Agroecology & climate change rapid evidence review

PERFORMANCE OF AGROECOLOGICAL APPROACHES IN LOW- AND MIDDLE- INCOME COUNTRIES

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COVER PHOTO: Farmer in Jawhar, Maharastra, India. Photo credit: Neil Palmer (CIAT/CCAFS).

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ACRONYMS AND ABBREVIATIONS

AE	Agroecology/agroecological
AFSA	Alliance for Food Sovereignty in Africa
AgR4D	Agriculture research for development
APCNF	Andhra Pradesh Community-managed Natural Farming
BMGF	Bill and Melinda Gates Foundation
C	Carbon
CA	Conservation agriculture
CCAFS	CGIAR Research Program on Climate Change, Agriculture and Food Security
CH_4	Methane
CIRAD	Centre de Coopération Internationale en Recherche Agronomique pour le Développement (French Agricultural Research Center)
CO_2	Carbon dioxide
COMDEKS	Community Development and Knowledge Management for the Satoyama Initiative
CoP	Communities of Practice
CRA	Climate-resilient agriculture
CRP	Community Resource Persons
CSA	Climate-smart agriculture
DG DEVCO	Directorate-General for International Cooperation and Development
EU	European Union
FAIR Sahel	Fostering an Agroecological Intensification to improve farmers' Resilience in Sahel
FAO	Food and Agriculture Organization of the United Nations
FCDO	Foreign, Commonwealth and Development Office
FTA	CGIAR Programme on Forests, Trees and Agroforestry
GCF	Global Climate Fund
GEF	Global Environment Facility
GHG	Greenhouse gas emissions
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit
IFAD	International Fund for Agricultural Development
IIRR	International Institute for Rural Reconstruction
INRAE	National Research Institute for Agriculture, Food and Environment
IPM	Integrated pest management
KALRO	Kenya Agricultural and Livestock Research Organization
LMIC	Low-and middle-income country
NDC	Nationally determined contributions
NGO	Non-governmental organization
NH_3	Ammonia
NORAD	Norwegian Agency for Development Cooperation
N_2O	Nitrous oxide
SDC	Swiss Agency for Development and Cooperation
SDG	Sustainable Development Goals
SI	Sustainable intensification
TAPE	Tool for Agroecology Performance Evaluation
TI	Title
TPP	Transformative Partnership Platform
TS	Topic
UNDP-GEF	United Nations Development Programme-Global Environment Facility
UNFCCC	United National Framework Convention on Climate Change
USA	United States of America
USAID	United States Agency for International Development
WFP	World Food Programme
WoS	Web of Science

Executive summary

Agroecology is increasingly seen as being able, or even necessary, to transform food systems (HLPE 2019). The Foreign, Commonwealth and Development Office (FCDO) and the CGIAR Research Programme on Climate Change, Agriculture and Food Security (CCAFS) commissioned this rapid evidence-based review to assess the quality and strength of evidence regarding (i) the impact of agroecological approaches on climate change mitigation and adaptation in low- and middle-income countries (LMICs) and (ii) the programming approaches and conditions supporting large-scale transitions to agroecology and transitions. The review also aims to identify knowledge gaps critical to understand and inform future public and private investment in research, development, and deployment of agroecological approaches. The focus here is on the science of agroecology at the field and landscape level, not on social movement, value chain or business aspects. We use the Food and Agriculture Organization of the United Nations (FAO) 10 elements of agroecology with the Gliessman (2016) framework to identify agroecology practices (transition level 2) and agroecology systems (transition level 3).

To assess evidence related to agroecology's climate change outcomes we conducted a systematic literature review of i) synthesis papers and ii) primary empirical studies related to nutrient and pest and disease management. For the latter we documented the presence of evidence for climate change outcome indicators, but not the magnitude or direction of the change. We also conducted semi-structured interviews with representatives from 12 organisations supporting or implementing on-the-ground agricultural development programmes to better understand the feasibility of scaling out agroecology.

How much evidence is there?

We identified 18 synthesis papers of high scientific quality relevant to the impacts of agroecology on climate change adaptation, mitigation or on the scaling of agroecology in the tropics or LMICs, representing over 10,212 studies. Nine papers presented findings based on 50% or more articles with data from LMICs, including four based 100% on LMICs data. Next, we conducted a systematic literature review to identify primary evidence for agroecological approaches related to nutrient management and climate change outcomes (15,674 articles) and for agroecological approaches related to pests and diseases and climate change outcomes (5,498 articles). From there, we identified a subset of 138 papers that also considered some aspect of scaling or adoption, and were conducted in the Global South. Of these papers, 115 reported on indicators relevant to climate change adaptation and mitigation. About one-third of these papers (48 papers) provided empirical evidence related to scaling agroecological approaches.

The availability of evidence for impacts on climate change outcomes is mixed. Substantial evidence exists for the impacts of practices and systems aligned with agroecology (e.g., farm diversification, agroforestry and organic agriculture) on indicators of climate change adaptation. Evidence for impacts on mitigation is modest, except for enhanced carbon (C) sequestration in soil and biomass associated with agroecological approaches, notably for agroforestry. The modest number of studies conducted in the Global South, and the short-term, field- and farm-scale nature of most studies highlights the need for more studies in the tropics and LMICs, including high-quality, long-term, research on farms and at landscape scales that compares agroecology against alternatives. Studies on climate change mitigation are particularly needed.

What does the evidence tell us?

CLIMATE CHANGE OUTCOMES OF AGROECOLOGY

The agroecological approach with the strongest body of evidence for impacts on climate change adaptation was farm diversification (strong evidence and high agreement). This included positive impacts of diversification on pollination, pest control, nutrient cycling, water regulation and soil fertility.

The agroecological approach with the strongest body of evidence for impacts on climate change mitigation was tropical agroforestry, which had associated sequestration of carbon in biomass and soil. In general, agroecology impacts on climate change mitigation were primarily substantial carbon sequestration benefits (medium evidence, high agreement). There was also evidence – primarily from the Global North – that mitigation of nitrous oxide (N_2O) is often associated with organic farming and ecological management of nutrients (medium evidence, medium agreement). However, a large data gap was found for agricultural greenhouse gas emissions, with almost no evidence from the Global South. There were also evidence gaps for agroecology approaches involving livestock integration, landscape-scale redesign and for multi-scalar analysis.

ADAPTIVE CAPACITY AND LOCAL ENGAGEMENT FOR IMPROVING CLIMATE CHANGE OUTCOMES

Agroecological approaches related to co-creation and sharing of knowledge support climate change adaptive capacity (strong evidence, medium agreement). Multiple lines of evidence show that engaging with local knowledge through participatory and education approaches are effective at adapting technologies to local contexts and thereby delivering improved climate change adaptation and mitigation.

AGROECOLOGICAL TRANSITIONS FOR LARGE-SCALE IMPACTS

Farmer co-creation and exchange of knowledge, community-based, participatory engagement, localised solutions and social organising were common components of field programmes for bringing agroecology to scale. Scaling agroecology systems, as opposed to practices, made more use of participatory and farmer-to-farmer processes and the role of policy, according to the literature. Scaling also relied on market and policy measures that privileged local production. The inherent complexity and knowledge intensity of agroecology, sometimes incurred higher cost and more time compared to conventional agriculture, but this also enabled effectiveness and sustained benefits. The literature review of scaling agroecological approaches for nutrient management and pest and disease management showed many of the same interventions, enabling conditions and barriers as those observed for conventional agriculture.

Recommendations

We recommend an outcome-based approach to assessing performance of agricultural development. This is to avoid contestation around what is encompassed by a specific label for an agricultural alternative, and instead assess performance in terms of environmental services and climate change response. A number of frameworks exist that can inform this work (Wezel et al. 2020, Kapgen and Roudart 2020, Grabowski et al. 2018) and can be used to measure performance. These include the Tools for Agroecological Performance Evaluation (TAPE by FAO), Sustainable Intensification Assessment Framework (USAID-supported). Labels like agroecology can still be expedient for communication; the point is to spend less time debating what is agroecology.

Based on the strength of the evidence, we can recommend investments in agricultural diversification, local adaptation, and in pathways to scaling both. Programme implementation experts indicated that promoting agricultural diversity can be a scalable intervention, and that it is often prioritised in programmes supporting agroecology. At the same time, trends are in the opposite direction, with widespread simplification of farms and cropping systems. Top down, single solutions are often promoted in agriculture development; thus, diversification and adaptation may require special attention and investment.

The lack of data on response to extreme climate events and on greenhouse gas emissions from tropical agriculture is a matter of great concern. We call for investment to fill these knowledge gaps, including comparative (alternatives versus conventional) and holistic (social, financial, and environmental as well as agronomic) assessment of climate change mitigation effectiveness and response to weather extremes that threaten future food security. There is urgent need for research on these topics in agricultural systems of LMICs, and by scientists and institutions from the Global South to build capacity in these regions.

Investment is also required in analysis of performance across multiple dimensions and trade-offs for approaches aligned with agroecology relative to other agriculture development approaches, at plot and farm levels, as well as beyond. This should include cost-effectiveness. Valuation of a range of agroecological benefits can be hard to quantify (e.g., environmental and social benefits), and economics often reflect current policy context and short time horizons.

Therefore, evidence-based priority investments include:

- The diversification of products and practices at field, farm and landscape level.
- Processes that support farmer innovation, co-learning and adaptation of innovations to local contexts.
- Move beyond contestation regarding what is agroecology and alternative labels. Focus instead on assessing outcomes of agricultural development approaches, building on indicator frameworks newly available (TAPE, Sustainable Intensification (SI) Assessment Framework).

To address urgent knowledge gaps, research priorities include:

- Barriers and how to enhance opportunities for scaling out of diversification and local adaptation processes, across landscapes and regions, through multiple agricultural development pathways that include agroecology.
- Research in tropical and low-income countries on climate change adaptation to extreme weather and quantitative assessment of mitigation outcomes at multiple scales.
- Scientific documentation of the effectiveness of agroecological approaches compared to alternatives, including performance in terms of environmental, social and cost-effectiveness, and direction of impact on climate change outcomes.
- South-South research collaboration.

1. Introduction

Background and objectives

It is widely recognised that transformation of food systems is needed to achieve food and nutrition security globally in the context of a changing climate (Steiner et al. 2020). Agroecology is increasingly seen as one pathway to transform food systems by applying ecological principles to ensure the sustainable use of natural resources and provision of ecosystem services (HLPE 2019).

In November 2020, FCDO and CCAFS commissioned this rapid evidence review to increase knowledge of impact of agroecological agricultural practices on climate change adaptation and mitigation. The goal of the study is to conduct a robust, but rapid synthesis of the quality and strength of evidence of the impact of agroecological approaches on climate change mitigation and adaptation in low- and middle-income countries (LMICs). Evidence for achieving agroecological impacts at large scales is an emphasis. The review also aims to identify knowledge gaps critical to understand and inform future public and private investment in research, development and deployment of agroecological approaches.

The objectives of the review are to synthesise the evidence and knowledge gaps for:

1. the impacts of agroecological approaches on climate change adaptation and mitigation in major agricultural systems in LMICs, and
2. the programming approaches and conditions supporting large-scale implementation of agroecological approaches and transitions.

We reviewed the evidence for climate change adaptation and mitigation impacts using a combination of systematic scientific review papers and primary evidence from scientific papers; we also conducted interviews to better understand the conditions supporting scaling up of agroecology (see Methods). Given the time constraints of a rapid evidence review we focused on agroecology approaches at field, farm and landscape scales, thus on practices and farm systems, not social movements, value chain or business aspects. Given these caveats, we synthesised key findings and conclude with recommendations to inform public investments in agricultural development.

Scope of agroecology and link to climate change adaptation and mitigation

Agroecology can refer to a (1) social movement (Altieri and Toledo 2011, Anderson et al. 2019), (2) set of principles (Wezel et al. 2020), or (3) scientific discipline (Tomich et al. 2011) (Andrieu and Kebede 2020). The role of agroecology in development is often divergent and contested, depending on these different perspectives (Bellword-Howard and Ripoll 2020). Our focus is on a scientific description of agroecology at field, farm and landscape levels, given our purpose of reviewing the evidence for impacts on climate change adaptation and mitigation (Tomich et al. 2011). We use the abbreviation AE to refer to agroecology or agroecological approaches in this document. Climate outcomes refer here to climate change adaptation and mitigation resulting from agricultural practices.

While there is no a priori, clearly defined single set of agroecological approaches to use for this analysis, we considered approaches as more agroecological to the extent they made use of ecological processes, supported increasing autonomy from external inputs, and enabled whole system change, rather than focusing on changing single practices (Sinclair et al. 2019, Leippert et al. 2020). We drew on the Food and Agriculture Organization of the United Nations' (FAO) ten elements of agroecology (Barrios et al. 2020) and Gliessman's (2016) agroecological transitions concept to provide a general framework for the analysis (Figure 1).

Given our scope, our review focus is on the scientific evidence for agroecological practices (agroecological transition level 2) and systems (agroecological transition level 3) (Gliessman 2016, Figure 1). Agroecological elements that support transition levels 2 and 3 include recycling, synergy and diversity, all of which foster ecological processes to provide ecosystem services in agricultural systems (Barrios et al. 2020).

Approaches aligned with agroecology were identified based on practices and system changes related to FAO's ten elements of agroecology (Box 1).

We propose that agroecology supports climate change adaptation and mitigation outcomes most directly by promoting resilience, diversification, efficiency, synergies, circular economy, recycling and co-learning (Andrieu and Kebede 2020). These elements do not inherently assure climate-related impacts however. For example, adaptation and resilience outcomes are not necessarily specific to climate change risk (Sinclair et al. 2019). Actual impacts depend on local conditions, for example, environment mediates the effect of crop diversification on soil carbon accrual (Hermans et al. 2020). Expected relationships between agroecology elements and climate change outcomes are summarised in Table A1 (Annex 1).

The approaches examined are not unique to agroecology and agroecology is not always labelled as such or implemented at whole system scales.

To distinguish agricultural methods in the literature aligned with agroecology, we considered field, farm and landscape-level practices that relied on enhanced ecological processes and services

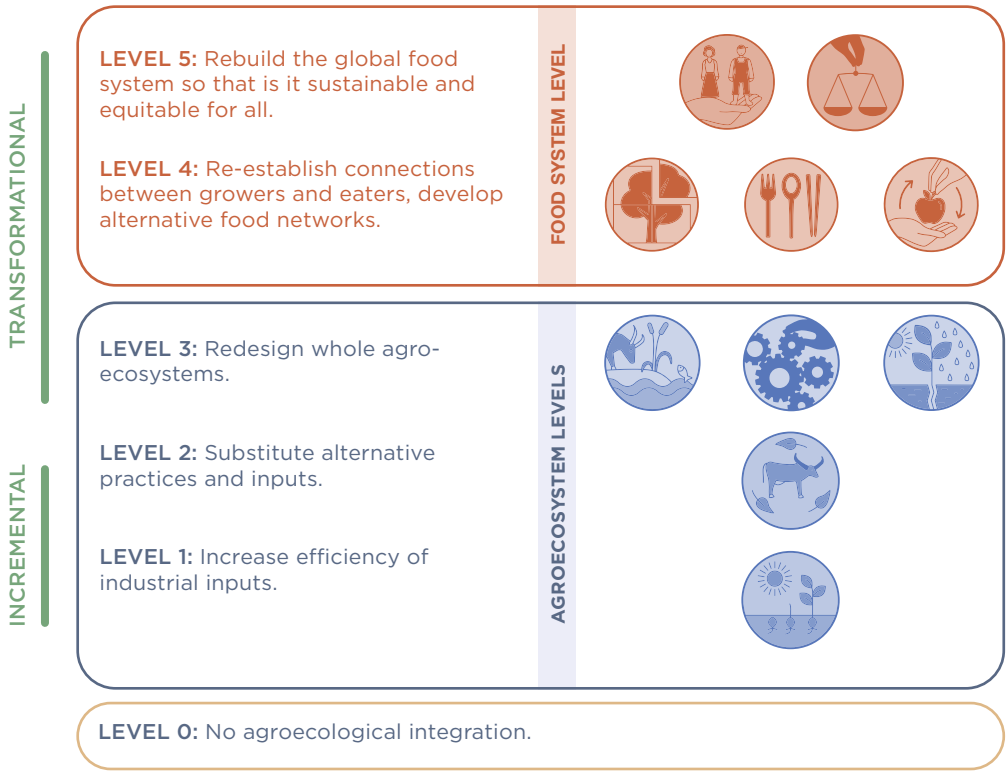

Figure 1. Agroecological transition levels as they relate to the FAO ten elements of agroecology (Source: Leippert et al. 2020).

BOX 1 – AGROECOLOGICAL APPROACHES

Sustainable intensification practices such as precision agriculture and fertiliser formulations to improve efficiency of agrochemical inputs are not considered agroecological practices here. Agronomic efficiency (Level 1 in Gliessman's framework) is insufficient on its own as an agroecological approach, especially if they are associated with other negative environmental impacts (Wezel et al. 2020). Agroecological approaches involve more than enhancing the efficiency of nutrient use and energy cycles. Instead, agroecology draws upon ecology, a scientific discipline that supports hypotheses that can be tested and used in designing agroecological practices and systems. An example is the role of diversity in resilience, an ecological theory drawn upon in AE. This stands in contrast to sustainable intensification, which is a general concept that doesn't generate design elements or hypotheses upon which to base the design of systems for agricultural development (Petersen and Snapp 2015).

compared to conventional agricultural. Examples of agroecology practices (level 2) reviewed here include diversifying crop production through growing accessory plants, e.g., cover crops, green manures and hosts for beneficial insects, managing organic nutrient sources, and biopesticides (Drinkwater and Snapp 2007). Examples of system redesign (level 3) include crop-livestock integration, landscape mosaics, agroforestry and certified organic farming (Table 1).

Research

To assess the evidence for agroecology's impacts, we addressed three research questions:

1. Climate change outcomes of agroecology: *Does agroecology support better climate change adaptation and mitigation as consequence of whole-systems approach, co-benefits in addition to productivity, or capacity to respond to extreme events?* We expect that agroecology's emphasis on whole systems lead to more comprehensive ecosystem services that support climate change adaptation and mitigation, such as agroforestry systems that support buffering of temperature and moisture regimes, nitrogen fixation and soil carbon sequestration.

2. Adaptive capacity and local engagement as a means for improving climate change outcomes: *Does agroecology provide more climate change adaptation and mitigation than conventional agriculture by emphasising locally relevant solutions, participatory processes and co-creation of knowledge?* Co-learning and development of locally relevant solutions are key elements of agroecology and are expected to better address local needs and environments, which are often complex and dynamic (Lindblom et al. 2017).

3. Agroecological transitions for large-scale impacts: *Do the programme interventions, enabling environment or barriers needed for agroecological transitions at scale differ compared to conventional systems?* Achieving agroecological transitions at significant scales to meet ambitious policy targets such as the United Nations Sustainable Development Goals (SDGs), raises questions for programme implementers about the cost of intensive community-level engagement and the feasibility of rapid, wide implementation.

The CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS) is a collaboration among CGIAR Research Centers and Research Programs, led by the International Center for Tropical Agriculture (CIAT), now part of the Alliance of Bioversity International and CIAT.

CCAFS brings together some of the world's best researchers in agricultural science, development research, climate science and earth system science, to identify and address the most important interactions, synergies and trade-offs between climate change, agriculture and food security.

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