**2.2**[18]**; 10**[31]	**+**[17]**; +**[18]						
Grassland diversity				**50**[8]								
Biodiversity general				**+**[3]**; +**[5]			**+**[3]	**+**[3]				

*: Agrof. (incl. silvopast.): agrocorestry (incl. silvopastoral); Org. fert. (incl. residues): organic fertilzers (incl. residues left on field);
Crop rot./diversity/intercr.: Crop rotations/crop diversity/intercropping

References with notes:

blue references: indicate studies on general ecosystems (or grasslands without grazing/mowing: Isbell et al), not focusing on agricultural production systems

Code	Reference	Notes
1	Bai et al. 2019	Values displayed are averaged over a number of more differentiated analyses, e.g. for soil type, climatic zone, duration of the experiment, etc.
2	Beckmann et al. 2019	Addresses effects of intensification, we framed it the other way round to capture the agroecologicla aspect of extensification; differentiates results between intensity levels: at low intensities, intensity increases did not affect species richness and yields; at high intensities, it increased yields but did not affect species richness, at intermediate levels, positive impacts on yields and negative on species richness were largest.
3	Cardinale et al. 2012	Refers to ecosystems and not to agricultural production systems
4	De Graaff et al. 2019	Refers to increase of soil bacterial and fungal diversity with N fertilization. Applications of less than 150kgN/ha lead to an increase in bacterial diversity, of more than 150kgN/ha lead to an insignificant decrease; mineral N does not lead to an increase, while organic N does. N fertilization leads to a decrease in arbuscular mycorrhizal fungi diversity of about 10%, but applications of less than 150kgN/ha lead to an insignificant reduction of 5% only, while applications higher than 150kgN/ha lead to a significant decrease of 20%.
5	Duffy et al. 2015	Refers to ecosystems and not to agricultural production systems
6	Gattinger et al. 2012	Reports absolute changes with respect to the baseline, not relative to the baseline values; reports data from net zero input systems only, as only those reflect the nutrient recycling paradigm of agroecology
7	Garcia-Palacios et al. 2018	Now additional data added - for their meta-analyses, they use largely the same data as Gattinger et al. 2012 (with some additional data, without changing anything significantly)
8	Isbell et al. 2015	Refers to grasslands without cattle, etc. and thus not to agricultural production systems in a more narrower sense; The 50% increase in stability are derived from the following numbers: productivity losses in ecosystems due to climate extremes are 50% in systems with few species, while they are only 25% with many species
9	Knapp and Van der Hejden 2018	
10	Lesk et al. 2015	We report a weak signal only, derived from their statement that the lower yield impacts of extreme events in developing countries may be due to the more diverse production systems
11	Letourneau et al. 2011	Q23 is significant (difficult to display above); Natural plant protection covers reduced pest abundance and damages and increased natural enemy numbers; crop-diversification covers various intercropping schemes and more detailed results are displayed in the paper
12	Li et al. 2019	Reports on a number of physical soil properties such as bulk density, water stable aggregate, soil available water capacity, etc. - we display them all together with the significantly positive signal reported only. "Organic fertilizers" mean here the retention of crop residues in no- and reduced-tillage systems
13	Liu et al. 2016	The entry on species richness is not significant; Species refer to nematodes, results are differentiated according to different types of nematodes and organic fertilizers, C-rich (straw, etc.) are more beneficial to nematodes than slurry, etc.; species richness generally decreaes with N fertilization, with the exception of organic N fertilizers, while nematode numbers increase with all fertilization, but the most with organic ones; from this we also derived the positive signal for low-input systems that come with less N
14	Lori et al. 2018	Soil microbial biomass is the average of microbial N and C increases; abundance of soil microbial communities and soil microbial activity are derived from various proxies reported in the paper (activity is based on 4 values at 74%, 84%, -4% (not significant) and 32% - we grossly capture this in 50%)
15	Muneret et al. 2018	Crowder et al. 2010 shows similar results but assumingly covers partly the same and less data, hence we did not cover it
16	Pittelkow et al. 2015	Looks at conservation agriculture, which is no-till, residue retention and crop rotation; in general, no-till leads to lower yields, while the other two aspects lead to increases again. The yield responses are different for different contexts, and under dry conditions, full conservation agriculture with all these three elements leads to significantly higher yields by about 7%
17	Raseduzzaman and Jensen 2017	Here, crop diversity is intercropping
18	Reiss and Drinkwater 2018	Crop diversity is crop mixtures; overall, the yield is 2.2% higher with mixtures; only considering misxtures with 4 or more components, the yield increase is 4%; differences also occur between crops, where the yield increase is around 8% for corn and around 4% for legumes. The design of the mixture is also relevant for the yields (intention and basis), and the mixtures perform also better in the face of stressors, in particular under high disease pressure; finally, differences occur between climate zones, mixtures in the tropics showing yields that are by 10% higher, in temperate zones 2% only.
19	Renard and Tilman 2019	The study refers to crop diversity and stability of total production at national levels
20	Santos et al. 2019	Agroforestry significantly correlates with higher ecosystem services provision - those are measured with a number of specific variables, here, we report on Microbial activity and total production, but others such as litter decomposition, etc. are also covered; performance for biodiversity was between 45% and 65% higher, so we report 55%; for ES, the signals are more heterogeneus, so we report the sign and significance only.
21	Seufert 2018	Many further details on determinants of yield gaps, some discussion of yield stability, etc., referring a number f other meta-analyses on the topic
22	Seufert and Ramankutty 2017	A study covering a number of other meta-analyses. We report the results from those not yet reported and that link to CC adaptation and resilience;
23	Sanders and Hess 2019	A German study synthesising a large number of other meta-studies on the performance of organic agriculture in temperate zones along a number of indicators; earthworm abundance and biomass combine the signals for those of 78% and 94%
24	Torralba et al. 2016	Agroforestry in Europe
25	Venter et al. 2016	Soil microbial richness +15%, soil microbial diversity +3%
26	Crowder and Reganold 2015	Also covered in Seufert and Ramankutty 2017, but reported separately
27	Tuck et al. 2014	Expands the meta-analysis of Bengtsson et al. 2005; effects are largest in intensively managed landscapes.
28	Lichtenberg et al. 2017	
29	Bongiorno et al. 2019	Inconclusive effects of organic matter additions on nematode community diversity, etc.
30	McDaniel et al. 2014	Soil nicrobial biomass C and N was measured, increasing by 20% and 25%, respectively; almost in all cases, cover crops were legumes.
31	Ponisio et al. 2015	General effects on yields are captured in Seufert 2018; the effects reported on rotations refer to organic systems, i.e. the yield is 10% larger than in general organic systems (which have a yield gap of 20%) - hence the yellow colouring
32	Poeplau and Don 2015	
33	Smith eet al. 2019	Based on meta-analyses already included, but adding a specific analysis of the variability of the indicators of interest
34	Lee et al. 2019	Covers many practices and indicators; we report on those with sample sizes of 8 or more studies only

Figure 11: Compilation of the results from the Meta-analyses, the values show changes in comparison to the baseline

For several results, further differentiation is warranted, e.g. regarding climate zones or soil types Thus, for example, more complex crop rotations in combination with crop residue retention and no tillage leads to significantly higher yields in dry areas (by 7-8 %) while this is not the case in other contexts (Pittelkow, Liang et al. 2015). This study is from a context of conservation agriculture, though, which not always can be related to an agro ecological practice, depending on how plant protection and weed management is implemented.

The 19 qualitative reviews provide ample details on certain aspects that are also well-covered by the metaanalyses, such as the relation of organic amendments and soil fertility or diversity and production. Some address aspects not widely covered in the metaanalyses, such as the effect of agro-ecological practices on various indicators for financial capital (D'Annolfo, Gemmill-Herren, Graeub & Garibaldi, 2017) and many other economic aspects (Van der Ploeg et al., 2019), and some address aspects that are not covered at all in the meta-analyses such as water use, and present information on single crops, such as the System of Rice Intensification (SRI)[20]. The results generally point to good performance of agroecology and related practices and characteristics. These review results are however based on an informal assessment of a wealth of anecdotic evidence and not rooted in systematic reviews of meta-analyses or robust systems comparisons studies and we thus give them less weight relating the

[20] SRI breaks with several rules of traditional rice growing by relying on intermittent flooding, mechanical weeding, and planting very young seedlings single at larger spaces than

robustness of results. Besides providing further, topically broad and for each topic detailed, albeit not systematically and statistically compiled and analysed evidence, this highlights the research gaps in the current meta-analyses: firstly, on the issue of water use and water management in different agroecological contexts and how various practices and characteristics perform with regard to this; secondly, on single central crops when grown in different agroecological contexts, such as rice, cassava, soy or wheat.

3.3.2 Single system comparison studies

The literature search on single system comparison studies resulted in 185 studies fitting the search terms (basically various forms and combinations of "agroecology" plus related terms such as "permaculture", "regenerative agriculture" etc. and "climate change"; see Annex 7.2.2). From these, we identified only 17 single system comparison studies that fulfilled all selection criteria for inclusion in the analysis (peer reviewed, clear baseline to which the agroecological systems are compared to, being the original data source (to avoid double counting – there is a number of studies that do not provide new data but refer to other studies), providing evidence for the relative performance). These reported 83 cases of implementation of agroecological practices. These cases covered a huge heterogeneity in agricultural production systems, practices, crop types, geographic location, pedo-climatic characteristics, political, social and cultural contexts, etc., and also in the indicators covered. In consequence, this heterogeneity in combination with the low case numbers (many indicators were reported per study only, not for single practices) hindered a thorough systematic meta-analysis. We thus present a descriptive analysis of these results, which nevertheless allows to identify a number of noteworthy patterns.

First, the distribution of practices covered in the case studies shows a focus on "agroforestry", and then also on "efficient water use", "biomass recycling" and "crop rotations", followed by "N-fixation", "cover crops" and "adoption of organic and low-input systems" (Figure 12).

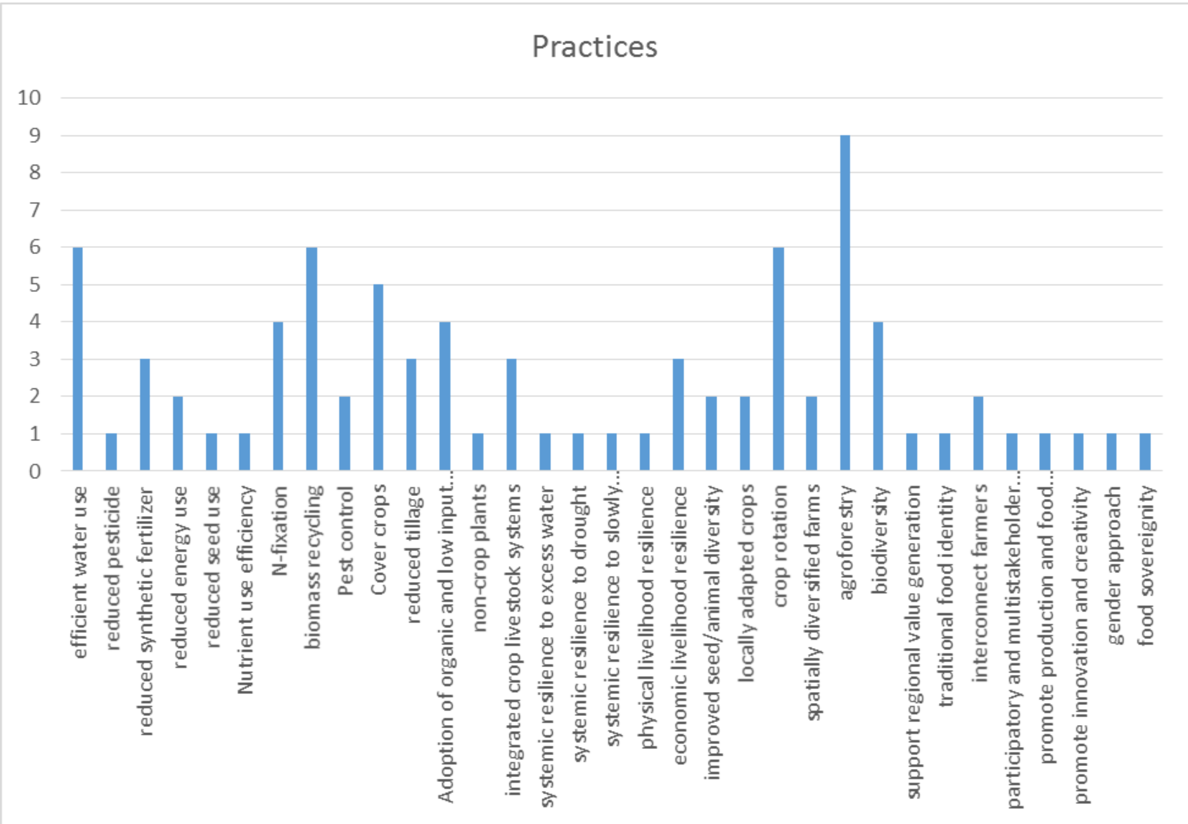


Figure 12: Distribution of agroecological practices in the single system comparison studies, ordered according to the 10 Elements of agroecology they refer to, from lower (left) to higher elements (right) (see section 1.3.1).

Second, on a more aggregate level, adopting the FAO 10 elements as lens to the analysis of the practices, we can notice a strong emphasis on the six "production related" elements of agroecology (i.e. efficiency, recycling, regulation, diversity, resilience, synergies, in total covering 90%), with a focus on diversity and efficiency (together 50%). The element "co-creation and sharing of knowledge" is reported 5 times (6%), while the other more encompassing elements, "circular and solidarity economy", "culture and food traditions" and "human and social values" are almost missing (Figure 13). Nevertheless, the elements covered closely relate to various aspects of increased resilience and thus, despite not resulting in a holistic coverage of agroecology, contribute to climate change adaptation. Furthermore, many elements relate to increased mitigation co-benefits, such as reflected in increased efficiency, reduced use of mineral fertilizers or increased soil carbon levels that are reported in the case studies.

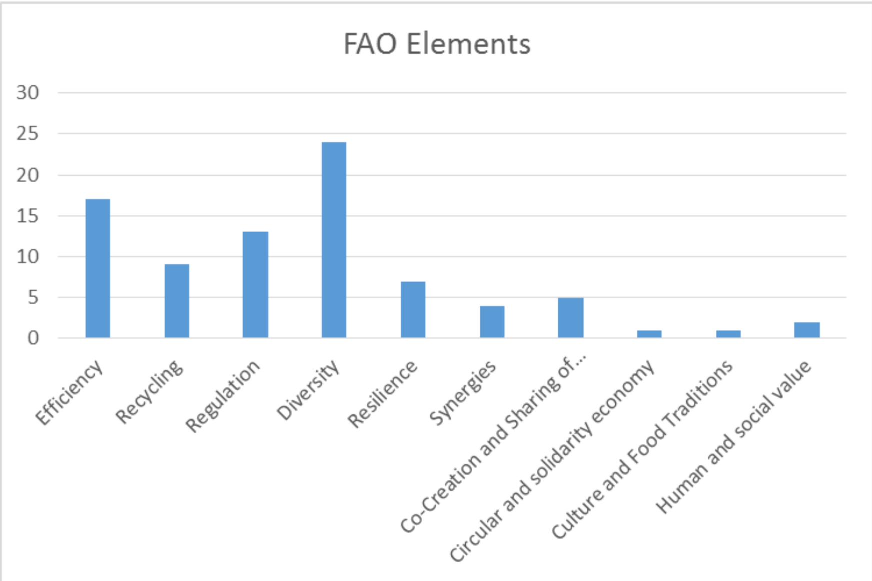


Figure 13: Distribution of FAO elements of agroecology in the single system comparison studies

This lack of coverage of systemic aspects is also reflected when relating the practices to the Gliessman levels (Figure 14). About 40% of the practices reported on in the studies refer to Gliessman level 3, i.e. to "Redesign the agroecosystem so that it functions on the basis of a new set of ecological processes" while almost 50% refer to the lower levels 1 and 2, where no re-design of production systems is taking place. Only about 10% of practices refer to level 4 ("Re-establish a more direct connection between those who grow our food and those who consume it.") and two only relate to level 5 ("…build a new global food system…").

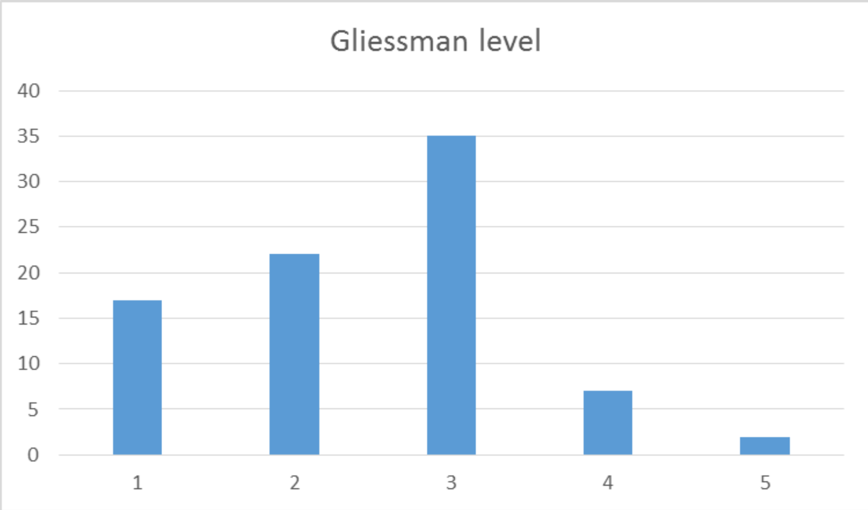


Figure 14: Distribution of Gliessman levels in the single system comparison studies

The analysis of these case studies thus shows that there is incomplete coverage of the different aspects of agroecology. Most studies focus on practices that are relevant in agroecology but taken for themselves do not provide a holistic coverage of agroecology as they miss a whole food-system focus. Another aspect of restricted coverage relates to the production systems. The studies mainly focus on crop production and silvo-pastoral livestock systems, while non-timber forestry products and aquaculture are lacking, which also reflects that agroecology is not prominently discussed in these contexts.

Figure 15 illustrates the extent in which some of the 10 criteria of performance of agroecology of the Test version of the FAO Global Analytical Framework for Multi-Dimensional Assessment of Agroecology - (TAPE – Tool for Agroecology Performance Evaluation (FAO, 2019) are reported in the single system comparison studies. Some papers used different indicators than suggested by the FAO global analytical framework to capture some criteria, such as "wealth", which we then subsumed under the corresponding criterion (here "income") in the graph.

The studies focus mainly on "productivity" (i.e. yields, 27% of cases reported), "soil health" (21%) and "agricultural biodiversity" (17%), followed by "food security" and "income" (each at 12%). This captures 4 of the criteria from the economy, environment and health and nutrition dimensions of the framework, which most closely relate to climate change adaptation (criteria: soil health; agricultural biodiversity; income; productivity).

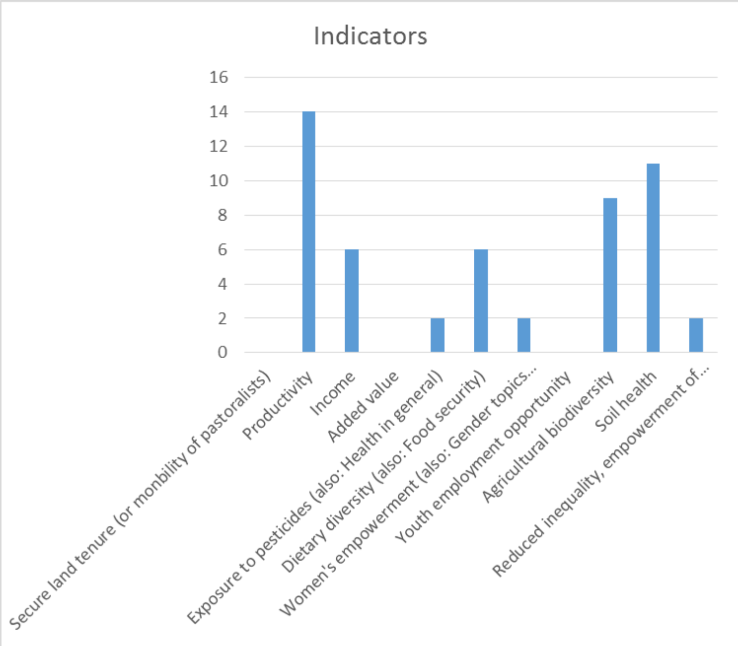


Figure 15: Number of reported cases that match the respective indicators in the single system comparison studies

The single system comparison studies generally report improved performance of the agroecological systems with respect to the respective baselines, i.e. the case-study location specific "average" (traditional, conventional) production system. Thus, they consistently report

- higher diversity and
- improved soil characteristics

with corresponding positive consequences for climate change adaptation, such as reduced erosion, increased water holding capacity and higher soil moisture conservation. In some cases, differences are not statistically significant, but in only one case worse performance is reported, namely in yields. Several important aspects are hardly or not covered, though, such as nutritional aspects of food security.

- Finally, a third of the studies explicitly report climate change mitigation co-benefits from carbon sequestration in soils and living biomass as well as from reduced fertilizer use.
- About 50% of the single system comparison studies highlight the role of institutional aspects, such as the enabling environment for the adoption of agroecological practices, knowledge transfer and exchange, co-creation of knowledge, (participatory) extension and advisory services and access to financial and other livelihood capital. The studies emphasize that without these enabling environment elements, agroecological practices would not have been adopted and their adaptation and mitigation benefits could thus not have been realised.

The evidence from these studies on the climate change adaptation related performance criteria of agroecology is mainly based on cases where specific agronomic aspects such as, for example, alternative production in agroforestry systems or more efficient water use are addressed. There is however a general lack of holistic systemic assessments addressing most or all aspects in one consistent approach (about a third of the studies analysed follow such an approach). It thus remains open whether the good performance reported in these studies relates to agroecology in an encompassing way or merely to these specific aspects (i.e. being agroforestry, adopting a specific water management regime, etc.) of it. Furthermore, as none of these studies specifically test for the role of institutional aspects, it remains open how much of the good performance is owed to well-organized knowledge transfer, extension and co-creation of knowledge, etc. and how much is owed to these cases being "agroecological".

3.3.3 Reviews on advisory services knowledge co-creation and knowledge transfer

The central role of knowledge transfer for the adoption of agroecological practices and the fact that knowledge co-creation is an integral part and knowledge intensity a main barrier to adoption of agroecology motivated a specific search for meta-analyses and reviews for those (see Annex 7.2.1). (Knook, Eory et al. 2018) present a systematic review of evaluations of participatory extension programmes, to better understand and provide **evidence on the effectiveness of capacity development interventions that are based on farmer demand and participatio**n. They find a strong positive effect for this, with the scientific robustness of evaluations being variable, though. A similar pattern of largely positive effects on mostly economic indicators can be seen in the review of (Davis, Nkonya et al. 2012) of farmer field school (FFS) impact evaluations. A third review is (Pamuk, Bulte et al. 2014), investigating Innovation Platform (IP) effectiveness in supporting the adoption of innovations across eight African countries using primary data. They found robust positive impact on the adoption of crop management innovations, but not so much for other areas of innovation, such as related to soils and fertility management and other more complex agro-ecological practices such as crop rotations. Importantly, the success of IPs seems to strongly depend on the presence and type of social capital and the relevance of specific context characteristics for innovation delivery. This is generally widely acknowledged (Dror, Cadilhon et al. 2016, Schut, Kamanda et al. 2018) and can inform agroecology related programmes and policies.

3.4 Discussion of the potential of agroecology to tackle Climate change

3.4.1 Increasing adaptive capacity, reducing vulnerability, and mitigation co-benefits

With the wealth of significant and positive results as synthesized in Figure 11, our analysis provides robust evidence on the performance of agroecological practices and key elements of agroecological agroecosystems with respect to central aspects of climate change adaptation and resilience, in particular on soil health and biodiversity, but also on income and productivity. Furthermore, the improved soil health correlates with higher soil organic carbon levels, with corresponding mitigation co-benefits.

These findings provide a robust basis for supporting agroecological production systems and practices as promising approaches for climate change adaptation in agriculture, with mitigation co-benefits. Such support is however faced with the challenge of not having a clear cut definition of agroecology that can be certified as organic agriculture. Thus, it is central to identify clear characteristics and indicators that would trigger such support, which is the main goal of the TAPE (Tool for Agroecology Performance Evaluation) still undergoing field testing.

The TAPE could be organized results-based, i.e. conditional on good performance in key indicators that correlate with climate change adaptation such as indicators for soil health and diversity. Or it could be linked to application of certain practices that in general show good climate change adaptation performance, such as optimized diverse crop rotations, use of organic fertilizers, or agroforestry, to name just a few.

Furthermore, we emphasize the central role of institution related aspects, such as knowledge co-creation and dissemination via advisory services and farmer-to-farmer approaches, etc. to support development, improvement and uptake of agroecological practices. When supporting agroecology and fostering climate resilience, it is thus important to establish and strengthen functional knowledge and innovation systems. This also comprises adequate investments in research and development which currently is hardly targeted at agroecological and related production systems that are chronically underfunded. A key aspect thereby is the need to approach innovation and knowledge transfer in a context-sensitive manner, i.e. that the suitability of an option depends on the context (Sinclair & Coe, 2019). Of particular importance is the question of how to reach out to the broader farm population and bring such "knowledge intensive" production systems to scale. This is corroborated by the High Level Panel of Experts of the Committee on Food Security and Nutrition report on agroecology (HLPE, 2019), highlighting that there is fewer investment in research on agroecological approaches when compared to other innovative approaches, in particular regarding the economic and social impacts of adopting agroecological approaches, the extent to which agroecological practices increase resilience in the face of climate, relative yields and performance of agroecological practices compared to other alternatives across contexts, and how to link agroecology to public policy (HLPE, 2019).

Another group of important findings from the meta-studies analysed are those on productivity and yields. Agriculture has to ensure food security and this is linked to the ability to provide decent output per hectare. From the meta-analyses we learn, that low-input systems such as organic agriculture show lower yields than high-input systems. On the other hand, higher diversity tends to correlate with increased productivity and stability. Single crop yields are however not the best measure to assess the productive potential of an agricultural production system. It is more adequate to average production over space and time by using more aggregate measures such as total income or total calories or human edible protein provided from a certain area over a certain period, or even more encompassing, the "land equivalent ratio" as suggested in HLPE (2019). Such measures are better suited to capture the relevant aspects of productivity, resilience, and adequate nutrient supply in relation to food security. The assessment of the performance and stability of such more encompassing productivity indicators, in particular in the face of ever more challenging climatic conditions, should become standard when assessing the climate change adaptation potential of agricultural production systems. Furthermore, yields have to be seen in relation to what they are used for and reducing areas cropped to produce feed or output that is then lost or wasted would reduce the pressure to achieve ever higher yields on given areas. Finally, agriculture is multifunctional and in an encompassing sustainability assessment, yields are only one indicator among many others. Sustainable future food systems depend on agriculture performing optimal on many indicators and not maximal on one and worse on others.

3.4.2 Research gaps

While there is much robust evidence from meta-analyses and reviews, our search did not result in many case studies that provide specific and robust evidence for the relative performance of agroecology with respect to some baseline production systems regarding climate change adaptation and resilience. The case-study based evidence on agroecology and climate change adaptation with a clear agroecology focus and a reference scenario thus remains scattered and anecdotic. This is also due to our aim to provide a most robust scientific knowledge basis for the climate change adaptation performance of agroecology, which resulted in many case studies not being included in our review (only 17 out of 185). There is a huge number of civil society organization testimonials and reports on agroecological case studies available, reporting their good performance, but hardly any of those met our selection criteria for the case study review. Furthermore, in this data, there may be a bias due to the self-declaration of being agro-ecological and the fact that most agroecological work is still done by institutions that are in favor of this approach. The self-declaration bias is somewhat mitigated by our complementing research based on other key-words than agroecology (Annex 7.2.3). We can however not judge on the importance of or control for the bias resulting from an institutional inclinations towards agroecology.

A big challenge for the work on agroecology and climate change adaptation and resilience is the need for truly encompassing studies to capture agroecology and for long-term studies to truly assess adaptation. Furthermore, there is a need for much more well-designed comparative studies ((Côte, Poirier-Magona et al. 2019)), with optimal sample design, where e.g. Bezner Kerr et al. (2019) may serve as an example. If done in the context of extreme events such as droughts, hurricanes, etc., such assessments of the relative performance of agroecological versus some baseline farms in the face of these shocks could provide key insights into adaptive capacity and resilience, as they would avoid the challenge of long-term observations to see some signals from adaptation activities. More research of this kind would be needed to be able to assess the adaptation potential of agroecology in its full complexity and to identify which aspects may be most important for successful adaptation.

3.4.3 Submission for Koronivia joint work on agriculture

Elements to be included in topics 2(b), 2(c) and 2(d)

Based on the results of this review on the potential of agroecology for climate change adaptation, the authors have submitted inputs to the Koronivia joint work on agriculture (KJWA). A first submission has been prepared between Biovision and FiBL, targeted at the topics 2(b) "Methods and approaches for assessing adaptation, adaptation co-benefits and resilience", and 2(c) "Improved soil carbon, soil health and soil fertility under grassland and cropland as well as integrated systems, including water management", for the SBI/SBSTA50 in June 2019. A second submission has been prepared between IFOAM Organics International, IFOAM EU, Biovision and FiBL, targeted at topic 2(d) "improved nutrient use and manure management towards sustainable and resilient agricultural systems".

3.5 Conclusions

First, albeit working with proxies, correlations and plausibility arguments, and having made explicit the potential challenges that come with such an approach and the underlying data we used, our results clearly allow to conclude that

- agroecology builds on key practices and characteristics that are performing well with respect to indicators that strongly correlate with climate change adaptation and resilience, such as various indicators related to soil health and biodiversity, but also productivity and yield stability
- Furthermore, these key practices and characteristics correlate with indicators for mitigation co-benefits, mainly related to soil organic matter, but also via reduced input use.

Hence, we can argue for increased support for those practices and characteristics which are central in agroecology, for supporting approaches that build on them, and for more investments in research and implementation of those, as they provide promising alternatives to the currently dominant approaches that come with a number of known drawbacks.

The results also allow to further refine some findings. An example would be the fact that organic agriculture shows lower yield stability, while increased diversity strongly correlates with more stable production and therefore long term resilience and livelihood resilience. This suggests that organic agriculture may not fully implement and build on its diversity potential and in this also differs significantly from agroecological approaches. This would be an important area for further research to improve organic agriculture as a well-defined exemplary system that is closely related to agroecology, and also to gain further insights on the relation between productivity, stability and diversity in agro-ecosystems. Several aspects are also missing in the meta-analysis, e.g. water management and water use, and also the role of seed availability and seed diversity

Second, the central role of knowledge transfer, co-creation of knowledge, etc. warrants a specific emphasis on this topic. This central role has been recently reemphasized in the High-Level Panel of Experts of the Committee on Food Security and Nutrition report on agroecology (HLPE, 2019), which highlights the key importance of enabling policies and instruments, as well as investments for transition pathways. NGOs and other institutions often play a central role as facilitators of these processes, in particular by providing funding and organizing exchange with relevant institutions. This is clearly illustrated for the innovation platforms, for example, where success seems to strongly depend on the presence and type of social capital and the relevance of specific context characteristics for innovation delivery.

4 Country case studies on the policy and technical potential of Agroecology

To further scrutinize the findings from the research meta-analysis, two case studies in Senegal and Kenya were conducted. Both countries have a track record of sustainable agriculture practices and currently consider those in their climate strategies. For each case study the policy and the technical climate potential was assessed, the methods for which are explained below.

The goal of the technical potential analysis is to provide a better understanding of the ecological and socio-economic performance of agroecology, based on a rigorous comparative analysis answering to the question “are and if so why agro-ecological agroecosystems are more resilient than non-agroecological ones?”.

The goal of the policy potential analysis is to provide a better understanding of the current political context as well as the enabling environment and the obstacles for agroecology to be considered in the decision-making process and out-scaling. The policy potential indicates to what degree the political context (in a country) provides an enabling environment through its polity, policies and politics that fosters the awareness, acceptance and implementation support for agroecology approaches.

4.1 Overall methodology

4.1.1 Methodology for assessing the policy potential for agroecology

4.1.1.1 Research methods and thematic focus:

For assessing the policy potential, firstly a reference analysis is conducted that reflects what the current overall policy situation is and whether/how agroecology is framed and embodied by such. Secondly and based on this reference, a hypothetical “ideal scenario” in 2025 is defined, that describes an enabling environment for agroecology to be politically considered (political awareness), accepted (political will) and effectively fostered (political commitment/action). The difference between these two situations defines the bandwidth of the future policy potential for agroecology. To specify for this, finally a gap analysis between these two settings will identify opportunities and challenges for a transition from the reference to the ideal scenario and thus validate the existing policy potential.

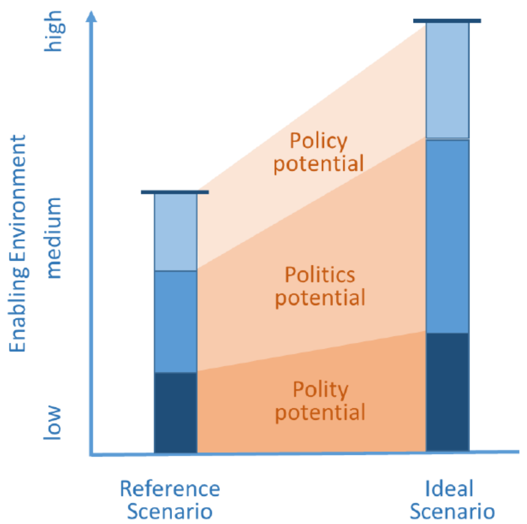


Figure 16: Potential *scenarios depending on enabling environment*

The assessment of the scenarios is based on literature reviews, semi-quantitative word analysis, questionnaire guided interviews and focus group discussions. Through interviews and focus group discussions multiple aspects of the methodology below can be covered at the same time.
For the reference analysis to assess the current political status of, and political will for fostering agroecology we we approach it from the following three angles:

Polity angle:
Literature review conducted to assess the political system, functioning of institutions in charge, existing visions and long-term strategies, priorities and major current programs in agriculture.
Focal group discussions conducted to discuss the functionality of institutions and the status of visions/long term strategies when compared to actions in reality. Further discuss the success and sustainability of implementation of policies and enforcement of regulations and assess the overall normative framing of agriculture and food system by the government (recognition, expectations).

Politics angle:
Focus group discussions and key stakeholder interviews conducted to assess the awareness, understanding and acceptance of the agroecology approach among power vested stakeholders engaged in the policy making process

Policy angle:
Assess the degree to which agroecology approaches are already addressed, fostered or hindered through existing or planned policies in the climate change context.

Literature review and word count analysis is conducted to analyze current key policies related to agriculture, climate change, natural resource management and/or economic development; identify and assess policies that don’t explicitly mention agroecology but address selected elements of it.

Through semi-structured interviews we assess what new policies are currently in the making or planned that could have implications for the agriculture sector in the climate context.

Finally, based on the above approach a qualitative rating for each assessment angle is conducted that will identify whether an overall low, mid or high enabling political environment exists in the country for agroecology.

To specify what a desired enabling political environment for the agroecology approach would look like in an ideal scenario 2025, the following aspects are addressed in focus group discussions:

- Identify a hypothetical setting within the political system in 2025 that provides a solid bedrock for the agroecology approach in the country
- Characterize and discuss the institutional and normative dimensions of such scenario.
- Specify which policy actors would need to take what position and actions to facilitate the development or implementation of policies that would be needed to follow this scenario.
- Describe realistic and lasting policies/regulations that would be needed to allow following this scenario.

4.1.2 Methodology technical potential

The technical potential analysis is done through a two-steps approach.

1. Sampling of smallholder farmers, based on partner organisation's assessment. Grouping into "Agroecological intervention group" and "control group" (Farmers not being part of an agroecological group/movement.)
2. Characterization of the level of the agroecological transition based on the Test version of the FAO Global Analytical Framework for Multi-Dimensional Assessment of Agroecology - (TAPE – Tool for Agroecology Performance Evaluation (FAO, 2019), based on the 10 criteria of performance of agroecology): this will provide a typology of the targeted farms, specifying those which are considered as agroecological or "in transition" or not agroecological.
3. Assess the resilience of these farms using SHARP and compare the two groups.

In detail these steps consisted of:

4.1.2.1 Sampling design

The agroecological system sampling was based on farmer's associations in long lasting relations with Non-Governmental Organizations (NGOs) and Community Based Organizations (CBOs). These NGOs and CBOs are supporting agroecology and use of indigenous knowledge systems for food production and provide insight into sustainable agricultural technologies for management of soils, water, crops, animals and pests. For purposes of the case study, the pursuance of sustainable agriculture through these pathways was taken as a representation of "agroecological transition". The sampling approach was based on spatial distribution and randomized sampling of farmers, identifying the "intervention group" of agroecological farmers based on the following criteria:

- Farmers who are part of such agroecology projects for at least five years
- Exposure to climate variability
- Close by control group members available
- Mixed cropping systems and crop-livestock integration

Non-agroecological farmers were randomly selected from the same regions ("control group") to closely match the agroecological/climatic conditions, livelihood strategies and land holding patterns of the agroecological producers ("intervention group").

4.1.2.2 TAPE

The results from these TAPE characterizations tests (Test version of the FAO Global Analytical Framework for Multi-Dimensional Assessment of Agroecology - (TAPE – Tool for Agroecology Performance Evaluation (FAO, 2019)) serve now as inputs for FAO's Agroecology team and have been compiled in a separate feedback document for FAO, not being part of this report.

4.1.2.3 SHARP

The collection of SHARP field data in both case studies was carried out through face-to-face interviews using the Self-evaluation and Holistic Assessment of climate Resilience of farmers and Pastoralists (SHARP) Tool app version 0.13.18, a structured survey tool for resilience assessments developed by FAO.

SHARP focuses on identifying the areas of vulnerability and strength of the farm systems and agriculture-based households, while building on flexibility, learning and knowledge of farmers (Choptiany et al. 2015). It considers resilience as an intrinsic aspect of the system and farmers themselves.

Consistent with the overall SHARP tool methodology, the collection of data on different farm system components was done in the form of 39 modules, broadly covering 4 domains i.e. agronomic practices, environmental aspects, social interactions, economic components and governance. However, the modules on governance and energy conservation practices were omitted in the survey exercise. Furthermore, since the module on general information doesn't result with the scoring, this brought the number of modules used for resilience assessment to a total of 36.

The SHARP assessment is based on the combination of quantifiable (objective) and qualitative (subjective) questions spanning across the above mentioned domains. Regarding the objective information, each module was divided into subcomponents defining different aspects of that farm component e.g. module 22 on Trees assessed i) diversity of tree species ii) number of trees and iii) use of tree products etc., each subcomponent was scored independently.

To translate into a resilience measurement tool, SHARP gives each subcomponent a score to identify the resilience levels of the farm systems. SHARP tool automatically generates three scores for each module: technical (objective), adequacy and importance score (subjective). The scores for the objective component (i.e. technical scores) are grounded on an academic and expert knowledge and they range from 0 for low resilience to 10 for high resilience. The subjective information (self-assessed adequacy and importance) is based on the perceived and expressed needs of farmers aimed to capture the perceptions of farmers regarding the adequacy/sufficiency levels of a given farm component or resource, as well as the priority of given elements in the farms. Both are measured through a Likert scale: the self-assessed adequacy score ranges from 0 to 10, with 10 corresponding to a high adequacy, while the score for the self-assessed importance is an inverse scale ranging from 10 to 0, where 0 is a self-reported high priority/importance.
The aggregate of the subcomponent scores, as described above, resulted in the technical score for each module, which provides an objective estimation of the resilience of the farm system.

Only considering the technical scores, the SHARP modules are compiled into sub-indicators and are aggregated in a manner that the 13 agroecosystem resilience indicators can be measured as defined by Cabell & Oelofse (2012). Table 1 below shows how the technical score of different sub-indicators are translated into resilience sores for different indicators of resilience.

Table 1: An extract of SHARP scoring of agroecosystem resilience indicators based on modules and sub-indicators.

SHARP agroecosystem resilience indicator	SHARP sub-indicators	SHARP Module Theme	SHARP Module sub-components (Questions)
1. Socially self-organized	1.1 Group Membership	36. Group Membership	36. Participation level
			36. Initiation of the group
	1.2 Access to local farmer's markets	30.Access to markets	30.Sell of produce in local markets/cooperatives/associations
			30.Access to information on market prices

	1.3 Previous collective action	35. Community cooperation	35. Joint problem solving by community members
			35.Mechanisms in place for problem solving
	1.4 Access to communal resources	5. Land access	5. Area of communal land accessible
	1.5 Financial support	33. Access to financial services	33. Financial support received when needed
5. Optimally redundant	5.1 Varietal Diversity	13. Animal Production	13. Number of Breeds
		6.Crop Production	6. Number of crop species

Resilience indicator score (Socially self-organized) is an aggregate of sub-indicator scores (1.1 group membership, 1.2 access to local farmer's markets etc.). The sub-indicator scores are obtained from the SHARP module subcomponents. Sub-indicator, 5.1 (Varietal Diversity) is an aggregate score obtained from both the animal and crop production module.

In this study, the 13 agroecosystem indicator scores were based on 92 sub-indicator scores. The sub-indicator score was assessed from the subcomponent (question) scores of the modules as shown in Table 1. For example, socially self-organized indicator assesses the farmer's ability to organize into grassroots networks and institutions such as cooperation and farmer's markets. Therefore, the final score will be an aggregate sum of scores from sub-indicators of 1.1) group membership, 1.2) access to local farmer's markets etc. derived from the sub-components of group membership and access to market modules respectively (Table 1).

In some instances, the sub-indicator was assessed through scores of subcomponents from multiple modules. For example, the sub-indicator score for varietal diversity was dependant on two subcomponents, number of animal breeds reared (from animal breeding practices module) and the number of crop varieties cultivated (from crop production module). The final scores were standardized on a scale of 0 -100%, classified as low-level (0 – 35%), mid-level (36-70%) or high-level (71-100%) resilience.

Aside from providing resilience scores, the module scores were used to identify areas of **priority intervention** based on the summation of technical, adequacy and importance scores. This means that interventions scoring low on the technical and adequacy score and high on the importance would be those with lowest total scores and thus highest priorities by the farmers. Therefore, lowest scores were considered to be areas of high priority.

A two-tailed sample t-test was used to assess differences for SHARP scores between agroecological and non-agroecological at the agroecosystem resilience indicator level (1. Socially self-organized, 2. Ecologically self-regulated etc.), the sub-indicator level (1.1 Group Membership, 1.2 Access to local farmer markets, etc.), module-level (2. Households, 3. Production activities, 4. Non-farm income generating activities, etc.) and at the domain-level (Agronomic practices, Environmental aspects, Social interactions and Economic components) (Table 1).

Prior to applying the t-test, suitability of the dataset was assessed for normality (using Shapiro-Wilk normality test) and homogeneity of variance (Levene Statistic). For non-normal distribution datasets, a non-parametric test (Wilcoxon rank sum test) was applied. For non-homogeneity of variance, a Welch two-sample t-test was applied. All tests were performed in R version 3.6.1.

4.2 Results case study Kenya

4.2.1 Context Kenya

Climate risks pose serious threats to Kenya's sustainable development goals. With the largest economy in East Africa and a population of 48.5 million, Kenya serves as the regions' financial, trade and communications hub. The country's economy is largely dependent on agriculture susceptible to climate variability and change and extreme weather events. Increasing inter-seasonal variability and declining rainfall in the main rainy season have impacted cereal production in recent years. Recurrent droughts and floods—likely to be exacerbated by increasing temperatures, heavy rainfall events and sea level rise—lead to severe crop and livestock losses, famine and displacement. The 2008–2011 drought caused $12.1 billion in losses and damage. As Kenya is deficient in its major staple crops and therefore has to import a substantial amount of food, further climate change perturbations will only increase this dependency. Models estimate that by 2030 climate variability and extremes will lead to losses equivalent to 2.6 percent of GDP annually (USAID 2018).
Despite the importance of agriculture in Kenya, the sector does not receive high priority in terms of budget allocation compared to other sectors such as infrastructure and energy. This is reflected in lower agricultural growth and therefore, a framework or strategy for adapting to climate change and mitigation is required within which there is increased investments in agriculture, supportive policy and use of climate resilient technologies appropriate to mixed farming conditions involving crops and animals.

4.2.2 Policy potential in Kenya

4.2.2.1 Policy setting in Kenya

Transforming agriculture productivity to deliver on food security and nutrition, build resilience to impacts of climate change, eliminate social inequality and minimizing biodiversity loss is at the heart of Kenya's Big Four Agenda, the national climate change response strategy and other economic and social development strategies. This recognition is embodied in various policies that aim to transition Kenya into a sustainable food and agriculture system. Through implementation of the Big Four Agenda, Kenya aims to reduce the number of food insecure people by 50% and achieve a 27% reduction in malnutrition among children under the age of five years (MALF, 2017).

Kenya's vision 2030 and implementation of the Big Four Agenda aims to move its economy away from over-reliance on agriculture by transforming itself into a hi-tech service hub that will generate innovative and entrepreneurial potentials. Despite that, Kenya has developed and is implementing several agricultural and climate change policies aimed at increasing food security and nutrition. The overarching goal of the agricultural sector in Kenya is to contribute to improvements in food and nutrition security and income generation through promotion of improved management of natural resources and practices compatible with sustainable and climate-resilient agricultural production (GoK, 2018). On the other hand, the goals of climate change policies and strategies is to enhance adaptive capacity and resilience while promoting low carbon development.

To address extreme weather events, the government developed and is implementing numerous agriculture and climate change related policies and strategies. One of these policy frameworks is the Climate Smart Agriculture Strategy (CSAS) developed in 2017 and complemented by the CSA Implementation Framework (2018) that was developed through a multi-stakeholder process. The two documents have identified challenges and opportunities for CSA to hedge against climate impacts in the agriculture sector in Kenya (GoK, 2017 and 2018). However, there is a feeling that the concept of CSA could be inclusive of "business as usual" approaches to agriculture (Osumba, 2018): "Kenya's agricultural policy environment is influenced by political economy of agriculture that is influenced by country political system which generates the policy incentives to promote agricultural development and/or private sector and donor interests. The existing agricultural policies are seldom farmer or community driven and thus often do not respond to the local needs."

Given these deficits, there is a need to leverage more specific approaches on the agenda of decision makers to facilitate the upscaling of good agricultural practices. One promising entry point are systemic approaches that build on agroecological practices in the agriculture sector or through incorporation of these practices in the CSA narrative, as it is well established in Kenya. However, despite the evidenced positive effects of systemic ecological measures to combat climate change, in numerous pilot-projects they often remain singular and small-scale interventions with limited opportunities to go to scale (Wankuru et al., 2019; Wigboldus et al., 2016). Factors limiting scaling up and out of agroecological approaches include the low awareness about the potential of these approaches. Others relate to the knowledge intensive nature of agroecology, its context-specificity and absence of a supporting political frameworks, and technical or economical barriers such as initial or transaction costs.

4.2.2.2 Research approach

Building on the above described context in Kenya, this case study aims to explore the policy potential of agroecology in Kenya, specifically to assess how the current agriculture and climate change related policies and strategies can support the uptake and upscaling of agroecology (see Chapter 4.1).

This case study used qualitative research methods, including literature review, semi-structured interviews and focus group discussions (FGD). During the literature review, a number of government policies, strategy and implementation documents were reviewed with an agroecology lens, specifically identifying agroecology elements and practices (Annex 7.2). For this study, we searched for agroecological elements such as resilience, efficiency, diversity, biodiversity, synergies, co-creation and sharing of knowledge, recycling and responsible governance in policies and strategies (Wezel et al. 2014). An analytical assessment of current agriculture, climate change and other related policies and strategies was undertaken to provide an overview and understanding on how much and how far agroecology is embedded within them. We analysed policies related to agriculture, climate change, forestry and water. In absence of a national policy specifically on agroecology, agroecology elements could be embedded in such existing related policies at least.

Twenty-one policies and strategies related to agriculture, environment, water and forestry from the past 20 years were reviewed (Annex 7.2). An integrated two-step analytical framework, focused on policy content, was adopted. Step one and two involved analysis of agroecology elements and practices, respectively. The elements and practices are drawn from FAO (Annex 7.2) that can be applied across ecological, economic and social-cultural environments.

Semi-structured interviews were conducted with fourteen participants from various organizations that are active in the agriculture sector. These are government institutions, policy makers, CSOs, NGOs, and national research organizations. The interviews focused on exploring the understanding of agroecology by stakeholders and the current political situation with regards to agroecology. We further assessed whether and how agroecology and its elements are currently considered within agriculture, environment, water, and forestry policies.

In addition, two Focus Group Discussions (FGD) were held. The first FGD comprised government officials from different sectors and departments. The second one comprised CSO and NGO representatives. Some of the issues discussed during the FGD included how agroecology is embedded in the agriculture discourse in Kenya, what current policies are related to agroecology and what is needed to support agroecology approaches and initiatives in Kenya.

4.2.2.3 Results and Analysis

4.2.2.3.1 Policy angle: analysis of policies in Kenya

The analysis revealed that no policy specifically related to agroecology exists within the current national agriculture and climate change policy arena even though there are some closely related frameworks such as the CSA strategy. Nonetheless, devolution has provided a chance for counties to develop policies based on the prevailing circumstances and a county like Kiambu already adopted a law on agroecology as the first one among the 47 counties. This seems to have had an influence on other counties, as in Meru interventions aimed at promoting agroecology are currently being elaborated (Osumba 2018).

Agroecology elements in existing policies in Kenya

The review of Kenya policies indicates that, despite the absence of the word “agroecology”, there is consideration of agroecology elements and practices aiming at increasing agricultural productivity and building resilience. Most of the policies mention or infer on two to three out of the 10 FAO agroecology elements. The elements culture and food traditions and circular and solidarity economy, however, are not mentioned nor inferred.

With regards to the agroecology elements mentioned in these policies, their goal is to improve food security and nutrition, building **resilience** (FAO agroecology element) of Kenya’s agricultural systems and, enhance the adaptive capacity of farmers. For example, the emphasis of Kenya’s NDC is on increasing resilience of food systems and enhancing adaptive capacity through enhanced coordination of climate change action, public participation and inclusiveness (implying the FAO elements human and social values as well as responsible governance). According to the NDC, building resilience implies improving **efficiency** (FAO agroecology element) of resource use in all agricultural production systems (including supporting sectors such as water and energy) as well as the implementation of polices that will lower costs of production and hence increase productivity. The FAO agroecology element **diversity** is mentioned in terms of increasing crop, livestock, plant and soil biodiversity, which is threatened by the changing climate and related effects such as pests and diseases.

Example of an existing policy referring to agroecology elements:
The Kenya national CSA Strategy and CSA Implementation Framework outline climate resilient agricultural elements and institutional arrangements to circumvent climate impacts in the agriculture sector. Some elements of agroecology do overlap or diverge with the CSA strategy and implementation framework. Of the 10 agroecology elements, **resilience, efficiency, diversity and synergies** are clearly articulated in the strategy and framework. Other elements such as **culture and food traditions, co-creation and sharing of knowledge, recycling and responsible governance** can be inferred. However, elements of **human and social values and circular and solidarity economy** as an

impetus for transformative agroecology that can lead to food security and sovereignty are not considered.

Identifying and **reinforcing synergies** between objectives of food security and, poverty reduction, adaptation and mitigation actions in agricultural sector is another FAO agroecology element considered within the policies. The policies will also integrate cross-sectoral approaches to enhance synergies and promote efficiency within implementing institutions and stakeholder. Agroforestry is one of the agroecology practices highlighted and seen as having the potential to provide this synergy and to offer resilience benefits and reduce emissions in agricultural systems (GoK, 2018).

"ASDS recognizes Kenya's agro-ecological diversity and aims to improve **diversity** of food to meet dietary and nutritional requirements, increase agro-biodiversity to include traditional sources of food and support use of organic methods for **sustainable** food production systems" (ASTGS, 2018)

Despite not clearly mentioning co-creation and sharing of knowledge in the policies, stakeholders including farmers will be involved in communication and awareness, education, advocacy, public participation, public access to information on priority climate resilient crops and livestock and, adaptation actions in agriculture sector such as water conservation and recycling, indigenous knowledge, efficient use of water and energy, early warning systems and agroforestry (KCSAS, 2017; 2018).

Governance frameworks based on the elements of accountability, transparency, rule of law and participation are applicable at national level and will be cascaded down to county levels and provide a clear system on what is expected to be done at each stage. However, good governance mechanisms such as equity and inclusiveness and community and traditional level governance (see FAO, 2011) that can support different actors to transform their practices to be climate resilient and sustainable and maximize synergies along agricultural value chains are missing within the policies.

Finally, the agroecology element recycling is not directly mentioned in the policies except in the water sector, whereby public awareness on water conservation and recycling is indicated as efficient water use practice. Accordingly, there is potential for further streamlining this element in other policies.

Agroecology elements in climate specific policies in Kenya

Agroecology is indirectly addressed in selected climate change policies and strategies in Kenya. Kenya passed the Climate Change Act (2016) which provides a regulatory framework to guide National and County governments to enhance response actions to address climate risks and to strengthen climate resilience in the country. The Act provides an elaborate mechanism to guide the mainstreaming of climate change into sectoral policies, including monitoring implementation. The National Climate Change Response Strategy (NCCRS, 2010) is the framework that guides integration of climate concerns into development priorities. The NCCRS is translated into National Climate Change Action Plans (NCCAP) through the Climate Change Act of 2016. Implementation of the Climate Change Act is through the National Climate Change Action Plan (NCCAP) 2018-2022.

Sustainable land management (SLM) is among the climate actions proposed in the NCCAP. The specific activities planned under SLM reflect certain agroecology elements and practices, such as integrated soil–crop–water management and agroforestry and agro-silvo-pastoral systems; managing soil organic matter for soil carbon sequestration; and preventing and mitigating land degradation and restoring degraded soils and lands (NCCAP, 2018).

In addition, the agricultural sector developed Kenya's Climate Smart Agriculture Strategy (KCSAS) 2017-2026 with the objectives of adapting to climate change and building resilience of agricultural systems while minimizing emissions for enhanced food and nutritional security and improved livelihoods (KCSAS, 2017). KCSAS outlined some of the climate change-related issues farmers are facing in Kenya, including unsustainable agricultural land management practices, inefficient crop and livestock production systems, the use of fossil fuel in the agriculture sector as well as poor management of fertilizers, manures and agricultural wastes. To implement the KCSAS and provide guidance in mainstreaming Climate Smart Agriculture, the Climate Smart Agriculture Implementation Framework 2018-2027 (KCSAIF) was developed. Agroecology is not explicitly referred to but some of its elements are indirectly implied. This includes diversified and improved crop varieties (high yielding, short duration, disease and pest tolerant, high nutritive value, flood tolerant), the use of integrated soil fertility management practices, and promoting indigenous and locally adapted breeds and varieties.

Agroecology practices in Kenyan policies

The key policies reviewed are to some extent consistent with agroecology elements and practices of achieving a balanced and sustainable agricultural system in socio-economic, ecological, political and environmental spheres. While the Kenyan government has promised a policy and institutional environment that is conducive to increasing agricultural productivity and resilience, the agricultural landscape is heavily penetrated and controlled by input supply agribusinesses (ASDS, 2010). This has created uniformity across farming landscapes, exposing crops and livestock to emerging pests and diseases.

Most of the policies and strategies propose to increase finances for external inputs and create awareness campaigns for their use. For example, the agricultural sector development strategy (ASDS) aims to bulk purchase and supply external inputs for smallholder farmers. This is in contrast to agroecology, which encourages the use of integrated and traditional soil fertility, disease and pest management practices that enhances farm, crop and livestock diversity and harnesses resulting synergies.

The CSA strategy and framework selectively incorporated some agroecological practices and combined them with adaptive, traditional and environmentally sustainable technologies such as provision of weather and agro-advisory information along value chains for decision-making and insurance, efficient water use including irrigation and, conservation and propagation of adaptive crop and livestock germplasm. Some of the CSA and agroecology practices that overlap include: integrated pest management that minimize the use of pesticides on emerging pests and pathogens brought by temperature rises; agroforestry to bridge agricultural development and forest protection; and integrated soil fertility management.

Nonetheless, also agroecology related practices are identified few and far between policy documents, which refer for instance to conservation agriculture, agroforestry, sustainable land management, cultivation of drought-tolerant indigenous crops, water harvesting, livestock management and integrated soil fertility management. Overall, almost all agriculture-related policies consider increasing crop-, livestock-, fishery- and soil- **diversity** to enhance ecosystem services and the sustainable use of resources, as key for adapting, mitigating and building resilience against climate change.

Agroforestry is most the popular agroecological practice mentioned in most documents to increase tree cover in farmland, improve nutrition and incomes, preserve and maintain the environment and, enhance carbon stocks.

Reasons for lack of agroecology policy in Kenya

During interviews and focus group discussions, various reasons were outlined by the respondents for a lack of agroecology policy in Kenya. These include:

- **Food security, is the current priority for the government**. It aims at maximizing yields for economic benefit as well as for providing enough food for the population. The focus is on production and integrated food system perspective is mostly missing. Agroecology is perceived as being applicable only on small scales, which the government sees as a limitation for meeting its objectives. CSA is thus seen as a more viable option towards achieving food security for the country.
- **Agroecology is not well-known**. Agroecology is a relatively recent concept in Kenya and its elements have not yet been well understood among the policy makers. Hence there is a need to invest more in research and sensitization so that its benefits can be well understood amongst stakeholders.
- **There is a multiplicity of terms and concepts**. Agroecology practices are being employed by farmers throughout the country even though they call it differently. If the government opts to develop strategies for every new approach that comes up, then there will be thousands of strategies which will be not only confusing but difficult to implement.
- **In Kenya, the distinction between CSA and agroecology is not clear**. For those who are somewhat familiar with agroecology, they consider it part of CSA with a lot of synergies between the two concepts. The elements underlying agroecology and CSA, have to be contextualized until the overlaps between the two are clearly defined.
- **There are powerful conflicts of interest**. If Kenya were to promote agroecology, there would be conflicting interests e.g. by policy makers that have vested interests in conventional agriculture or by profiteers of other opposing policies.

The lack of understanding of agroecology amongst policy makers may be the greatest barrier to its inclusion in climate change policies and strategies. As one interviewee puts it:

"Agroecology has a space in climate policy dialogues but very few people who design policies know or even understand it. Additionally, agroecology is not being discussed or advocated for like climate change. No one is talking about it, no one is teaching the policy makers about it and information is not being shared. The perception is that if they are aware of the practice and understand how it works, then it might be an issue for discussion but this, however, may take a long time".

4.2.2.3.2 Analysis of the politics setting in Kenya (Politics anlge)

This section analyses the role, awareness, understanding and acceptance of the agroecology approach among key stakeholders engaged in the policy making process. We assessed whether they understand the agroecology approach and how it differs from other concepts, whether they accept it as a valuable approach and whether they would be willing to support and promote it in their policy work.

Actors involved in agriculture and related policy making and implementation process in Kenya

During focus group discussions (FGDs), the main actors (state and non-state) in agriculture and climate related policy making and implementation were identified. The major state actor identified was the Ministry of Agriculture, Livestock, Fisheries and Irrigation (MOALFI), specifically the policy directorate. In some cases, the engineering department within the MOALFI can initiate a policy development. County governments are also expected to identify policy gaps and implement policies at the county level.

Non-state actors identified were donor organizations, international non-governmental organizations (INGOs), national non-governmental organizations (NNGOs), universities, research institutes, development partners, private sector and civil society organizations (CSOs). Non-state actors such as donors and INGOs contribute through policy gap identification, funding, and providing scientific evidence to the development of policies. CSOs and NNGOs are usually involved in development and validation of the policies and lobbying policy makers to support policy proposals.

Table 2: Actors engaged in the Kenya policy making process and their roles

Actors	Roles
State actors	
Policy Directorate and Engineering Dept. at MOALFI	• Identify policy gaps • Main actor to develop policies
County Government	• Identify policy gaps • Once a policy has been developed, domesticate the policy to suit their context • Implement policies
Members of Parliament	• Pass or reject the policy
Non-State Actors	
Donor Organization	• Provide funding for policy development and/or implementation • Provide technical expertise
INGOs	• Provide funding for policy development and/or implementation • Provide scientific evidence to identify the extent and nature of the problem that the policy will address • Provide technical expertise
Universities and research institutes	• Provide scientific evidence to identify the extent and nature of the problem that the policy will address • Provide technical expertise
CSOs	• Involved in policy validation processes • Lobbying with policy makers • Summarizing the policy into a text that is easily understood by farmers and consumers • Policy implementation at grassroot level • Policy gap identification
Private sector	• Policy gap identification • Funding for policy development
Farmer organizations[21]	• Policy development and implementation

[21] Kenya small scale farmers' federation (KEFF); Kenya national farmer federation; Kenya Agricultural Industrial networks; Kenya Dairy Board

Notwithstanding the generalities outlined in Table 2, the specific roles and agendas of different actors are highly dependent on the policy being developed. Further, two insights that were given by FGD participants are particularly noteworthy:

"Kenya lacks a strong consumer movement that can participate in agriculture policy design and implementation."

and

"The policy directorate in the Ministry of Agriculture does a lot of moderation in policy development. They do not want every actor to start proposing policy development."

Overall perception of agroecology among stakeholders

The interviews and FGDs revealed that agroecology is an ill-defined and seldom used term among stakeholders in Kenya. Frequently, it is interchangeably used with Climate Smart Agriculture (CSA). For many actors there is not a clear line that sets agroecology apart from CSA. On the other hand, the perception prevails that agroecological practices are commonly used by Kenyan famers, although mostly under different umbrella terms. Only stakeholders who are directly involved in promoting agroecology (mostly CSOs) are able to define what it entails and clearly distinguish it from CSA.

For most of these stakeholders, agroecology is seen as a holistic farming process that involves a number of practices such as integrated soil and water management, crop diversification, use of natural processes and inputs in crop and livestock production and that emphasises sustainability, biodiversity and human health. It is considered an approach that can help communities adapt to the effects of climate change while at the same time building their resilience and hence a means of feeding the population especially at a time of changing weather patterns.

Most of the respondents felt that agroecology still needs to be researched on in terms of its potential benefits, unpacked in a way that will be clearly understood and the practices well explained before thinking of developing a policy; and even then, not all of them agreed there is need to have an agroecology policy. There is a diversity of opinion among the stakeholders in terms of accepting agroecological approaches for food production in Kenya. One government official pointed out:

"The ministry supports technologies that give farmers food, we do not have a blanket that this (agroecology) is the only thing to support. We support strategies which ensures farmers grow food and as much we would support agroecology, we still have to support the usage of conventional fertilizers for maximum yield."

A CSO representative, on the other hand, reiterated that:

"Agroecology is probably the only option to address climate change as it is a holistic approach to ecosystem protection".

The general agreement is that indeed climate change is making it impossible to grow food under the 'business as usual' scenario and therefore climate smart strategies should be incorporated. This will ensure farmers are able to produce food which can feed the population but at the same time caution should be taken to ensure that biodiversity is not hampered since it supports the functioning of agroecosystems which include adaptation to climate change.

Perception of agroecology in the context of climate change

Osumba (2018) states that there is a high potential for CSA policies to support systemic and sustainable agriculture, including agroecology. This conclusion is supported by the stakeholders who participated in the interviews and FGDs, concurring that agroecology has a space in climate change policy dialogues. However, their perception is that addressing climate change in agricultural sector does not have a single solution to it. It needs a number of strategies and agroecology is one of them. According to one interviewee:

"Some of the agroecology practices are already practiced by farmers such as crop rotation, soil and water conservation among others to fight the effects of climate change. While it is not a new concept, it is still not being discussed during climate change meetings."

Changing the mindset of Kenyan farmers and other stakeholders to embrace agroecology in the face of the changing climate might be difficult. According to another interview partner:

"Kenyans, including farmers and policymakers, don't like to change easily and so they are stuck at what they know. Therefore, introducing agroecology to Kenyans implies to change their mindset so that they are not only thinking about chemicals and new seeds, but they see things from a different perspective."

Increasing awareness on the potential of agroecology might change the perceptions of the wider population. Devolution of agricultural policy processes is a positive aspect in this case, since each county can be engaged in promoting agroecology elements and practices. Furthermore, the county government can develop their own agroecology polices or strategies that are embedded within or linked to climate change policies and use them to influence the national government. Unfortunately, this might take a long time to implement as one respondent stated:

"The mindset of policy making people at the national level is focused only on what they learned in college years ago and new ideas such as agroecology are not easily embraced. Additionally, a lot of funding/scholarships in agriculture are funded by donors who have an interest in something they want to promote (e.g. genetic modifications etc.) and hence trying to change the mindset of people trained in such a system is hard"

According to another respondent,

"Agroecology has a great potential to be included in climate dialogues because agroecology pushes for sustainable agriculture which considers the economic, ecological and social aspects of agriculture, important elements to consider when developing strategies for climate change mitigation. However, the challenge of agroecology is that of quantification. One critical question to ask is, what are the benefits vs losses when practicing agroecology? Agroecology should be unpacked in terms of what are the special practices which then need to be quantified. In climate change cycles, one should be able to report, that practicing agroecology to mitigate against climate change, it reduced X amount of GHG emissions, or it makes farmers more resilient by X percent etc. Unfortunately, what is currently being done is simply the promotion of agroecology without hard data to back its contribution to mitigation against climate change".

Finally, another respondent mentioned that

"Agroecology has space in climate change dialogues, but it should not be the main agenda. There can be an agricultural/climate change policy in place and agroecology to be part of one of the approaches towards mitigating impacts of climate change. For example, CSA strategy can be amended to adopt agroecology."

4.2.2.3.3 Institutional framework and coordination mechanism in Kenya (Polity angle)

Policy formulation and implementation in Kenya:

Kenya's constitution of 2010 introduced the devolved system of governance, with the main aim to bring services closer to the people. The devolved system introduced two levels of governance, the national and the county governments. One of the services to be devolved is agriculture and various county governments have put forth efforts and programs geared towards improvement of agriculture. The county governments are equally expected to be involved in agricultural policy development. However, despite agriculture being devolved from the national government, the Ministry of Agriculture, Livestock, Fisheries and Irrigation (MOALFI) at the national level is still playing a key role in identifying policy gaps and initiating policy development. Within the MOALFI, the Policy Directorate (PD) identifies policy gaps and develops policies, without involving the county governments. Other stakeholders at the national level can also identify a policy gap and spearhead development of a policy. As one participant of a focus group discussion (FGD) puts it:

"Development partners including donor organizations can identify a policy gap and engage the Ministry of Agriculture in development of the policy. Since such policies are not country driven, implementation is usually a problem. This has led to several policies being written and shelved."

During policy gap identification, the PD at the MOALFI has to address the following questions: What is the nature and magnitude of the problem? What groups in the population suffer from the identified problem? How did the problem come about and why does it continue? What are the immediate and underlying causes? What should be done about the problem? (KIPPRA, 2015)
The ability to successfully implement agricultural policies requires a keen knowledge of the policy implementation plan in order to trigger change amongst farmers and other affected stakeholders, such as consumers. However, in Kenya the policy makers who are at the national level are often removed from implementing institutions. Policy implementation is under the jurisdiction of county governments. Once a policy has been developed, it is devolved down to counties, who might alter it to suit their county context. CSOs are also expected to implement the policies at a local level, as highlighted by an FGD participant:

"*The work of the government is to develop policy and its implementation framework. However, actual implementation is left to the other players on the ground such as CSOs, farmers' organizations, development organizations etc."*

Options for stakeholders to render the agroecology ideal scenario reality

From the focus group visioning exercise, multiple entry points for mainstreaming agroecology in Kenya have been identified and their number might increase as policy makers, farmers, and other stakeholders become more aware of the opportunities and potentials that agroecology provides in the face of climate change. In order for agroecology to reach its full potential, there are several issues that the various stakeholders can address to achieve the ideal institutional setting as outlined in the section above:

- **Review existing agricultural policies and develop guidelines on agroecology**. This can be done by government officials in conjunction with CSOs and NGOs.
- **Working with local communities and farmer groups** to promote the concept of agroecology and setting up demo-farms for farmers to learn and share knowledge.
- **Capacity building and awareness raising** for farmers, government officials, CSOs, consumers and private sector entrepreneurs.
- **Conduct research and provide evidence** to show that AE can contribute to increasing food security.
- **Introduce agroecology in school curricula.**
- **Train agricultural extension workers** and other agro-advisory service providers on agroecology.
- **Provide incentives for private sector stakeholders to invest in agroecology**.
- **Labelling of agroecology products and promoted in the markets**. Additionally, create demand for agroecology products - working closely with the media to market AE products.
- **Promote diverse diets**, this will ensure more crop varieties will be grown. Kenyans should be encouraged to explore other varieties of food in order to improve their nutrition and increase the demand for other crops varieties.
- **Influence donor and development partners** to set it as an agenda so that the government can easily adapt it.
- **Encourage agroecology as a social and political movement**: bring people on board to help convince profiteers of the conventional systems e.g. fertilizer and seed industries.
- **Piloting and testing of agroecology practices** in different agro-ecological zones and culturally diverse communities in Kenya. The country has diverse climatic conditions that can support different agroecology practices. The potential for each area should be identified tested and promoted for maximum efficiency rather than engaging in uniform farming activities, which are not sustainable for some areas.
- **Unpack and explain agroecology** so that farmers and diverse stakeholders can understand it. Farmers do not get excited about terminologies. They need simple practices that they can easily use on their farms

Table 3 summarizes some key results of the analysis of the policy potential for agroecology in Kenya.

Table 3: Summary: policy potential of agroecology in Kenya. The policy potential is characterized by the following challenges and current opportunities to design and implement agroecology policies and strategies to hedge against climate change in Kenya:

Challenges	*Opportunities put forward by respondents*
Capacities and knowledge	
• Lack of capacity at the national level to develop appropriate/ country-specific agroecological policies and at the county level to domesticate such policies • Knowledge of agroecology in relation to climate change is a major obstacle • Major stakeholders lack knowledge on definitions and concepts of agroecology	• Integrating agroecology into CSA strategy and implementation plan • Build capacities at national and county levels on agroecology and its importance in building resilience • Engage civil society and academic institutions, knowledgeable about agroecology and climate change action, to help sensitize on agroecology

<table>
<tr><td>There can be limited staff capacity at county level to implement agroecology</td><td>Development of agroecology curricula</td></tr>
<tr><td>Prioritization of agroecology</td><td></td></tr>
<tr><td>The prioritizing of agroecology is non-existent at the national level
A lack of knowledge among policy makers at national level with regard to the importance of agroecology in addressing climate change in agriculture sector</td><td>Provide evidence-based examples and case studies on why agroecology is important in addressing climate change
Communicate the evidence carefully to policy makers explaining why agroecology is important for building resilience
Demystify ‘agroecology’ – using advocacy strategies, highlight the practices and benefits of agroecology for farmers</td></tr>
<tr><td>Institutional structures and platforms to support agroecology</td><td></td></tr>
<tr><td>Currently, there are no institutional structures or platforms for supporting agroecology
Since CSA strategy and implementation plan are in place, introduction of agroecology might create confusion
Including the private sector and working with non-state actors in agroecology can be an issue
Weak monitoring and evaluation system of policies; therefore if an agroecology policy is developed, it may be shelved and never implemented
Agroecology has not been promoted / incentivized to a point where it can be adopted at a large scale</td><td>Sensitization on agroecology is needed so that stakeholders, especially farmers, are aware of agroecology.
Engage CSOs and other non-state actors in advocating for agroecology
Mobilize or engage the private sector involved in agriculture in agroecology dialogues
Start advocacy and alliances at county level especially counties that are already accepting of agroecology and then cascade from there to other counties
Embed agroecology in existing policies that already have implementation strategies</td></tr>
<tr><td>Financial and time resources</td><td></td></tr>
<tr><td>It is too costly and there is a lack of resources to develop and implement a policy in Kenya
Time consuming: the process involved in designing an agroecology policy will be long</td><td>Embed agroecology policy within existing policy or strategy such as KCSA and KCSAIF
Use a pilot county such as Kiambu where agroecology policy is already understood to showcase what can be done with limited resources</td></tr>
</table>

4.2.2.4 Conclusion

Climate change is becoming a critical concern in Kenya since it is deterring development efforts especially in the agricultural sector. Societal awareness of and political will to address the impacts of climate change are growing and as a consequence there is an increasing potential for systemic alternatives to conventional agriculture.

This study reveals several insights on the policy potential of agroecology in Kenya and describes existing opportunities and challenges to institutionalizing agroecology:

It is clear from the literature review, semi-structured interviews and focus group discussions that the concept of agroecology is not yet clearly understood by stakeholders, including government officials, policy makers, CSOs, NGOs, and private sector actors. Even most stakeholders that are somewhat aware of agroecology have not embraced it as an agricultural practice that can contribute to food security and build resilience to climate change in Kenya.

Nonetheless government officials recommend mainstreaming agroecology within existing policies and strategies such as the Kenya CSA strategy and its accompanying implementation strategy and the new agricultural policy. They also propose providing subsidies and incentives to support farmers to invest in agroecology practices. Private sector actors are usually not willing to invest in organic agricultural practices such as mass production of organic fertilizers and pesticides, and the government does not have incentives to entice them. Furthermore, according to government officials who have an understating of agroecology, farmers may not embrace agroecology, as it is labour and resource intensive. These two constraints can be addressed by providing subsidies and incentives to encourage farmers to adopt agroecology practices.

The current agricultural and related policies will not contribute to sustainable food systems that enhance community and socio-ecological resilience to climate change. Additionally, the current Kenya CSA and other agricultural policies are not well suited in terms of achieving transformative visions of agroecology that are supported by fundamental principles of human and social values and promote circular and solidarity economy.

Engaging multiple stakeholders that have an interest in agriculture can help to improve the understanding and adoption of agroecology. Of fundamental importance is an improved evidence base for informing policy makers of the potential of agroecology to contribute to food security and nutrition as well as climate change strategies at national and county level. The key steps and entry points for mainstreaming agroecology are:

- Alignment and coherence of policy processes related to agriculture and climate change towards agroecology elements and practices.
- As Kenya is currently formulating its agriculture policy, this presents a great opportunity to re-evaluate the policy to ensure that agroecology is included.
- Develop agroecology guidelines to guide and inform different stakeholders, especially policy makers. This can also include capacity building, awareness creation and sensitization for all stakeholders on agroecology.
- Provide scientific evidence that shows that agroecology can contribute to increasing food security and nutrition in Kenya and share this evidence with policy makers.

For the longer term the following programmatic activities are recommended to ensure a sustained embedding of agroecology elements in Kenya:

-Development of an agroecology strategy and implementation plan that is anchored to an existing agricultural policy. Currently Kenya is drafting its agricultural policy 2019 which is an opportunity for such. Agroecology can also be mainstreamed into the existing CSA strategy and implementation mechanisms that is being promoted across the country.

-Use the devolved county system to integrate agroecology practices. Some of the counties, for example, Meru, Kiambu, Kitui, Embu and Tharaka Nithi Counties are already receptive of agroecology.

-Further opportunities exist in including agroecology in education curricula, by supporting farmer organizations that can foster adoption of agroecology practices, and training of agricultural extension workers on agroecology

4.2.3 Technical potential in Kenya

4.2.3.1 Methodology

4.2.3.1.1 Defining Agroecological Systems for the Kenyan Context

Two institutions, Sustainable Income Generating Investment Group (SINGI) and The Institute for Culture and Ecology (ICE), were noted to support farmer groups in adoption of sustainable agriculture practices in Western (Busia County) and Eastern (Meru & Tharaka-Nithi County) Kenya respectively, as described below and therefore selected for this agroecology assessment.

Busia county is in the Western part of the country where agriculture is the main economic activity of the region. The land holdings range from 0.4 Ha for small-scale farmers to 6 ha for large-scale farming, 84% of the crop output is for subsistence use (USAID, 2014). Approximately, 36% of the total arable land in the area is under maize, whereas sorghum, cassava, cash crops occupy 10% ,14% and 10% respectively. The observed climate extremities include increased frequency of drought occurrence from 10 years to every 2-3 years adversely affecting productivity which is mainly rain-fed. Agricultural productivity is further affected by declining soil fertility (MoALF, 2016).

In Busia County, SINGI CBO is recognized as one of the institutions promoting biodiversification through growth of African Leafy Vegetables (ALV) to enhance sustainability and the reclamation of once diminishing nutritious genetic resources. Aside from promoting diversification, SINGI also equips farmers with knowledge on i) integrated management of soil fertility and pest through production of own compost and intercropping and ii) input substitution using manure, crop residues, compost and biopesticides. Farmers with acidic soils are encouraged to use manure and wood ash to increase the availability of nutrients to the crops. Other practices taught include water and soil conservation techniques (raised beds, semi-circular bunds/*mandalas and* keyhole gardens). The transfer of technology is through farmer-to-farmer training and demonstration farms set up by farmer groups in different locations within the county. SINGI was established in 2005 and has grown to a membership of over 50 groups with an average of 20 farmers per group.

Tharaka-Nithi and Meru County is located in the Eastern part of Kenya where agriculture is the main economic activity. The projected changes in climate include an increase in moderate temperatures which may lead to future moisture stress (MoALF, 2017). The main cultivated crops include green grams, millet, sorghum, cowpeas, pigeon peas, maize and beans (Recha et al., 2017).

In Eastern Kenya, the Institute for culture and ecology (ICE) promotes agro-ecological farming practices such as the use of indigenous crop varieties, agroforestry, organic farming and livelihood diversification among smallholder farmers. ICE has successfully conducted training programmes geared towards food sovereignty with impacts including: i) the revived use of twelve (12) varieties of indigenous seeds, ii) erection of effective cereal storage structures for over 100 households, iii) equipping 470 households with water harvesting and storage tanks and iv) the adoption of agroecological practices such as agro-forestry, terracing, water and soil conservation techniques by at least 800 farmers.

The reduction of industrial input usage can be regarded as level 1 agroecology while the substitution of conventional practices with agroecological practices can be regarded as level 2 agroecology (Gliessman, 2016; Mier y Terán Giménez Cacho *et al*>, 2018) . Based on the training and eventual adoption of the practices farmers were trained on (to varying degrees), farmer affiliation with SINGI and ICE for more than 5 years was considered to be in “agroecological transition” or “agroecological”.

4.2.3.1.2 Sampling Design

The sampling approach was based on spatial distribution and randomized sampling of farmers. The spatial sampling focused on 88 farmers from 4 agroecological zones (AEZ), spanning 3 county regions in Kenya namely Busia, Meru and Tharaka-Nithi. The distribution across county regions was to enable maximum heterogeneity of the sample in terms of gender, age and wealth. Farmers sampled were further categorized as agroecological ($N = 44$) and non-agroecological ($N = 44$) (Table 4).
The agroecological farmers (N = 23) from AEZ LM1 and LM2 were randomly selected from SINGI’S membership list while the rest of agroecological farmers (N = 21) located in AEZ LM5 and IL 5 were randomly selected from a membership list of farmer groups affiliated with ICE (Table 4).

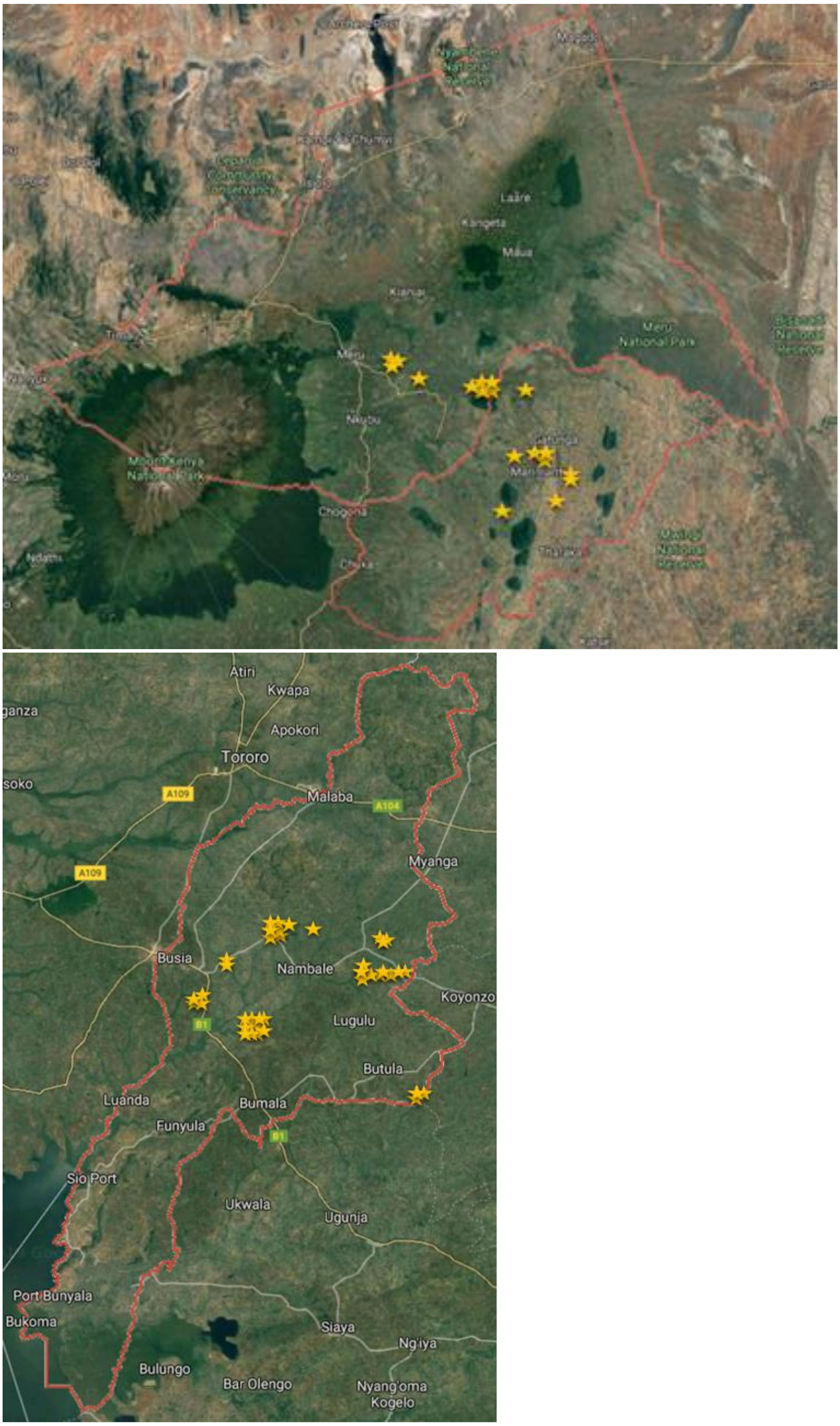


Figure 17: Maps of the three Kenyan counties (Meru, Tharaka-Nithi and Busia (from left) and the sampling sites

For comparison purposes, non-agroecological farmers (N = 44) were randomly selected from the same regions (Busia, Meru and Tharaka-Nithi) to closely match the agroecological/climatic conditions, livelihood strategies and land holding patterns of the agroecological producers. Key trained personnel

(extension officers) of SINGI and ICE, identified a list of non-agroecological farmers within their areas of operation who were later picked randomly for participation in the survey.
The data collection through survey was conducted beginning of July, typically end of the wet season or harvesting for the cropping season. Based on the Kenya Meteorological Department review of the long rain season of 2019 (March-April-May), the seasonal rainfall was characterized by late-onset and poor (below average) temporal and spatial distribution (KMD, 2019).

Table 4: No. of farmers sampled from four agroecological zones in Kenya

Zone	**Characteristics of zones**		**No. of Farmers in each zone**	
	Altitude (m)	**Min. Annual Rainfall (mm)**	**Agroecological Farmers**	**Non-agroecological Farmers**
LM1	1200 -1440	1800-2000	23	23
LM2	1200-1350	1550-1800		
LM5	<900-1800	500-900	21	21
IL 5	<900m	500-900		
Total			44	44

Characteristics of the AEZ: Western Kenya, AEZ Zones LM1 – Lower Midland Sugar Cane Zone (sub-counties sampled Nambale, Matayos and Butula); LM2 – Marginal Sugar Cane Zone (sub-counties sampled Teso North), the main staple crop grown in the sampled sub-counties is maize. Eastern Kenya, AEZ LM5 – Lower Midland Livestock – Millet Zone (sub-counties sampled Tharaka-Nithi), AEZ IL 5 – Inner Lowland Livestock – Millet Zone (sub-county sampled – Imenti North) (Jaetzold *et al*>, 2011).

4.2.3.1.3 Specifities for the Kenyan SHARP survey

- administered via SAMSUNG Galaxy Tab A).
- Four enumerators with minimum a BSc degree, received training on SHARP Tool from 17th to 20th of June 2019 and conducted the survey between 1st and 14th of July under the supervision of a research consultant.

4.2.3.2 Overall Findings SHARP resilience assessment.

There was no statistically relevant difference between the three counties in regard to their performance in SHARP even though they were located in different agroecological zones. Due to the homogeneity of the results, the differences in SHARP performance were analysed wholly as either agroecological or non-agroecological systems without regard for the agroecological zones.

Statistical analysis **indicated a significant difference *(P* < 0.001) between the average mean overall SHARP scores for the agroecological and control group farmers.** The agroecological farmer mean score was 5.2% higher than the non-agroecological farmer (Table 5).
The resilience scores of both the agroecological (59.9%) and non-agroecological farmers (54.7%) characterises the systems as mid-level climate resilience which implies that the farmers have certain abilities and knowledge to withstand unexpected shocks and climate variability, however, there is still a need to further strengthen their capacity to adapt to climate change (Hernandez-Lagana, Nakwang & Muhamad, 2018).
For the **agroecosystem resilience indicators, significant statistical differences were observed for 7 of the 13 agroecosystem indicators whereby the scores for the agroecological farmers were higher than for the non-agroecological farmers (*P* < 0.05**) (Figure 18).
Table 5: Summary of SHARP dataset scores for sampled farmers

Variable	Type of Farmer	Sample No.	Mean (%)	Min (%)	Max (%)	Standard deviation	Coefficient of Variation (%)
SHARP	Agroecological	44	59.9	43.8	75.9	±7.1	10.7
SCORES	Non-agroecological	44	54.7	40.2	67.7	±6.6	10.3

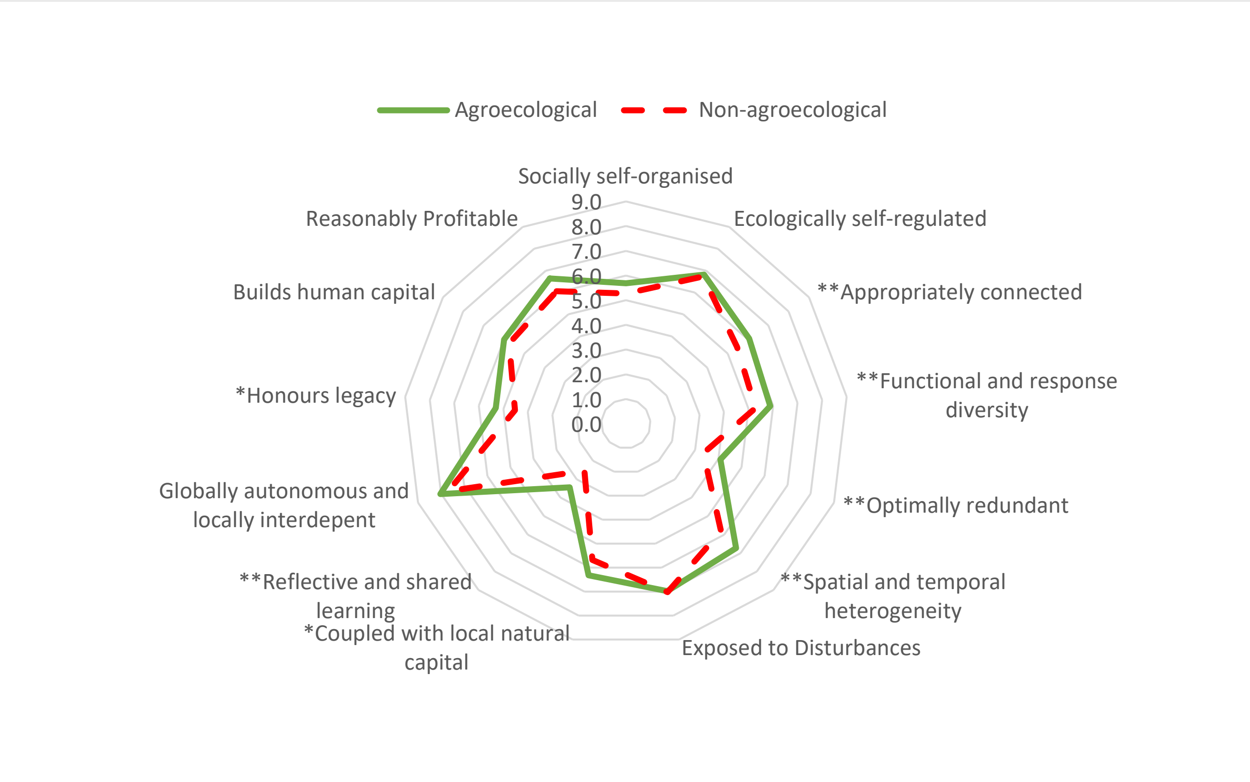


*Figure 18: Agroecological and non-agroecological mean scores for 13 agroecosystem indicators for climate resilience. Significant differences were observed in 7 of 13 resilience indicators determined by t-test and indicated as *P < 0.05, ** P < 0.01 ***P > 0.001. Agroecological mean scores were higher compared to the non-agroecological farm system for all the resilience indicators that are statistically different.*

At the sub-indicator level, significant differences in mean scores were observed in 12 of 92 sub-indicators ($P < 0.05$). Agroecological farmers had higher mean scores in 11 of these 12 sub-indicators. At the module level, mean scores for 6 of 36 modules were significantly higher for the agroecological farmers than the non-agroecological farmers (Annex 7.3).

Priority ranking

Based on the priority ranking assessment (SHARP's self-assessed importance from the technical, adequacy and importance scores of each module as generated by SHARP tool) as shown in Table 6 and Annex 7.4, both the agroecological and non-agroecological farmers identified similar modules as priorities, sharing 15 of the top 20 modules for intervention.

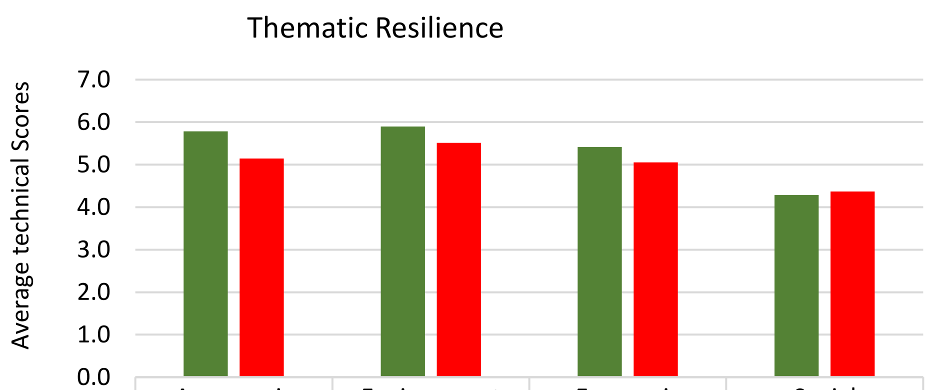
Table 6: Priority ranking assessment (Greatest priorities on top and least priorities at the end of the table) for agroecological and non-agroecological farm systems based on technical, adequacy and importance scores of each SHARP module. The lowest scoring modules are considered of the highest priority and requiring intervention.

Sharp farm system module	Agroecological farm system	Non-agroecological farm system
Insurance	1	1[a]
Animal Breeding Practices	2	2[a]
Non-Farm Income Generating Activities	3	7[a]
Water Access	4	4[a]
Land Access	5	8[a]
Leguminous Plants and Trees	30	32
Animal Nutrition and Health	31	30
Decision Making (Household Level)	32	33
Access to financial Services	33	36
Major Productive Assets	34	31
Information and Communication Technologies (ICTs)	35	34
Decision Making (Farm Management)	36	35

Domain results

SHARP results were also assessed on the four domain level of agronomic practises, environmental aspects, social interactions and economic components as shown in Figure 19. Based on the technical scores (4.3 – 5.9), the farmers indicate a mid-level resilience.

A **significant difference was observed in the agronomic practises domain** (P < 0.001) which covered modules on agricultural production, crop production, intercropping, pest management, animal production, animal health and nutrition, new varieties and breeds, trees and information access.



	Agronomic practises	Environment aspects	Economic components	Social interactions
Agroecological Farmers	5.8	5.9	5.4	4.3
Conventional Farmers	5.1	5.5	5.1	4.4

Figure 19: Average technical scores for the four domains

4.2.3.3 Detailed Results: Agroecosystem resilience indicators

This chapter provides a detailed analysis of the agroecosystem resilience indicators results

4.2.3.3.1 Socially self-organized

The socially self-organized indicator assesses the farmers' ability to organize into grassroots networks and institutions such as co-ops, farmer's markets and community sustainability associations. There were no significant differences between the two farm systems. Agroecological and non-agroecological farmers showed a similar access to communal land resource and financial support.

To assess this organization regarding access to local farm markets the two measurable variables considered for this indicator were i) household to market distance and ii) access to market price information; however, it is important to highlight that a multiplicity of indicators can be used (Chamberlin and Jayne, 2013) to proxy this.

Most farmers indicated having access to a local market within a 10 km radius. The findings are consistent with a study by Chamberlin & Jayne (2013), indicating household to market distances of roughly 0.85 km which implied that even "remote" villages which lacked physical access to infrastructure such as all-weather roads and electricity, still had i) a large number of small traders competing for local purchases and ii) many villagers are able to and choose to sell their grain surpluses at the farm gate. The proximity to markets signifies a local food movement which is smaller and easily adaptable to changing conditions of the local groups when compared to larger groups at a regional or national level hence more resilient (Cabell & Oelofse, 2012).

A slight difference was observed with market pricing decisions as 48% of agroecological farmers compared to 58% of non-agroecological farmers set produce prices based on market prices. According to Alene et al., (2008), price information in Kenya is mostly published in newspapers and only for the major markets which are not accessible to majority of the farmers. This results in the farmers relying on physically gathering information from local assembly markets or by letting main dealers/buyers to set the price. The farmers reported that market prices tend to be volatile yielding lower returns during surplus harvest seasons, which has a direct impact on their income and indirect impact on the resilience of the farmer.

Cooperatives have the benefit of organizing farmers into strong producer and marketing associations; however, only 3 of the 88 farmers sampled (all agroecological farmers), declared to have relied on cooperative organizations to set the market prices for their agricultural produce.

The priority ranking assessment indicates that both farmer groups deemed group membership as a priority of near-equal importance, priority No.21 and No.17 respectively for the agroecological and non-agroecological farm systems (Annex 7.4).

4.2.3.3.2 Ecologically self-regulated

There were no significant differences observed for the agroecological and non-agroecological farming systems for the ecologically self-regulated indicator. According to Cabelll & Oelofse (2012), a self-regulating agroecosystem is governed by the feedback mechanisms created through ecosystem services such as the hydrological cycle, biodiversity and soil resources.

Self - regulation was assessed using sub-indicators such as soil health, environmental-friendly energy sources, presence of ecosystem engineers (buffer zones), biodiversity (perennials and trees), utilization of local animal breeds and crop varieties, fertilizer practices and leguminous plants. There were no significant differences between the farming systems at the sub-indicator level, e.g. the majority of the agroecological (90%) and non-agroecological farmers (88%) were observed to utilize local animal breeds and local crop varieties. Likewise, 100% and 95% of the agroecological and non-agroecological farmers (respectively) grew perennial crops while both farming systems appeared to incorporate agroforestry based on the presence of trees on their farms. Traditional varieties offer great defences / buffer capacity

against vulnerability and enhance harvest security in the midst of diseases, pests, drought and other stresses (Altieri, 2009) .
Due to lack of waste management services in the areas sampled, farmers utilizing synthetic pesticides were noted to dispose of their containers through burning, burying in soil or throwing in pit latrines. Poor disposal methods for pesticide waste may result in biodiversity loss, soil pollution and health risks. Based on the priority ranking assessment (Annex 7.4) both farm systems indicated a high importance, (ranked as priority 11) for farm inputs.

4.2.3.3.3 Appropriately connected

Significant statistical differences ($P < 0.01$) were evident between the agroecological and non-agroecological systems with a higher mean score (6.1%) for agroecological farmers (Figure 18 and Table 5). As one of the resilience indicator agro-ecosystems, appropriately connected is a measure of the dynamic relationships and collaborations within the agro system over a spatial and temporal scale (Cabelll & Oelofse, 2012).
The relationships at the farm/field level cover aspects of biological interactions e.g. vegetation growth through nutrient cycling, predator/prey interactions, competition, commensalism and successional changes (Altieri, 2002). Connectedness outside the farm level reviewed existing networks between the farmers, suppliers, fellow farmers and consumers. Ties with multiple suppliers, outlets and fellow farmers ensures non-essentiality and continued functionality within an agro system in case one of the ties is cut off (Cabelll & Oelofse, 2012). The sub-indicators reviewed to verify these collaborations included access to information (market prices, weather forecast and climate adaptation practices), the existence of multiple suppliers for farm inputs, access to markets and veterinary services and the level of trust among community members.
The sub-indicators used to measure farm-level relationships are: ….
One of the farm-level relationships were assessed through the sub-indicator of intercropping, there were no significant differences between the farm systems. This may imply that non-agroecological farming for smallholder farmers in Kenya is not strictly a monoculture. According to Adamtey et al., (2016), non-agroecological farming for smallholder farmers in sub-Saharan Africa consists of maize-mixed farming where farmers grow more than one crop species for subsistent and commercial purposes. The agroecological farmers were observed to incorporate intercropping practices as a means of crop diversification.
For the exogenous relationships (ties outside the farm level), significant differences were observed for access to information and access to market between the two types of farming systems. The agroecological farmers indicated higher access to information to climate adaptation practices and weather patterns.
The information pathways for climate change adaptation and weather patterns could be most likely due to extension services provided through NGOs such as ICE/SINGI. According to past research on sources of agricultural information in Kenya (Goldberger, 2008), NGOs are the most important source of agricultural information for sustainable methods such agroecology and organic farming. The information is disseminated through formal workshops, exposure visits, demonstration farms and conversations with NGO staff. Some of the organic techniques taught and practised by the agroecological farmers included *mazimbuko* trenches, *mandala*, raised beds and key hole kitchens which are paramount for water conservation and consequently, climate adaptation. Access to these extension services increases the probability of adopting different climate smart/adaptation practices which would hedge the farmer against climate change (Belay *et al.*, 2017).

Access to markets for the appropriately connected indicator was assessed through the ability of the farmers to sell their produce when desired and the use of certification schemes to increase product value. Based on the mean scores, the agroecological farmers had higher chances of selling their produce when desired compared to non-agroecological farmers. However, only 7 % of all farmers were observed to participate in certification schemes. The farmers cited various reasons for the lack of participation in the schemes, the main one being non-existence of these within their reach.
Based on the priority scores, agroecological farmers indicated community cooperation as of greater priority (ranked 16) compared to non-agroecological farm systems (ranked 28) (Annex 7.4). This is in line with the agroecology principles in which the links to the members of the community for knowledge sharing and problem solving are key to strengthen sustainability and resilience.

4.2.3.3.4 Functional and response diversity

Significant differences were observed between the mean scores of the agroecological and non-agroecological systems ($P < 0.01$) for this indicator. Functional and response diversity was assessed using sub-indicators such as diversity in crop species, tree species, animal species, agricultural production activities, food, landscape and fertilizer inputs; assets owned; non-farm income generating activities; membership in groups; pest and disease management practices**.** Significant differences were observed in species diversity ($P < 0.001$) and group membership ($P < 0.01$).

Higher diversity in crop production was evident with 69% of agroecological farmers, as they tend to mix both seasonal and perennial crops in the same system (usually more than 5 seasonal and perennial species), compared to only 48% of the non-agroecological farmers (Figure 20). According to Folke, (2006), biological diversity is essential to a system's ability to attain resilience as it improves the capacity for a system to self-organize both in absorbing disturbance, regenerating and re-organizing. As biological diversity, economic and social diversity are important for climate resilience as they serve as buffer when certain aspects of the farm system are jeopardised.

The practise of crop diversification for the agroecological farmers was likely due to capacitating through NGO's and CBO groups and to spreading of climate related risks. Thus, agroecological farmers appear to have higher adaptive capacity than non-agroecological famers.

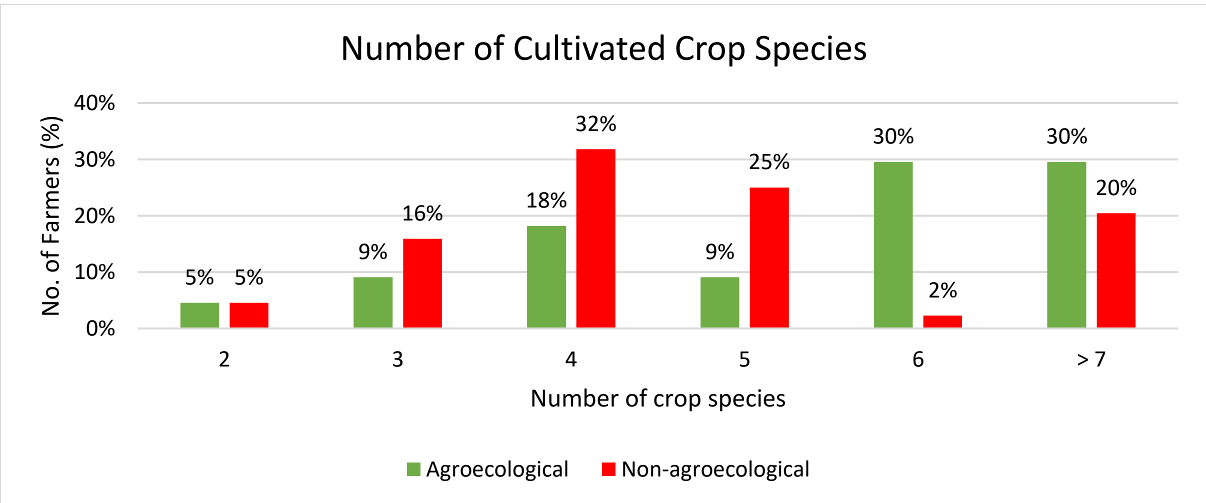


Figure 20: Number of crop species grown

The agroecological farmers were also noted to have active membership in multiple groups compared to non-agroecological farmers. Both farmer groups regarded additional and diversified income from non-farm activities as one of the top 10 priorities to enable household food security and enhanced resilience (there was also no statistical difference for this sub-indicator) (Annex 7.4).

4.2.3.3.5 Optimally redundant

Optimal redundancy serves to ensure elements perform multiple functions as multiple elements could perform a single function in an agroecosystem (Cabelll & Oelofse, 2012). In essence, ecosystem's redundancy serves as the backup and ensures functioning should any element fail in the case of shock. There were significant differences between the agroecological farmers and non-agroecological farmers ($P < 0.01$) (Figure 18). Redundancy was marked by access to multiple sources of water, energy, nutrients, seeds, financial sources; access to land; multiple varieties of crops and animal breeds; animal nutrition; food stocks and presence of cereal banks (see also box 1 below on that particular aspect). Of particular importance on these sub-indicators was the varietal diversity, which captured the number of breeds owned and the number of varieties cultivated ($P < 0.01$). Similar to crop diversification, agroecological farmers had a higher reliance on multiple traditional crop and animal varieties.
The average private land area owned for the sampled farmers was 1.47 ha. Access to communal land resources for pasture and other agricultural activities was low, where only 17% of all farmers had access to communal agricultural land and 23% had access to pasture land. Increased farm size has a positive influence on adaptation strategies as it increases the probability of planting numerous fodder trees and integrating crop with livestock production and therefore allowing for the ecological redundancy which contributes to resilience building of agroecosystems. It also provides an opportunity for crop diversification thereby distributing risks associated with climate variabilityThis corrobrates, Alen *et al.,* (2008) who hypothesised that a minor increase in access to land per capita (1%) would boost market participation of farmers by 11%. Improved market participation will strengthen the multiple networks of the local food movement as well as increased income for the individual farmer positively contributing to their resilience levels.

Seed granary for the "Agroecological" farmers in AEZ IL 5. a) The equipment was provided by Biovision Foundation and ICE NGO. Farmer testimonial: The equipment allows the farmers to store their seeds for up to upto a period of 3 years, which is more effective than storing seeds in the (b) gunny bags. The seed granary is also useful to farmers not only to store seeds for the next cropping season but also for food in emergencies during the failed long rains. The farmers were not actively involved in cereal banks however they pointed to the potential of cereal banks to stabilize prices/as a source of credit. If cereal banks were set-up as feature within their farmer's group, during periods of urgent need one could have an option of borrowing money from the farmer groups against his/her seeds instead of selling them at extremely low prices due to urgent and unexpected needs.

BOX 1. *Cereal Bank*

Based on the priority ranking assessment (Annex 7.4), both farmer groups indicated access to land as a major priority (ranked 5 and 8 for agroecological and non-agroecological farmers respectively).

Spatial and temporal heterogeneity

This indicator looks into the patchiness of the farm system and across the landscape. As such, it comprises aspects related to the diversity of across and within agricultural activities, practices uses for resources management and landscape diversification.

Agroecological farmers were observed to have a significantly higher degree of spatial and temporal heterogeneity ($P < 0.01$). At the sub-indicator level, these differences were evident in temporal heterogeneity ($P < 0.01$) as intercropping, and a mix of crop cultivation ($P < 0.01$).

Agroecological farmers more commonly used land management practices such as agroforestry, crop rotation and manure/composting to increase the temporal and spatial heterogeneity when compared to their non-agroecological counterparts.

This can be attributed to the higher access of agroecological farmers to technological know-how through farmer to farmer training that allowed their diffusion and adoption of such techniques. The adoption of the techniques increases the adaptive management within the Agroecological systems when compared to the Non-agroecological systems. Based on the priority ranking assessment, non-agroecological farm systems had a higher priority to learn land management practices (ranked 12) compared to agroecological farm systems (ranked 28) (Annex 7.4). The agroecological farmers also indicated a higher mix of crops through planting more perennial and seasonal crop species.

4.2.3.3.6 *Exposed to disturbance*

There were no significant differences between the agroecological and non-agroecological farmers with regard to this indicator; implying a similar level of exposure to disturbances. At the sub-indicator level, exposure to disturbance was denoted by the presence and management of weeds; climate-related relate shocks experienced; presence of buffer zones; use of pest management practices; presence of animal diseases; water and soil quality and external financial support received. Due to the similar geographic setting, the farmers reported experiencing comparable disturbances in climate-related events such as rainfall variability and other shocks hence the lack of differences for this resilience indicator. These findings were similar to a study by Heckelman et al., (2018) who found no significant differences between organic and non-agroecological rice systems due to both systems experiencing comparable levels of multiple small-scale disturbances.

4.2.3.3.7 *Coupled with local and natural capital*

Coupled with local and natural capital indicator is an assessment of the system's ability to recycle and reuse waste and encouraging the system to live within its own means (Heckelman, Smukler and Wittman, 2018).

It was measured in terms of land improving practices (use of techniques improving the spatial and temporal heterogeneity, presence of leguminous plants and trees, use of natural fertilizers), energy and water conservation practices, water quality, pest management practices, the presence and increase/decrease trend of trees within the farm. Although there were significant differences reported for the use of land improving management practices, there were no statistical differences observed in the fertilization practices, growth of leguminous trees and pest management practices. **Ultimately, due to the differences in land management,** significant differences were observed ($P < 0.05$) in the coupled with local and natural capital indicator.

Further assessment of the types of inputs used in the farm systems revealed that approximately 50% of the agroecological farmers relied on natural fertilizers compared to 18% of non-agroecological farmers. Non-agroecological farmers mostly applied a mix of natural and synthetic fertilizers (57%) compared to agroecological farmers (41%) (Figure 21). Overall, more agroecological farmers relied on crop and farm residues, compost and manure for fertilization developing a higher adaptive capacity of converting waste to resource which contribute to the preservation of the natural resource base, increasing climate resilience and sustainability of the farm systems.

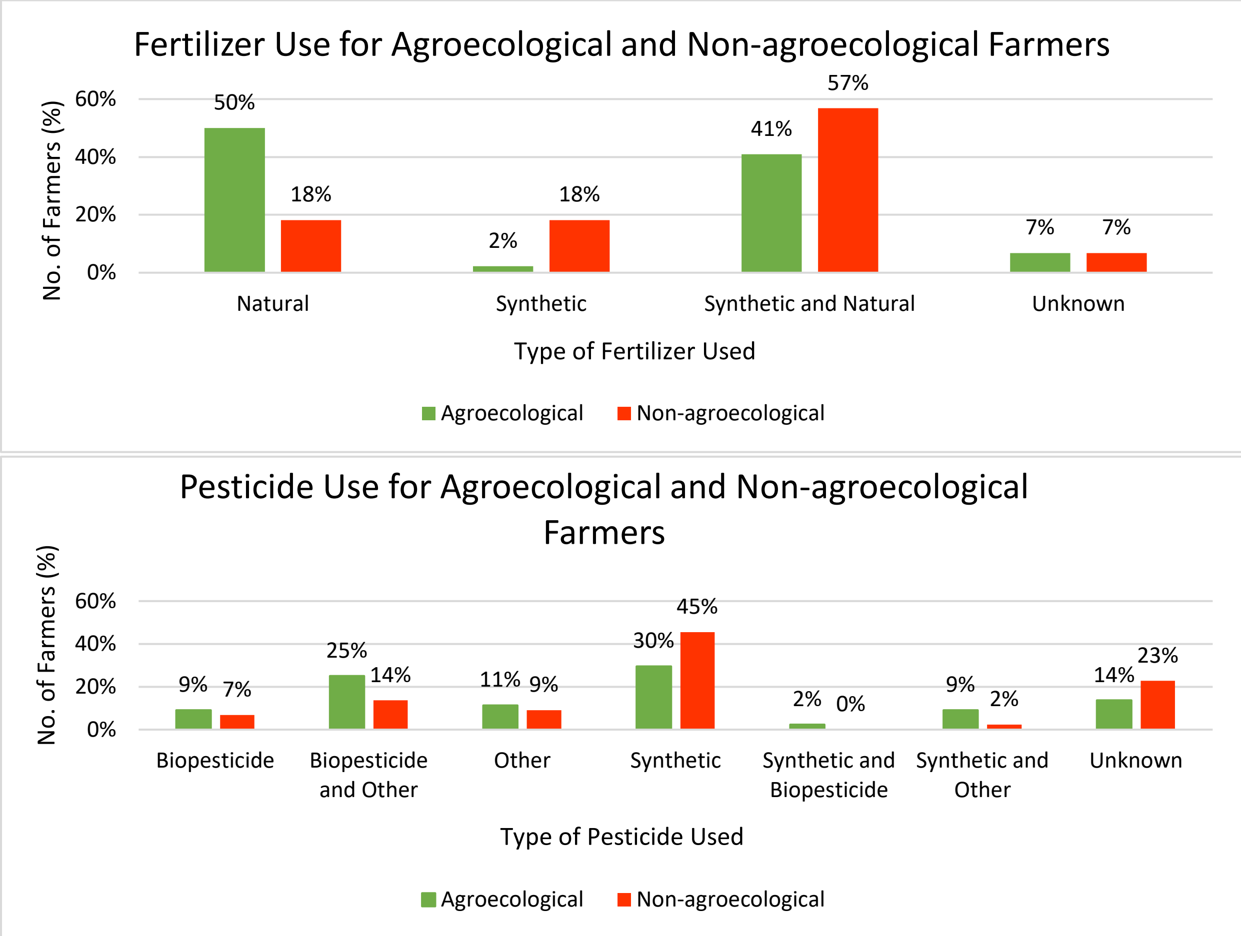


Figure 21: A comparison of the synthetic and natural input use between agroecological and non-agroecological farmers. Approximately, 55% of the agroecological farmers relied on natural fertilizers compared to 18% of the non-agroecological farmers.

For the agroecological farmers, 30% applied synthetic pesticides when compared to 45% of the non-agroecological farmers. The use of bio pesticides was comparable between the two farm systems (9% and 7% respectively for agroecological and non-agroecological). The lower use of synthetic pesticides and higher use of Bio pesticide and other methods for pest control among agroecological farmers is reflective of the level of awareness of environmental quality and soil health effects. Input substitution is not only a maker of agroecological transition (Gliessman, 2016) but it also denotes the reliance of natural systems to self-regulate making it more resilient (Cabell & Oelofse, 2012). Based on the ranking assessment, pest management practices emerged as one of the top priorities of near equal importance for both agroecological (No.12) and non-agroecological (No.13) farmers (Annex 7.4).

4.2.3.3.8 Reflective and shared learning

Active membership in agricultural groups provides a platform for reflection and shared learning leading to an increase in the adaptive capacity of the actors in the agro system. The actors (farmers) are able to anticipate the future based on experiences rather than the present conditions. The adaptive capacity will, therefore, trickle down to the system (farm) itself (Cabelll & Oelofse, 2012). SHARP methodology attempts to capture this through the inclusion of questions related to group membership, access to information and changed behaviour after expected and unexpected shocks are experienced.

Significant differences were observed between the two farm systems for the reflective and shared learning indicator ($P < 0.01$). At the sub-indicator level, agroecological farmers showed a significantly higher participation ($P < 0.001$) in agri-related groups compared to non-agroecological farmers Agroecological farmers also indicated better access to information on the weather forecast ($P < 0.05$). The access to weather information by agroecological farmers means they are better able to plan their agricultural activities which leads to informed adaptation planning and higher resilience level.

4.2.3.3.9 Globally autonomous and locally interdependent

No significant differences were observed between the two farm systems for the globally autonomous and locally interdependent indicator. Reliance on exogenous controls such as global markets, regulations and subsidies on agricultural production tends to reduce resilience and adaptive capacity of the agro system (Cabell & Oelofse, 2012; Milestad, Westberg, Geber, & Bjorklund, 2010). Therefore, resilient systems are globally autonomous however, they also establish effective collaborations and interlinkages at a local level.

At the sub-indicator level there were no significant differences. Global autonomy was assessed using the ability of farmers to breed at local level, reliance on local species, access to local markets, reliance on local energy sources, locally sourced food, purpose of production (for selling/on-farm production).

4.2.3.3.10 Honour's legacy

Honour's legacy is a measure of the preservation and use of traditional and indigenous knowledge in the management of the farm. Assessment of the indicator was based on sub-indicators such as the engagement of elders in the community, preservation of traditional knowledge, customary mechanisms, tree products, disease management and use of new varieties.

Agroecological farmers scored significantly higher in the honour's legacy indicator ($P < 0.1$). At the sub-indicator level, agroecological farmers were observed to have a higher integration of tree products for agricultural production as well as anthropogenic use. Due to the transfer of traditional knowledge through their associative groups, the farmers were more likely to use trees for natural remedies, pesticide and soil fertilizer.

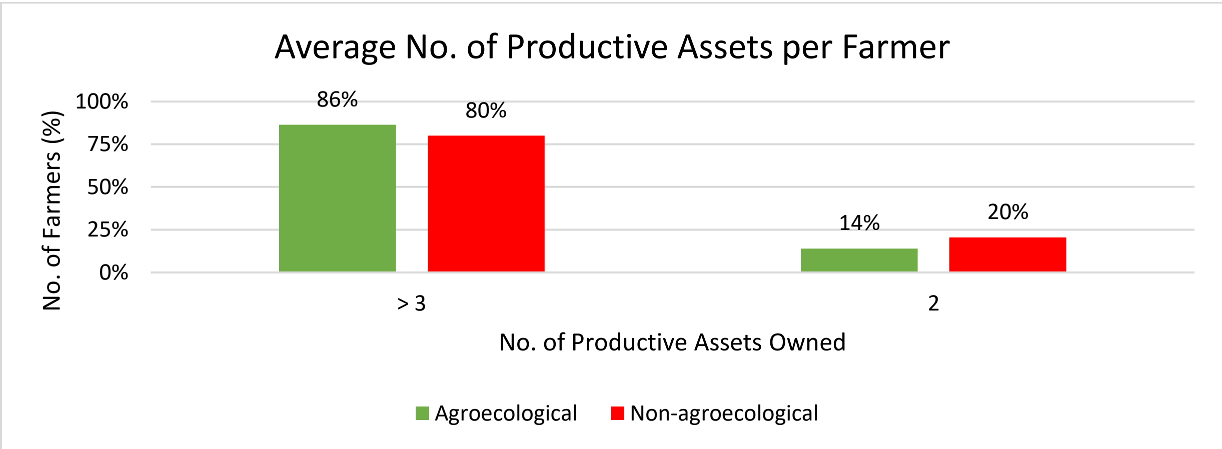
4.2.3.3.11 Builds human capital

With regard to this indicator, "A system that builds human capital mobilizes social relationships and resources that improve household well-being, economic activity; technology, infrastructure, individual skills and abilities and facilitates social organization and norms, as well as formal and informal networks" (Cabell & Oelofse, 2012; Heckelman et al., 2018).

There were no significant differences between the agroecological and non-agroecological farmers. At the sub-indicator level, human capital was assessed through social capital, animal care, education, household equality, ownership of ICT devices and household health. The non-agroecological farm system had significantly higher scores than the agroecological farmers for social capital which was evident for the farmers in AEZ LM 2 ($P < 0.05$). Social capital was assessed through community organization of festivals linked to key moments of their season (e.g. coinciding with harvest, planting, flowering). Non-agroecological farmers in AEZ LM 2 reported festival celebrations during harvest season, closely linked to religious festivities in the area.

4.2.3.3.12 Reasonably profitable

This indicator aims to assess the extent to which farmers and farm workers can earn a liveable wage through agriculture and other non-farm activities, and capture whether the agriculture sector is not relying on distortionary subsidies to be profitable. Profitability was assessed through financial support, income sources, access to markets, assets owned, insurance, savings and post – harvest handling.
Through the analysis, it was found that there were no significant differences between agroecological and non-agroecological farmers for the reasonably profitable indicator.
At the module level and sub-indicator level insurance had the lowest average scores for both farm systems (Annex 7.3) and ranking as the highest priority for farmers (Table 6). The farmers expressed having no access to insurance.
An assessment of the productive assets owned indicated no significant differences for the number of assets owned per farmer (Figure 22a) as well as the type of assets owned (Figure 22b) between the agroecological and non-agroecological farmers. The most commonly owned assets in both farm systems was land and livestock animals.



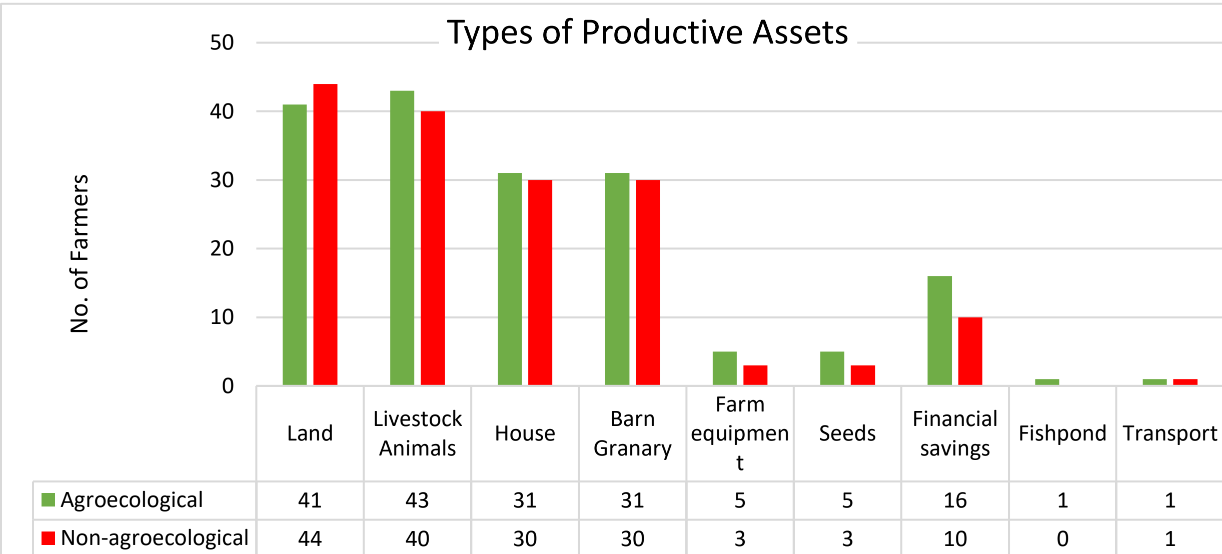


Figure 22: a) Number of productive assets owned by agroecological and non-agroecological farmers, 86% and 80% of the agroecological and non-agroecological farmers owned more than 3 assets respectively b) Types of productive assets owned by the farmers, most common assets owned by both agroecological and non-agroecological farmers included: - land, livestock animals, infrastructure (house and barn granary)

Higher income per hectare has been observed in different markets e.g. in the United States, 2 ha farms exhibit higher yields and income than non-agroecological large-scale farms. Polycultures exhibit higher productivity in the form of harvestable products per unit area which results in yield advantages ranging from 20% to 60%, compared to monocultures, due to reduced losses by weeds, insects and diseases

(because of the presence of multiple species) and more efficient utilization of available resources of water, light and nutrients. However, higher profitability arises from farmer-to-consumer solidarity (direct linkages between farmer and markets) as well as payment of premium prices for their local and organic products (Altieri, 2009).
Despite higher harvestable products, agroecological farmers were observed to attain similar profitability/income levels with non-agroecological farmers. Hindrances to higher income per hectare arise could be arising from the lack of farmer to market solidarity and the reliance on volatile market prices. Policies supporting farmer to farmer networks which would set/stabilize product prices will result in fair trade and higher incomes for the farmers which will hedge in resilience. This also shows that there is a need to promote circular and short circuit markets that brings consumers closer to farmers. Different NGOs working with Agroecological farmers will need also to sensitize consumers on the importance of agroecological produced products.
Farmers also expressed the need for value addition in order to fetch higher prices for their products. Simple infrastructure such as posho mills within the communities would allow a farmer to grind their products fetching higher prices in the market.

4.2.3.4 Conclusions

Our comparative assessment between agroecological and non-agroecological farm systems using FAO's SHARP methodology indicated a difference in climate resilience. In general, the agroecological farmers were more resilient with 5.2% higher mean score. The assessment was based on 13 agroecosystem resilience indicators for socio-ecological systems (Cabell & Oelofse, 2012). **Out of these 13 indicators, agroecological systems were hedged as more resilient than the non-agroecological farm system on 7 indicators.**

Agroecological farmers indicated a higher significant statistical difference for the appropriately connected indicator. The farmers had better access to information on climate adaptation practises and weather forecast and better access to markets which was indicated by the Agroecological farmer's ability to sell produce when desired as well as higher participation in certification schemes relative to their non-agroecological counterparts. Access of information was mostly from NGO'S.
Significant differences were observed between the mean scores of the agroecological and non-agroecological systems for the **function and diversity redundancy indicator**. Agroecological performed better in this indicator in particular due higher species diversity with at least 69% of the agroecological farmers growing more than 5 crop species compared to only 47% of the non-agroecological farmers. The agroecological farmers also had a higher participation in agro-related groups.
There were significant differences between the agroecological farmers and non-agroecological farmers ($P < 0.01$) for the **optimally redundant indicato**r. Optimal Redundancy was marked by multiple varieties of crop and animal breeds.
Agroecological farmers **had a higher reliance on multiple traditional crops,** averaging growing more than 1 crop variety for each crop species growing. Traditional varieties used were adapted to local conditions and therefore able to withstand shocks produce relatively stable yields with minimum external inputs under changing environments (Altieri, 2009), therefore they are increasing resilience to shocks and changing climates.
However, access to communal land resources for pasture and other agricultural activities was low, where only 17% of all farmers had access to communal agricultural land and 23% had access to pasture land, thereby presenting a point of intervention, as also the priority ranking clearly shows (land access rankes on place 1). Holding (a larger extension of) land can also allow farmers to access the financial

markets (e.g. requests for loans) as it serves as collateral. This might have positive effects on farmers' incomes as with new income flow they can incur in higher-value investments at the farm level. Cereal banks were also not a common practise among the farmers, through a participatory approach, the setting-up of cereal banks will aid the farmers to maintain a continuous supply of food while preserving landraces for the next cropping season.

Agroecological farmers were observed to have a **significantly higher degree of spatial and temporal heterogeneity *(P* < 0.01)**. Agroecological farmers had a more diverse mix of crops also in terms of spatial distribution as well as a higher temporal heterogeneity on their farm system, due to the use of land management practises such as crop rotation, terracing and wind breaking. Heterogeneity in landscape also provides more diverse habitats and fosters diversity of plant and animal species which benefit from dynamic relationships and provide ecosystem services, creating a more resilient agro system against climatic changes.

Statistical differences were observed for the **coupled with local and natural capital indicator** due to differences observed in the land management practises between the agroecological and non-agroecological farmers. External Input substitution was evident among the agroecological farmers as 50% of the agroecological farmers relied on natural fertilizers compared to 18% of non-agroecological farmers while for synthetic pesticides, only 30% of the agroecological farmers used them compared to 45% of the non-agroecological farmers.

Nonetheless all farmers still expressed the strong need to have more guidance and assistance to produce their own top dressing and biopesticides to wean off their reliance on external inputs. Farmers in the drier AEZ zones also expressed the strong need for infrastructure such as irrigation or access to groundwater resources to enable continued harvest in the face of rainfall variability. In these dry areas, water seemed to be an extremely limiting factor, in particular in this year of below average rainfall. Fair and sustainable irrigation schemes would be needed, however water shouldn't be sourced from river sources and thereby triggering water conflicts downstream, as happening now.

Significant differences were observed between the two farm systems for the **reflective and shared learning indicator (*P* < 0.01)** as the agroecological farmers were observed to have a higher participation in AP/FFS groups and better access to extension services availed by NGOs**.**

Agroecological farmers scored significantly higher in the **honour's legacy indicator (*P* < 0.01).** At the sub-indicator level, agroecological farmers were observed to have a higher integration of tree products for agricultural production as well as anthropogenic use. Due to the transfer of traditional knowledge through their associative groups, the farmers were more likely to use trees for natural remedies, pesticide and soil fertilizer.

Some of the limitations and vulnerabilities according to the farmer's priority ranking, include low access to communal land resource, financial services and insurance for both farmer groups.

4.2.4 Social component: perception of farmer's communities

To complement the findings from the SHARP survey, we provide additional information on the farmer's and farmer communities' perception of climatic change and their main coping strategies. The information is based on an participatory mapping exercise conducted by ICE (Mburu, no date). Participatory mapping is a simple visual tool used to engage the community in thinking about their ecosystem and building a common understanding, laying the foundation for improved community based governance of natural resources.

4.2.4.1 Methodology

The mapping involved One hundred and twenty (120) community members who comprise the Eight (8) communities that live along the Kathita River in the same area as the SHARP assessments took place. Assembled in groups, they were asked to come up with three maps; that of the past to reflect on tradition, the present to highlight the current challenges and their vision of the future in an ideal scenario (see Annex 7.5). They were led by the elders who are custodians of knowledge, especially in drawing the map of the past. These three maps help engage the community in critical thinking about the environmental changes and challenges facing them. They probed the elders that came before them for the map of the past; and probed each other on what they visualized as being the map of the future.

In order to put this mapping into a climate perspective for the current study, the main facilitators of the participatory mapping in 2014 where gathered in a extra climate focus group discussion. The questions asked, were priorly extracted and adapted from Merelyn, Mondoví and Phillips, (2018).

4.2.4.2 Results

The main insight of the exercise was the stark contrast between the maps and calendars of the past and those of the present. The map of the present reflected the reality of the destruction of ecosystem habitats that have happened over time, and all participants agreed that the river is faced with a serious threat of running out of water. Using the map of the future, they envisioned a future in which the river would undergo restoration back to a state analogous to the map of the past.

However, the group highlighted the possible tensions, especially with landowners who may view the restorative activities as trespass on their farms. They also identified the possibility of resistance by farmers who are flouting existing water abstraction guidelines as well as those who have installed illegal abstraction points.

The degradation of Kathita River begun with land adjudication when sacred sites were allocated to individuals instead of being designated as community land. Under such circumstances, community members would be denied access to such sacred sites for their rituals, which made the sites weak. This also weakened the traditional ecological law, which could not be enforced by the custodians on private property. The landowners then failed to protect the riparian reserves and opened their land to the banks of the river for agriculture and grazing, exposing the banks to severe soil erosion. The community also identified the weakened traditional initiation and clan governance system as the main culprits in differential integration of youth into the system for the subsequent protection of sacred sites. Also, The Water Resources Management Authority failed to enforce and enhance the policy guidelines on the abstraction of water from Kathita. Many illegal abstraction points were installed and those which are legal are not following the laid down regulations. The combined impacts of these failures have caused significant reduction of river water volumes increasing making the whole system more vulnerable to climatic changes.

The climate focus group discussion then stressed the prolonged drought that has persisted from 2018 to date, probably linked to climate change, which caused the complete failure of harvest for two years in a row in some parts. **The discussion affirming again that while all areas are affected by climatic shocks, protected and reforested areas like riverines and forests have retained some level of resilience against climate change induced draught since they manage to keep a good level of moisture.** (This is because they are in the valleys where the water converges, the water table is high and the trees work as hydraulic pumps. Further some of the present soils are not very vulnerable to erosion due to good protective vegetation cover and consequently have a higher water storage capacity. However, due to the overgrazing of other parts, agropastoralists tend to take their animals for grazing along the riverine, increasing pressure on these sites, resulting in degradation and pollution. Overgrazing in the uplands also threatens the rivers through contamination and increased erosion.

The mapping clearly shows that these communities' livelihoods strongly depend on ecosystem services. In particular provision of (clean) water, medicinal herbs, building materials, fuelwood, grazing resources, pollination, and natural healing (traditional medicine prescribes going to the forest). However, these services are threatended and in particular soil erosion is rampant due to steep areas being overcultivated or overgrazed. To **tackle the root causes threatening the very foundation of their livelihoods, community conservation groups are spearheading the following measures to achieve their vision of the map of the future:**

Reforestation of degraded forests, riverine and communal lands. The communities are planting species like *Senna Siamea*, *Melia Volkensii*, *Azadiracta Indica* to control erosion. Further, they are terracing, making stone lines and trash lines out of crop residues to facilitate infiltration and minimize run-off of rainwater. **Also key is that elders are re-establishing local resource governance**, by reviving rituals to prevent unauthorised access and extraction of timber, sand and charcoal burning from sacred natural sites. A key outcome of the mapping exercise was the formation of a Coalition of Custodians, which was meant to consolidate and amplify the participant's voice in campaigning for the protection and recognition of Kathita River as a sacred river.

4.2.4.3 Conclusions:

The comparison of the past and present maps shows the stark degradation of the ecosystems and the subsequent ecosystem service provision over the last decades. The climate focus group discussion stressed that the region has been affected by climatic shocks and continuous draught, but **the protected areas like riverine and forests have retained an increased level of resilience**. To achieve their visionary map of the future, lead communities and the partner organisation ICE came to the clear conclusion, "that only integrated agroecological measures can bridge the gap between these two maps" ('Eco – Cultural Mapping Workshop Tharaka , Kenya', 2011).

To tackle the root causes threatening the very foundation of their livelihood, community conservation groups need to push for agroecological measures which are very much in line with GKP and tend to ameliorate the 5 capitals of the sustainable livelihood framework and are determinats of the adaptive capacity as defined by the IPCC (Chapter 0). As the expected threats of climate change for Kenya include more frequent temporary droughts the **community approach of applying agroecological practices, in particular sustainable land management measures and reforestation as well as diversification (e.g. bee keeping), has shown to have the potential to increase the communities' resilience to face these challenges.** Achieving this transformation and closing the knowledge gap towards integrated agroecology needs external facilitation and support, due to lack of finance and knowledge, as well as political support to improve resource governance..

4.3 Results case study Senegal

4.3.1 Context Senegal

The climate is of the Sahelian type, characterized by a rainy season whose duration gradually decreases towards the north (June-October in the south, July-September in the north, although this year a 2 months delay in rainfall was noted) and a dry season (November-June). The temperature drops a little below 16°C in winter but is often above 40°C in summer. The country is subject to the influence of the maritime trade winds and harmattan in the dry season. The average rainfall on the territory is 687 mm/year. El Niño events are associated with drier conditions in the Sahel, la nina decreases temperatures (FAO, 2005b; C. McSweeney, New and Lizcano, 2010). Following climatic zones occur in Senegal: semi-arid (BSh), arid (BWh) and tropical savannah (Aw), with developed biomes of grass savannah, tropical rainforest and tree savannah. Regions with a structural precipitation deficit are defined as arid zones with less than 50mm annual rainfall. Semi-arid climates receive less precipitation than potential evapotranspiration.

Senegal includes 6 major agro-ecological zones (we highlight in particular two of them which will be part of the technical potential analysis, Niayes and Eastern Senegal):

The Senegal River Valley	Strip of about 15 km, composed of a series of alluvial plains and sandy highlands, it covers part of the Saint-Louis and Matam regions.
The sylvo-pastoral zone	Located to the south of the Senegal River Valley, it is the country's main livestock region. Rainfall is very low. Forage resources are scarce and severely degraded.
The Niayes area	Covering a strip of 5 to 10 km along the Atlantic coast, this area has a high concentration of population and is the main horticultural region in the country. Its is challenged by urbanization, and also by land tenure and water related issues.
The groundnut basin	Composed in its northern part by the regions of Thies, Diourbel and (partially) Louga and in its southern part by the regions of Fatick, Kaolack and Kaffrine, this basin has suffered from severe droughts in recent decades. Ecosystems have been degraded and soil fertility has been severely affected. The groundnut crisis (2002/2003) has exacerbated the region's difficulties.
Casamance	Country’s zone that benefits from abundant rainfall. There is a diversified traditional agriculture: rainfed rice, fruit production, cereals, cotton (in Upper Casamance)
Eastern Senegal	It includes the regions of Tambacounda (where Koussanar is located) and Kedougou. It is a cotton and cereal area.

70% of the population work in the agricultural sector, resulting in 17% of the GDP (*Agriculture, forestry, and fishing, value added (% of GDP) | Data*, no date). While forests cover about 43.8% , agriculture covers about 46% of the area of which more than 17% is arable (*FAOSTAT*, no date). Agriculture in Senegal is largely dominated by very small family farms (occupying 95% of the country’s agricultural land, representing 80% of the country’s population), depending on traditional rainfed agriculture and activity which represents all village agricultural activities. Pastoral systems and polyculture systems can be found respectively in rainfed and irrigated farming areas (less than 5% of the agricultural land is irrigated). Next to a multi-purpose family agriculture, a commercial type of agriculture emerges as well. These farms are located in the peri-urban area of Dakar, in the Niayes area, where they are dedicated to horticulture and intensive livestock farming. They are also beginning to appear in the Senegal River delta area in irrigated areas, although their share in agricultural production and exports is still low, with the exception of the horticultural and poultry sectors. They employ 1 percent of the working population and control 5 percent of agricultural land.

Agriculture is based on both cash crops (groundnuts 21%, cotton, horticultural products in part) and food crops (mainly cereals, millet 20%). Livestock farming also plays an important role (29%), as does fishing. Indeed, the country must import nearly 70 percent of its food needs, mainly rice (main stable food, 65% of the countries consumption is imported), but also wheat and maize (CIAT; USAID, 2016). This dependence on global markets exposes households to price fluctuations and greater vulnerability (WFP, 2014). Agriculture results in 49% of the greenhouse gas emissions.

Ranked 154th out of 186 countries on the Human Development Index (HDI) in 2013, food insecurity remains a constant concern in Senegal.

4.3.1.1 Challenges for agriculture and CC impacts

Ensuring and improving food security and nutrition for vulnerable populations despite the effects of climate change is the key challenge today in Senegal. Agriculture and water resroueces are cited as the two most vulnerable sectors (CDN, 2015). According to the country's National Determined Contribution (CDN), the projected climate change impacts focus particularly on rising temperatures (projected 0.2C / decade) and decrease in rainfall, which would have devastating consequences on livelihoods and socio-economic activities. Climate change is already an undeniable reality for Senegal. In a report published on the State of the Environment by the Ecological Monitoring Centre (CSE), the following trends are noted:

- Mean annual temperature increased by 1.6 °C since 1950 with a stronger observed increase in the north of Senegal, averaging 3 °C. Temperatures continue to increase by 1.1 to 1.8 °C by 2035, and up to 3 °C by the 2060s. Warming is faster in the interior of the country than compared to the coastal areas.
- A 30% reduction in rainfall between 1950 and 2000, with a strong variability from one year to another and from region to region. While precipitation trends have improved since 2000, it does not necessarily signal an end to the dry cycle.
- Higher frequency are noted in flood events, particularly in the lower lying areas of Dakar and north-western Senegal.
- Extreme droughts in 2002 and 2011 heightened food insecurity for over 200,000 and 800,000 people, respectively.
- Changes in the production of biomass, especially in the northern part of the country, reducing forage production for livestock activity. (CIAT; USAID, 2016)
- The groundnut–millet rotation has traditionally been the dominant practice with more area devoted to groundnuts. However, in recent years, as groundnut yields have begun to decrease due to poor soil conditions and climatic factors, millet has increased in area(CIAT; USAID, 2016)

In addition and also partly linked to climate change, agriculture in Senegal is negatively impacted by land access problems, deterioration of soils, of water resources (in quality and quantity), of forests and high use of pesticides (DYTAES, 2019). The Niayesm, as peri-urban horticultural zone (studied furter in the technical potential analysis), is particularly impacted by these challenges.

4.3.2 Policy potential in Senegal

4.3.2.1 Introduction: relevance of agroecology in the context of climate change in Senegal

In Senegal, agroecology has emerged in the 1980s, as an answer to the disastrous environmental and human and animal health consequences agricultural chemicals had caused and as a promising solution to open up new horizons for future generations (Enda Pronat, 2010). Its evolution has been marked by the implementation of a multitude of local initiatives, experiments mostly carried out by NGOs, farmers' organizations and some private sectors (Touré and Sylla, 2019) and also national level platforms. For more than 30 years, actions have focused on integrated and sustainable land management, water and soil conservation practices, crop associations, biological control of plant pests, organic conservation methods for agricultural products and agroforestry (AgriSUD, 2015). In the same line, universities and research centers, such as UCAD, ISRA, CIRAD, INP, IRD, have long been involved in the creation and dissemination of knowledge, training of human resources, supervision of agricultural practices and promotion of products from healthy and sustainable agriculture. Different experiments on agroecology and experiences arising thereof, has produced visible effects at different levels within the society. These are on the socio-economic level (consumer awareness on products' origin, promotion of healthy food and enhancing local economy through short circuits markets); on the environment (promotion of organic fertilizers, biocides); and at the political level (Public authorities have manifested their interest in agroecology, as part of the political discourse and agenda) (Cissé, 2018)
This year 2019 has seen an acceleration of milestones and achievements, creating a real momentum for agroecology:

- the Senegalese government placed agroecological transition among the five major initiatives of the Priority Action Plan of the second phase of the Plan Senegal Emergent (2019-2024), the key national policy framework.
- Producer organisations, civil society organisations, research, consumers, local authorities and sectoral ministries have decided to join forces and create an umbrella initiative to co-create a policy document (through a participative bottoum-up process) to support the government's commitment and to move towards an effective agroecological transition– a unitary framework consolidating all the numerous existing platforms and initiatives - called la *Dynamique sur la Transition Agroécologique au Sénégal* (DyTAES).

Building on thirty years of existence, this current combination of national multistakeholder momentum and political commitment raises questions on the past, current and up-coming policy potential of agroecology in regard to the multiple challenges of climate change.

4.3.2.2 Research approach

The methodology used in this research combines a literature review, stakeholder discussions (during workshops, including the 28-29 May 2019 workshop launching this study, organized by FAO in collaboration with *Institut Sénégalais de Recherches Agricoles* -ISRA- and *Environnement et Développement Action pour une Protection Naturelle des Terroirs* - Enda Pronat, and individual interviews with key different stakeholders). The desk research aimed to characterize the political and institutional environment in Senegal, relating to the implementation of agricultural policies, adaptation to climate change and assessing the explicit or implicit recognition of agroecology in institutional mechanisms.

The main question focused on the Nationally Determined Contribution, the actors responsible for its implementation at the national level, the financing instruments for the agricultural sector as a necessary condition for the success of agroecological initiatives, and finally the involvement of actors in charge of developing climate change policies in the agricultural sector. The desk research focused on online resources, state and civil society documentation platforms. The diagnosis focused on finalized or in effect institutional documents (laws, public policy documents, sectoral policy letters, final reports of national projects and programmes, conventions and treaties) in the agricultural sector and adaptation to climate change in Senegal. To assess the quality and relevance of the documents, the strategy used is to diversify the sources for each search algorithm to ensure consistency of the results obtained.
In total, the research examined 57 public policy documents related to the theme of the analysis. In particular, it sought to assess the extent to which agroecology is embedded into policies, and the evolution of concepts used in documents and speeches related to agriculture and climate change in Senegal.
For that purpose, the grid of analysis used focused on the declinations of ''agroecology'' when the concept is mentioned in policy documents, with reference to the FAO 10 elements on agroecology (FAO, 2018). Finally, as this study was conducted concurrently with the local consultations with communities led by the DYTAES on the issue of agro-ecological transition, several actors involved in the different stages of the process were interviewed, providing an analysis of the enabling environment at the local level as well.
In the same line, a large number of people from different backgrounds were interviewed: members of NGOs, farmers' organizations, local authorities, ministries, decentralized government departments, research institutions, associations, etc. These interviews were done through various site visits, focus group discussions, (including discussions in farmlands), discussions in local gatherings (palaver three), offices, and local product processing units.

4.3.2.3 Results and Analysis

4.3.2.3.1 Analysis of policies in Senegal (policy lens)

Agroecology in Senegal : a recent acceleration of high level recognition opening some hope for a proper institutionalization

Senegal has not stood on the sidelines of the emergence of agricultural practices inspired by agroecology, the strong scientific research ongoing and linked to the social movement observed at the international level. Initiatives have been ongoing and multiplying from the local to the national level since the 1980s by producer organizations and pioneering civil society organizations (CSOs) (such as Enda Pronat). These have gradually attracted the attention of the Senegalese authorities, who embodied the idea that "agroecology can bring about many benefits to Senegal and to achieve more resilient and sustainable production systems".
At the first International Symposium on Agroecology for Food Security and Nutrition held at FAO headquarters in September 2014, Senegal's Minister of Agriculture referred to Senegal's position as "responding to the international market but also to create an environmental legacy of high quality on the one hand. On the other to manage the present while taking into account generational solidarity in agriculture". Adding that such an option should be supported by a "co-constructed, co-managed and co-evaluated agroecology approach".
In late 2018, the President of Senegal Monsieur Macky Sall also announced at the end of his first term, through the Plan Senegal Emergent Vert, the importance for Senegal to achieve an ecological transition. This institutional commitment was further demonstrated after his re-election in 2019, by the

implementation of a programme on "sustainable reforestation of the national territory" in the semi-arid zones of the country, in conjunction with local authorities. The appointment of M. Haïdar El Ali, strongly committed in environmental issues and former Senegalese Minister of the Environment, as Director General of the Senegalese Agency for Reforestation and the Great Green Wall (ASRGM) was yet another favourable element illustrating the increasing institutional commitment. Finally, very recently, the government flagged its support to the *Journees de l'Agroecologie* taking place end of January 2020 in Dakar. The discourse of national authorities', at the highest level, thus reveals a plan to move towards an agroecological transition. An effective implementation and institutionalisation however will need to go through strategies, plans, policies and programmes.

Presence of agroecology and its practices in policies

Institutional commitment is increasingly visible, but still needs to be accompanied and translated into policies to ensure a proper institutionalization.
Indeed, among current policy instruments related to agriculture, climate change, natural resource management and to economic and social development, there today are rarely specific references to agroecology. However, policies generally promote some of the principles and practices related to agroecology, in particular: reforestation; replanting; agroforestry; and organic, sustainable and competitive agriculture. These orientations have emerged at different periods of times and differ in their focus: consideration of the environment in production systems, characteristics of the producers, the food systems and the modes of integration into the markets they support.

- In 1960-2000, which coincides with the creation of the UNFCCC in 1992 and the emergence of the Conferences of the Parties (COPs), the term "agroecology" does not appear explicitly in any public policies.
- 2000-2012: the terminology "agro-ecology" appears only once on all public policy documents of the country. The document in question is the National Strategy for Agricultural and Rural Training (SNFAR) of 1999, updated in 2005.

Among 21 public policy documents analyzed, related to agriculture and climate change in Senegal, the adjectives "agro-ecological" and "agroecological" are used 64 and 9 times respectively. According to the surveys, the lack of consideration of agroecology is explained by the fact that the concept was still new and still little known in these arenas. However, even if the concept does not appear clearly in the main programmes of the government, fundamental ideas underlying the agroecological principles are reflected in some documents, such as the protection and improvement of rural livelihoods, the promotion of equity and social well-being, and the good governance of natural resources.

The analysis and interviews led further highlight some policies and actions with negative externalities to the environment, which are not only not compatible with agroecology, but even hinder its possible scaling-up. These are in particular: the subsidization of synthetic fertilizers and the development of intensive agriculture and agro-industry oriented towards exports.

Since 2012, Senegalese authorities have advocated to accelerate the pace of work to achieve Senegal's growth. The *Plan Senegal Emergent* (PSE), which is the main reference policy document for the government, has implemented plans, programmes and strategies for agricultural development viewing to make agriculture a lever for economic and social development. Of these policy documents, 25 were analyzed (see Appendix 1). The lesson learned is that agroecology is not the subject of a specific policy, but its promotion and integration in national agricultural production systems are taken into account in the *Programme de l'Accélération de la Cadence de l'Agriculture Sénégalaise* (PRACAS), 2014 and the *Programme National d'Investissement Agricole pour la Sécurité Alimentaire et la Nutrition* (PNIASAN) 2018-2022.

Assessment of the integration of agroecology and agroecological principles into public policies on agriculture and climate change

The increasing impacts of climate change have prompted actors to reflect on mechanisms of adaptation and resilience (PANA, 2006). As such, several policies were developped that tend to promote different actions aimed at reducing sensitivity and exposure of agriculture to climate risks without explicitly labelling them as agroecology (LOASP, PNIASAN, etc.). In their development, these policy documents incorporate a holistic approach and ambitions that reflect the elements of agroecology, as defined by FAO (FAO, 2018). These include aspects related to biodiversity conservation, the promotion of more intensive and sustainable agro-sylvo-pastoral production and integration, diversification of production, etc. (Sectoral Policy Letter, MEDD, 2016-2020).
The PNIASAN (2018-2022) is the one document which makes explicitly reference to the concept of agroecology and its principles, relating it mainly on production. With the oective to increase and diversify production sources, the National Agricultural Investment Programme for Food Security and Nutrition (PNIASAN, 2018-2022) promotes agro-sylvo-pastoral integration to address three challenges: (i) developing production systems that respect the environment; (ii) ensuring the safety of food consumed by populations; and (iii) improving the integration of agricultural/breeding, aquaculture and plant production systems.

Senegal's national determined contribution (NDC), key national document providing guidelines for action to address climate challenges, does not explicitly refer to agroecology. Yet, it highlights that Sustainable Land Management (SLM) has significant potential as an adaptation measure and that it is important to combine approaches and measures to strengthen the capacities of agro-sylvo-pastoral producers to resist shocks and adapt to the threats of climate change, while aiming to improve their food and nutritional security and increase their incomes. As recently brought forward by the IPCC, agroecology is a promising approach for SLM (IPCC, 2019).

It is noteworthy to highlight that, agroecology being interdisciplinary (considering all natural resources, all sectors) and multi-scale in its nature, synergies between multiple stakeholders is thus key to scale it up. Policies encouraging synergies between stakeholders to ensure optimal land management reflect this idea. These include the National Strategic Investment Framework for Sustainable Land Management (NSIF/SLM), which seeks to ensure synergy in the intervention of stakeholders who are encouraged to work together to reverse land degradation trends in a sustainable manner.

The analysis draws ou possible entry-points to scale-up the consideration of agroecology in existing laws and policies. In particular in:

- <u>Laws and policies currently in favor of agroecology</u>: which integrate the principles of agroecology and create opportunities to integrate all relevant actors into the dynamics of agroecology. One can refer to the Agro-Sylvo-Pastoral Orientation Law, the National Strategic Investment Framework for Sustainable Land Management (CNIS/GDT) and the National Strategy for Sustainable Development (SNDD); Senegal's NDC already draws out many elements related to agroecology (production-related) such as SLM and needs and challenges related to more environmental and social aspects of agroecology. The 2020 NDC revision could therefore be a very interesting momentum to ensure a further integration of agroecology, taking it in all its holistic dimensions (environmental, social and economic) into thiskey climate framework.

- Partially incentive-based laws and policies: which are neutral in their construct, and could provide an entry-point to scale-up agroecology. This is the case of the Environment and Sustainable Development Sector Policy Letter (LPSEED), which aims mainly at combatting deforestation and land degradation, and the Agriculture Sector Development Policy Letter (LPSDA MAER), which envisages the reconstitution of seed capital, the intensification of agricultural production and the development of mechanization adapted to production systems.

When there are some favourable policies related to the multi-dimensional challenges of climate change and also positive possible entry-points to scale-up agroecology, it is also important to not some current challenges.
Indeed, some laws and policies continue to be unfavourable to AE, strongly undermining a possible scaling-up, in particular those promoting intensive systems, the overuse of fertilizers and herbicides, the promotion of monoculture, as well as others related to access to land and seeds (in particular the protection of peasant seeds from seed industries). Regarding the latter, when Senegal ratified the International Treaty on Plant Genetic Resources for Food and Agriculture (ITPGRFA), which guarantees these rights to farmers, peasant seeds are not yet recognized in national legislation and remain often threatened (SWISSAID, April 2019).

4.3.2.3.2 Analysis of the politics setting in Senegal (Politics lens): Level of preparation and acceptance of agroecology by policy makers

Differences understanding of agroecology between stakeholders: from a land restoration programme to a "society project".

Interviews highlighted the challenge of translating the interdisciplinary nature of agroecology in policies but also to understand its holistic and systemic nature and achieve a common vision and understanding. This leads to different views and positionings on this issue. Indeed, when civil society organizations see agroecology as a “society project”, a “social transformation” (DYTAES, 2019), it seems that most of the government-led initiatives relate more to forestry programmes, focusing mostly on production, and the operational principles of resource-efficiency and resilience. The scope also differs between stakeholders. CSOs, research organizations, producer organizations understand agroecology as interdisciplinary and grasping the entire food system, “from seeds to watse treatment”.
Interviewees mentioned that the current focus of policies are often on quantity production, focusing on 2 of the 4 pillars of food security and nutrition (FSN): availability and stability. As highlighted by HLPE (2019), agroecological approaches contribute rather to the two other pillars of FSN, access and utilization, highlighting participation and empowerment related elements. This production-oriented focus can be explained by the double challenge of 1) the need to feed a continuously growing population and 2) the lack of conclusive evidence on the ability of agroecology to produce the same quantities of food and within the same time frame as conventional agriculture.

Stakeholders interviewed during the local consultation workshops understand agroecology as an approach revaluing diversity and human values, enabling the co-construction and sharing of scientific and local knowledge, focusing on effectiveness, efficiency and drawing out priority on responsibility in the governance of natural resources.

Many highlight the need to reconsider and ensure the consistency of policies and legislation in various fields, including land, energy, spatial planning, market regulation, agricultural research, youth education, engineering training, etc.

Challenges to scaling up agroecology

The absence of both a clear and jointly agreed definition and a national reference document containing a common vision of the government and its partners on agroecology, contributes to keeping it out of the policy-making realm. The compartmentalization of decision-making spheres between the various sectoral ministries brings an additional layer of difficulty.

The analysis compiled the following identified challenges:

- National priorities translated in policies seem to be more oriented towards production in quantity, with no strong priority made on environmental issues. The idea of generating economic gains through exports is often mentioned in the discourses and thus relegating alternative options such as agroecology.
- The concept of agroecology is seen as relatively new and is still the subject of much confusion, particularly because of many other concepts in parallel, in particular: "organic farming" in the 1980s, "sustainable agriculture" in 1999, "healthy and sustainable agriculture" in 2004, with a resolution called "Mbawane".
- The absence of a common understanding of the holistic principles of agroecology, hindering the translation into a political vision;
- The lack of awareness on agroecology, absence of specific training, etc.
- The lack of organization, of a clear unitary framework for formulating policy proposals to ensure an agroecological transition. The low level of involvement of agricultural research structures at the national level, which have difficulty in multiplying evidence of the economic, social and environmental viability of agroecology. This should soon evolve with the recently launched *Dynamique pour la transition agroécologique* (DYTAES) in Senegal.
- The absence or weakness of social demand by consumer associations due to their lack of resources means of communication and interaction with the population.
- External pressure, lobbying, promiting the use of synthetic fertilizers and other practices which are opposed to agroecology.

4.3.2.3.3 Institutional framework and coordination mechanism in Senegal (polity lens): barriers and levers for an agroecological transition

Design of the political system and national dynamics

The issue of climate change in the agriculture has a multi-sectoral dimension requiring strong synergies, increased collaboration, effective coordination system and the inclusive participation of all actors involved in state processes, to create a policy environment conducive to scaling up agroecology.

The current institutional framework and mechanisms for coordinating the processes, design and implementing agricultural policies and strategies brings together various actors. These are: the President of the Republic; the National Assembly; the Economic, Social and Environmental Council (ESEC), the Ministry of the Environment and Sustainable Development (MEDD), the Ministry of Agriculture and Rural Development (MAER), the Centre de Suivi Ecologique (CSE), the Comité National sur les Changements Climatiques (COMNACC), the Direction de l'Environnement et des Établissements Clés (DEEC), the Agence Nationale de l'Aviation Civile et de la Météorologie (ANACIM) and the Collectivités Territoriales (CT). Also other non-governmental actors are involved such as members of civil society, local consultation frameworks, technical and financial partners, customary authorities and religious leaders, universities and research institutes, etc. These different stakeholders operate with very different levels of involvement, but remain complementary to each other in addressing the climate challenge in the agricultural production sector.

Interventions related to agricultural and adaptation to climate change policies, are the government's responsibility. The analysis highlights the difference in regard to agroecology, for which CSOs, Research and development partners are those driving the major dynamics, strongly committed in supporting the search for innovative alternatives to the challenge of grassroots development.
Born very recently, on 24 May 2019, to answer the challenge of the multiplication and fragmentation of initiatives, platforms (3 AO, TAFAE, AEB) and the lack of coordinated action and unified advocacy work, the *Dynamique sur la Transition Agroécologique au Sénégal* (DyTAES) led to the establishment of a unitary framework for multi-stakeholder exchanges on agroecology.
It brings together all stakeholders: producer organisations, civil society organisations, research, consumers, local authorities and sectoral ministries. This dynamic aims at stimulating political dialogue on the agroecological transition, by engaging in broad consultations with stakeholders at different level. From August to October 2019, local consultations took place in the six agro-ecological zones in Senegal, aiming at, in a participative and bottom-up process: 1) drawing out a diagnosis of the challenges regarding agricultural development, 2) raising awareness on the agroecological transition 3) identifying local initiatives on agreooclogy, collect best practices happening on the ground 3) identifying challenges and levers 4) drawing out recommendations. About one thousand local stakeholders participated throughout these six consultations. One additional took place in Dakar, targeting consummers and consumer organizations.
Building on the results of these local consultations and thus on grassroot concerns, the current key objective is to co-create a contribution document to feed in national policies on the agroecological transition. The very first official national workshop of DyTAES took place on November 18-19 2019, with the objective of presenting the results of these local consultations and working towards the contribution document.
It gathered more than 100 participants from different backgrounds (Research, CSOs and government representatives) and levels (local, national and international actors). Among the government representatives were present in particular: some mayors (in particular the Ndiob Mayor, renowned promoter of agroecology, district which was distinguished by a price delivered by FAO), the Centre de Suivi Ecologique (CSE), a Deputy from the National Assembly, in charge of local consumption. The Technical Adviser number 2 of the Minister of Agriculture give a keymote speech as well.
Throughout this process, the Media played a crucial part as they disseminated information to the broader audience following the local consultations. A video on DyTAES was also produced, so as to ensure visibility and common understanding of the dynamic.

DyTAES paves out a way on how promoters of agreocology work, from "opposition power" for more than twenty years, to a strong unified "proposing power" today, stimulated by the growing institutional commitment. The key idea is to build proposals stemming from a participative consultation process at local level and draw out how these can be promoted and inserted throughout the lines of existing policy frameworks. The plan is to hand out the political document to the government, to the President Macky Sall himself, during the *Journees de l'Agroecologie*, taking place end of January 2020 in Dakar, Senegal.

Stakeholders involvement

Results from the participative diagnosis led in 28-29 May Workshop in Dakar distinguish two categories of stakeholders: (i) those already involved in agroecology and climate change policy development processes (Table below in green); and (ii) thos not yet involved, and barriers to overcome to successfully involve them (Table below in red). The organization of their respective interventions should be based on inclusive and effective coordination mechanisms.

Table 7: Stakeholders involved (green) and currently not involved (red) in agroecology-related issues

<table>
<tr><th>Entity</th><th>Structure</th><th>Role (related to AE) for those involved/ challenge to overcome for those not involved</th></tr>
<tr><td rowspan="10">State</td><td>Ministry of Environment
Division taking care of water resources and forestry
Division taking care of climate change related issues</td><td>- Elaborating and managing Agroforestry and CC related projects
- Managing the NDC</td></tr>
<tr><td>Ministry of Agriculture
CCASA</td><td>Information and training of state institutions for climate change adaptation
Advice and support from the on CC issues</td></tr>
<tr><td>Green Financing and Partnerships Branch</td><td>Management of the support programme for the creation of green jobs</td></tr>
<tr><td>Centre de Suivi Ecologique (CSE)</td><td>Management of climate funds, implementation of projects and programmes</td></tr>
<tr><td>Some sectorial Ministries (Livestock, agribusiness, other departments of Agriculture and Environment, etc.)</td><td>Awareness raising missing; lack of understanding of the potentials of AE</td></tr>
<tr><td>Strategic Direction Office of the Plan Senegal Emergent (BOS/PSE)</td><td rowspan="5">Awareness raising missing</td></tr>
<tr><td>National Assembly</td></tr>
<tr><td>Social and Environmental Economic Council (CESE)</td></tr>
<tr><td>High Council of Territorial Communities (HCTT)</td></tr>
<tr><td>Rural Development Support Fund</td></tr>
<tr><td></td><td>Non governmental organizations (NGOs)</td><td>Developing initiatives, advocacy work, communication</td></tr>
</table>

Civil Society	Producer (Livestock & fisheries included) organizations	Facilitation, promotion of good practices, promotion of local know-how, marketing
	FENAB	Production of a strategic and prospective note in favour of agroecology
	Associations and individual consumers	Lack of communication, information and awareness
	CNCR	
	Media / Opinion leaders	
Research and Academia	ISRA / CDH / BAME CIRAD UCAD	Experimentation, training, provision of documented scientific and technical evidence, innovation
	GGGI	Development of strategies around green growth
	Advanced Education	Training of managers : Lack of communication, information and awareness
	Basic education (national education)	Lack of communication, information and awareness
Collectivites territoriales	Local elected officials and grassroots communities	Support/promotion
	Consumers	Demand for quality products
	Associations of Mayors of Senegal (AMS)	Absence of institutionalisation
	Grassroots communities	Lack of communication, information and awareness
Private sector	AE input suppliers	Production and marketing
	Non AE input suppliers	Actors to raise awareness of the agro-ecological approach
	Various businesses	Lack of communication, information and awareness
Banks & Insurance companies	Microfinance institutions and banks	Lack of communication, information and awareness
	Agricultural insurance	

MTo grasp the interdisciplinarity of AE, many stakeholders highlightagreed the need to set up a coordination mechanism. Based on a cross-cutting and transversal approach, the resource persons suggested to link the different dimensions of agroecology through a coordination mechanism in order to overcome the fragmentation challenges. Others have recommended establishing a new coordination mechanism linked to the agroecological and climate change policy development process. this coordination mechanism should be multi-sectoral, mutlistakeholder and supported politically (led by a Ministry).

A currently challenging environment to ensure a true agroecological transition

A participatory diagnosis carried out during a workshop as part of this research reveals a rather challenging current environment to ensure an effective agroecological transition, mainly related to:

- the current deficit of institutionalisation of agroecology: the need to translate agroecology and its principles into political reference framework
- Issues related to access to land and natural resources
- The current absence of public incentives and risk mitigation mechanisms.

4.3.2.3.4 . Setting an ideal scenario for a true agroecological transition in Senegal (polity lens)

After more than thirty years of existing initiatives, 2019 seems to be the year sowing the seeds for a turning point on the enabling environment and the institutionalisation of AE in Senegal.
Indeed, the combination of an increasing institutional commitment with a strong national multistakeholder dynamic (speaking in a unified voice, ensuring a cohesion in the existing initiatives and platforms), positioning itself as a proposing power to the government, is a promising milestone towards an agroecological transition in Senegal.

The ideal scenario for an effective agroecological transition seems rather realistic, provided some key needs. Change is happening now in Senegal, and quite in a high pace. Differences and progress can be already between May and November 2019. As an example, some stakeholders which were noted a not involved in AE related processes, have been targeted in the meantime and were present at the first official 18-19 November national workshop organized by DyTAES. In particular: association of consumers, a Deputy of the National Assembly, the CNCR, the Economic, Social and Environmental Cuouncil (CESE), the Media and Opinion Leaders (the Mayor of Ndiob).

Vision for an agroecological transition in Senegal: preliminary roadmap for 2035

The stakeholders interviewed were unanimous on the fact that the development of agroecology presupposes a supportive government, which guides its decisions based on the principles of agroecology. This requires a true behavioural change regarding conventional agriculture and sharing a common understanding and vision between all stakeholders.
The ongoing dynamic, in particular through DyTAES, can positively contribute to a redefinition of the government's conceptions of agroecology and a refocusing of priorities by 2035. The steps to be taken are multiple: (i) build a common understanding and vision around agroecology; (ii) build a unified advocacy framework bringing all actors together, based on scientific evidence validating the benefits of agroecological systems; (iii) give greater visibility to agroecological initiatives; and (iv) clearly distribute the roles to the different stakeholders.
Figure 23 summarizes the findings from the participatve diagnosis and interviews, highlighting the different milestones, challenges and levers for an effective agroecological transition in Senegal

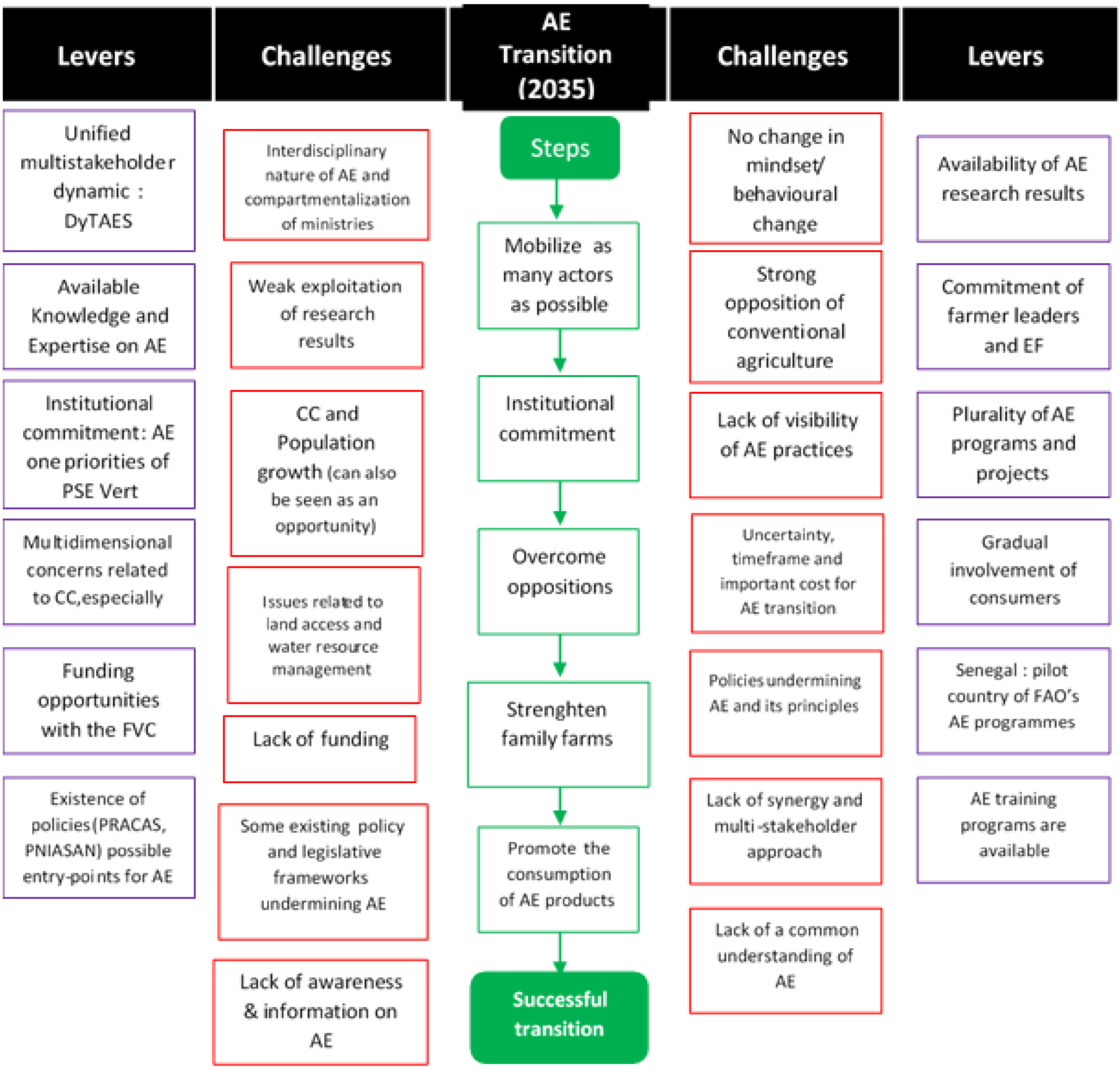


Figure 23: AE Transition (2035), Challenges and Levers

4.3.2.4 Conclusions and Recommendations

After more than thirty years of multiplying initiatives, platforms, mobilizing a wide range of stakeholders from producer organizations, to CSOs, Researchers, etc. 2019 appears to be the year sowing the seeds for change and for a proper agroecological transition.

Although agroecology and its principles do not yet appear fully in policy frameworks, not ensuring yet an enabling environment for the scaling-up of agroecology, the institutional commitment is there and increasing. In 2019, the Senegalese government placed agroecological transition among the five major initiatives of the Priority Action Plan of the second phase of the Emerging Senegal Plan (2019-2024).

In parallel, the concern of the multiplication and fragmentation of intiaitives, platforms advocating and working on AE was overcome through the establishment of an umbrella initiative called "Dynamique sur la transition agroeologique au Senegal (DyTAES). Aiming at gathering all stakeholders in a unified framework, binging coherence between the initiatives, DyTAES also aims at accompanying the increasing institutional commitment with strong proposals to ensure an AE transition. Local consultations followed by a national workshop - gathering a wide range of stakeholders from the government to Research, NGOs, producer organizations, etc. from different levels (local, national, reinoal and international)- aim at co-creating a contribution document proposing concrete steps to

ensure a transition. This contribution document will be handed to the government during the *Journees de l'AE* end of January 2020.
Thus, the institutionalisation of AE is on its way, with remaining key challenges to overcome, in particular related to existing policies undermining any agroecological transition but also the lack of awareness, communication and knowledge on agroeoclogy, the lack of scientifically supported evidence translated into policy and strategies.

Building on these findings, the following recommendations are proposed:

- Consolidate the current multi-stakeholder dynamics
- Strengthen the framework harmonizing platforms of interventions working in agroecology in order to build a common vision and unify advocacy efforts (work of DyTAES)
- Ensure and work towards a common understanding ofagroeoclogy and its potential to build resilience to climate change so as to translate it into a policy vision.
- Carry out awareness-raising activities to strengthen the strategic dimension and ensure the institutionalization of agroecology;
- Strengthen scientific research to produce evidence about the benefits of agroecology; develop more comparative analysis to influence policy changes
- Disseminate scientific results to a wide audience, communicate about agroeoclogy and its potentials, stregthen the media coverage
- Advocate at the sub-regional level to influence community decisions that have an impact on national development strategies.
- Promote a revision of the legislative framework to ensure the integration of agroecology into policy strategies and field interventions;

4.3.3 *Technical potential in Senegal*

4.3.3.1 *Methodology*

4.3.3.1.1 Defining Agroecological Systems for the Senegalese Context

The choice of the areas for the study builds on the selection elements defined in the methodology Sampling design (part 4.3.3.2).

Specificities of each of the two selected areas

Zone 1 – Niayes (4 municipalities: Bargny, Keur Moussa, Diender et Cayar): there is a strong concern for the future of this vegetable producing area. Indeed, it supplies large cities with horticultural products, but faces today food security, economic, political (land use planning) and climatic (low rainfall and high pressure on groundwater by various users, which leads to a decline in the water table) and environmental (pollution by the use of chemicals: use of organic matter, fertilizers and pesticides) issues. Agriculture is very diversified in this zone, with a predominance of onions, aubergines and cabbages.
One finds there 1) small individual farms, operating on the basis of rental or sharecropping contracts and whose diversified productions are intended to supply the local market, but also 2) large potentially specialized agricultural companies for which the products are intended for export markets (Touré and Seck, 2005). A wide range of family farms, with varying degrees of performance, find themselves between these two typologies.
The family farms supported by ENDA PRONAT in the agroecological transition in the communes of Cayar, Diender and Keur Moussa focus mainly on the supply of organic matter and phytosanitary treatment based on biopesticides. There are different profiles in this area: women with very diversified small plots, men who integrate arboriculture and vegetable producing, others in monoculture of onions in irrigated systems under pressure (drip irrigation). ENDA PRONAT has data on the production of about thirty farms in this area.

Zone 2 – Koussanar (Sénégal Oriental): Koussanar is a municipality located in the Eastern agroecological region of Senegal, characterized by farms with a predominance of arable crops (groundnut, millet and sorghum) under rainfall with a strong agriculture-livestock integration. Enda Pronat has been supporting 18 family farms over the past 4 years in the agroecological transition (organic fertilization, assisted natural regeneration, etc.) and has data on the areas farmed, practices, yields, cereal consumption, etc. The evaluation of the 2017 season had shown that among the 18 family farms monitored, 7 (all of which are women-led and were in difficulty in 2016) made significant progress in improving their yields (mainly of groundnuts), due to several factors such as rainfall, but also to the implementation of certain recommendations such as early planting with seeds distributed in 2016 that were saved, support in seeders and the application of biofertilizer and natural phosphate.

4.3.3.1.2 Sampling Design

The sampling approach was based on spatial distribution and random sampling of farmers. In each of the two sites (Niayes and Koussanar), 40 producers were targeted on the basis of the knowledge of ENDA PRONAT and ISRA.
Among these 40 producers:

- 20 were selected as “agroecological” (later labeled as “AE”),

- 20 so-called "control group" referents selected on the basis of experience and knowledge of the environment by the ENDA PRONAT and ISRA field teams. These were therefore not categorized with the TAPE tool. These producers generally use a massive amount of pesticides and synthetic chemical fertilizers in an intensive production system, characterized by a monoculture. The lack of knowledge of the exact agroecological transition level of farms considered non-agroecological could lead to biases in results. Indeed, a farm that is considered non-agroecological may actually be in transition and therefore not really correspond to what is expected to be the characteristics of the control group.

Table 8: Number of farmers sampled in 2 agro-ecological zones in Senegal

Zone	**Characteristics of the zones**	**Nb. of farmers for each zone**	
	Yearly rainfall (mm)	**AE**	***control group***
Niayes	*400*	*14*	*31*
Koussanar	*700*	*20*	*20*
Total		*34*	*51*

4.3.3.3.1.2. Specifities for the Senegalese SHARP survey:

Data was collected throughout interviews with the producers, using the structured SHARP survey developed by FAO, deployed in tablets SAMSUNG Galaxy TabA.

4.3.3.1. Overall Findings SHARP resilience assessment

There are interesting differences between the two zones in regard to their performance in SHARP according to each of their specificities. We therefore propose to first showcase SHARP performance analysed wholly as either agroecological or non-agroecological systems, without regard for the agroecological zones and secondly zoom into the specificities of each zone.

The mean resilience scores of both the agroecological farms (5.2) and the control group (4.8) characterises the systems as mid-level climate resilience which implies that the farmers have certain abilities and knowledge to withstand unexpected shocks and climate variability, however, there is still a need to further strengthen their capacity to adapt to climate change (Hernandez-Lagana, Nakwang & Muhamad, 2018).
According to these results and the graph below, agroecological farms are in average more resilient than the control group.

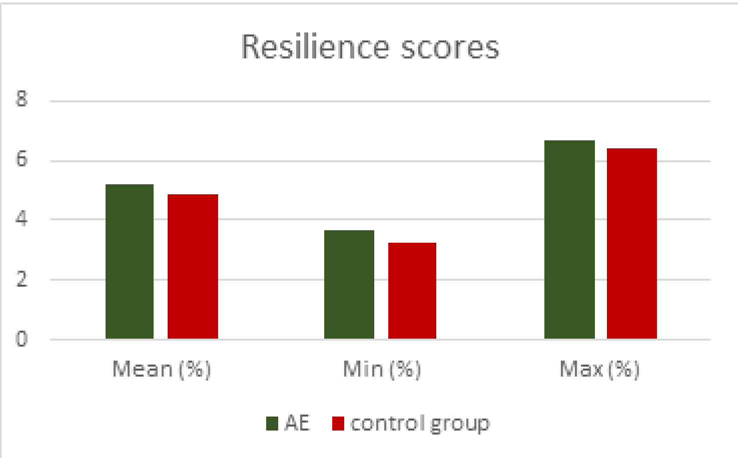


Figure 24: Average resilience scores of AE and non-agroecological farm systems

Table 9: *Summary of SHARP dataset scores for sampled farmers*

Variable	Type of farmer	Sample No.	Mean	Min.	Max.
SHARP scores	AE	34	5.1996565	3.680125	6.719188
	Control group	51	4.8407545	3.277916	6.403593

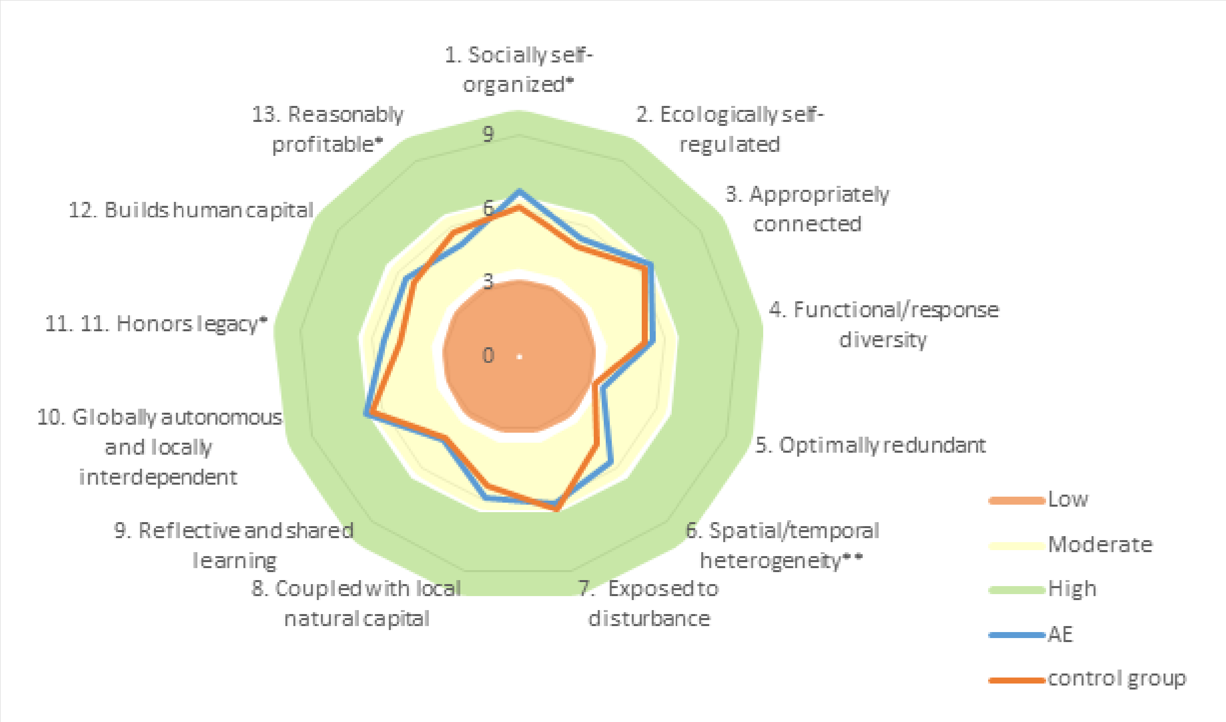


Figure 25: Average levels scores of AE and non-agroecological systems by agro-ecosystem indicator and level of resilience

Among all the agroecosystem resilience indicators, **significant statistical differences between agro-ecological farms and the control group were observed for 4 of the 13 indicators (*Figure 25*)**.

The **scores of agro-ecological farmers are higher than those of the control group for 3 of these 4 indicators** (**socially self-organized; spatial and temporal heterogeneity, heritage of traditions**) and **lower for 1 of the indicators, the reasonably profitable indicator**.

At the module level, significant differences in average scores were observed for **11 out of the 35 modules.** Agroecological systems have **higher average scores for 8 out of these 11 modules** (all the 3 statistically different ones of the agronomic domain modules; 2 out of the 4 of the economic; none from the only environment one; all the 3 of the social domain modules).

4.3.3.1.3 Domain results

SHARP results were also assessed for each of the four areas (agronomic practices, environmental aspects, social interactions and economic components), as shown in Figure 26.

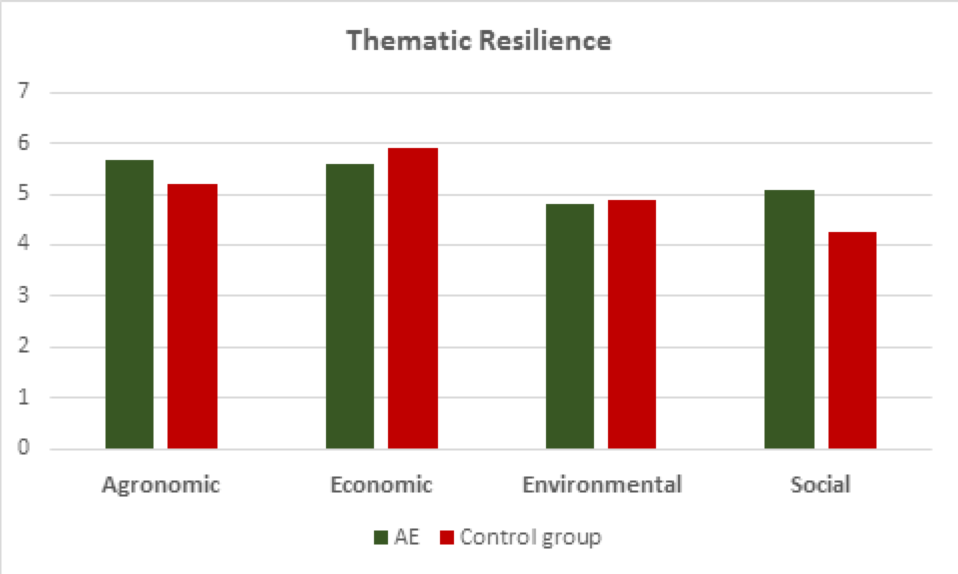


Figure 26: Average technical scores for the four domains

Based on the averages of the technical scores, there is a significant difference between AE farms and the control group for the social domain (P < 0.01), which covers the modules concerning disturbances, community cooperation, group membership, meals, decision-making at household level and in farm management. It should be noted that even if there is no statistically significant difference, there is a higher average score for AE farms in the agronomic field compared to farms in the control group (5.67 and 5.20 respectively) and practically the same levels for the economic and environmental fields.

<u>Detailed Results: per domain</u>

<u>Social</u>

Agroecological farms have a higher level of resilience in the social domain than the control group, being this difference statistically significant at the 0.01 level. The following graph gives us an overview of the results for the different modules constituting the social aspects.

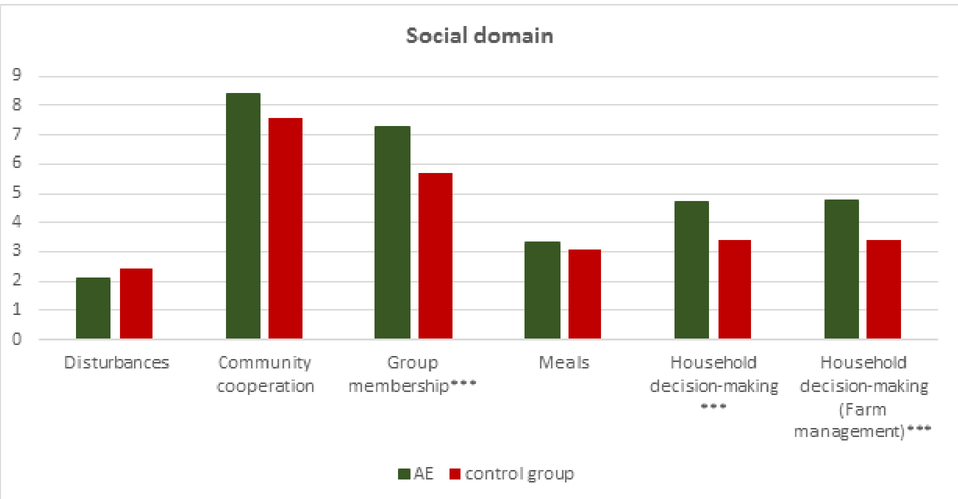
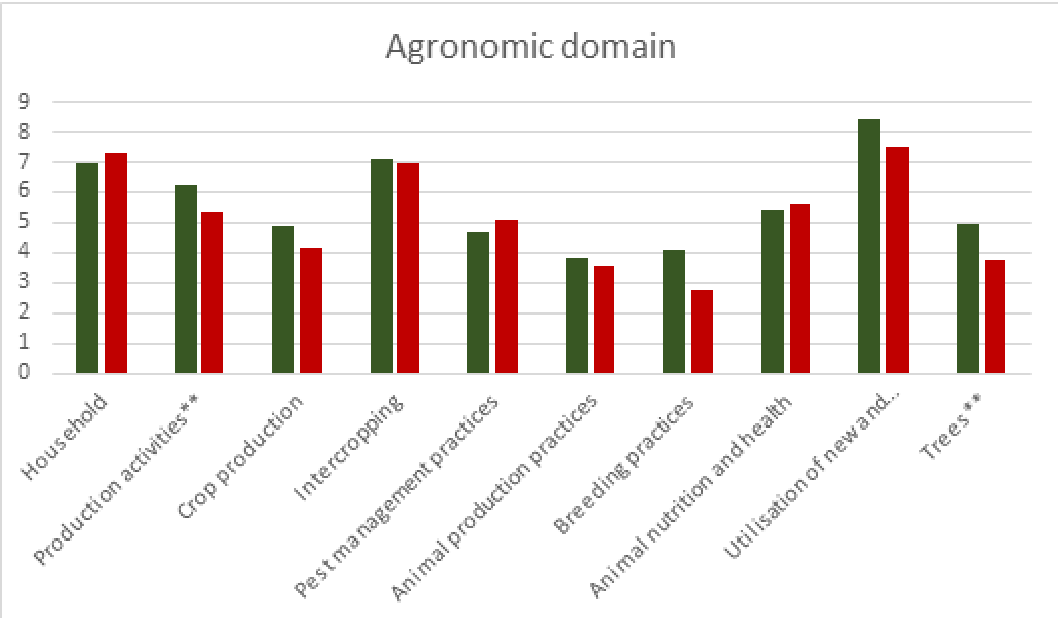


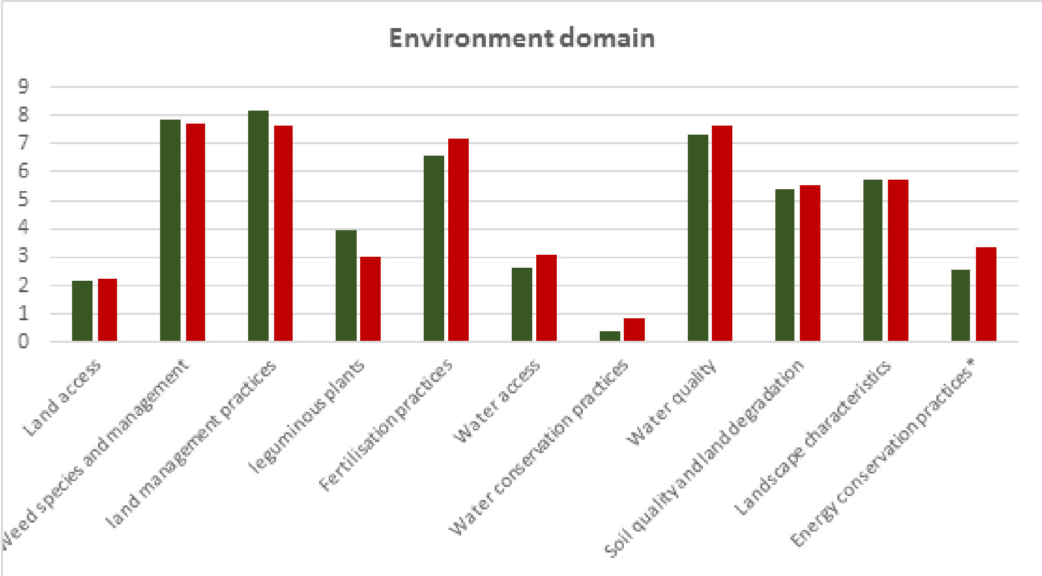
Figure 27: Average technical scores for modules within the social domain

Table 10: Summary of SHARP dataset scores for sampled farmers

Modules with a statistical difference	Interpretation

Group membership	The difference is significant (P<0.05) for this indicator, indicating that agroecological farms are very well interconnected with their communities, promoting knowledge exchanges on agricultural practices (crops, animals, forestry and fisheries) and traditional knowledge.
Decision-making (farm management)	The difference is significant (P<0.05), indicating that on agroecological farms, decisions about farming activities and farm management probably taken in a more collaboratively manner by household members (especially the head of household and his / her partner); whilst the load of activities are divided more equally among the household members. It is important to note that agroecological farms generally require more labour, which that is often family-sourced.
Decision-making (household)	The difference is significant (P<0.05), indicating that on agroecological farms, household decisions are made jointly by the members of the household (especially the head of the household and his / her partner) and housework equally shared.





4.3.3.1.4 Detailed Results for all farms: Agroecosystem resilience indicators

This chapter provides a detailed analysis of the results of the 13 agroecosystem resilience indicators.

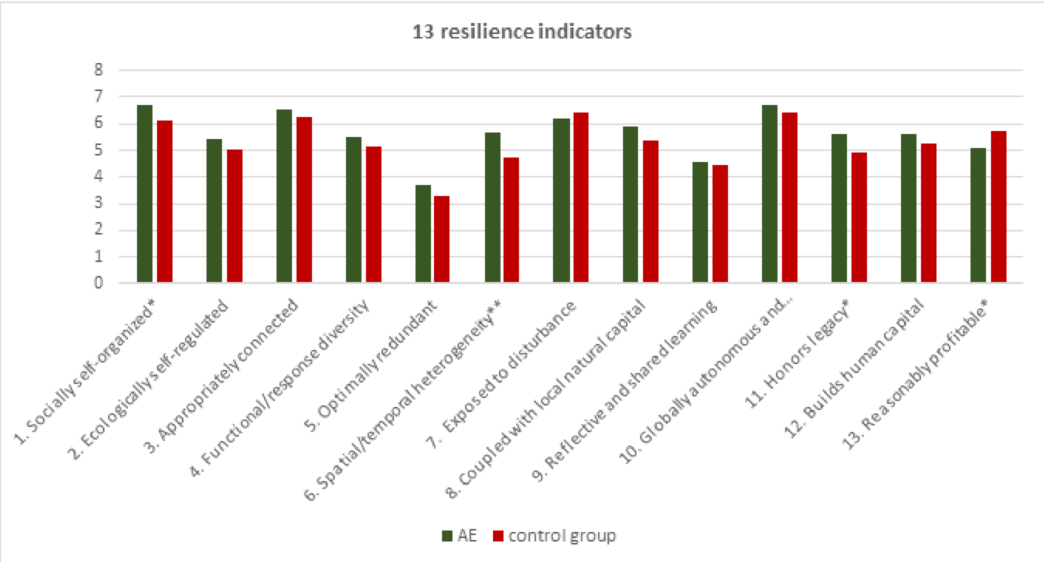


Figure 28: 13 agro-ecosystem indicators by type of farm: AE and control group in Senegal

Socially self-organized

The socially self-organized indicator assesses the ability of farmers to organize themselves into networks and basic institutions such as cooperatives, farmers' markets and community sustainability associations. There is a significant difference for this indicator between AE farms and the control group ($p<0.1$)

In agroecological farms, farmers are very well interconnected with their communities, as the characterization tool has also shown, with high scores for the elements “Human and social values”; “Co-creation & sharing of knowledge”; “Culture and dietary traditions”. This means that they share more knowledge and participate and integrate their grassroots institutions such as cooperatives, farmers' markets, community sustainable development associations, community gardens and advisory networks and are also often supported by NGOs.

Ecologically self-regulated

No significant differences were observed between the agroecological systems and the control group for this indicator. This indicator for AE farms has a higher score than for the control group (5.4 versus 5.03). This indicator measures the performance of farms in maintaining land cover, their ability to provide habitat for predators and parasitoids, their ability to use ecosystem engineers and to align the production with local ecological parameters. The characterization showed that AE farms cultivate, a diversity of crops and practice the association that most often allows them to cover their land. They use an integrated approach to manage pests and a rational use of synthetic products to reduce pests and diseases and improve soil fertility. These practices have favoured the development of natural predators allied to the farmer for the biological control of pests and maintain or enhance the health of the soil they use.

Appropriately connected

The indicator indicates not only from a social point of view, collaboration with several suppliers, points of sale and other farmers; but also from an ecological point of view, the crops planted in mixed farming that encourage symbiosis and mutualism. The difference is not significant but resilience scores have a **higher average in AE farms compared to the ones in the control group** (6.5 versus 6.2). This slight difference can be explained by the growing system. Indeed, it is easier to find the association of crops in AE farms than in the control group.

Functional/response diversity

This indicator reflects the heterogeneity of functions within the landscape and farm; the diversity of inputs, outputs, sources of income, markets, pest control, etc. There is no significant difference, but a **higher average for AE farms** (5.4 versus 5.1). However, the **difference is significant ($P<0.05$) for the sub-indicator "species diversity"** which shows that on AE farms it is easier to observe crop diversification in terms of types (annual and perennial cultivars), species and varieties. Moreover, there is a presence of mixed systems such as agro-forestry to improve fertility and promote the manufacture of bio pesticides in AE farms.

Optimally redundant

The indicator indicates the level of redundancy the farm has within it, that can serve as buffer in case shock occur. This indicator is measure by features related to the planting of several crop varieties rather than just one, keeping several animal breeds, obtaining nutrients from multiple sources and capturing water from multiple sources. There is no significant difference but **AE farms** present **higher average resilience scores** (3.6 compared to 3.2 in the control group), and significant differences are shown in the sub-indicators that measure the **diversity of cultivated varieties and animal production practices**. These two sub-indicators are very favourable to AE farms, which in their production systems develop polyculture and sometimes integrate livestock, which leads to variety diversity.

Spatial/temporal heterogeneity

This indicator measures heterogeneity within the agricultural system and landscape. It considers aspects related to the diversity of agricultural activities, resource management practices and landscape diversification, as well as within landscapes. **Agroecological farms have a significantly higher degree of spatial and temporal heterogeneity** ($P<0.05$) than the control group.

At the level of the sub-indicators, these differences are visible with regard to **intercropping** and **crop mix** ($P <0.01$) but also with regard to the **presence of trees on the farm** ($P<0.05$), see attached table under indicators.

Agroecological farmers more commonly implement land management practices such as agroforestry, crop rotation and manure/composting which increases temporal and spatial heterogeneity compared to their counterparts of the control group. This can be explained by the better access of agroecological farmers to technological know-how thanks to the support of NGOs and umbrella organizations, of which they are members, which have enabled their popularization and adoption.

Exposed to disturbance

The indicator seeks to assess the level to which the farm system has been exposed to a discretionary level of disturbances and thus, its capacity to withstand and overcome them. Disturbances are captured by the exposure to climate and non-climate related shocks, while the behaviours towards them are captured by a number of management practices used (e.g. pest management practices, coping mechanisms). There is a significant difference with a slight advantage for the control group with an average of 6.4 versus 6.1 for AE farms. The difference can be found in the sub-indicators measuring weed management and pest management practices. Indeed, the control group has a higher average value (6.4 versus 6.1) than AE farms because they have the ability to use a variety of treatment products that allow them to control weeds or pests. Nonetheless, it should be noted that some of these products (e.g. synthetic or mineral pesticides) are harmful to the environment, biodiversity and health and thus, are not considered as sustainable if not well managed (e.g. in high and frequent doses, not in mix with organic fertilizers, not following safety measures). Moreover, when looking at the climate-related shocks, although most of respondent experienced these, only about half of them declared to have changed their behaviour in respond to these. The results show that in spite of experiencing events that are harmful for the household and livelihoods, there is still need to improve the way in which actions are taken to respond to these.

Coupled with local natural capital

This indicator assesses here the system's ability to recycle and reuse waste and to encourage the system to live within its own means and without depleting the natural resources base. There is no significant difference for this indicator, but **the average for AE farms remains higher** than the control group (5.9 versus 5.4). This advantage can be explained by the 3 following sub-indicators which measure **water conservation practices** such as crop association, bowl cultivation, mulching, etc.; **pesticide use** where AE farms use these in rational fashion and by trying to take protective measures when handling and disposing chemical products; and the **use of trees**, which as shown above for temporal and spatial heterogeneity remains significant ($P<0.01$), which shows that in AE farms the tree is more used than in the control group to participate in soil fertilization and as a source of biopesticide.

Reflective and shared learning

This indicator measures the collaboration between extension and advisory services for farmers; universities, research centres and farmers that allow the improvement of production practices and livelihood overall. It also indicates cooperation and knowledge sharing among farmers (e.g. to improve bargaining power and market access, enhance productivity) ; record keeping; and basic knowledge of the state of the agro-ecosystem. AE farms have a slightly higher average than the control group (4.6 compared to 4.5) and a significant difference for the market access sub-indicator ($P<0.05$). AE farmers are most often members of marketing networks or sales cooperatives (sell selal) and in the Niayes area AE farmers are part of a participatory guarantee system that allow them to increase and keep a constant and profitable selling price of their products.

Globally autonomous and locally interdependent

This indicator measures independence from the global level and solidarity and inclusion at the local level. It also assesses the level of dependence of farms at the market level on the supply of raw materials and the reduction in the use of external inputs; sales on local markets; the use of local resources; the existence of cooperative farmers; close relations between producer and consumer; and shared resources such as equipment. There is no significant difference for this indicator but AE farms have a higher average on the resilience scores than the control group (6.7 versus 6.4). This slight difference can be explained at the level of the sub-indicators for which we note: a significant difference (P<0.05) for access to markets, reliance of local crop varieties and breeds and the multiple purposes for agricultural production (i.e. on farm consumption and marketing).

Honours legacy

The legacy of traditions is a measure of the preservation and use of traditional and Aboriginal knowledge in the practices used for agricultural production and in the way the farm is managed. The evaluation of this indicator is based on sub-indicators such as community engagement of elders, preservation of traditional knowledge, customary mechanisms, tree products, disease management and the use of new varieties.

Agro-ecological farmers scored significantly higher for this indicator (P<0.1). At the sub-indicator level, we observe that agroecological farmers have a **greater use of tree products as natural remedies** as well as **for crop protection**. Likewise, significant differences (p<0.05) are found in the **use of local and new varieties and breeds** that are adapted to local condition. As a result of the transfer of traditional knowledge through their grassroots organizations, farmers are more likely to use trees as natural remedies, as natural treatment products and as a means of soil fertilization.

Builds human capital

For this indicator, "a system that strengthens human capital mobilizes social relationships and resources that improve household well-being, economic activity, technology, infrastructure, individual skills and abilities, and facilitates social organization and norms, as well as formal and informal networks" (Cabell & Oelofse, 2012; Heckelman et al., 2018). The difference is not significant but the average score is higher for AE farms (5.6 compared to 5.2). This higher average is explained by the fact that AE farms are less exposed to the use of chemicals and they tend to participate in the grassroots organizations and are often supported by NGOs. The membership to these organizations have allowed them to receive technical training, which has contributed positively improve their skills on their organization and production system in terms of management and production.

Reasonably profitable

This indicator aims to assess the extent to which farmers and agricultural workers can earn a decent wage through agriculture and other non-agricultural activities, and to determine whether the agricultural sector does not depend on distorted subsidies to be profitable. Profitability is assessed through the number of income sources of the agricultural holding, financial support received when needed, market access, assets held, insurance, savings and post-harvest handling practices to improve produce value. For this indicator, **the control group has a higher level of resilience than AE farms** with a significant difference (P<0.1). The control group has a **significant difference for the insurance sub-indicator** (P<0.05) that shows that they manage to financially protect their products (e.g. crops, livestock, land) against loss or damage. This practice is more observed among the control group farmers who grow field crops in Koussanar, which is less so among vegetable producers in the Niayes. Although not significant difference is observed, farms in the control group seem to have a larger diversity of income sources (farm and off-farm), hold a larger number of productive assets, which also is reflected in better access to financial services (e.g. credits).

4.3.3.2 Overall conclusions technical potential

Comparing AE and the control group using the SHARP tool indicates that **overall AE farms have a higher level of resilience than the control group** (with a mean resilience score of 5.2 versus 4.8 respectively).
It is important to highlight a possible bias in the results as the control group was not initially characterized using the TAPE tool, which would clearly classify these as non-agroecological farms. It could be that some of the farms in this group have a transition level close to AE farms, impacting therefore the scores.

Each indicator was assessed using sub-indicators, which are key entry points of possible interventions for intrinsic and external farm relationships. The comparison showed **that out of the 13 indicators studied, AE farms have a higher level of resilience on average on 11 indicators** (see graph below), **3 of which show a significant difference (Socially self-organized; Spatial/temporal heterogeneity; Honours legacy).**

Meaning that agroecological farmers show greater adaptability and resilience in terms of:

a. maintaining a high diversity within their farm systems,
b. a better capacity to self-organize, and
c. preserve and use traditional knowledge and traditions within and outside the farm activities.

Regarding point a) significant differences were observed regarding **varietal diversity** (giving an indication of the number of breeds owned and the number of varieties grown), **polyculture systems being highly developed among AE farms**. Agroecological farmers are also make **greater use of many traditional varieties of crops and animals adapted to local conditions**, especially in Koussanar, a livestock and agricultural area.

Self-organization (point b) shows that AE farms are well connected to their communities and share knowledge on sustainable development issues.
As a result of the transfer of traditional knowledge through their grassroots organizations, AE farmers are more likely to use trees as natural remedies, as natural treatment products and as a means of soil fertilization (point c). Agroecological farmers have also a **greater integration of tree products for agricultural production as well as to source their own energy for domestic use** (firewood).
Limitations and vulnerabilities of AE farmers include poor access to effective natural treatment products for pest control and weed management, as well as limited access to financial services and insurance. These results are highlighted by the significant difference regarding the reasonably profitable indicator (for which the control group has a higher score). Therefore, enhancing the access of producers to knowledge on how to manage pests in an integrated and sustainable manner is key to build their resilience levels. Likewise, improving their access to financial services like credits or insurance would also increase farmers' ability to invest in more and better productive assets, protect them against (expected and unexpected) shocks and increase their liquidity, among others.

4.3.3.3 Context specific Findings : per agroecological zone

Niayes

Challenged by the high use of pesticides and fertilizers in this area, Enda Pronat has undertaken the promotion of the "Healthy and Sustainable Agriculture" (Agriculture Saine et Durable), " characterized as an agriculture, which is: economically viable, ecologically sound, meeting food security requirements and underpinned by an organizational dynamic of producers in partnership with support and research structures" (Enda Pronat, 2012).

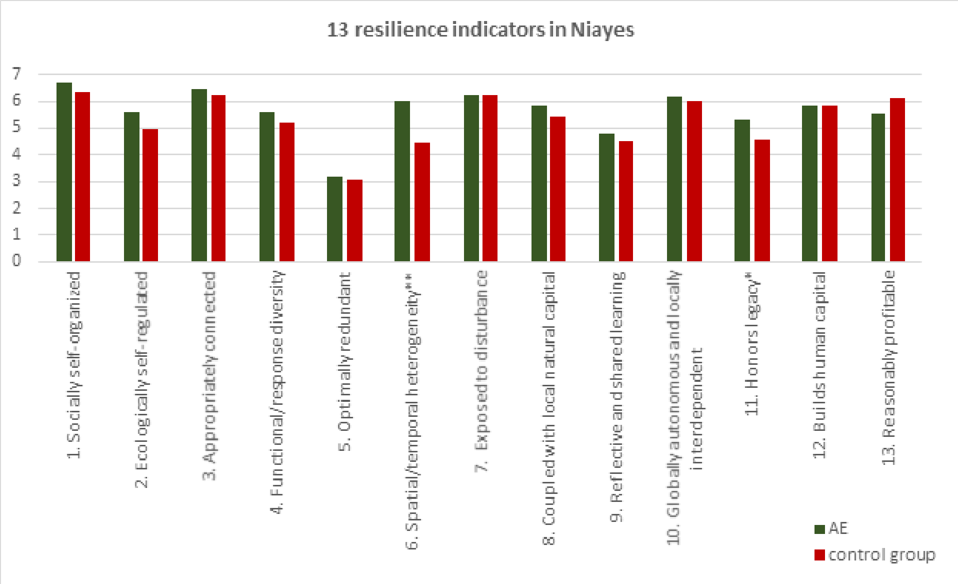


Figure 29: 13 resilience indicators in Niayes

Significant differences can be observed for indicators Spatial and temporal heterogeneity (P<0.05), honours legacy (P<0.1) and ecologically self-regulated (P<0.1).

In AE farms, several plant species are grown on the same land, including seasonal and multi-annual crops and a wide variety of varieties grown in some crops and plant species by intercropping on their farms. Agroecological farms use more natural/biological methods to manage animal diseases (biological pesticides, biological control methods, manual capture of pests found on crops, use of traps or trap plants, increasing biodiversity around fields to allow other pest control insects).

Koussanar

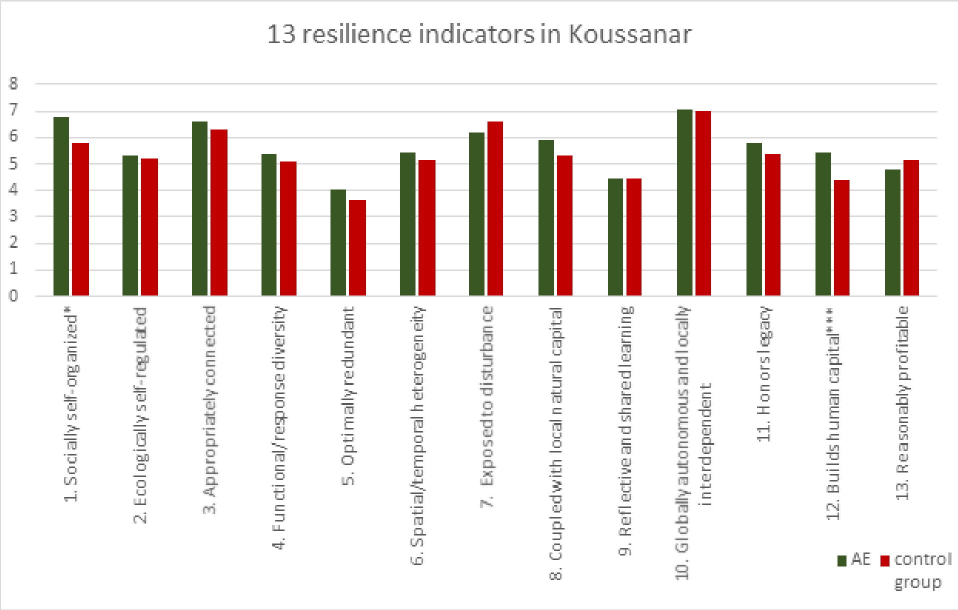


Figure 30: 13 resilience indicators in Koussanar

Significant differences can be observed for the socially self-organized indicators (P<0.1) and Builds human capital (P<0.05).

In the characterization suing the TAPE tool, it was noted that agroecological farms are very well interconnected with their communities and this really facilitates support for social events (building human and social capital) and knowledge sharing. Producers participate and integrate their basic institutions such as cooperatives, farmers' markets, community sustainable development associations, community gardens and advisory networks and are often also accompanied by NGOs. Unlike Koussanar, in Niayes the indicator 12 (Build human capital) does not present significant differences between AE farm and control group farms since there are several producers who often participate in the activities of grassroots organizations to share knowledge, training and awareness.

4.3.3.4 Context specific conclusions of the findings, per agro-ecological zones

Table 11: Comparision between Niayes and Koussanar : significant differences between AE and control group

zones	Significantly different agroecosystem resilience indicators			
Niayes	Spatial and temporal heterogeneity (6)	Honours legacy (11)	Ecologically self-regulated (2)	
Koussanar	Builds human capital (12)	Socilly self-organized (1)		

In conclusion, we can say that **in the Niayes area, out of all the indicators studied, AE farms show on average a higher resilience on 11 indicator, including 2 with a significant difference: spatial and temporal heterogeneity (P<0.05) and the heritage of traditions (P<0.1).** The temporal and spatial heterogeneity indicator presents significant differences between AE and control farms, meaning that in the Niayes area, which is a favourable area for vegetable production, there is a diversity of crops, and the practice of intercropping and crop rotation. Jointly, these practices not only improve the diversity of production but also enhance soil health and serve as a mechanism to help prevent from pest invasion and plant diseases. Nonetheless, in this area, shortfalls for AE farms are noted on access to financial services. Therefore, the focus should be on access to financial services, i.e. finding financing mechanisms for AE farms to enable them to increase their investment options and thus, their agricultural potential.

For Koussanar, AE farms present higher resilience scores on 9 indicators, 2 of which have a significant difference: the self-organisation of farms ($P<0.1$) and the construction of human capital ($P<0.01$). The latter indicator, taking it from the large sample, is not significant; however, by contextualizing it in the Koussanar area it has a very large significant difference. These results suggest that in this area the manner in which farming systems and agricultural-reliant households work promote the strengthening of human capital that mobilizes social relationships and resources, improving household well-being, economic activity, technology, infrastructure, individual skills and abilities, whilst facilitates social organization and norms. Being an area that is also practically cultivated during winter, the use of pesticides is less intensive and therefore the health of the population is less exposed.

The analysis of the results shows weaknesses in indicators related to disturbance, as well as pest and weed management. It would therefore be key to focus on strengthening producers' ability to manage weeds and pests in a sustainable, diversified and effective manner to enhance their resilience.

5 Conclusions and recommendations

5.1 Overall conclusions

Summarizing the more detailed chapter specific conclusions for policy potential, meta-analysis, and the two case studies we can conclude:

Agroecology is gaining momentum

A systemic assessment of the potential for agroecology (according to FAO's 10 elements definition) considered and recommended as a relevant adaptation / mitigation approach in the international agriculture-climate discussions, in particular also in the UNFCCC process and the Koronivia Joint Work on Agriculture (KJWA) revealed that:

- A increasing number of countries and stakeholders from different backgrounds see agroecology and related approaches as a promising mean for reaching adaptation and mitigation targets and to achieve an effective transformational change**.**
- More than ten percent of the national determined contributions (NDCs) (17 out of the 136 analyzed) explicitly mention "agroecology", as either an adaptation strategy (11 percent) or as mitigation to climate change (4 percent).
- Without addressing Agroecology specifically, isolated agroecologcial approaches are mentioned in additional NDCs, picking selected agroecological elements e.g. such as "efficiency", "recycling", "diversity" and "co-creating of knowledge
- Agroecology has also seen considerable attention in 2019 at CFS (comitee on world food security) and in CBD (convention on biological diversity) discussions.

Solid evidence demonstrating that agroecology increases climate resilience

The meta-analysis of peer reviewed studies on agroecology results (N=34 meta-analysis and 17 case studies selected out of 185) bring forward some clear patterns:

- Agroecology builds on key characteristics which have a strong positive correlation with climate resilience.
- Most solid evidence on strengthening climate resilience through increased adaptive capacity and reduced vulnerability is through improved soil health, biodiversity and high diversification, i.e. integrating different breeds, varieties and species into agricultural production systems but also productivity and yield stability.
- Mitigation co-benefits are also achieved, mainly related to increased soil organic matter (carbon sequestration) and reduced use of synthetic fertilizers.
- Institutional aspects, such as knowledge co-creation and dissemination via advisory services and farmer-to-farmer approaches have a key role to support the development, improvement and uptake of agroecology.
- When supporting agroecology and fostering climate resilience, it is key to establish and strengthen functional and context specific knowledge and participatory innovation systems.

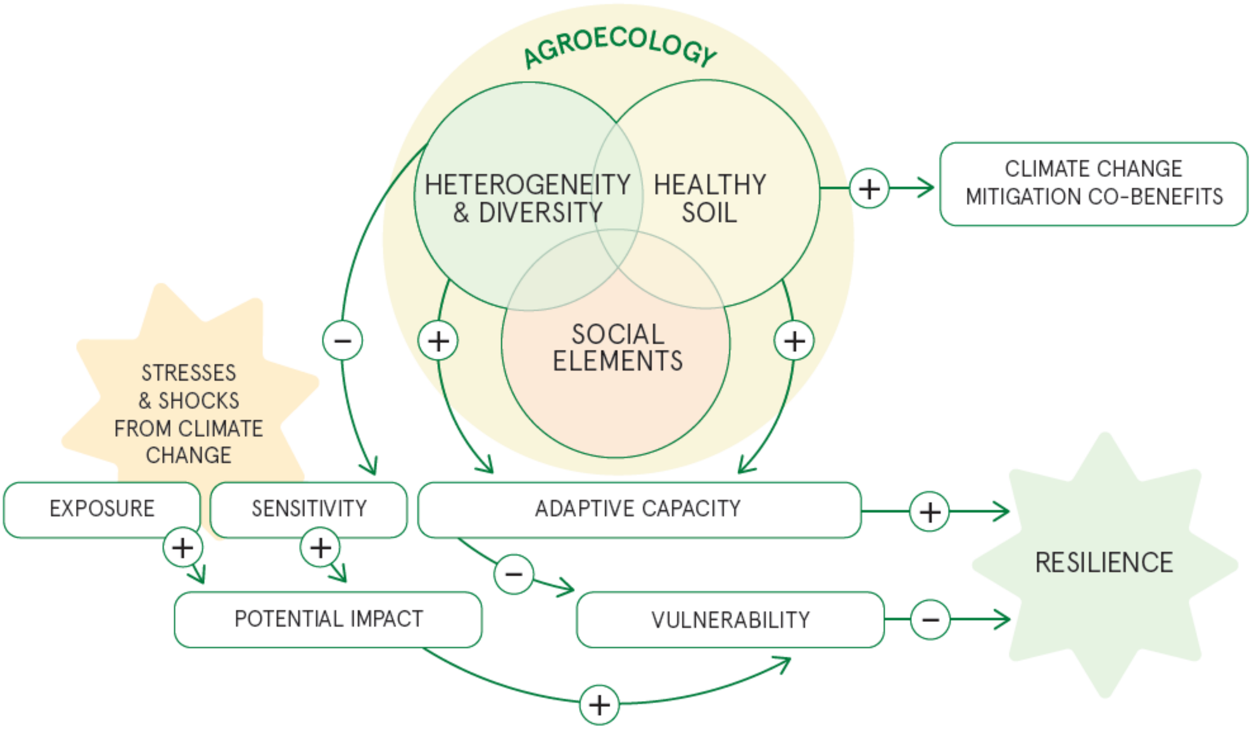


Figure 31: Summary of main agroecological resilience strengthening pathways.

Lessons learned from countries on agroecology's potential

Policy potential

The national case studies assessed each country's institutional frameworks in terms of the potential to incorporate agroecology to hedge against climate change, providing a deep understanding of the current national context, the enabling environment as well as the opportunities and challenges for agroecology to be considered in the decision-making process and to scale it up.

While Kenya and Senegal have different policy settings, in both countries there is considerable potential for agroecology to gain momentum. However, it is challenging to translate the interdisciplinary and systemic nature of agroecology into policies, laws, strategies. Both case studies highlight the importance of training and awareness raising activities to ensure common understanding of agroecology and to ensure its translation into appropriate institutional frameworks.

Kenya policy Environment

- Climate related policies in Kenya do not emphasize systemic, ecologic farming approaches but selectively address agroecology elements such as soil and conservation practices.
- Through increased understanding of agroecology, stakeholders see opportunities of integrating it into sub-national institutional processes.
- Good opportunities to embed agroecological approaches into existing policies.
- Further efforts to provide evidence, training and policy guidance for agroecology would need to be matched with increased levels of public and private investment and financial support.

Senegal policy Environment

- Agroecology emerged in the 1980s in Senegal and many promising initiatives spread out since then that have influenced policies. However policies and laws do not yet include agroecological approaches, as there is still a strong focus on high external input dependent agricultural systems.
- Favorable conditions for scaling-up agroecology exist today: 1) an increasing institutional commitment, since agroecological transition ambition is included in the government's priorities (among the five major initiatives of the Plan Senegal Emergent 2019-2024); 2) the strong multi-stakeholder group *Dynamique sur la Transition Agroécologique au Sénégal* (DyTAES) aspires to develop a contribution document to transform national policies and work towards an agroecological transition.

Technical potential

In both countries a comparative analysis of 40-50 farmers that have been included in agroecological projects supprted by Bioversity, Enda Pronat and ICE for more than 5 years versus 40-50 not practicings agreocology (control group), was conducted to gain better understanding of the ecological and socio-economic resilience performance of agroecology (based on the FAO SHARP tool):

- Overall results show that agroecological farmers have significantly higher SHARP resilience scores.
- These agroecological systems have a higher capacity to absorb, cope, adapt to climate change and are therefore more resilient.
- In both countries and despite very different contexts, spatial and temporal heterogeneity as well as integrating and sharing of traditional knowledge ("honours legacy") where both significantly higher in the agroecology samples, which indicates that they are key apsects in strengthening resilience through Agroecology.

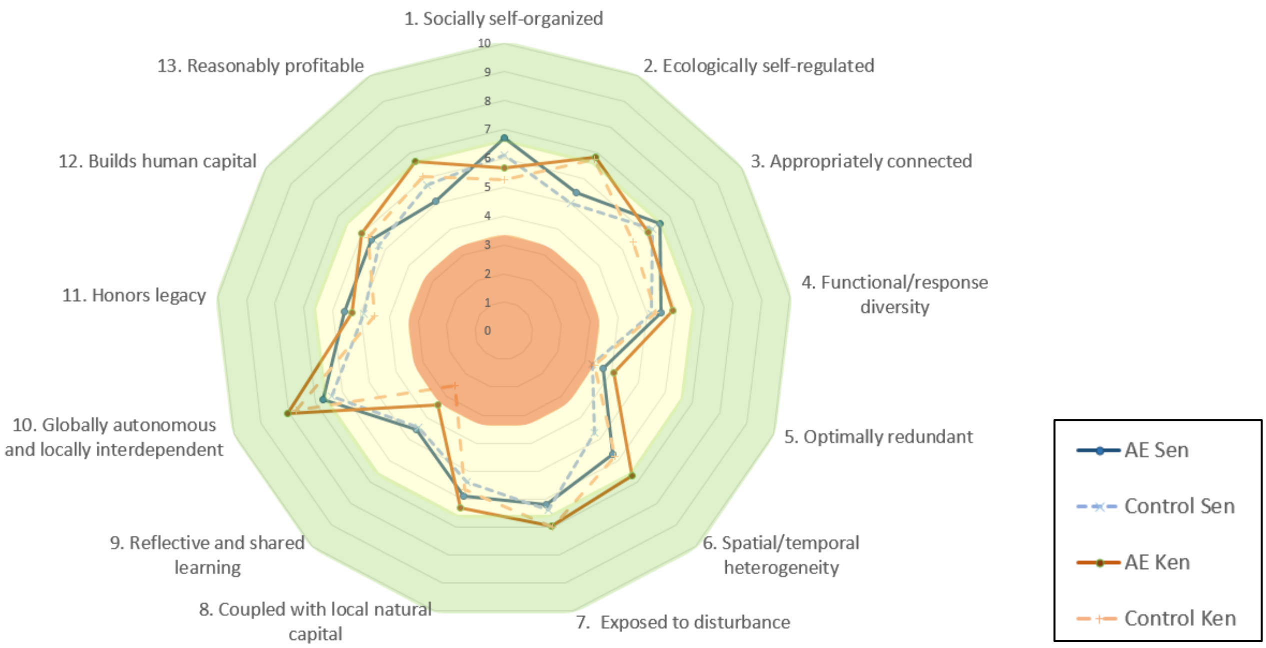


Figure 32: Average SHARP scores of Kenya's (Ken) and Senegal's (Sen) agroecology and control group, by resilience indicator

The results of this study support the claim, that agroecology should be acknowledged as a truly powerful integrated approach to transform agriculture production systems into a more sustainable and climate resilient future, on various levels.

Agroecological farmers show greater adaptability and resilience in terms of:

KENYA	SENEGAL
3. Appropriately connected (i.e. access to information, forecasts, markets, participatory guarantee schemes) **	
9. Reflective and shared learning indicator (i.e. higher farmer group participation & access to extension) **	
11. Honours legacy indicator (i.e. higher integration of trees for natural remedies, pesticide and fertilization due to the transfer of traditional knowledge) *	**11.** Honours legacy indicator (i.e. use of local and new varieties and breeds that are adapted to local condition; greater use of tree products as natural remedies) *
5. Redundancy (functional and species diversity i.e. number of crops). **	
5. Optimally redundant (i.e. variety diversity) **	
6. Spatial and temporal heterogeneity (i.e. intercropping; crop mix; terracing, wind breaks, presence of trees on the farm **	**6.** Spatial and temporal heterogeneity (i.e. intercropping; crop mix; terracing, wind breaks, presence of trees on the farm) *
8. Coupled with local and natural capital (i.e. substitution of external inputs) *	
	1. Socially self-organized (i.e. ability of farmers to organize themselves into networks and basic institutions such as cooperatives, farmers' markets and community sustainability associations)*

Kenya:

- For 7 out of 13 SHARP indicators agroecology-based systems perform significantly better.
- The agroecology group scores better in the averages of environmental aspects, economic components and significantly better in agronomic practices.
- Both the agroecological systems and control group identified similar priorities and needs for further support, in particular insurance, animal breeding, non-farm income generating activities, access to water and land.

Senegal:

- For 3 out of 13 SHARP indicators agroecology-based systems perform significantly better.
- The agroecology group performed significantly better on social related indicators, and better for agricultural practices. Same performance levels as the control group were reached for the economic and environmental related aspects.
- Barriers for agroecological farmers include access to effective biological products for pest control and weed management, as well as limited access to financial services and insurance.

General observations on Agroecology from a resilience perspective.

The following graph summarizes well the interactions and the close connectedness of elements of resilience (13 principles from Cabell and Oelofse (2012) and the characteristics of Agroecology as described by FAO's 10 elements, all contributing to resilience. On the left, y-axis, are Gliessmann levels of food system transformations according to his 5 levels.

The core principles on which agroecological practices build (i.e.: diversity, efficient use of natural resources, nutrient recycling natural regulation and synergies) characterize their inherent adaptation and resilience potential to climate change (Côte et al., 2018). This interconnection between the two concepts is the exact reason why agroecology, from a conceptual point of view, possesses an inherent resilience to climate change..

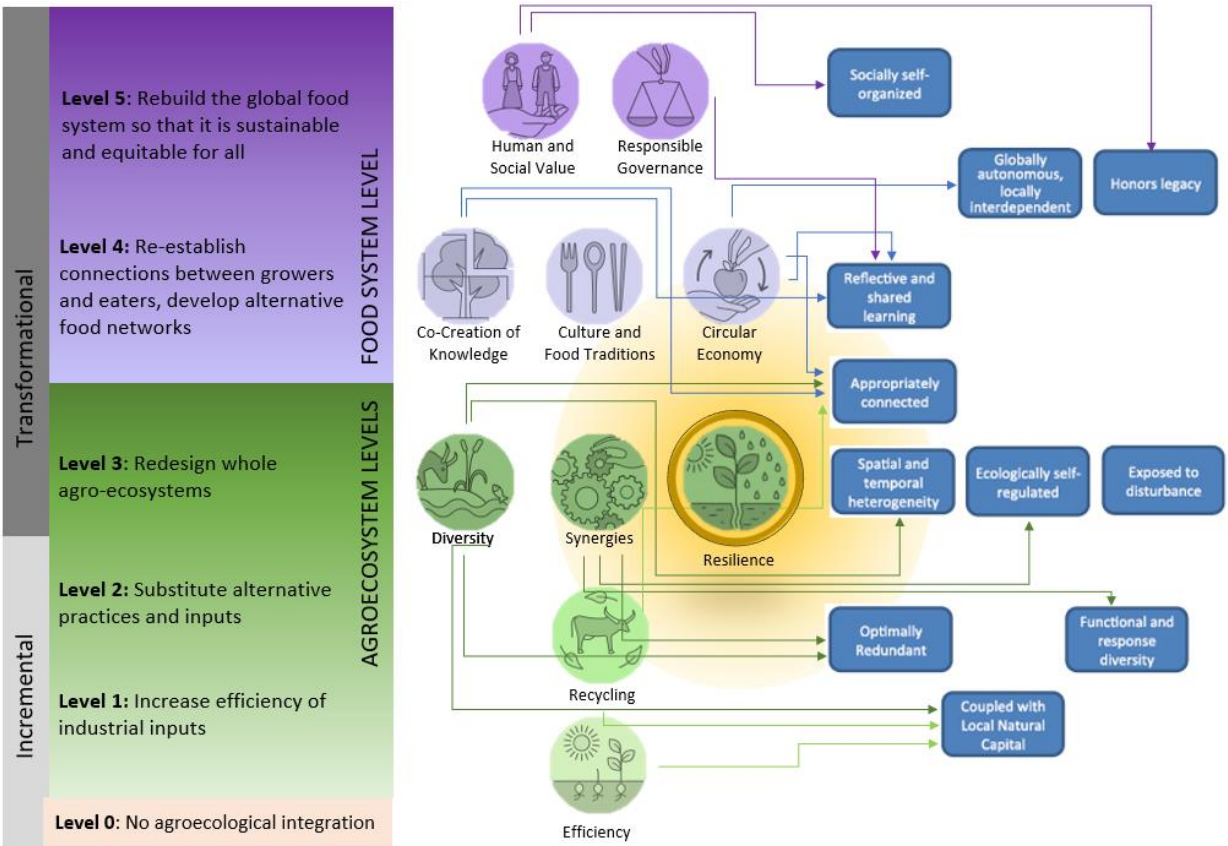


Figure 33: The FAO Agroecology element on resilience is at the very center of this graph as, in the context of this study, it is rather an outcome of the various agroecologial interventions and interactions than a agroecological element, a property itself. Therefore it also cuts across levels, indicated by the yellow color.

5.2 Recommendations

Profound holistic and systemic transformation is needed to address climate change as well as the Agenda 2030 and to achieve food security and nutrition (FSN) in its four dimensions of availability, access, utilization and stability, and to face further multidimensional and complex challenges, including a growing world population driving increased pressure on natural resources, impacting land, water and biodiversity.(HLPE, 2019)"

To address these multidimensional challenges and forstering climate resilience in agriculture, donors, decision makers and other stakeholders should:

- Embrace complexity, adopt a more systemic understanding of challenges and solutions to hedge against climate change, grasp environmental issues in a holistic way and move towards more policy convergence, by breaking silos and working across agricultural sectors.
- Acknowledge that the current knowledge base is robust enough to supporting agroecology as an effective climate change adaptation strategy and strengthening farmers' resilience.
- Increase investment in research on agroecological approaches, support transdisciplinary and participatory action research, conducted by innovation platforms that foster co-creation and dissemination
- Develop comprehensive performance metrics, covering all the impacts of agriculture and food systems, for rational decision-making and efficient resource allocation at all levels
- There are no "one-size fits all" solutions, no silver bullets: consider individual contexts and local knowledge building on the Ten Elements of Agroecology

Recommendations in the context of Koronivia

- Seize the opportunity of the June 2020 workshop on socio-economics related aspects and consider associated submissions to move agroecology forward
- Build on the core aspects of agricultural resilience demonstrated in this study: diversification, biodiversity and healthy soils.
- Science and policy interfaces are necessary for agriculture and food systems in the UNFCCC.
- NDC momentum: Seize the 2020 NDC year of revision to further incorporate agroecological approaches as a way forward towards transformational change.

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6.2 List of the literature analysed in the meta-analysis (chapter 2)

6.2.1 Single System comparison studies (#17)

*indicates studies (#5) with a holistic approach, presenting a comparably rather complete coverage and assessment of agroecology

+indicates studies (#3) that build on a before/after comparison of an extreme weather event

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Martin, G. and M. Willaume (2016). "A diachronic study of greenhouse gas emissions of French dairy farms according to adaptation pathways." Agriculture, Ecosystems & Environment 221: 50-59.

Montagnini, F., M. Ibrahim and E. M. Restrepo (2013). "Silvopastoral systems and climate change mitigation in Latin America." Bois et forets des tropiques 316(2).

*+Rosset, M. P., B. Machín Sosa, A. María Roque Jaime and D. Rocío Ávila Lozano (2011). "The Campesino-to-Campesino agroecology movement of ANAP in Cuba: social process methodology in the construction of sustainable peasant agriculture and food sovereignty." The Journal of Peasant Studies 38(1): 161

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6.2.2 Examples of anecdotic evidence (#8)

For illustration, we provide some examples for the anecdotic evidence (of which there are many more), as these contain interesting and inspiring cases, but they cannot be included in a rigorous scientific synthesis:

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6.2.3 Meta-analyses (#34)

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6.2.5 Reviews on extension services and knowledge transfer (#3)

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7 Annex

7.1 List of stakeholders interviewed (for parts 2.2 and 2.3)

Involved/not involved in Koronivia	Category pf interviewee		Name
Involved	**Government (4)**	Senegal Negotiator	M. Lamine Diatta
Involved		French Negotiator	Mrs. Valerie Dermaux
Involved		Kenya Negotiator	*Ms Veronica Ndetu*
Involved		Swiss Negotiator	*Ms Christine Zundel*
Involved	**UN organization (2)**	Climate Change, Natural Resources Officer	M. Martial Bernoux
Involved		Climate Change, Natural Resources Officer	Mrs. Julia Wolf
Not directly involved		CCAFS	*Mr Dhanush Dinesh*
Involved	**Research (5)**	INRA	M. Jean-Francois Soussana
not directly involved		INRA	Mme. Claire Weill
not involved		INRA	Ms. Allison Loconto
Involved		IDDRI	M. Sébastien Treyer
not involved	**CSOs and environmental organizations (3)**	IPES-Food	M. Emile A. Frison
Involved		Secours Catholique	Mrs. Sarah Lickel
not involved		Le Gret	M. Laurent Levard
Involved	**Farmers organizations (1)**	United Kingdom National Farmers Union	Ms. Ceris Jones

7.2 Literature review

7.2.1 Meta-analyses and reviews

We searched for meta-analyses on 1) the performance (with respect of a number of agronomic, environmental or social indicators) of agricultural practices or production systems that are part of or closely related to agroecological production systems, such as organic agriculture or agroforestry; 2) the relation between a number of sustainability indicators to the characteristics of agricultural production systems or ecosystems in general that closely relate with characteristics of agroecological production systems and with climate change adaptation; an example is the relation between diversity and productivity. We identified the meta-analyses by web-searches in Google Scholar and discussion with experts.

Search terms were “meta analysis”, “meta review” and “review” combined with search terms for production systems: “agroecology”, “agroforestry”, “organic agriculture”, “organic farming”, “permaculture”, “reduced tillage”, or for system characteristics (“diversity”), and with search terms for indicators related to climate change impacts and adaptation (“productivity”, “yield”, “performance”, “income”, “stability”, “resilience”, “extreme events”, “drought”, “pests”, “diseases”) – and variations of these terms. These search terms cover key aspects of climate change adaptation and resilience as framed in (FAO 2015).

While compiling this literature data base, we also added related literature which we occasionally identified while scrolling through the studies, e.g. from the reference list, or which have been pointed out to us by other researchers directly.

This search resulted in 51 review articles, whereof 33 were statistical meta-analyses, and 18 more descriptive literature reviews.

Part of the single system comparison studies identified above are also covered in these meta-analyses and reviews. This is however no problem, as the search for and analysis of the single system comparison studies aimed at identifying and synthesizing the evidence on “agroecology” (and some closely related systems) and “climate change adaptation”, while the meta-analyses are designed to address single specific aspects and characteristics of these two topics only.

7.2.2 Single system comparison studies

We did a literature review searching for peer-reviewed studies that compare agroecological production systems with some baseline and provide qualitative or quantitative evidence for the difference in performance regarding climate change adaptation (“Single system comparison studies”). Thereby, we considered studies only that termed themselves to be assessing agroecology or agroecological practices. We thus neglect studies whose authors did not explicitly frame them in the context of agroecology. Given the inclusion criteria we used for them, these other case studies without explicit reference to agroecology are however to a large part already covered in the meta-analyses and reviews we searched for as described in the previous sub-section.

For the single system comparison studies, we used the following search terms in two search engines, completed in April 2019:

a) Web of Science:
    - TOPIC: “climate change” AND TOPIC: “agroecology”, scrolling through all results

b) Google Scholar:
    - “agroecolog*” AND “climate change”, scrolling through the first 200 results

As this search only captures articles that are self-declared to somehow refer to agroecology by the authors, we expanded the search to terms closely related to agroecology as follows

- “permaculture” AND “climate change”, scrolling through the first 100 results
- “regenerative agriculture” AND “climate change”, scrolling through the first 100 results
- “silvopast*” AND “climate change”, scrolling through the first 100 results
- “Zero budget natural farming” AND “climate change”, scrolling through the first 100 results

We complemented this search with a search for Spanish, French, Italian and Portuguese literature in June 2019 using the following search terms in Google Scholar, scrolling the first 100 results (in many cases much less were found):

- “agroecolog*” AND “cambio climatico”
- “permacultura” AND “cambio climatico”
- “agricultura regenerativa” AND “cambio climatico”
- “CSA” AND “cambio climatico”

- “agroecolog*” AND “changement climatique”
- “permaculture” AND “changement climatique”
- ”agriculture regeneratrice” AND “changement climatique”
- “CSA” AND “changement climatique”
- “agroecolog*” AND “cambiamento climatico”
- “permacultura” AND “cambiamento climatico”
- “agricoltura regenerativa” AND “cambiamento climatico”
- “CSA” AND “cambiamento climatico”

For the literature in Portuguese, we approached Dayana Andrade, a PhD student in agroecology in Brazil; this did however not result in any additional studies.

While compiling this literature data base, we also added related literature which we occasionally identified while scrolling through the studies, e.g. from the reference list, or which have been pointed out to us by other researchers directly.

This primary search resulted in 185 studies (120 E; 35 F; 23 ES; 4 I; 3P)

We then screened all studies for

- Being peer-reviewed or “close to it” (such as PhD theses)
- Addressing climate change adaptation or related aspects (and not purely focusing on mitigation)
- whether they indeed analyse agroecology. This was determined by identifying whether practices from the framework from Biovision were analysed or not (cf. above). Only those articles referring to such practices have been retained for further analysis.
- whether they compare an “agroecological” to a “conventional” baseline situation. Studies reporting on agroecological situations without reference to a baseline with which to compare the performance to have been excluded from further analysis.
- whether they report quantitative or qualitative indicators for the differences in performance. Articles without such data have been excluded from the analysis.

This left us with 17 studies. Many studies had to be dropped because of lack of evidence, lack of a baseline for comparison, or because they represented reports from NGOs, research institutes, etc. without being peer-reviewed. In particular the latter provide interesting information, but adopting a conservative approach, we could not include them in the analysis. Some of them are listed under the header “Examples of anecdotic evidence” in the data base file “Review_AgroecAndCCAdapt_LiteratureAnalysed.docx”.

For all these studies, we then reported

- the agroecological practices implemented
- the performance indicators used
- the country, region, continent, where the study is located
- the agroecological zone, in which the study is located
- the scale of implementation of the practices (1 local; 2 regional; 3 national; 4 international)
- the FAO element the agroecological case refers to
- the Gliessman level the agroecological practices refer to

- Whether the practices also show climate change mitigation potential or not (only qualitative evidence needed, coded as a binary indicator: 1 yes; 0 no).
- Whether the study referred to a specific extreme event such as a storm or drought where adaptation or resilience become very well visible and can be observed on the ground in short time periods
- Whether the study adopted a holistic approach attempting to covering agroecology in its whole complexity in its empirical approach.

7.2.3 Potential bias in the data

Besides the case studies that are self-declared agroecological, the data basis we compile also covers the huge number of case studies that analyze how agricultural production systems, practices and characteristics that strongly relate to agroecology (but without referring explicitly to this term) correlate with indicators of climate change adaptation and resilience. Examples are comparisons of organic versus conventional production systems with respect to yield stability, comparisons of different levels of species richness in agro-ecosystems with respect to total biomass production, or comparisons of systems with organic fertilizers to such with mineral fertilizers with respect to soil fertility. As these second type of case studies have repeatedly been synthesized in a number of meta-analyses and reviews on various topics, we do not search for these case studies specifically, but directly draw on the results from the corresponding meta-analyses and reviews. By this, we cover the knowledge based on case studies that do not explicitly refer to agroecology as well.

This approach may result in two types of bias, though. First, the review on the single case-studies does not cover any study that is not self-declared agroecological. The studies without reference to agroeocology are however covered in the meta-analyses and reviews included, and this bias in the choice of the case studies does thus not result in a bias in the knowledge base covered. Second, the meta-analyses and reviews may cover some of the single agroecological case-studies as well. However, given the low number of the latter compared to the huge number of studies covered in these meta-analyses and reviews, this potential double-count will neither result in any relevant bias.

7.2.4 Reviews on extension services and knowledge transfer

We use reviews on the role of extension, rural advisory services (RAS) and knowledge dissemination on the performance of agricultural production systems as a third body of literature for the assessment of the potential of agroecology for climate change adaptation. This is based on the assumption that to promote the transformation of farming systems through agroecology, effective innovation delivery is essential and that co-creation and sharing of knowledge is considered an integral part of agroecology (FAO 2018). Furthermore, the mandate of RAS has widened from a productivity focus to a more holistic perspective, including, among other things, nutrition, livelihoods, gender and environmental sustainability issues, thus relating it closely to central aspects of agroecology (David and Cofini 2017).We used a large meta-study on agricultural innovation by the International Initiative on Impact Evaluation (3ie) as a starting point (Lopez-Avila, Husain et al. 2017) and from there identified 3 articles of relevance, i.e. quantitative reviews on the effects of knowledge dissemination and co-creation on the performance of agricultural production systems. These do not directly relate to agroecology, but given the central role knowledge transfer and exchange plays in agroecology, they serve to potentially identify important patterns relating to this aspect of agroecology, just as we identified patterns relating to diversity from the meta-analyses above as one characteristics of agroecology, without specifically referring to papers explicitly addressing agroecology.

7.2.5 Data analysis

Due to the small number of studies identified and the heterogeneity of contexts and indicators reported, it has not been possible to perform a formal meta-analysis. We analysed the data as follows:

- Descriptive analysis of the Gliessman level to which the practices implemented in the single system comparison studies refer to
- Descriptive analysis of the 10 elements of agroecology to which the practices implemented in the single system comparison studies refer to
- Descriptive analysis of the agroecological practices the single system comparison studies refer to
- Descriptive synthesis of the performance of agroecology in the single system comparison studies regarding the FAO performance indicators, with a focus on the indicators most directly relating to climate change adaptation (9 agricultural biodiversity; 10 soil health), but also considering those more broadly relating to resilience (2 productivity; 3 income).
- Descriptive synthesis of the patterns identified in the complementary meta-analyses
- Descriptive synthesis of the reviews on rural advisory services and knowledge transfer

7.2.6 Data base

All data is contained in the excel-file "LiteratureReview_Data_1_11_2019.xlsx", the first Sheet "Notes" contains some information on its structure and contents.

All papers covered in the analysis of the single system comparison studies and the meta-analyses/reviews are referenced in the Word-File "Review_AgroecAndCCAdapt_Literature Analysed.docx".

7.3 SHARP module mean scores Kenya

		Mean Scores		
	Module	**Agroecological Farmers**	**Conventional Farmers**	**Difference in Mean Scores**
2	Household	11.3	11.0	0.4
3	Production Activities	12.6	12.4	0.2
4	Non-farm Generating Income	5.8	6.8	-1.0
5	Land Access	8.1	7.5	0.6
6	Crop Production	7.4	6.6	0.8
7	Intercropping	12.0	10.9	1.2
8	***Weed Species and Management**	**13.6**	**12.0**	**1.6**
9	Pest Management Practices	10.4	9.8	0.5
10	***Land Management Practices**	**13.4**	**10.3**	**3.1**
11	Leguminous Crops and Trees	14.7	14.1	0.5
12	Fertilizers Practices	12.7	12.0	0.7
13	****Animal Production Practices**	**8.8**	**6.5**	**2.3**
14	Animal Breeding Practices	5.6	4.8	0.8
15	Animal Nutrition and Health	14.9	13.4	1.5
16	Utilization of New and Locally adapted varieties	14.1	13.8	0.4
17	Farm Input	10.0	10.1	-0.1
18	Water Access	7.6	7.2	0.4
19	Water Conservation Practices and Techniques	8.3	6.3	2.0
20	Water Quality	12.4	11.8	0.6
21	Soil Quality and Land Degradation	12.0	12.9	-0.9
22	****Trees**	**12.9**	**10.3**	**2.6**
23	Landscape Characteristics	11.0	10.4	0.6
24	Energy Sources	12.5	11.4	1.1
25	Disturbances	8.3	8.7	-0.4
26	****Access to Information on Weather and Climate Change Adaptation Practices**	**9.4**	**6.3**	**3.0**

Module		Agroecological Farmers	Conventional Farmers	Difference in Mean Scores
27	Information and Communication Technologies (ICTs)	15.3	14.6	0.7
28	***Access to Markets**	**10.4**	**9.4**	**1.0**
29	Income Sources, Expenditure and Savings	11.4	10.3	1.1
30	Major Productive Assets	15.2	14.7	0.6
31	Access to Financial Services	11.1	11.7	-0.6
32	Insurance	2.4	0.8	1.6
33	Community Cooperation	11.4	10.9	0.5
34	Group Membership	9.3	7.9	1.4
35	Meal/Food stocks	8.9	9.2	-0.3
36	Decision Making (Household level)	11.3	11.7	-0.4
37	Decision making (Farm Management)	12.5	12.9	-0.4

Agroecological and conventional mean scores for 36 modules describing various components of the farm agro system. Significant differences determined by t-test are indicated as *P < 0.05, **P <0.01, ***P<0.001.

7.4 Priority ranking assessment Kenya

Priority ranking assessment for agroecological and conventional farm systems based on technical, adequacy and importance scores of each SHARP module

SHARP farm system module	Agroecological farm system	Conventional farm system
Insurance	1	1[a]
Animal Breeding Practices	2	2[a]
Non-Farm Income Generating Activities	**3**	**7[a]**
Water Access	4	4[a]
Land Access	5	8[a]
Meal/Food Stocks	6	9[a]
Disturbances	7	10[a]
Water Conservation Practises and Techniques	**8**	**5[a]**
Animal Production Practices	9	6[a]
Access to Information on Weather and Climate Change Adaptation Practices	**10**	**3[a]**
Farm Input	11	11[a]
Pest Management Practices	12	13[a]
Access to Markets	13	14a
Soil Quality and Land Degradation	14	21
Income Sources, Expenditures and Savings	15	16[a]
Community Cooperation	**16**	**28**
Crop Production	17	15[a]
Household	18	22
Landscape Characteristics	19	24
Water Quality	20	23
Group Membership	21	17[a]
Intercropping	22	19[a]
Fertilizer Practices	23	25
Production Activities	24	27
Energy Sources	25	20[a]
Trees	26	18[a]
Weed Species and Management	27	26
Land Management Practices	**28**	**12[a]**
Utilization of New and Adapted Varieties and Breeds	29	29
Leguminous Plants and Trees	30	32
Animal Nutrition and Health	31	30
Decision Making (Household Level)	32	33
Access to financial Services	33	36
Major Productive Assets	34	31
Information and Communication Technologies (ICTs)	35	34
Decision Making (Farm Management)	36	35

7.5 Social module Kenya

List of climate change related questions for focus group discussion:

- In what year did they perceive that the climate has changed significantly? List extreme weather events that have occurred between the date identified and the present. Where there any changes in the start date of the rains or the length of the rainy season?:
  Climate change has changed drastically from 2015 starting with El Nino rains of 2015/16 and the prolonged drought that has persisted from 2018 to date. Rainfall levels are below normal and cannot sustain rainfed agriculture. The just concluded 'long' rains started late April and ended late may leading to crop failure especially for green grams, the most popular crop in Tharaka. No harvest for 2 years in some parts.
- Can you locate and mention the effects of this event on the map? How did this effect occur? For example: how were the crops lost? What crops have been lost? Due to increased heat? Due to a pest? What pest? Is it new? Was there a lack of water in the flowering months?:
  The available maps do not capture 2016-2018. However crop failure is mainly due to below normal rainfall around flowering time. Green grams, cow peas and pigeon peas crop lost to the drought. Few cases of fall army worm affecting maize (very recent).
- Please describe how this event affected soil, water, vegetation and/or crops and animals and/or livestock:
  Drought generally led to land/soil degradation, drying of crops and some streams and reduction in pasture plus other herbaceous plants leading to death of some livestock
- If an area has been heavily affected, has this affected other areas to which it is connected? If so, how?:
  When the higher grounds are degraded, the agropastoralists take their animals for grazing along riverines which results in riverine degradation due to overgrazing. In addition erosion on uplands leads to pollution of rivers.
- Are areas that benefit more from nature more adapted to major climatic events? Have they been more or less affected by the changes? Has this affected the provision of services?
  Every part has been affected by climatic shocks but the protected areas like riverines and forests have retained some level of resilience amidst severe climatic changes
- Why do they think that is? How do the species present in this area contribute to this observation?:
  Forests and riverine are retaining a good level of moisture, and so plants growing there are more resilient. Soils in these areas are also not very vulnerable to erosion due to good protective vegetation cover

Water:

- What changes have been observed in the water (decrease in sources, quality, etc.)? Where and since when? Why is this happening? - How do they recognise them?:
  Reduction in water volume due to aridification and overabstraction; and sedimentation due to erosion (quality). 15 years little irrigation but now-> excess water with pesticides. People getting sick not very prominent. Some cholera.
- Do they know any method that is used to conserve the water system? (practices, plant/animal species). How do they do it?
  Yes. Tree planting and avoiding grazing in forests and riverines
- What structure or species help to conserve water?
  Fig trees and herbaceous plants

Seasonal calendar:

- What are traditional climate predictors, i.e. signals that allow them to predict the start of the given season? For example, the flowering of a specific tree that signals the beginning of the rainy season.:

Some changes in cosmos eg stars(constellation studying by the elders); environmental changes like flowering of certain trees, shedding of leaves; birds movement(moving away from droughts and pest); insects like butterflies (move in a certain direction a lot of pest). Movements of the clouds southeast direction.

- What are major diseases that affect the community and economic spending - over the seasons?: Mostly pests like fall army worm which destroy maize crop. New castle poultry desease during dry season. Flue with dry and cold and windy. cholera with rainy season and floods.

  Most spendings in dry season because of malaria and flues. Warm temperature are good for breeding insect carring diseases.