

EVALUATING THE BENEFITS OF AGROECOLOGICAL FARMING SYSTEMS FOR SMALLHOLDER FARMERS: ENHANCING PRODUCTIVITY, SUSTAINABILITY, AND SOCIOECONOMIC RESILIENCE IN SUB SAHARAN AFRICA

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Abstract

The ongoing issues regarding food scarcity, environmental resource depletion, and changes in climate within the Sub-Saharan African region necessitates the use of farming practices that are more ecologically sustainable and increase productivity and resilience. This paper examines the impact of agroecological systems on smallholder farmers' productivity, sustainability, and socio-economic resilience. By evaluating key narratives portfolio such as agroecology, regenerative agriculture, sustainable intensification, and case studies from Ethiopia and Rwanda, the paper showcases successful innovations and best practices meant to address the smallholder farmers' diverse challenges. The results reveal that integrated natural resource management, participatory watershed management, and climate change mitigation and adaptation strategies identified can improve productivity, ecosystem services, and rural livelihoods. The study highlights the need for targeted, results-based approaches that are not only relevant to smallholder farmers' multiple livelihood needs, but are also sustainable in the long run. Multiple studies confirm that these farming methods both increase crop yields while fixing environmental degradation and strengthen systems to handle climate threats. Successful adoption of agroecological approaches requires technical progress alongside community engagement and enabling regulations supported by constant financial backing as Ethiopian and Rwandan cases show. A successful approach must unite prolonged sustainable development plans together with quick food security requirements in order to achieve future progress. The development of both humans and the environment depends on applying nature-based solutions while connecting small-scale farmers to markets in addition to climate-resilient technology and financial resources. Smaller agriculturists who adopt targeted initiatives and support collaborative efforts between stakeholders will enhance their yields and economic flexibility while strengthening their resilience to climate changes.

Keywords: "Agroecology", "Regenerative Agriculture", "Sustainable Intensification", "Smallholder Farmers", "Sub-Saharan Africa", "Climate Change Adaptation", "Food Security", "Natural Resource Management", "Resilience", "Sustainability".

INTRODUCTION

Africa is beset by an array of development issues such as poverty, resource degradation, food insecurity, gender inequality, and social exclusion, all of which are worsened by yield stagnation and climate change. Smallholder production is estimated to account for 50% to 70% of global food production, while providing for a slowly growing population relies heavily on new land, evidenced by Africa's 34% cropland expansion from 2003 to 2019 (Potapov, P.; Turubanova, S.; Hansen, M.C.; Tyukavina, A.; Zalles, V.; Khan, A.2021). The cultivated area also increased from 170 million hectares in 1963 to 272 million in 2015 due almost entirely to the clearing of forests and grasslands (FAO; UNEP. The State of the World's Forests 2020). Increased competition for natural resources and the declining security of land tenure (Amede, T.; Desta, L.T.; Harris, D.; Kizito, F.; Cai, 2014) together with the predatory market conditions stifled any serious possibilities of agricultural transformation. The cost of land degradation, the highest in the world, constitutes seven percent of sub-Saharan Africa's GDP (Nkonya, E.; Mirzabaev, A.; von Braun, J.2016). Just like other regions, the Africa continent suffers immensely from factors such as global warming, which leads to drought and floods. Just like in other parts of the globe, Africa suffers from the premises these issues are deeply rooted political dynamics that plague global economics and healthcare. Most parts on the continent cannot easily be accessed due to socio-economic conditions and the basic healthcare systems, which are impacted by the asymmetrical distribution of resources, be it natural or human-made physical. Intending to treat such conditions brings about harsh treatment methods that further reinstate the aforementioned issues. These dynamics further dissect windows of opportunity posing the risk of closure, which leads to extreme vulnerability

for around fifty percent of the populace during times of heightened level such as severe climate change. The melioristic approach to these issues aims towards achieving food security and building resilient systems, deeply relies on doing something about the productivity resources, agricultural service centers and infrastructure in place from the services and provisions available. The bust of the primary productive base along with enabled healthcare services can aid in drastically reducing malnutrition and the sub region's economic stratification and as an outcome make the region substantially less climate susceptible. The traits of the drought in SSA are depicted as greatly varying upwards of the rain being too short and too unpredictable pouring down during the infamous dry months along with the bone-chilling heat stress only driving up the increasing temperature. Indeed, the lack of anticipation comes hand in hand with a worrying rate of decline of precipitation, something that needs to be accounted while pinpointing other means. The set north toward southern Africa being the severely impacted regions while the rest of Africa escapes however all seem to be charmed under the prediction of enduring reductions long term.

Because of food insecurity, climate change, natural resource depletion, and increasing socioeconomic disparities, concerns about healthy nutrition and the ecosystem services that sustain them have heightened, especially with the increase in scientific evidence (Dixon, J.; Garrity, D.P.; Boffa, J.M.; Williams, 2020). These issues could have been partially solved with the implementation of sustainable intensification [SI] principles, which are described as a process or system that increases agricultural productivity without harming the environment or converting more non-agricultural land for use (Pretty, J.; Bharucha, Z.P., 2014). High

external input industrialized agriculture systems have adopted SI as a primary strategy due to the specialization of certain commodities, large mechanization, and an emphasis on economies of scale. In contrast, the smallholder farming systems in Africa have adopted SI at a much slower pace due to limited capital investment, fragmented land, minimal agricultural input, low mechanization, and nonfunctioning markets. Amidst the looming threat of climate change, there is an increasing willingness from the public to shift away from conventional farming and high inputs towards more nature-based approaches such as agroecology or regenerative agriculture. Nonetheless, there are many sets of definitions in.

Agroecology exists as a farming approach that blends food production with ecosystem service value and ecological process respect according to Wezel et al,2020). A total of thirteen principles comprises biodiversity, soil and animal health, input reduction, recycling, connection, land and resource governance, participation, synergies, knowledge co-creation, equality, social values, and economic diversification (FAO'S Work on Agroecology,2018). GIZ (2020) characterizes agroecology as an adaptable system focused on encouraging synergies which maintains and strengthens biological and ecological operations in agricultural production. FAO (2018) underlines the requirement to go past definitions in favor of pinpointing essential elements that will guide development partners' pursuit of sustainable agricultural and food systems (Razanakoto, O.R.; Raharimalala, S,2021). The Global North supports both regenerative agriculture and agroecology alongside its recent promotion of regenerative agriculture. Regenerative agriculture (RA) lacks a single accepted definition at present yet it remains defined as grazing and farming techniques that enhance ecosystem performance through

biodiversity restoration and organic matter regeneration to reverse climate change (Regenerative International,2017). Most AR practices focus on soil carbon enhancement since proponents think it improves crop production while reducing global warming speed (Burgess, M.G.; Langendorf, R.E.; Moyer, J.D,2022). The core concept of AR consists of establishing biological systems including crop rotation with composting and manure use and inoculation and cover crops among other microbial activities for soil restoration and improved resource efficiency without mineral fertilizers (Regenerative International,2017). There are environmental and climate change-related concerns from excessive utilization of external inputs particularly fertilizers. The use of AR shows increasing popularity among large-scale agricultural commercial farmers as well as outside investors (Tittonell, P.; El Mujtar, V.; Felix, G,2022). The creation of globalization alliances like Regen 10 marks a growth in regenerative techniques usage yet their precise definition and difference from previous models remains confusing. Due to ambiguous meanings and lack of regulation several interest groups made their own definitions of regenerative agriculture.

This article explores whether farming methods like agroecology and regenerative agriculture along with sustainable intensification express goals clearly enough to help smallholder farmers in sub-Saharan Africa thrive. How much expense would be required to put these best practices into effect? During implementation of these practices researchers need to examine how environmental conservation meets food security goals. Smallholder farmers need to determine proper ways to manage their long-term planning against immediate tasks. Local communities in sub-Saharan Africa require sustainable and nature-based approaches to solve their most critical short-term problems. The three

fundamental problems revolve around enhancing crop yields while maintaining farming stability on small farms alongside land management (i) and decreasing environmental decline alongside system resilience (ii) alongside climate change adaptation and risk reduction (iii). Feeding an expanding population stands as our main agricultural goal although this directs us toward minimizing our ability to duplicate natural ecosystems completely (Denison, F.; McGuire, 2015). The creation of adaptable sustainable smallholder agricultural systems represents our main objective to support human development along with environmental sustainability. The large environmental and food security and socioeconomic concerns in Africa drive the need for reassessing existing techniques.

The specific objectives of this paper are:

Review the various narratives (agroecology, regenerative agriculture, sustainable intensification) from the perspective of smallholder farmers;

(b) Based on case studies, identify key lessons, best practices and innovations with high potential to address the multiple livelihood objectives of small-scale farmers;

(c) Introduce outcome-oriented and context-specific principles and approaches that would concomitantly address the complex and emerging challenges of climate risks and food insecurity.

RESEARCH METHODS

This text contains four elements which connect with one another. A section of case studies comes after Section 1 introduces the evaluation approach for multiple narratives. The next section (3) conducts a detailed evaluation of critical findings from the established case studies. We suggest how these complex resources and management methods and innovative solutions can assist farmers at large scale based on AGRA's organizational experience

(Section 4). The widespread application of integrated natural resource management concepts and techniques allowed us to locate three case studies of land restoration and ecosystem service recovery along with agricultural yield increases within sub-Saharan Africa particularly in Ethiopia and Rwanda (Figure 1). Project effects and landscape features exist in three consecutive cases (1, 2, and 3). Different farmer goals receive solutions through these case studies which show beneficial outcomes for farmers between productivity improvement and climate change adaptation. The evaluations for smallholder farmers yielded 11 essential objectives which tackle the present issues regarding food security and climate risk management. The results were derived from a questionnaire and survey which were submitted to three consecutive webinars (July 13, July 28, and August 24, 2021) between subject matter experts. Smallholder farmers in Africa were used as the basis for participants to review world knowledge gathered through group discussions. The evaluation process for applicable narratives/approaches (agroecology, regenerative agriculture, and sustainable intensification) on smallholder farmers involved studying eight specific outcomes. The development of Figure 2 relied on evaluating the ranking of eight distinct outcomes assigned to four different approaches by ninety-three experts who identified three as best possible while one ranked as the lowest.

Evaluation of potential contribution levels from different storylines toward addressing food security and climate change adaptation and land restoration simultaneously included existing research review along with specialist consultation. A total of six scholarly databases were utilized for this research: Google Scholar (scholar.google.com, accessed 5 October 2022), Scopus (www.scopus.com, accessed 5 October 2022), AGRIS (agris.fao.org, accessed 8 October 2022), Web of Science

(apps.webofknowledge.com, accessed 20 September 2022) and ResearchGate (<https://www.researchgate.net>, accessed 5 October 2022). We sought literature published until 2022 which contained the terms "regenerative agriculture" together with "agroecology" and

"sustainable intensification" and "sustainable agriculture." A total of 55 academic papers provided theoretical models with empirical evidence about environmental and food security management and climate challenges from over 200 original research items.

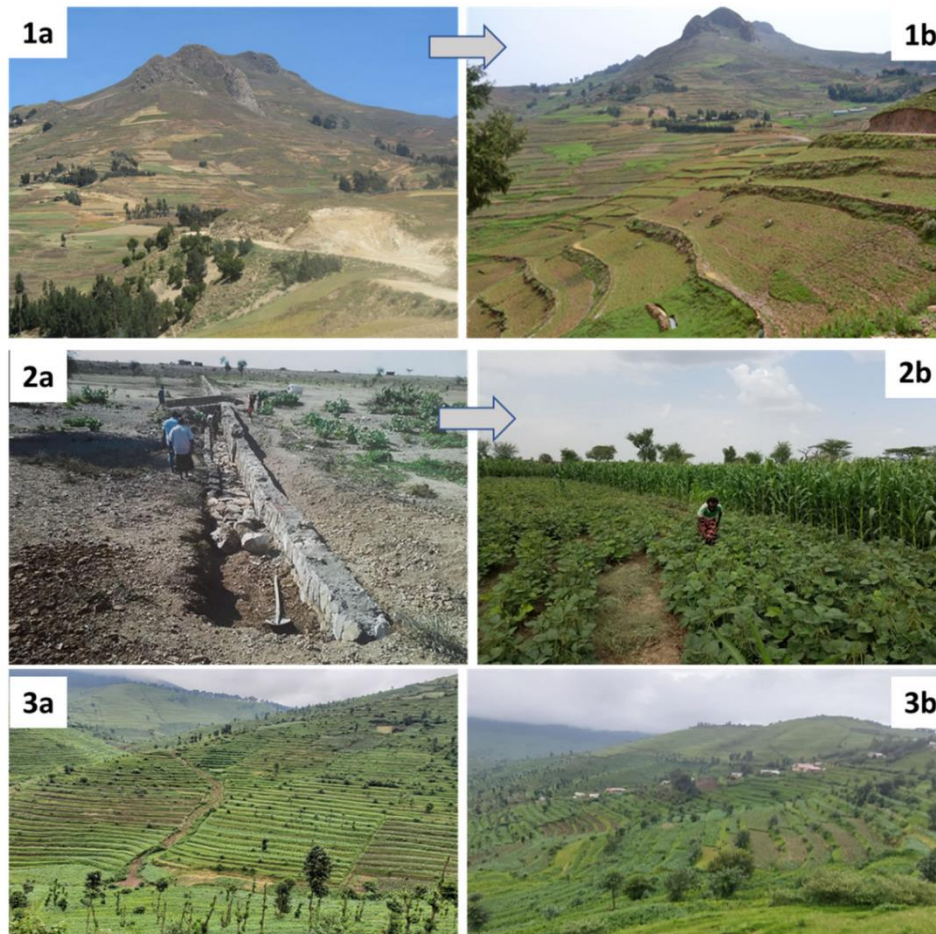


Figure 1. Rehabilitation of degraded landscapes and enhancing productivity of farms and production systems in Ethiopia (1a,1b,2a,2b) and Rwanda (3a,3b). The change from landscape ‘a’ to ‘b’ was achieved through collective action and targeted investments in land and water management.

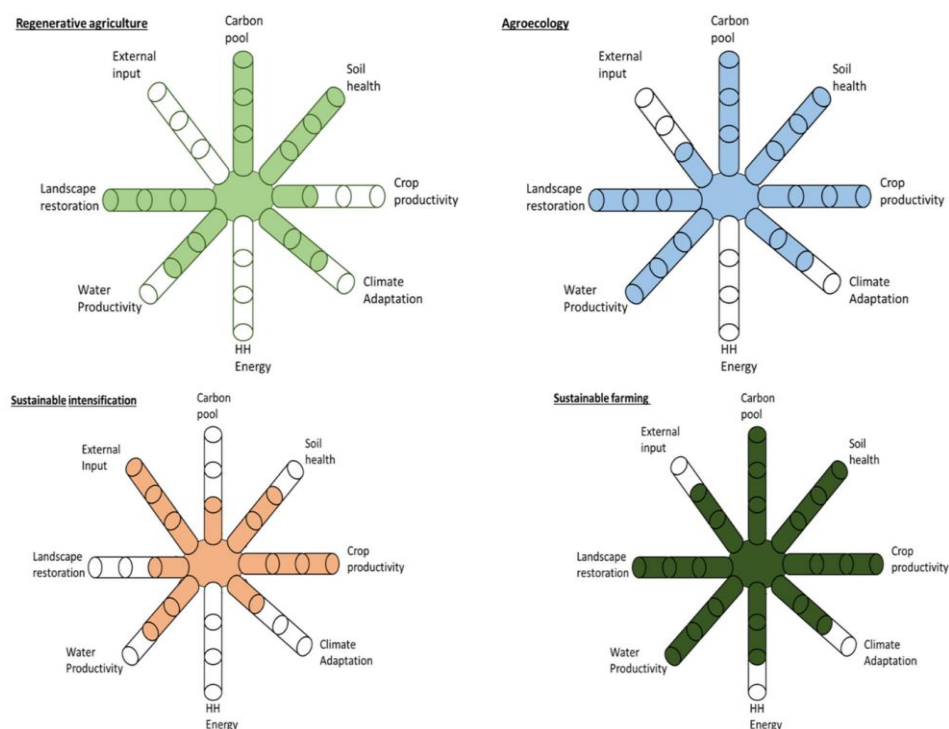


Figure 2. Characteristics of differing agricultural production systems and approaches that have been widely promoted and highlight the ultimate objects of these narratives and the methods used to achieve the intended goals. Each wing represents an outcome, with the colouring within the wing representing possible contributions to the stated outcome.

RESULTS

Case Study I: Restoring Degraded Landscapes for Rebuilding Livelihoods

The food-deprived area of the Amhara region within the Ethiopian highlands presents the Yewor River Basin which has considerable connections to both upstream and downstream regions (Figure 1 (1a, 1b)(ICRISAT. Restoring Land to Sustain Life,2019). Acidity, erosion and low soil fertility restrict this system to limited crop variety production leading to food shortages that last for five months every year. Participatory watershed management and community outreach programs safeguarded 8,000 hectares of degraded land throughout a three-year time period. Research team members provided training to extension workers as well as new crop and fodder varieties and cool-

season trees (such as apples) and site-specific composting and green manure practices for brief rain periods to prevent freeloading. The team promoted both collective work practices and local community laws for adoption. Research organizations conducted training about soil and water conservation (SWC) technologies, community facilitation, market connections and wheat and barley seed quality control and multiplication for development staff and district authority personnel. The made investments display promising results. Research demonstrated that watershed SWC methods reduce sediment generation by approximately 75% and the same methods at the plot level achieve average runoff reduction of 27% and soil loss decrease of 37%. The total area with irrigation expanded from 270 to 940 hectares throughout six years because of upstream water replenishment. Farmer adoption of advanced

crop types expanded the local variety from three to eight different species. Farmer-manufactured compost from recycled nutrients served to enrich garden vegetables in household spaces. The introduction of superior sheep breeds enables farmers to sell lambs within three months so they obtain funds to acquire agricultural necessities. Watershed implementation led to 40% reduction in peak food shortages and 60–100% yield increases for wheat, barley and lentil starting from the third year when compared with regular non-target villages in nearby areas. Through this initiative a total number of 40,000 local residents found direct assistance. Extension officers and workers utilized the watershed as their training field to develop wider service networks which enabled them to achieve broader operational expansion. Leadership at the highest level of the national government decided to tour this area. The sustainable management of national land in Ethiopia recovered 7.7 million hectares through multiple donor-funded initiatives which achieved significant agricultural production growth (Gumma, M.; Amede, T.; Getnet, M.; Pinjarla, B,2022).

Case Study II: Managing Floods, Enriching Soils

Periodic floods and droughts affect communities in the Afar agropastoral agricultural system of the Ethiopian Rift Valley because of the Amhara Plateau (Bizoza, R.A. Farmers,2021). People utilize moving to nearby highlands throughout at least five months per year to acquire pasture and water as their main survival practice. Flash floods cause annual destruction that reaches every community as well as damaging meadows and farmland. The strong competition exists among communities for biomass distribution between cooking fuel and soil fertility and animal feed resources. The project seeks to enhance the availability of water for pastoralists by converting highland floods into agricultural land at

"water distribution dams" (WSWs) entry points in this study area (Majoro, F.; Wali, U.G,2020). The cascading dams maintain seasonal flood control while distributing surplus water and silt as they exist 75 meters apart from each other. When WSW treats flood waters they generate different land characteristics during flooding periods which mainly depend on flood intensity alongside composition and volume. The area received 47 hectares of land suitable for crops and feed through land quality divisions based on soil water retention and nutrient buildup standards. The newly implemented agricultural practices led to a fourfold increase of both crop and fodder outputs during the first season while waterlogged areas harvested eleven tones of waste crops from every hectare while other fields remained limited to extracting only one tone. The modification of water patterns across plains became possible through the settlement program that the intervention used to attract new residents. Additional local government support resulted in investments for primary school construction together with health facilities. The local government both recognized their community leaders as well as involving them in critical choices for development. The local government uses this strategy through major development intervention based on findings that flooding can restore 1.2 million hectares of land in the Afar region (FAO,2012).

Case Study III: Hillside Irrigation for Commercialization

The Rwandan government recognized land degradation as a significant danger for environmental stability and food security across the country because of its wild topography and steep terrain changes (Bizoza, R.A. Farmers,2021). Due to its alarming land degradation problems the nation formed Land Management Water Harvesting and

Hillside Irrigation (LWH) with development partners including WB as its main backer to restore the landscape while boosting agricultural production and commercial farming across selected pilot watersheds covering 30,250 hectares in five districts (MINAGRI. Gishwati Water and Land Management (GWLM) Project,2010). Soil and water conservation efforts received substantial investment to establish the collection and drainage of excessive watershed rainfall through hillside irrigation systems (The World Bank. Land Husbandry,2009). The government implemented a plan of restoration for the deteriorated environment and local communities actively participated in its success which restored the environment within five years. The districts underwent development which transformed them into major vegetable export regions. Physical investments in the design and implementation of soil conservation and water storage structures, context-specific supplementary slope irrigation, the selection of crops and tree species appropriate for the landscape and soil type, integrated soil fertility management interventions (including liming to control soil acidity), the development and implementation of laws and policies for the sustainable management and use of restored landscapes, and the capacity building of local communities and institutions in integrated landscape management are among the priority investment areas (The World Bank.,2018). The proposed framework breaks landscapes into segmented units through slope and soil depth and fertility and erodibility index categories for the purpose of strategic investment and proper land management. In the 6,600-hectare Gishwati Water and Land Management Project (GWLM) site natural forest regeneration covers approximately 45% of the total area while grasslands and different tree and food crops occupy the rest of the land. Through Local Water and Habitat investments farmers

increased their sales revenue by 130% and obtained 85% more financing and gained 35% additional market share of goods. The number of farmers who received direct benefits reached approximately 300,000 while the country gained private investments and donor funding to expand its intervention programs. The Bonn Challenge spans more than 700,000 hectares while covering 30% of the forested territory allowing further expansion of these initiatives. The opportunity for these investments in Rwanda is demonstrated by the existing heightened political will and commitment to supporting measures that constitute the national governance framework for forests, land and other aspects. These projects have now evolved, and ownership has been slowly transferred to the local communities, though the initial role of the government in policy formulation and leadership and investment from development partners was critical.

DISCUSSION

Need for Increasing Crop Yield and Productivity of Smallholder Farms

Independent farmers today face a meaningful gap between existing and reachable yields since rainfed maize yield potential remains between 1.2 and 2.2 tons per hectare but actual production stays below 15% to 27% of this level. Agricultural decisions in smallholder farming operations show regular influence from short-term priorities that focus on crop yield increases and reduced labor costs together with production expenses. The population of the Yewol Basin started adopting locally-fit crop varieties along with proper farming practices (Case 1). Farmers started implementing land and water management tactics due to positive crop yield reactions resulting from rainwater management although these benefits appeared only after three years had passed. Different land management

practices such as mulching and soil building with farmyard manure and composting elevated crop yield output between 0.5 to 4 tonnes/ha but the soil response depended on slope conditions along with farmer approaches. The methodical utilization of land management strategies reduces soil erosion losses of seeds along with nutrients while improving soil water retention which leads to increased yield production. Floodwater management upstream proved especially beneficial to downstream farms (Case II) because the farmers achieved almost 300% yield growth in their maize fields (Gumma, M.; Amede, T,2022).

CONCLUSIONS

Relocating to regenerative and agroecological farming systems represents a great opportunity to solve existing problems faced by smallholder farmers throughout sub-Saharan Africa. This article supports targeted investments into land and water management coupled with participatory techniques while demonstrating the importance of integrated landscape management. Multiple studies confirm that these farming methods both increase crop yields while fixing environmental degradation and strengthen systems to handle climate threats. Successful adoption of agroecological approaches requires technical progress alongside community engagement and enabling regulations supported by constant financial backing as Ethiopian and Rwandan cases show. A successful approach must unite prolonged sustainable development plans together with quick food security requirements in order to achieve future progress. The development of both humans and the environment depends on applying nature-based solutions while connecting small-scale farmers to markets in addition to climate-resilient technology and financial resources. Smaller agriculturists who adopt targeted initiatives and support collaborative efforts between

stakeholders will enhance their yields and economic flexibility while strengthening their resilience to climate changes.

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