

VANJA WESTERBERG AND ALI DIANOU • JUNE 2025

Transformational Agroecology in Burkina Faso

An Assessment of the Impact of Agroecology on Farmer Livelihoods in Eastern Burkina Faso

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Publication Date

October 2025

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The Casey & Family
Foundation

**Acknowledgements:**

We are grateful to the diligent and hard-working Burkinabè interviewer team and farmers - including Natama So-leymane and Justine Natama (from Tibga), Tambiga Clement, Mano David and Mano Lamoussa, (Gayeri), Adama Lankoande and Josué Sagadou (from Bilanga) - in addition to the more than 400 farming households who agreed to participate in surveys and focus groups. We are also sincerely thankful for the valuable inputs provided by key informants, including Philippe Ouaba and Antoine Dori from ANSD, as well as for the support and advice provided by ANSD's president, Clarisse Diasso and the Groundswell International team, including Dioma Komonsira, Tsuamba Bourgou, Steve Brescia, Rebecca Wolff, Maylis Moubarak, and Peter Gubbels. Lastly and importantly, we would like to thank The Casey & Family Foundation and the Heidehof Stiftung GmbH for their financial support for this study.

Co-published by:**Altus Impact**

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EXECUTIVE SUMMARY

At the heart of the Sahel, Burkina Faso is an arid, landlocked country, facing multiple and interrelated challenges, stemming from climate change, food insecurity, increasing competition for land and armed conflicts. Recent years have been characterized by more extreme rains and flooding events, as well as longer droughts, while the clear-cutting of vegetative woody biomass for fuelwood and agriculture, and shortening of fallow periods have contributed significantly to large-scale land degradation and biodiversity loss, especially in the northern and eastern regions of Burkina Faso (Reij et al., 2005; Sylla et al., 2021).

Recent studies indicate that an additional 105,000 to 470,000 ha of land are degrading year-on-year in Burkina Faso (Carlucci & Guzzetti, 2024; MEEVCC, 2018; FAO, 2025), compromising agricultural productivity and the livelihoods of the approximately 80% of Burkinabe who depend on farming and pastoralism. With a surge in conflicts and an increasing incidence of climate hazards, displacements in Burkina Faso have increased by over 7,000% since 2018. This is one of the fastest-growing displacement rates in the world, alongside Mozambique and Ukraine (Carlucci & Guzzetti, 2024). For the most part, rural popula-

tions remain very poor, food insecure and with low levels of formal education. Of the farmers interviewed for this study, 80% have never received any schooling.

Confronting Land Degradation with Agroecology

In the face of these challenges, the Association Nourrir Sans Détruire (ANSND) was founded in 2011 to support a community-based, farmer-driven process of agroecological innovation and dissemination in the East Region of Burkina Faso. Since that date, it has been a partner of the Groundswell International network, which supports similar goals in 11 countries in West Africa, Latin America and the Caribbean, and South Asia. Agroecology incorporates ecological, health, social, and economic considerations into agricultural systems design, with a focus on using and regenerating the resources provided by the local ecology and minimizing dependence on external inputs like inorganic fertilizers and phytosanitary products (Wezel & Soldat, 2009; FAO, 2015).

Agroecological approaches, such as Farmer Managed Natural Regeneration of trees (FMNR), intercropping with legumes, and diverse soil and water conserving



Photo A1: An agroecological farmer with an ANSD promoter. Credit: ANSD

structures, offer both productive and protective services. The former includes the production of food, firewood, fodder, forage, timber, and diverse non-timber forest products (NTFPs). The protective roles stem from the slowing and prevention of soil and water runoff and erosion, enhanced crop-livestock integration, the maintenance and addition of organic matter through decreased burning, leaf litter-fall and manure, the fixation of soil nitrogen, modification of soil porosity and water infiltration rates, as well as shade from the sun which helps keep moisture in the soil and available for intercropping (Nair, 1984; FAO, 2015). Today, ANSD has reached and intervened in approximately 89 villages and 125 intervention sites (1 or more per village, depending on the village size) within the departments of Tibga, Bilanga and Gayeri in the East Region of Burkina Faso.

Methods

With ample testimonies and field observations showing that agroecological adoption has been transformative to the well-being of smallholder farmers (ANSD, 2015a; ANSD, 2015b; ANSD, 2015c), the following study aims to assess empirical evidence on the economics of agroecology. Our purpose is to provide easy access to data, that farmers' organizations, NGOs, investors, donors and government agencies can use to assess the effectiveness of agroecology, through the lens of comprehensive household and land use budgets that rigorously account for inputs, outputs, prices and costs, so as to consider the profitability of the full spectrum of farming practices.

To do so, we draw on focus groups, key informant interviews and a state-of-the-art household survey undertaken with over 400 randomly sampled smallholders. The surveys were implemented between June and September 2024, in three to four randomly selected and accessible villages in each of the departments of Gayeri, Bilanga and Tibga. Building on this data, our study employs data analytics, regression modeling and remote sensing data, to:

- Assess and compare the per-hectare profitability for the full suite of farmers, ranging from conventional/early transition to advanced agroecological farmers, based on a representative population sample who

were surveyed about inputs, outputs and agricultural practices for the 12 months preceding the interview (June 2023-June 2024).¹

- Analyze the drivers of land use productivity improvements.
- Conduct a cost-benefit analysis (CBA) to compare the total costs and benefits of transitioning to advanced agroecology over time, and to determine the profitability of investing in agroecology.

Study Insights

The study yielded significant insights. Farmers in the East Region of Burkina Faso grow a diversity of subsistence and cash crops, first and foremost the staple crop sorghum, followed by groundnuts, maize, cowpea, millet, sesame, and rice. The typical farmer associates 3 different crops on their main plot, with a minimum of 1 (monocrop) and a maximum of 6 crop associations.

The average yield per hectare (all crops combined) is in the order of 825 kg/ha, but underlying this is a wide distribution, ranging from 200 kg/ha to a maximum of 2,800 kg/ha². The questions are therefore: **What are the high-performing farmers doing? Why are they successful? What is the role of agroecological practices and conventional inputs - pesticides, inorganic and organic fertilizers - in driving those higher yields? And among those successful farmers, how are their livelihoods impacted, in terms of food security, total household income and financial creditworthiness?**

As we sought to answer these questions, there were many noteworthy findings:

First, agroecology has scaled throughout the agricultural landscapes of the eastern region where ANSD is working. Farmers are practicing an average of 7 agroecological techniques, ranging from a minimum of 1 to a maximum of 16 (Table A1). With 95% of farmers adopting at least 2 techniques, nearly all farmers are either on a journey to transition towards advanced agroecology or have already achieved a new, regenerative level of production. This data indicates that farmers consider agroecological practices to be beneficial, and that they are spreading wide and far between farmers

¹ With the agricultural cropping season running from June and October 2023, and many forest products (e.g. shea nuts, and locust beans pods) collected later in 2023 and the first half of 2024.

² Deleting 1 outlier at 3700 kg/ha.

Table A1: Characteristics of advanced agroecological farmers and conventional farmers in transition

	Average number of agroecological practices used on the main plot	Approximate duration of agroecological adoption
Average farmer	8 (min 0 - Max. 16)	5.8 yrs
Farmers in early transition	7 (min. 0 - Max. 14)	5.5 yrs
Advanced agroecological farmer	10 (min 7 - Max. 16)	6.7 yrs

and communities. Creating a farmer-to-farmer multiplier effect is one of the key strategies of ANSD and Groundswell International.

We also find that the more agroecological practices that farmers adopt, the higher their crop yields, which confirms the creation of symbiotic relationships among practices. Production function modelling revealed **that a smallholder family³ that is initially cultivating on degraded soils can increase yields from 320 kg/ha up to 1,420 kg/ha** by moving from sorghum monocropping to legume-cereal associations, integrating micro-water catchments in their fields, adopting low-tillage and avoiding residue burning. Finally, higher tree-canopy densities using FMNR is also integral to enabling this transformation, as illustrated in Figure A1.

There is no specific order in which these agroecological practices should be or are implemented, as farmers have agency in deciding which combinations of practices to adopt based on their circumstances. Other agroecological practices, such as composting or stone barriers, also contribute to enhancing crop yields, but could not be isolated in the statistical analysis, as they

are usually combined with other practices (such as FMNR and zai).

One common denominator that characterizes all high-performing farmers, however, is the elevated use of manure (minimum 2 T/ha), which is conditional on the uptake of agroecological practices. Using a production function model again, Figure A2 demonstrates the actual contribution of agroecological practices to increased use of manure. It also illustrates an example of how ownership of livestock and household numbers, as factors of production, contribute to manure application. As the farmer introduces various agroecological practices and the agroecosystem matures (at least 7 years of application), the average manure application rate increases from 0.4 T/ha to 4.6 T/ha per year.

As such, with agroecology, a circular and self-reinforcing cycle of increasing productivity is created, as more biomass, shade and grass strips along contour barriers allow for higher livestock holdings, which produce more manure, which in turn contributes to higher land productivity. This beneficial cycle is in line with the 13 core principles of agroecology (HLPE, 2019), which

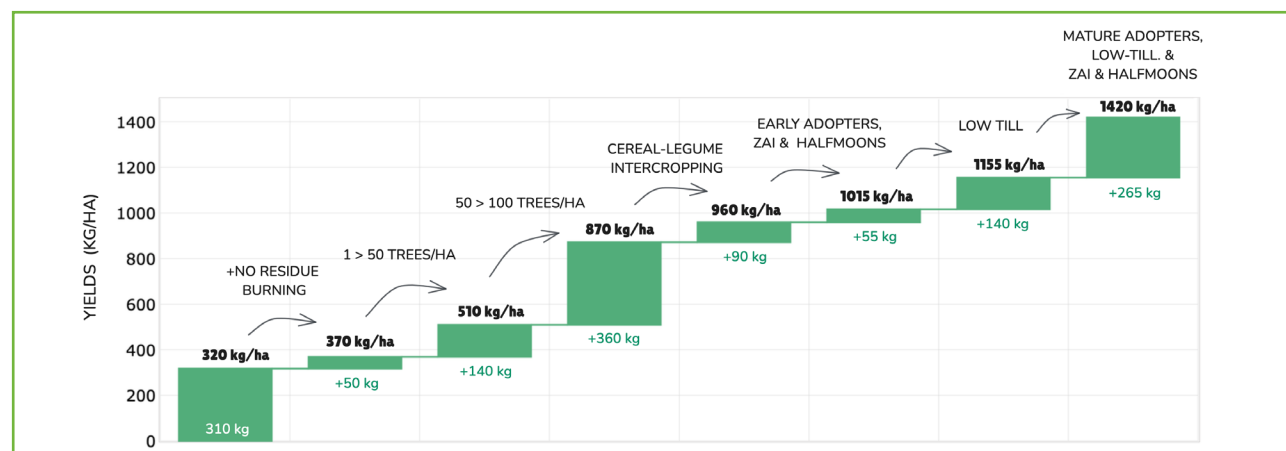


Figure A1: An example of how crop yields increase with increased uptake of agroecological practices (that can be applied in any order)

³ With 8 household members in the 18-64 year category.

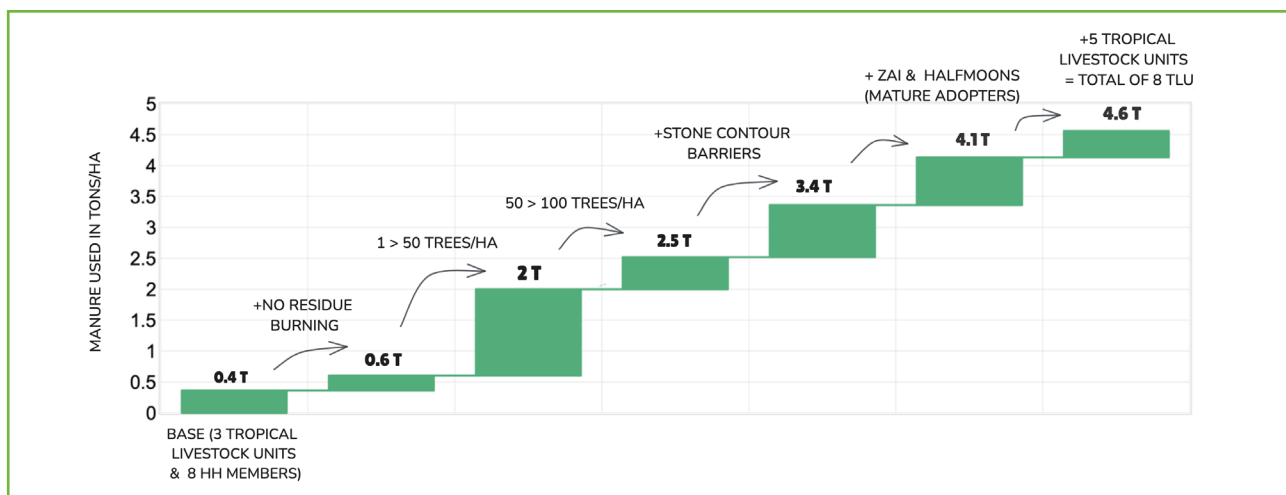


Figure A2: Manure use as a function of agroecological practices (2 T=5 carts)

emphasize positive ecological synergies, biomass and nutrient recycling (HLPE, 2019).

Defining Advanced Agroecological Farmers and Farmers in Early Transition

Data analytics also revealed that farmers with elevated uses of manure (min 2 T/ha) all employ at least three key agroecological practices (out of the following: zai, half-moons, low tillage, no residue burning, stone contour barriers, FMNR), along with cereal-legume intercropping in all cases.

These were labeled as **advanced agroecological farmers**, and they currently comprise 25% of the farming population in ANSD's intervention zone. The remaining three quarters of farmers who use less than 2 T/ha of manure are referred to as **farmers in early transition to agroecology**. Within this group, there is a broad range of farmers, from conventional farmers who only rely on inorganic inputs, to farmers who are already adopting some agroecological practices, such as intercropping with legumes and farmer managed natural regeneration of trees.

Considering the average agricultural holdings and population data, we can deduce that ANSD and its network have created pathways to more nature-positive and economically viable livelihoods across more than 100,000 ha of farmland⁴. Approximately one-quarter of all farmland (25,000 ha) is under advanced agro-

ecological management within the Gayeri, Bilanga, and Tibga departments of Burkina Faso.

The transition to agroecological farming is a process of constant innovation and improvement of farming systems, rather than a perfect end state. Accordingly, many farmers in the East Region use some degree of conventional inputs. Their contribution to yields is as explained below.

Understanding the Role of Inorganic Inputs in Agricultural Productivity

Approximately one-third of the farming population in the program area uses inorganic fertilizers. Interestingly, however, **inorganic NPK fertilizers were found to have no statistically proven impact on yields**. The lack of correlation, between NPK fertilizer use and farmers' yields is noticeable from the scatter plot (Appendix 1). Most likely, the regenerated soils are constraining the effectiveness of inorganic fertilizers, as fertile fields are typically unresponsive to inorganic fertilizers (Nziguheba et al., 2021; Vanlauwe et al., 2011).

Half of farmers use pesticides of some kind, and 46% use herbicides, 30% use insecticides, and 10% use fungicides. There were no statistically significant relationships between the use of fungicides and insecticides and crop yields. In the case of herbicide use, beyond US\$8 of spending per hectare, the additional yield gains do not compensate for the additional costs.

⁴ With a population of 270,000 inhabitants (across Bilanga, Gayeri and Tibga, growing by 2% since the 2019 census), an average of 12.7 individuals per household, and 5.1 hectares of cultivated land per household.

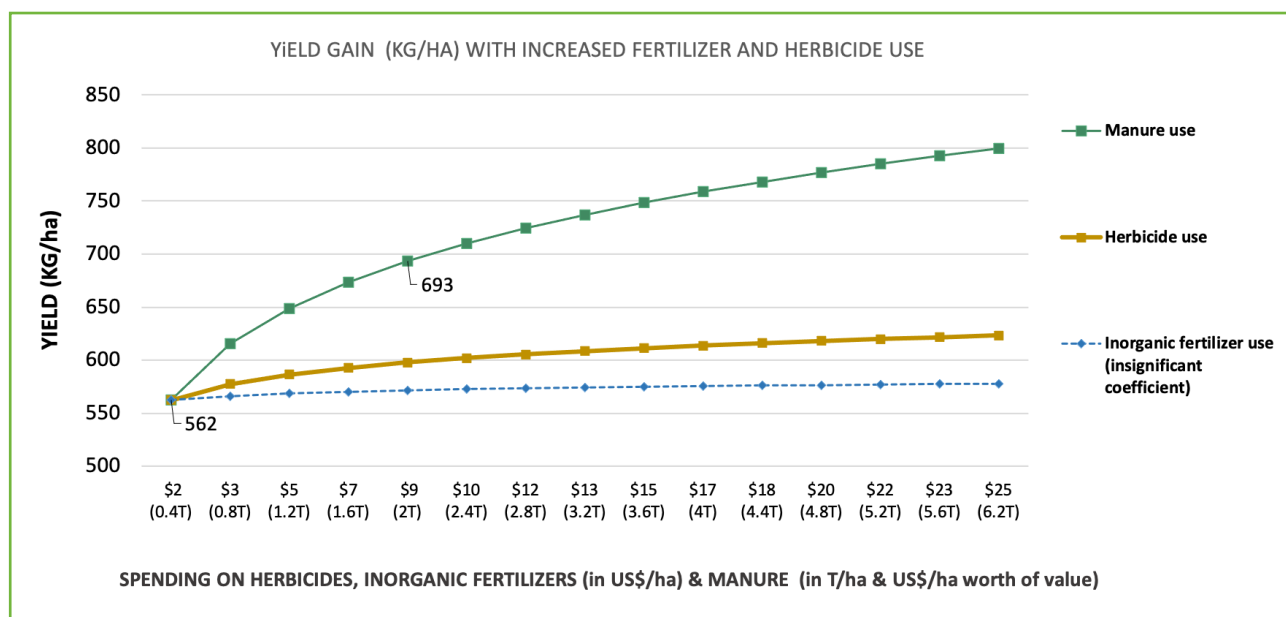


Figure A3: Relationship between manure use, herbicide use, inorganic fertilizers and yields

The returns to manure use are significantly more noticeable. For every 1% increase in the use of manure, yields increase by 0.13%. Thus, by increasing manure use for example from just 0.4 T (1 cart) to 2 T (5 carts) per hectare (an additional US\$7 worth of manure), yields increase by 131 kg, providing approximately US\$62 worth of additional crop revenues⁵, or a benefit-cost ratio of 9 (US\$62/US\$7). As the farmer applies more manure, the benefit-cost ratio decreases, but remains positive until application rates of 13 T/ha. This is in contrast with inorganic fertilizer use, which has a negative benefit-cost ratio at any level, on average, across the case-study area.

Productivity and Income Differentials Among Advanced Agroecological Farmers and Farmers in Transition

Farmers in the study have one main plot, which serves to provide the food security of the household, and a couple of smaller marginal plots often managed by other household members other than the household head. The average size of the main plot is 3.1 hectares, providing a wide range of yields. Advanced agroecological farmers, for example, achieve an average yield of 1,231 kg/ha, with more than 10% reaping harvests in excess of 2,000 kg/ha, revealing an inherent potential for fur-

ther yield increases within the overall population. Farmers in early transition attain a mean yield of 694 kg/ha. Figure A4 shows the distribution of yields for *farmers in transition* and *advanced agroecological farmers*.

Income from Agroforestry

With a canopy cover density of 50 trees/ha, against 20 trees/ha among farmers in early transition, advanced agroecological farmers earned an average of US\$68 per ha, against US\$31 per ha, from forest produce such as locust beans, tamarin pods, and shea nuts. These are, however, conservative estimates, because insecurity in 2023/24 prevented many farmers from accessing their fields throughout the year, and it was a particularly poor year for shea harvests.

Adding crop and forest revenues, and subtracting the costs of production, **advanced agroecological farmers generated a net income of US\$489 per ha, against US\$293 for farmers in transition. Aside from income diversification, agroecology also promotes increased market-readiness**, with a higher share of production from the main plot (40%) destined for sale among advanced agroecological farmers, compared to farmers in transition (28%). The land use budgets for the two farmer segments are shown in Table A2 and Figure A5.

⁵ With an average price per kg of produce of US\$0.47 for all crops (cowpea, sesame, sorghum, maize, millet) confounded.

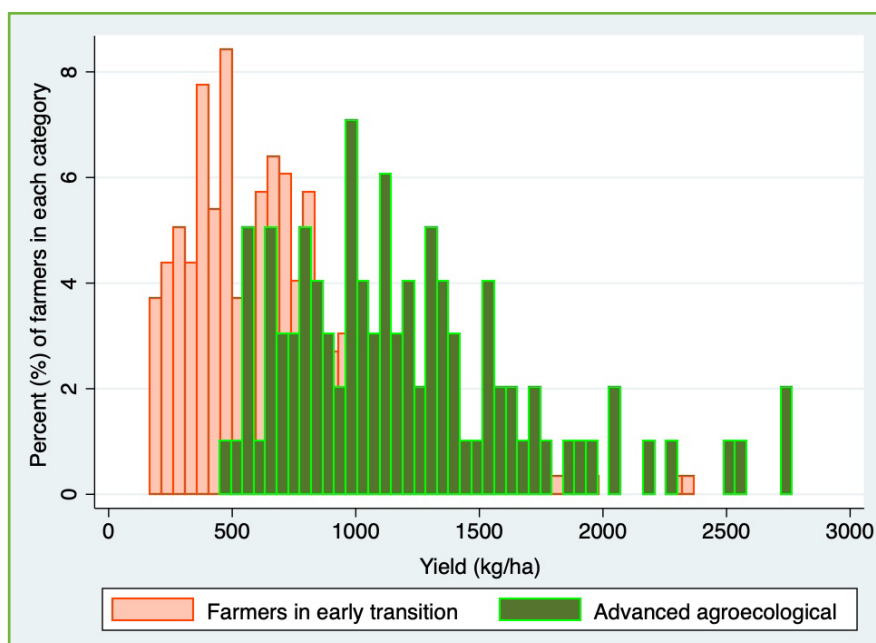


Figure A4: Distribution of yields of farmers in early transition, against advanced agroecological farmers

Table A2: Land use budgets for the average advanced farmer and farmers in early transition

Per hectare yields, revenues, costs and net income	Advanced agroecological farmer	Farmers in early transition
Yield (kg per ha)	1231 kg/ha	694 kg/ha
Total revenue (\$USD per ha)	\$ 558	\$ 328
Crop-based revenue	\$ 490	\$ 297
Forest-based revenues	\$ 68	\$ 31
Costs (US\$ per ha)		
Manure and compost	-42	-17
Chemical pesticides	-10	-8
Chemical NPK fertilizer	-11	-5
Hired labor, plowing & seeds	-6	-5
Total cost	-69	-35
Net crop and forest income	\$489	\$293
Approximate share of produce sold	40%	19%

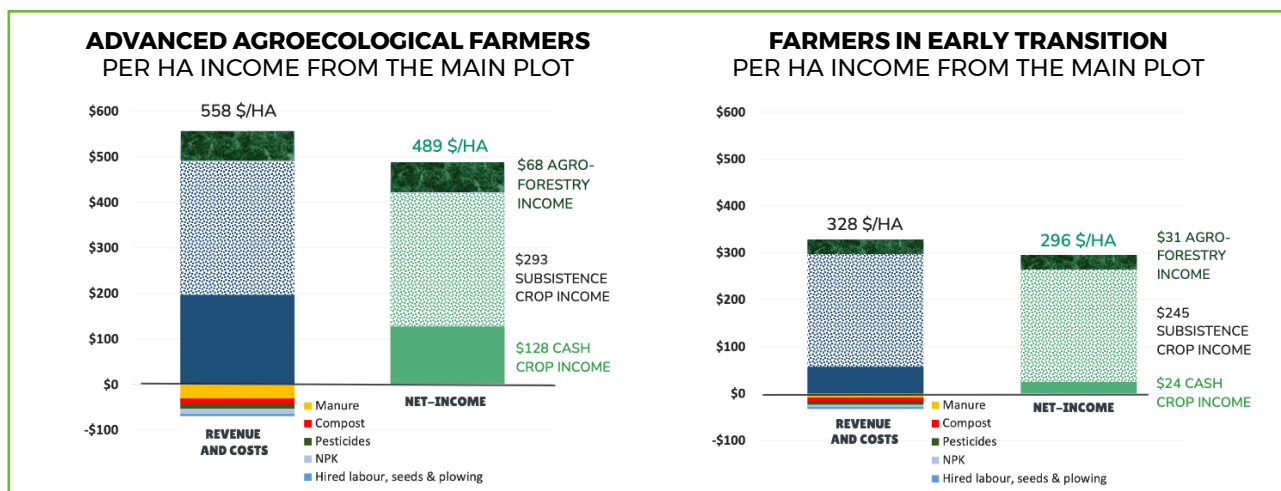


Figure A5: Revenues, costs and net income for advanced agroecological and farmers in early transition

Total Household Income and Meeting Living Income Levels

With increased forage biomass, whether from tree canopies or crop residues, agroecological farmers also have higher livestock numbers, counting 76 sheep units or 7.6 Tropical livestock units (TLU)⁶ per household, against 3.9 TLU among farmers in transition. Not surprisingly, the large majority of advanced agroecological farmers (85%) sold or consumed livestock produce during the 2023/24, while that was only the case for half of all the farmers in transition. Livestock also act

as an effective buffer against economic shocks or crop failures (Batta & Bourgou, 2017; Amejo, 2024). As a result, **advanced agroecological farmers have greater resilience.**

When adding the full spectrum of household income sources, including farm and non-farm income (such as own-business earnings and remittances), the total household income of an advanced agroecological smallholder farmer amounts to US\$2,951 against US\$1,331 for farmers in transition (US\$580 / US\$261 per adult household member). With a Living Income Benchmark

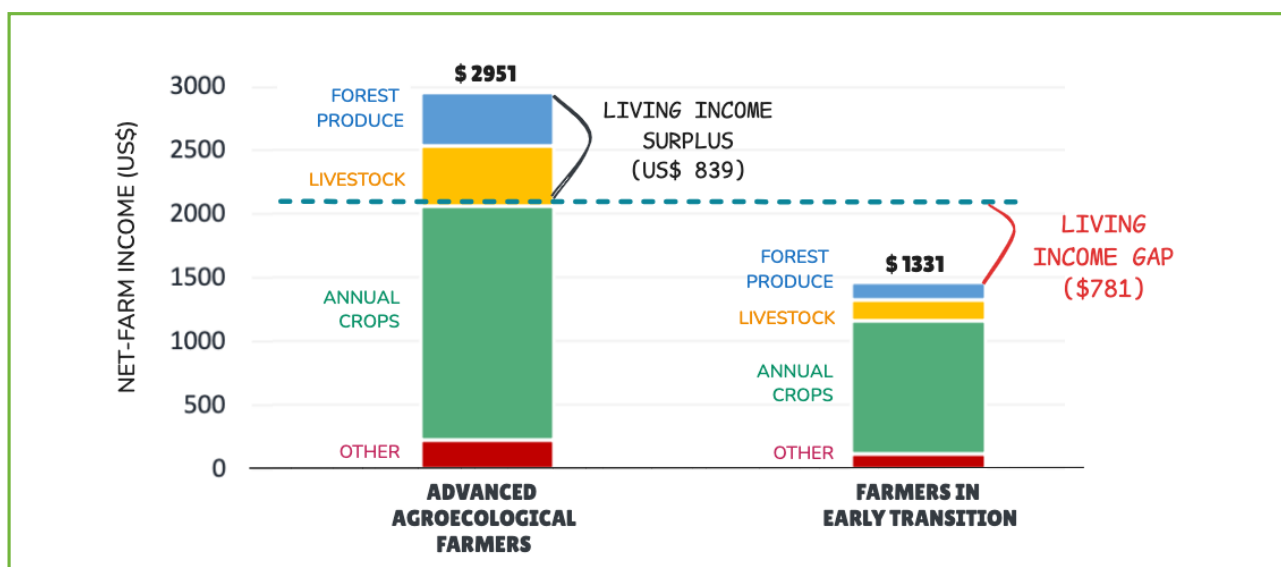


Figure A6: Yearly net farm household income and the living income gap/surplus

⁶ Sheep Units (SU) or Tropical livestock Unit (TLU) measures the number of livestock in a common unit, where one TLU measures 250 kg of live weight and one SU = TLU/10, following Pica-Ciamarra et al. (2011).

for rural households in Burkina Faso of US\$2,112 (Medinaceli et al., 2024), advanced agroecological farmer households are able to meet a decent standard of living for all their members, encompassing essentials such as nutritious food, shelter, education, health care, and extras for emergencies (Figure A6).

It is not possible to draw a direct inference and conclude that farmers are better off on all fronts due to agroecological adoption. However, our data analysis reveals that agroecology has played a crucial role in boosting land use productivity and making manure available in Sahelian zones that are otherwise known to be vulnerable to degradation, due to their low structural stability and levels of organic matter in most land use types (Batino et al., 2007).

Resilience and Well-Being

Other indicators of resilience point in the same direction: The total food stock of advanced agroecological farmers at the time of the household survey was 300 kg (median), triple that of farmers in transition (median of 100 kg). Nearly half (45%) of farmers in early transition had experienced running out of food in the year preceding the interview, compared to only 13% of the advanced agroecological farmers. Advanced

agroecological farmers also have lower debt levels (US\$8 versus US\$35) and are more creditworthy, as indicated by their superior ability to borrow from rural banks and other finance institutions.

Farmer perceptions of soil health also align with the economic results, with 72% of advanced agroecological farmers considering that their soil health has regenerated, against 18% of the remaining farmers. Protective benefits from improved soil health include nitrogen fixation, the addition of organic matter through leaf litter and decaying roots, a modification of soil porosity and infiltration rates leading to reduced erosion, as well as increased shade from the sun, which helps retain soil moisture (Nair, 1984). All these factors also improve climate resilience through the reduction of drought stress and flood risks.

Given such promising figures, one may ask what is holding back the further transformations and horizontal scaling of agroecology across the landscapes of Bilanga, Gayeri and Tibga, recalling that currently only one-quarter of the population classifies as advanced agroecological farmers. The typical advanced agroecological farmer presented above started his/her transition journey nearly 7 years ago. In the first years, however, implementation costs are incurred. To mean-



Photo A2: A farmer with her full granary of sorghum after harvest. Credit: Andrew Esiebo and The Gaia Foundation

ingfully compare such investment costs with the flow of benefits increasing over time, a cost-benefit analysis was also undertaken.

Cost-Benefit Analysis (CBA) of the Transition to Advanced Agroecology

The CBA analyzed the returns from the adoption of *zaï*, *stone barriers* and *FMNR*, a popular combination of agroecological practices seen in the case-study area and throughout the central and northern regions of Burkina Faso, as well as in Senegal and Niger (Bado et al., 2018). Using a 4.5 discount rate⁷ for a 15-year time horizon, and in the absence of any government subsidy, the transition to advanced agroecological farming generates US\$4.8 of revenue for every US\$1 spent, an internal rate of return of 43%.⁸ With a Net Present Value (NPV) of US\$2,308, and an average annual additional income of US\$154 per ha, this is a substantial increase, considering that the typical farmer *in early transition* is earning US\$265 per ha (Table A3).

Table A3: CBA analysis results of *zaï*, stone barriers & FMNR

Evaluation criteria	r=4.5 %, T=15 years
Net Present Value (NPV)	\$2,308
Average annual net benefit	\$154
Benefit-Cost Ratio (BCR)	4.8
Internal Rate of Return (IRR)	43%
Return on Investment (ROI)	540%
Pay-back period (in years)	5.4

In the first three to four years, however, the cash flow is negative, as the innovations require pruning and thinning young trees, digging of *zaï* pits⁹, preparation and transport of compost, the transport and construction of stone contour barriers, as well as the acquisition of basic equipment. Over time, yields of crops, fodder, fuelwood and NTFPs increase, but it takes 5.4 years before the farmer has recuperated all of the initial investment costs. Herein lies the potential challenge for the large-scale adoption of agroecological innovations.

Overcoming the Long Pay-Off Period

Upfront investment costs and labor constraints can be covered with appropriate technology (such as pick-axes, carts drawn by donkeys, cutlasses, roller-crimpers that can replace herbicides, transport of stones for contour barriers, etc.). The financing of such assets could be unlocked by revisiting the existing use of public funds for agricultural development. Currently, the Burkinabe government spends millions of US\$ on subsidizing chemical agricultural inputs every year.

With the impending biodiversity and climate crises, the repurposing of agricultural subsidies towards land regeneration is arguably more urgent than ever. Our study also shows that agroecological solutions generate economic returns on par with commercial seeking capital, yet farmers in the case-study area only have access to short-term loans (of maximum 2-year duration). A shift in priorities and policies is needed to scale up these proven solutions.

Fortunately, there is a growing understanding across diverse actors - businesses, NGOs, development finance institutions (DFIs), and some governments - that in addition to creating immediate economic returns, investments need to align with planetary health and long-term resilience. In order for emerging agroecological innovations and solutions to grow, perverse subsidies need to be phased out to help create a level playing field that would foster such investments.

Conclusion

Agroecology addresses broader environmental and social dimensions, sequestering carbon, fostering biodiversity conservation, building soil health as an asset, and materially improving future economic performance at the farm and community level. It is also a risk-mitigation strategy, as farmers are building higher livestock holdings and lessening their dependency on volatile market prices by promoting agricultural diversification. Full business value and resilience may be further realized with support for community-managed grain reserves (referred to as *warrantage* locally), which allow communities to store grain and capture price increases over the months after harvest. We plan to address this in a pending, complementary report.

⁷ Representing Burkina's average lending rate, for the last 10 years.

⁸ Using a 4.5% discount rate, representing Burkina's average lending rate, for the last 10 years.

⁹ It is assumed that all additional labor effort is acquired through the hiring of paid workers, as opposed to family labor.

This study has taken us from observing the benefits of agroecology for farmers to evidencing the economics of agroecology and the additional opportunities that are generated and seized. The findings will contribute to a wider body of evidence and recommendations, as we, together with Groundswell International, develop relevant lessons for NGO partners, allies and government actors in Burkina Faso, Mali, Senegal, Ghana, and outside of West Africa. Evidence and standardized measures of productivity, income and well-being allow stakeholders to track progress and identify areas for improvement. Groundswell International's regional network of collaborating partners in West Africa has as its goal to elevate the standards of living for farmers and ensure more sustainable and impactful agricultural practices, through an actionable understanding of what initiatives, strategies and policies truly benefit smallholder farmers in the Sahel.

Rather than supporting conventional agricultural paradigms, West African governments would have achieved

greater well-being for their populations by supporting transitions to agroecology. This transition can still reverse the alarming degradation of soils and natural resources, reduce poverty, vulnerability, and chronic hunger for rural communities, and build resilience to climate change and market volatility. This would be a strategy of proactive climate change mitigation and adaptation. Regions and nations lagging behind will face disadvantages in all these areas in the future.

The government of Burkina Faso has the opportunity going forward to develop a *lighthouse* example of scaling agroecology that can be a reference point in West Africa and more broadly. This study provides evidence and recommendations to accomplish that goal, by more deeply engaging farmers in the innovation and the *co-creation of knowledge*, in agroecological extension by farmer champions, and by shifting agricultural subsidies, investments, infrastructure, technologies and extension.

1. Introduction

1.1 Background

Burkina Faso is a landlocked country located in the West African Sahel, with a climate that is dominated by high average temperatures and low average rainfall. Its economy relies on agriculture and mining, particularly gold production. Burkina Faso agriculture predominantly consists of rain-fed subsistence systems that are characterized by small family farms from 1.5 to 12 ha per household (Korodjouma, n.d.).

Agricultural crops destined for exports are mainly cotton, sesame seed and cashew nuts, while production for subsistence typically consists of sorghum, millet, maize, rice, and cowpeas. Burkina Faso imports significant quantities of food to cover national consumption, such as rice, wheat, flour, sugar and oil. In 2017, it imported food items worth CFA 235 billion, against CFA 215 billions of food exports, making it a net importer of food (Agrisud International, 2020). In 2023, agriculture contributed approximately 16% to the GDP of Burkina Faso (Statista, 2025), down from 22% in 2016, despite employing more than 80% of the economically active population (The Global Economy, 2025; USAID, 2022). More than 40% of its population lives below the national poverty line (IFAD, 2024), and an estimated 2.7 million people (12% of the population) were facing severe food insecurity between June and August 2024 (World Bank, 2025).

The causes of rural poverty in Burkina Faso are commonly attributed to low crop and livestock productivity, along with shortages and poor quality of arable land, land insecurity, poor communications and transport networks, and weak non-financial and financial services (IFAD, 2023). Processing and marketing constraints include high energy and equipment costs and difficult access to production areas (IFAD, 2019).

Other challenges include insecurity and armed conflict (WFP, 2025). The security crisis has worsened since mid-2019 and is marked by vast areas in the north and east of the country controlled by Jihadist terrorist groups (Zida, 2018), with the number of internally displaced people recorded at 2.01 million in March 2023 (World Bank, 2025).

1.2 Land Degradation, Conventional Farming and Agricultural Policies

Recent studies indicate that an additional 105,000 to 470,000 ha of land are degrading year-on-year in Burkina Faso (Carlucci & Guzzetti, 2024; MEEVCC, 2018; FAO, 2025), compromising agricultural productivity. In the semi-arid regions of West Africa, soils are known to be sensitive and vulnerable to degradation, mainly due to their low structural stability associated with the type of clay (kaolinite) and the low levels of organic matter in most land use types (Batino et al., 2007).

The annual cost of land degradation in Burkina Faso is estimated at US\$1.8 billion,¹⁰ equivalent to 26% of the country's Gross Domestic Product. About half of the cost is attributed to the decline in land productivity (e.g., food availability, wood production, etc.). The remaining share is attributed to the loss of key regulation of ecosystem services (e.g., carbon sequestration, water regulation flows, etc.) associated with the conversion of high-value biomes (e.g., forests) to a lower-value biome (cropland). Between 1992 and 2014, the country lost nearly half of its forested area (47.5%) in just 22 years (UNCCD, 2018). It is estimated that less than one-quarter of the land that is degraded annually, i.e., about 117,500 ha, is restored each year thanks to efforts from state actors, NGOs, and other stakeholders (Zida, 2018).

Land degradation affects most Sahelian countries. By 2030, climate change could result in Africa's drylands expanding by 20%, with larger increases in Sahelian countries (Cervigni & Morris, 2016). Considering these trends, the need for increased investments in land restoration cannot be overstated. **But these investments must be effective and regenerative. How they are made, and into what, matters tremendously.**

Through the lens of conventional agriculture, low fertilizer use has generally been considered a key contributing factor to lagging agricultural productivity growth in sub-Saharan Africa (Morris, 2007). As a result, from 2007 to 2012, many sub-Saharan African countries (e.g., Burkina Faso, Ethiopia, Ghana, Kenya, Mali, Nigeria, Tanzania) introduced fertilizer subsidy programs,

¹⁰ The costs of land degradation for Burkina Faso is measured in terms of 1) changes in land cover from a high-value biome to a lower-value biome (e.g. forest land converted to cropland); and 2) the decline in ecosystem services provision (e.g. cropland yields) within a certain land cover type due to degrading land-use practices, following Nkonya et al. (2016).

and some other countries introduced subsidized credit for fertilizer (e.g., Rwanda and Benin) (FAO, ECA, and AUC, 2020; Westerberg et al., 2017).

In Burkina Faso, the government introduced a fertilizer subsidy program in 2008, which targeted rice, maize and cotton. According to empirical evidence, the subsidy has incentivized farmers to allocate more land to these target crops, to the detriment of cowpea, intercropping, and crop diversity overall (Ahmad et al., 2023). Others have shown that the push for agrochemical-based input farming methods has exacerbated poverty and corroded local systems of knowledge, trade, and labor across Sub-Saharan Africa (Dawson & Sikor, 2016).

Groundswell International's NGO partners in the West African Sahel, have also witnessed how overreliance on conventional, high external input agricultural techniques and practices has led to soil degradation, the loss of ecosystems (trees, water, pasture, vegetative cover, agro-biodiversity), in addition to the bioaccumulation of agrochemicals in soils and water bodies (Dawson et al., 2016; Mentz-Lagrange & Gubbels, 2018).

The more fundamental challenge with subsidies for conventional agriculture (e.g., for chemical fertilizers, pesticides, herbicides, tractor services, etc.), which encourage *business as usual* practices that degrade land, is that they create an unlevel playing field. As a result, they hinder agroecological innovation and dissemination, especially among risk-averse smallholder farmers seeking alternative ways of generating land use productivity.

It should also be noted that the government of Burkina Faso has initiated numerous sustainable agriculture and land management programs to address soil degradation and its effects on the environment, human and animal health (including the National Strategy for Soil Restoration, Conservation and Recovery in Burkina Faso, 2020-2024 and the National Land Management Program 1 & 2 (Komonsira, 2025)). Such programs are challenging to implement in practice, but much can be learned from ANSD's approach to agroecology, as explained in this report.

1.3 Agroecology

Agroecology, contrary to *conventional farming*, allows farmers to work with and mimic nature's processes, and to test and develop their own solutions to prob-

lems that are adapted to the local context. Ecological principles ensure regenerative use of natural resources, while also fostering socially equitable food systems within which farmers exercise choice over how they produce food (Wezel et al., 2020). In Burkina Faso, the adoption of agroecological practices is spreading, and agroecology is increasingly featured in the popular press as a strategy to combat drought and food insecurity (minute.bf, 2024a, 2024b, 2025).

Pathways to agroecological transition combine farmer-centered technical interventions, investments, and enabling policies and instruments, involving a variety of actors at different scales. To guide such transitions, the High-Level Panel of Experts on Food Security and Nutrition (upon request from the UN Committee on World Food Security) produced a minimum, but comprehensive set of agroecological principles to achieve food security, nutrition, and sustainable food systems (HLPE, 2019). These 13 principles are illustrated in Table 1.

In the East Region of Burkina Faso, the Association Nourrir Sans Détruire (ANSD, or in English, the *Feed Without Destroying Association*) has worked in 3 rural departments since 2011 to support agroecological scaling with 125 sites across 89 villages, through a community-based, farmer-driven process of agroecological innovation and dissemination. Using farmer experimentation and field schools, geographically strategic pilot villages, learning exchanges between farmers, village-level action plans, cascading farmer-to-farmer training, and collaboration with many local leaders and government agencies, farmers and project collaborators have found effective ways to spread innovation among farmers (Brescia, 2024). In eastern Burkina Faso, ANSD and its network of farmer leaders have created pathways to more nature-positive and economically viable livelihoods across more than 100,000 hectares. These successes have until present mostly been captured in anecdotal information, farmers' own experiences, project reports, and case studies (ANSD, 2015a; ANSD, 2015b; Brescia, 2017).

In the following study, we go further, using comprehensive impact measurement and valuation to understand the extent of agroecological adoption within a landscape, how deep the transformation is, how rural livelihoods are impacted, and where public and private resources can best be spent to help ensure long-term profitability, sustainability, and further scaling efforts.

Table 1: Thirteen principles of Agroecology (from HLPE, 2019)

Principle
1. <i>Recycling</i> . Preferentially use local renewable resources and close as far as possible resource cycles of nutrients and biomass.
2. <i>Input reduction</i> . Reduce or eliminate dependency on purchased inputs and increase self-sufficiency.
3. <i>Soil health</i> . Secure and enhance soil health and functioning for improved plant growth, particularly by managing organic matter and enhancing soil biological activity.
4. <i>Animal health</i> . Ensure animal health and welfare.
5. <i>Biodiversity</i> . Maintain and enhance diversity of species, functional diversity and genetic resources and thereby maintain overall agroecosystem biodiversity in time and space at field, farm and landscape scales.
6. <i>Synergy</i> . Enhance positive ecological interaction, synergy, integration and complementarity among the elements of agroecosystems (animals, crops, trees, soil and water).
7. <i>Economic diversification</i> . Diversify on-farm incomes by ensuring that small-scale farmers have greater financial independence and value addition opportunities while enabling them to respond to demand from consumers.
8. <i>Co-creation of knowledge</i> . Enhance co-creation and horizontal sharing of knowledge including local and scientific innovation, especially through farmer-to-farmer exchange.
9. <i>Social values and diets</i> . Build food systems based on the culture, identity, tradition, social and gender equity of local communities that provide healthy, diversified, seasonally and culturally appropriate diets
10. <i>Fairness</i> . Support dignified and robust livelihoods for all actors engaged in food systems, especially small-scale food producers, based on fair trade, fair employment and fair treatment of intellectual property rights.
11. <i>Connectivity</i> . Ensure proximity and confidence between producers and consumers through promotion of fair and short distribution networks and by re-embedding food systems into local economies.
12. <i>Land and natural resource governance</i> . Strengthen institutional arrangements to improve, including the recognition and support of family farmers, smallholders and peasant food producers as sustainable managers of natural and genetic resources.
13. <i>Participation</i> . Encourage social organization and greater participation in decision-making by food producers and consumers to support decentralized governance and local adaptive management of agricultural and food systems.

1.4 Impact Valuation of Agroecological Innovation in the Eastern Region

This impact valuation focuses on measuring, evaluating and comparing impacts in monetary terms, and builds on a representative full-scale household survey and complementary focus groups. This approach provides a holistic view of farmers' backgrounds, conditions, access to credit and grain storage, as well as a comparative assessment of the performance of agroecological and conventional farming techniques on farmers' incomes, well-being, and climate resilience.

In addition, a cost-benefit analysis (CBA), a vital component for comparing the total costs and benefits of agroecological adoption over time, has also been un-

dertaken to assess the return on investments into agroecology and the pay-off period to the farmer or the investor.

This impact valuation was undertaken with a view to empowering farmers and decision makers to:

Gain in-depth understanding: Providing granular, quantified insights into how the full suite of agroecological farming techniques, in comparison to conventional inputs, impacts yields, profit margins and credit-worthiness of farmers.

Enhance resilience: Showcase robust strategies to improve climate change resilience, livelihoods and food security.

Discover hidden opportunities: Explore how market access, crop diversification, price gains, and volumes of marketable produce can be catalyzed by agroecological innovations and complementary strategies such as community grain reserves.

Reduce costs: Achieve greater resource efficiency in the allocation of public funds and farmer resources through the efficient use of farm-level inputs and agroecological practices. These inputs and practices enhance profitability at the farm level, improve Burkina Faso's trade balance, and generate savings for the public treasury.

Key to this assessment's relevance has been the effort to capture data and perspectives from as many farmers as possible, allowing comparisons across representative segments of farmers and their various livelihood-generating activities. Furthermore, quantitative household data is triangulated with farmers' qualitative assessments of land regeneration, and the successes and challenges associated with agroecology.

Why is such an assessment important?

This assessment comes at a crucial moment, when major public development agencies are cutting back international development assistance, and while the financing of Burkina's public debt (54% of GDP) has faced a significant surge in interest rates¹¹. Elevated borrowing costs will reduce development expenditures (World Bank, 2024a), which further highlights the importance of *endogenous low-cost development* offered by agroecological innovation.

As highlighted by the World Bank (2024a), accelerating poverty reduction in Burkina Faso is crucial and will require higher growth per capita in agriculture. As will be shown in the following report, **investments into a regenerative farm economy deliver high-impact development and financial returns**, increasing rural incomes, boosting food security, making affordable and more nutritious food available to rural areas and bustling cities, while also protecting natural resources. Our purpose with this report is to provide easy access to data that government actors, investors, and funders can use to assess the effectiveness of agroecology in Burkina Faso and the West African Sahel.

¹¹ Burkina's debt is 54% of GDP and is predominantly financed through domestic borrowing from the regional market, exceeding 9% per annum for 12-month bills.

2. Land Regeneration and ANSD's Work in the East Region

2.1 ANSD's Work in the East Region

ANSD started working within the departments of Bilanga and Gayeri (two of the East Region's 22 rural departments) in 2011. Since that time, they have been a partner of the Groundswell International network that pursues similar strategies with local NGO partners in 11 countries. ANSD targeted more villages in Bilanga, relative to Gayeri, because they had more land degradation and less tree canopy cover. Because of higher degradation levels in Bilanga, farmers have had to work harder, but the results on regeneration are more visible (Bourgou, 2025). These results correspond to what we see with satellite imagery (Table 2).

In 2015, ANSD extended its work to Tibga (Figure 1). Together, the three departments cover 593,850 hectares. In terms of land use transitions between barren and regenerated land, over the last 10 years (2014-2023), 11,800 ha have been regenerated to cropland from degraded barren land; a further 926 ha to forest cover; and 17,260 ha to scrubland. The latter likely includes cropland under intensive farmer managed natural regeneration of trees (FMNR)¹², since scrubland is

defined as vegetation that is dominated by shrubs or short-statured trees, generally < 5 m tall (Belay et al., 2019). In total, some 30,740 ha have been regenerated from a state of total degradation, while approximately 28,000 ha have been degraded to a state of *barren land*. Overall, the net balance in terms of regeneration on barren land is positive (+2,727 ha), driven by regeneration in Bilanga.

As ANSD started their programs, they quickly realized there were farming practices such as micro-catchment planting pits (zaï and half-moons) and farmer managed natural regeneration of trees, which were effective in maintaining soil health. But they were not spreading quickly enough to address declining conditions faced by communities and ecosystems. So ANSD went directly to the communities and facilitated discussions with farmers where they discovered that while some villagers had heard of these agroecological innovations, most farmers hadn't seen them and did not know much about them (Bourgou, 2024).

ANSD, therefore, decided they would work to support farmer experimentation and farmer-to-farmer spread

Table 2: Land cover transitions to and from bare land in hectares, from 2014-2023

Degraded hectares, 2014-2023	Bilanga	Tibga	Gayeri
Cropland to bare soil	641	0	1,332
Tree cover to bare soil	0	183	2,527
Scrubland to bare soil	6,762	2,876	10,871
Grassland to bare soil	665	531	1,065
Waterbodies to bare soil	402	85	71
Total degraded (28,011 ha)	8,470	3,675	15,866
Regenerated hectares, 2014-2023	Bilanga	Tibga	Gayeri
Bare soil to cropland	7,734	1,468	2,556
Bare soil to tree cover	655	33	238
Bare soil to scrubland	5,669	701	10,890
Bare soil to grassland	0	545	249
Total regenerated (30,738 ha)	14,058	2,747	13,933
Net change (+2,727 ha)	5,670	-928	-1899

¹² FMNR is an agroforestry approach which allow farmers to regenerate trees on their farms from existing stumps and roots, pruning the shoots and integrating the trees into their farming systems in a way that restores soil fertility and productivity.

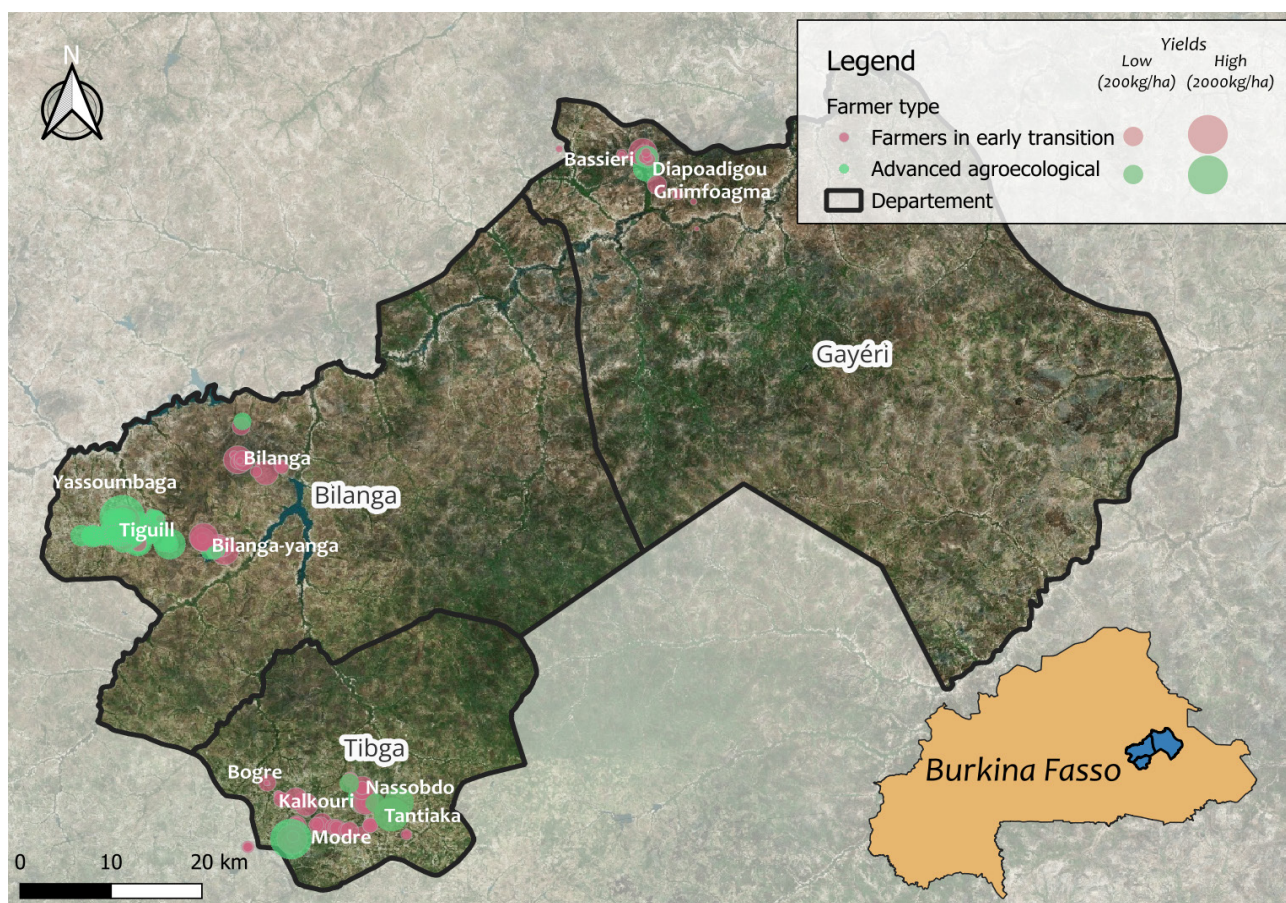


Figure 1: Case-study area, including the departments of Bilanga, Gayeri and Tibga in the East Region of Burkina Faso, including household plot locations, villages where the survey was implemented, and main farm plots of farmers in early transition and advanced agroecological farmers by magnitude of yields.

of agroecological practices. As a precondition, this also entails strengthening the structures and capacities of village organizations to lead the process and create networks between villages for sharing knowledge and effective practices. While ANSD started their work in Bilanga more than 13 years ago, they are currently expanding their reach to more villages, especially in Tibga. The typical process and steps by which they catalyze change are explained in Box 1 and are based on an interview with Ali Dianou (2024), Executive Secretary for ANSD.

As the program has reached greater maturity, linking stronger social infrastructure with effective technical alternatives, a multitude of landscape-level activities continue to unfold. For example, innovative farmers work with ANSD to develop

community radio programs to share the benefits of specific agroecological techniques in local languages. Youth storytellers¹³ are trained to document and disseminate effective strategies, through videos and other means, to more communities and decision makers.

Complementary activities are supported to continue to build human, physical and social capital, including the establishment of women's savings and credit groups; the construction of community grain storage reserves; the establishment of local seed preservation and distribution systems; improved access to short cycle seed varieties; rotating livestock schemes targeted at the most vulnerable households and individuals; and women's microenterprises to process and market non-timber forest products. Today, community agroecology committees, which coordinate experimentation

¹³ ANSD supports and trains youth storytellers who are part of the Groundswell International Youth Storyteller Program <https://www.groundswellinternational.org/youth-storytellers/>.



Photo 1: ANSD staff facilitating a farmer-to-farmer training on the use of the A-frame level to draw contour lines for soil conservation structures. Credit: ANSD

and extension of key practices to more farmers, have been established in all 125 sites across 89 villages¹⁴ where ANSD has worked.

Regrettably, the region's insecurity has meant that ANSD staff can no longer travel to certain villages, and some farmers have become internally displaced refugees. In these cases, the strengthened social infrastruc-

ture and capacity of community-based organizations have allowed farmers to continue their work in their villages autonomously or to establish themselves elsewhere if displaced.

The household surveys for this evaluation were carried out in villages that were relatively less affected and more accessible.

¹⁴ A site may refer to one village, or it may be one site within a sub-section of a large village.

BOX 1: How ANSD engages with communities to foster agroecological innovation and adoption

1. Context analysis: ANSD undertakes participatory research to identify villages with the highest needs, regarding land degradation, poverty levels, and lack of access to services.

2. Village assembly with community leaders and farmers: Participatory diagnosis is used to identify key constraints and priorities.

3. The community formally requests collaboration, and work begins: ANSD staff and promoters decide jointly with the village on priority interventions and educational activities. The program seeks to reach the entire village population rather than any pre-defined target group.

4. Learning exchange visits: ANSD supports village leaders to conduct exchange and learning visits to see agroecological innovations in more advanced communities in similar agroecological zones. They identify options or *baskets* of agroecological techniques relevant to their needs.

5. Joint experimentation of promising innovations in the new intervention villages: The village selects farmers motivated and interested in experimenting with agroecological interventions. Farmers typically start by implementing priority agroecological practices on a small plot and retain a control plot, so that skeptical farmers can see and be convinced by the results of those demonstrations. ANSD uses a monitoring protocol to follow farmers' adoption of practices.

6. Advanced farmers from other villages lead trainings: ANSD provides support, supervision and backstopping. Trainings focus on community priorities (e.g., soil and water conservation techniques, FMNR, processing non-timber forest products, etc.). Farmers start with a small number of practices to address priority challenges and generate initial success.

7. Identification of peasant educators: ANSD works with village leaders to identify two farmers per neighborhood for each village, designated by their peers as 'innovative producers' who are implementing effectively and can replicate the training for those unable to attend. This creates a system of *farmer-to-farmer cascading training*. ANSD undertakes backstopping and provides supporting materials, but farmers do the training under ANSD's supervision and according to the community's priorities.

8. ANSD organizes cross-visits and self-evaluations between farmers: Cross visits occur in and between communities engaged in agroecological experimentation on their farms to further promote a dynamic of learning from each other and observing effective agroecological practices at work.

9. Village-level agroecological committees are created: ANSD works with community leaders to organize a general assembly to form an Agroecological Committee. The committee elects six members, with a minimum of two women. Their role is to coordinate educational activities and promote agroecology within their village, ensuring that everyone is involved.

10. Expanding local alliances: Additional visits are organized with extension service providers, local government and ministry officials, and traditional and religious leaders, to see what has been achieved, what practices are most promising in a given context, and how to advance faster. This boosts wider and growing knowledge of, confidence in, and support for agroecological innovations.

11. Strengthening the capacity of agroecology committees: As the process evolves over multiple agricultural cycles, ANSD reinforces the capacities of the agroecology committees so they can develop action plans, implement activities, and develop activity reports which describe their processes and the results they have achieved. Once they develop these capacities to plan, implement, monitor and evaluate, the agroecological committee has complete autonomy over organizing and implementing their activities to spread agroecology.

12. Strengthening local movements: Local authorities and stakeholders, such as NGOs and technical services, contact agroecological committees to build relationships and find ways to collaborate. ANSD reinforces leadership within the communities so they can defend agroecology, organize more programs, help raise funding from other organizations (private, NGO, or governmental), and collaborate with other local NGOs.

13. Ongoing guidance and mentoring: ANSD continues to strengthen the agroecology committees, with attention to their governance, so there is ongoing membership renewal, regular activity reporting, and periodic coordination meetings (early and mid-year) to plan and implement educational activities. Outcome documents are produced mid-year to explain key achievements to other members and plan and implement educational activities.

3. Methods

3.1 Household Survey Implementation and Sampling

To assess the implications of this agroecological transition on farmer livelihoods, we relied on expert interviews, focus groups with farmers, and quantitative analysis of a household survey undertaken with over 400 randomly sampled farmers between June and September 2024. The data and information from these sources have been used to build the cost-benefit analysis (CBA) over 10-year and 15-year time horizons, and to make comparative land use budget analysis.

The household survey was designed to comprehensively cover the full spectrum of farmers, from conventional to those in early transition, to advanced agroecological farmers, and to analyze the impact of agroecological adoption on per-hectare profitability and household incomes. Sampling was done in the ANSD intervention and non-intervention villages. However, in Bilanga, all villages have benefited from ANSD's interventions, and in the remaining two departments, the non-ANSD intervention villages are so few due to effective farmer-to-farmer extension. Therefore, the notion of a control village does not exist. Indeed, the analysis did not reveal statistically significant differences in yields and agroecological uptake among ANSD and non-ANSD villages.

Because of insecurity in the case-study area, only about one-third of all villages were considered accessible at the time of the study. From this list, 3-5 villages per department were randomly selected. Table 3 shows the villages where interviews were undertaken, and the number of interviews undertaken in each village.

Interviews were done by six enumerators, who ANSD selected based on their familiarity with the geographical region of interest and their previous interviewer experience. Interviews were conducted with one or two representative household members, using mobile phones with Kobo Toolbox software. After the interview, the farmer and interviewer walked to the farmer's main plot, where a GPS point was recorded, and they took photos. The locations of the plots are shown in Figure 1.

The population from which the sample was selected included all farming households within the three depart-

ments of the East Region, comprising approximately 246,416 households (45,463 in Tibga, 61,048 in Gayeri and 139,905 in Bilanga, based on the 2019 population census) (City population, 2022). After deleting pre-tests and incomplete questionnaires, the total sample was reduced from 415 households to 397 (Table 3).

The survey was complemented with four focus groups in the departments of Gayeri, Tibga and Bilanga (Table 4).

3.2 The Economics of Agroecological Farming

To assess the productivity and incomes from farming, we relied on the households' self-reported physical quantities of harvested products and inputs used in the 12 months prior to the interview.¹⁵ For this purpose,

Table 3: Household numbers interviewed and retained for the analysis, by department and village.

Department - Bilanga (n=126)	Households interviewed
Bilanga	26
Bilanga-Yanga	29
Tiguili	21
Yassoumbaga With warrantage	50
Department - Gayeri (n=91)	
Bassieri (& Diapoadigou)	33
Carmaman	28
Gnimfoagma	30
Department - Tibga (n=180)	
Bogre	32
Kalkouri	25
Modre	30
Nassobdo	44
Tantiaka	49
Total	n=397

¹⁵ From June 2023 to June 2024.

Table 4: Location of focus groups

Village name – Focus group	Dates	Approximate number of people in the village	Approximate number of households
Ouagadougou – with farmers from Gayeri, Tibga and Bilanga	May 2024	NA	NA
Bilanga – Bilanga-Yanga	August 2024	3,670	450
Bilanga – Yassoumbaya	August 2024	1,866	196
Tibga – Kalkouri	October 2024	2,000	167
Bassieri – Gayeri	September 2024	7,400	822

land use budgets were designed and pre-tested as part of the household surveys. Focus groups served to elicit and validate farmgate prices obtained from the household survey and generate prices for forest produce.

Detailed questions on inputs, outputs and prices pertained to farmers' main plots of land, which serve to *guarantee food security* at the household level. The main plot averages 3.1 ha out of a total of 5.1 ha of land managed by the average household (Table 6). The spouse, the children or the parents-in-law may cultivate other plots belonging to the household.

Net income per ha from the main plot of land is estimated as per equations 1 through 3.

1) Revenue^{-ha} = (Σ Quantity^{-ha} $\times$ Price) / size of the main plot

2) Input cost^{-ha} = $\Sigma Q \times P$ (seeds, fertilizers, compost, manure, hired labor, rental of plowing equipment) / size of the main plot

3) Net crop income^{-ha} = Revenue^{-ha} – input cost^{-ha}

Where the total revenue from the main plot is estimated by multiplying the harvested quantities of each crop by the standardized prices, notably the average farmgate prices¹⁶ from the last harvest season preceding the interviews. Input costs refer to spending on seeds, fertilizers, pesticides, rental of plowing equipment, and hired labor costs. Own-family labor is treated as sweat equity and not included as expenses. Investment costs into agroecological practices, such as the transport of stones for contour barriers, are typically one-off (and not recurring every year) and are therefore accounted for in the cost-benefit analysis (Chapter 8).

Among the farmers interviewed, only four households

reported actual investment costs in the year preceding the interview.

Input costs for manure and compost were estimated based on farmers' own revelation of the quantities of carts of manure and compost that they used. The typical price of a cart and its weight were assessed in focus groups. For other items (seeds, land preparation, hired labor, NPK fertilizers, and pesticides), farmers reported the total expenditure for each item they had incurred in the year preceding the interview.

Whether produce is destined for subsistence consumption or sale, we have valued it the same way. By producing one's own food, the household forgoes the opportunity to sell it, yet does not need to buy it elsewhere, lowering the household's cost of living. This is also in accordance with guidelines by the Living Income Community of Practice (Tyszler & Carlos De Los Ríos, 2020).

3.3 Cost-Benefit Analysis

A cost-benefit analysis (CBA) was also developed to assess the net present value (NPV) benefits and returns from adopting advanced agroecological practices, involving FMNR, stone contour barriers, and zai micro-water catchments. By accounting for the flow of benefits and costs over time, CBA provides a strong basis for assessing the investment case for transitioning to advanced agroecological farming.

The net present value (NPV) is the estimated difference between the present value of revenues (cash inflows) and the present value of costs (cash outflows) (equation 4), estimated over a time horizon – chosen to be 15 years to reflect the upfront costs associated with transitioning to agroecology, as well as the benefits that increase over time (equation 4). This time horizon

¹⁶ Or median price, when the distribution of prices was skewed in one direction.

is also comparable to the traditional following period (10-15 years) previously used by farmers to restore soil fertility.

$$eq4. NPV = \sum_{t=0}^T \text{Revenues}_t - \text{Costs}_t / (1 + r)^t$$

The net present value benefits of transitioning fully to advanced agroecology are then simply the difference between the additional revenues and the additional costs of fully transitioning to advanced agroecology. Additional revenues include increased crop yields, forage biomass, and income from timber, fuelwood and non-timber forest products (equation 5).

$$eq5. NPV_{\text{transition} \rightarrow \text{AdvAE}} = \sum_{t=0}^T \text{Additional Revenues}_t / (1 + r)^t - \sum_{t=0}^T \text{Additional Costs}_t / (1 + r)^t$$

3.4 A Novel Approach to Defining Agroecological Farmers and Comparing Incomes

At the outset of this study, we did not have a pre-defined definition of an agroecological farmer in the local context. Instead, we used the household survey data to assess features that distinguished one or several groups from one another. Interestingly, we found

that the quasi-totality of farmers adopt some degree of agroecological practices due to ANSD's extensive program reach and effective farmer-to-farmer training strategy. However, the number of practices, types of practices, and maturity of adoption vary significantly, indicating a broad spread of knowledge of these practices and farmers' perceptions of their benefits.

One specific farming segment and combination of agroecological practices stood out - namely, farmers who use more than 2 T (5 carts) of manure per hectare. These farmers have significantly higher yields, and interestingly, all of them adopt at least three key agroecological practices (of the following five: zaï, half-moons, no-residue burning, stone-bunds, conservation tillage, FMNR) along with legume-cereal intercropping in all cases.

We have labelled these farmers (25% of the population) as ***advanced agroecological farmers***, who are compared to the remaining 75% that we have labelled ***farmers in early transition***, or simply *farmers in transition*.

4. Socio-Economic Characteristics & Dryland Farming Systems

4.1 Socio-Demographic Characteristics of the Farming Households

Household interviews took place between June and September 2024. In 47% of interview cases, a woman was present, either as the main or the secondary respondent (Table 5).

A woman is the head of 7% of households. The household head has lived an average of 43 years in the vil-

lage where she was interviewed, while 7% of all the households interviewed have been displaced due to violent conflicts (for an average of 3 years). The typical household head started his/her farm 20 years ago, and the typical household has 12 household members, with 4-5 children who are less than 14 years old. Advanced agroecological farmers have more household members, including an additional 4 children and 1 additional adult (19-64 years).

Table 5: Socio-economic characteristics of the household

Variable / Question	Share/ mean	Variable / Question	Share or mean (min-max)
The main respondent is the household head	77%	Years displaced (average)	3 years
Spouse/husband of the head of the household	18%	The household head is literate	22%
Brother, sister of the household head, son or daughter	4%	Highest degree achieved by the household head	
The main respondent is a woman	25%	No education	80 %
Woman presents as a secondary respondent	22%	Primary school completed	9 %
Male present as a secondary respondent	15%	Secondary school completed (BEPC)	3 %
The main respondent is a woman and head of household	7%	BAC/high school completed	0 %
The household head is divorced/widowed/single	5%	University diploma	0 %
For how many years has the household head lived in this village?	43	Household head has benefitted from informal education	9% 6.2 % Trans* 17.2% AE*
The household is displaced	7%	Age of the household head (mean, min-max)	48 (19-89)
For how long has the household been displaced?		Household members aged less than 14 years old	4.6 4 Trans 6.3 AE
0-1 years	12%	Household members aged between 14 and 17 years old	2.8 2.4 Trans 4 AE
2-3 years	54%	Household members aged between 18 and 64 years	4.4 4.1 Trans 5.1 AE
4-5 years	16%	Household members aged 65 years or more	0.9
6-7 years	4%	Total number of household members	12.7 (1-61) 11.4 Trans 16.3 AE
8 years or more	15%	Years since household head started his own farm	20 (0-89)

*AE refers to advanced agroecological farming households, and Trans refers to farming households in early transition.

When it comes to literacy, 22% of the household heads are literate, and 80% of the population has never attended school; there are also no significant differences between advanced agroecological and farmers. However, in terms of informal education, 17% of advanced agroecological farmers, against 6% of farmers in transition, have benefited from an informal education (including, for example, training in agroecology).

4.2 Land Ownership and Land Rights

Farmers cultivate an average of 5 ha of farmland, with a minimum of 0.5 ha and a maximum of 15 ha. Advanced agroecological farmers have more land under management, averaging 6.7 hectares against 4.6 hectares for conventional farmers in transition.

Farmers typically have one main plot, averaging 3.1 ha in size (3.7 ha for advanced agroecological and 2.9 ha for farmers in transition). The average distance to their main plot is 1.5 km, and there is no difference between the two segments of farmers (Table 6).

Most farmers have obtained their main plot by inheritance, and a smaller fraction (10%) by request from the village chief (Table 7). Interestingly, no one in the sample has bought land, but 40% consider that they would be able to sell their land (62% among advanced agroecological and 33% among farmers in transition).

This suggests that land governance is changing, arguably related to Law 0034 that came into effect in 2009. This law modified the rules governing land-property sales, allowing for the sale of land to the highest bidder,

Table 6: Number and size of plots cultivated per farmer

	Mean	Minimum-Maximum	Average Advanced Agroecological	Average Farmers in transition
Number of plots (cultivated last 12 months)	3.5	1-25	4.0	3.3
Surface of cultivated land *	5.1 ha	0.5-15	6.7 ha	4.6 ha
Size of the main plot*	3.1 ha	0.5-4.5	3.7 ha	2.9 ha
Distance of the main plot to the household in km?	1.5 km	0-10	1.5	1.7

*Statistically significant differences between advanced agroecological and farmers in early transition

Table 7: Ownership and land acquisition

Variable / Question	Share of household
How has the household obtained his/her main plot of land?	
By inheritance	84%
At the request of the village chief, another official or customary authority (borrowed)	10%
By lending it	5%
By buying it	0%
By renting it	1%
A donation	6%
Land lending to and from other households or the village chief	
The household is borrowing a plot of land from another household or the village chief	15%
The household is lending a plot to another household	22%
Does the household have an official ownership title for its main plot of land?	
Yes	8%
No and don't know	83%
Not yet	9%

whereas previously land ownership was transmitted through the family (Noria, 2020). Moreover, the ability for agroecological farmers to restore soil health, or make previously barren land fertile, may also explain why a larger share of advanced agroecological farmers consider that they would be able to sell their main plot (Table 8) (the reader is referred to farmer testimonies in ANSD 2015a, 2015b & 2015c).

Regarding land tenure security, most farmers consider that they have strong rights over their main plot of land, expecting that they can cultivate it forever (Figure 2). Nevertheless, 8% consider that they have very weak rights, and may be requested to leave at any time, which may be linked to the insecurity in the region. The results are nevertheless encouraging from the perspective of providing confidence to farmers that they can invest in agroecology, improve their land, and reap the returns.

4.3 A Description of Cropping Practices

The agricultural systems in eastern Burkina Faso predominantly consist of rain-fed subsistence systems. Historically, the average yield for Burkina Faso from 1961 to 2022 has been 790 kg per hectare. The minimum value, 409 kg per hectare, was recorded in 1961, while the maximum of 1262 kg per hectare was recorded in 2020 (The Global Economy, 2025).

In our case-study area, most production is dedicated to sorghum, followed by groundnuts, maize, beans, millet, sesame and rice (Figure 3). 92% of all farmers practice intercropping, with up to 6 different crops on the same plot of land (Figure 4). We did not attempt to measure crop-specific yields because of the high prevalence of intercropping. Instead, we have estimated yields in kg/ha of all crops combined for a given plot of land. Farmers themselves measure their output in 100 kg bags, which are then divided by the size of the main plot to derive yields in kg per ha.

Table 8: Percentage of farmers likely to sell

Would you be able to sell your main plot of land today if you like to?	Average	Advanced agroecological	Conventional farmers in transition
Yes	40%	62%	33%
No	47%	28%	54%
I don't know / Not applicable	13%	10%	13%

*Statistically significant difference between advanced agroecological and conventional farmers in transition.

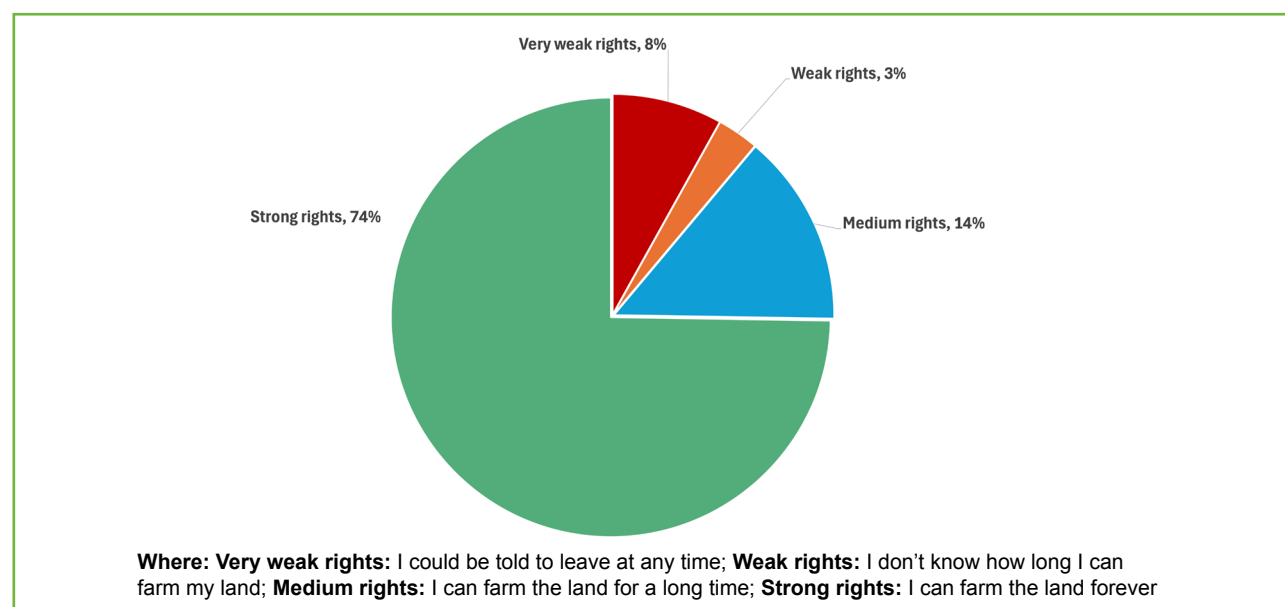


Figure 2: Households' sentiment around tenure security over their main plot of land

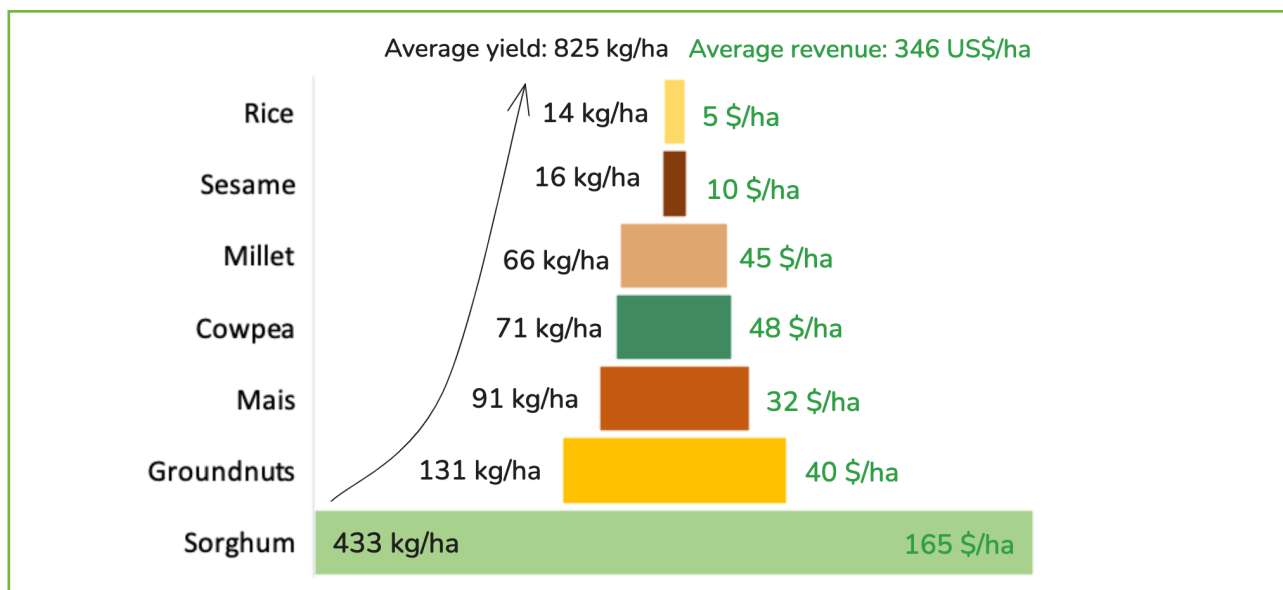


Figure 3: Crops that make up the average yield (of 825 kg/ha) in the case-study area, and the relative importance of each crop in terms of yields and revenues for the case-study area as a whole

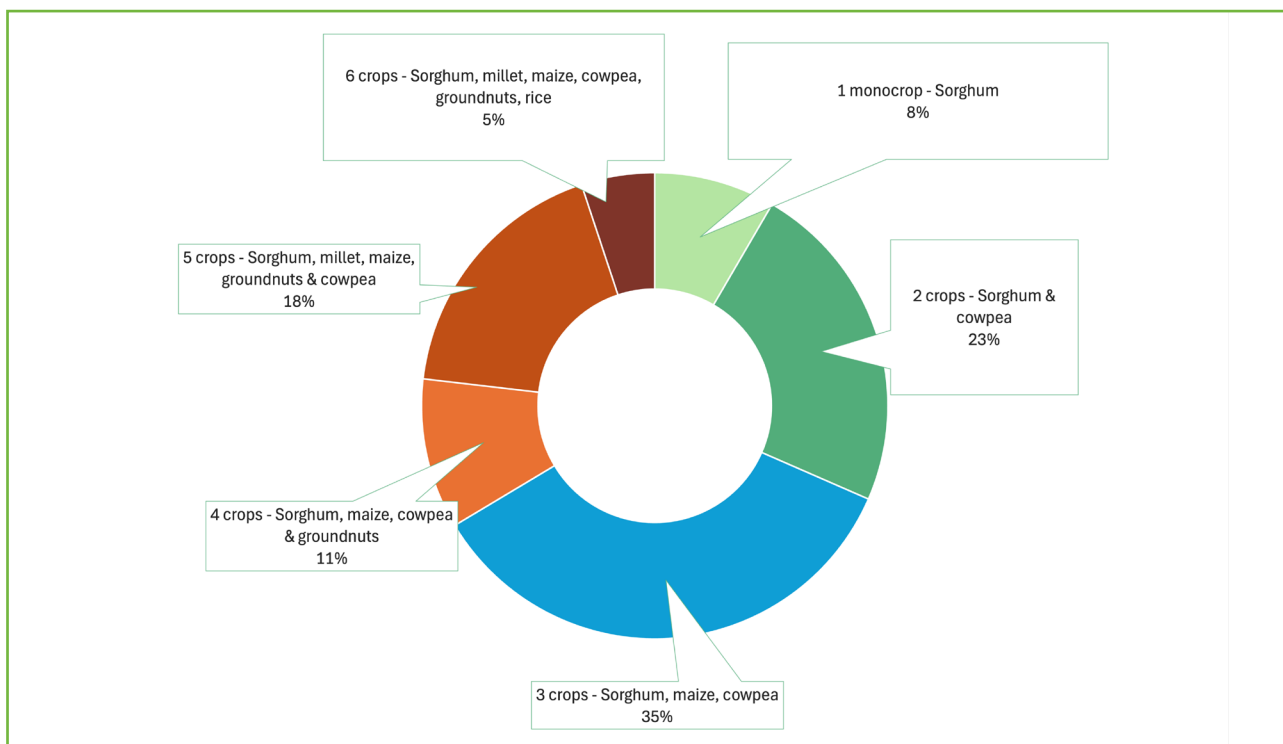


Figure 4: Prevalence of intercropping and typical intercropping associations

4.3.1 Intercropping Among Advanced Agroecological Farmers and Conventional Farmers in Transition

As shown in Figure 5, advanced agroecological farmers intercrop to a greater extent than conventional farmers

in transition, using most commonly five crops together (typically sorghum, millet, maize, groundnuts and cowpea) against three crops for farmers in their early transition to agroecology.



Photo 2: Agroecological farmer practicing intercropping. Credit: ANSD

4.4 Estimating Revenue from Cropping the Main Plot of Land

Table 9 shows the average farmgate prices¹⁷ from the harvest season (ending 2023 for annual crops) that preceded the interviews (carried out in 2024). For some crops, such as maize and sorghum, that are almost exclusively consumed at the household level and not sold in markets, observations of farmgate market prices from the household survey were limited. For example, only four households provided information on the price at which they sold sorghum (4th column, Table 9), and in such a situation, we used focus group information to ascertain the price that best represented the value of these crops.

For crops, such as sesame, rice and groundnuts, nearly all the households (89 to 98%) have sold at least one bag (Figure 6). These may therefore be considered cash crops, while millet and cowpea are for cash and subsistence consumption. In terms of the value of the produce coming from the main plot of land, sorghum is by far the most important crop, the farmers earning an average of US\$165 from sorghum per hectare (Figure 3, above).

4.5 Cost of Production – Organic and Inorganic Inputs

4.5.1 Land Preparation and Hired Labor

Farmers in the eastern part of Burkina Faso are cash-constrained and are farming first and foremost for food for consumption (Bourgou, 2024). The amount that farmers can spend on inputs is therefore limited. Table 10 shows the proportion of households that use a specific service or input. As for land preparation, plowing, and tillage, most households use mostly manual labor, animal traction, or both. Only 1.3% use tractors. A focus group organized in Ouagadougou in May 2024 revealed that plowing services are mostly obtained for free, as opposed to leased (e.g., through the lending of an animal and a plow from a family member). The use of hired labor is also minimal.

4.5.2 Compost and Manure

Farmers measure the use of manure and compost with reference to the number of carts applied. While farmers often produce their own livestock manure and compost, the number of carts used on the main plot is valued at their market price (revealed in focus groups)

¹⁷ Or median price, when the distribution of prices was skewed in one direction.

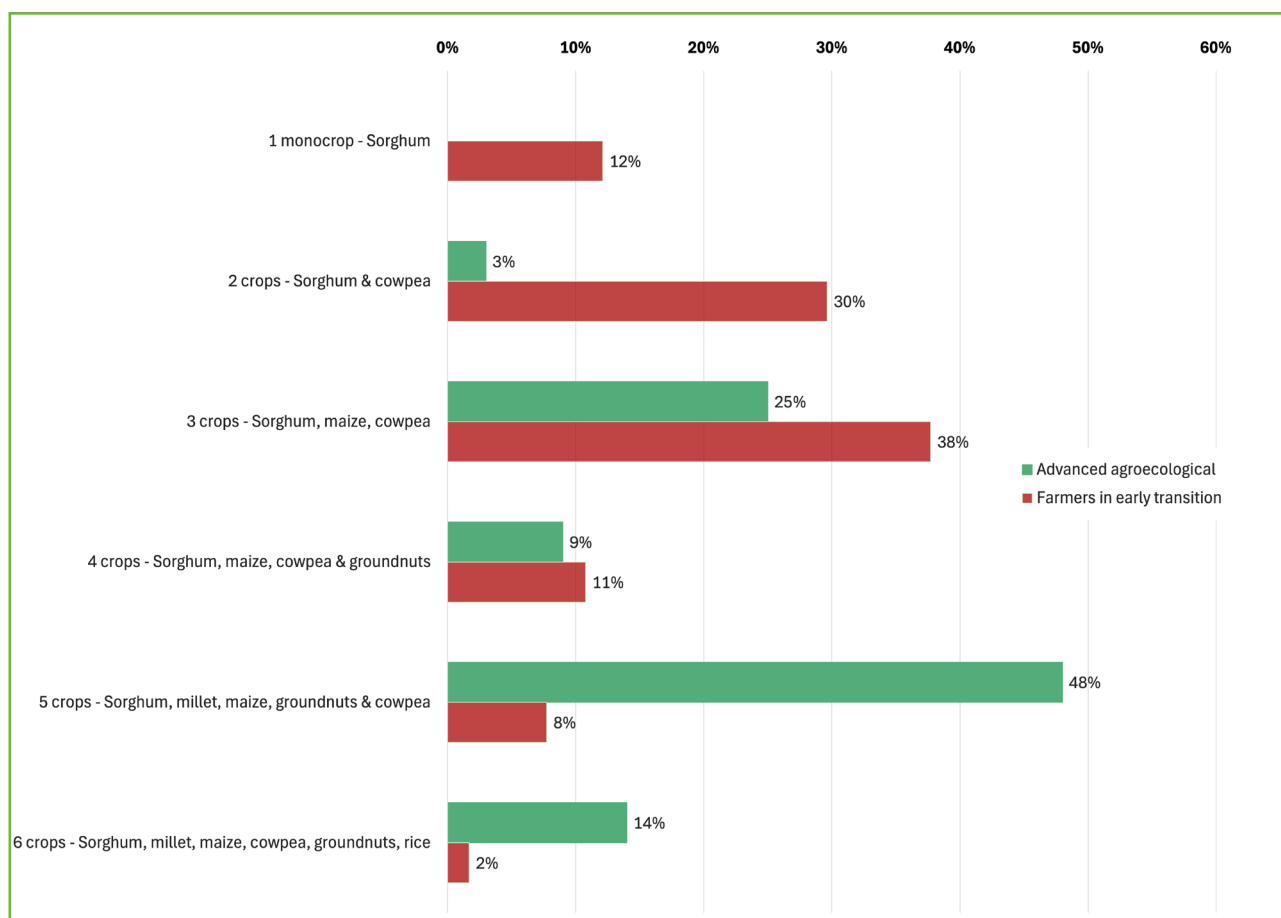


Figure 5: Degree of intercropping and typical crop combinations on farmers' main plot, by category of farmer

Table 9: Farm gate market prices of the main crops (US\$ per kg) for the 2023 cropping season

Crop	Average price* US\$/kg	Minimum price	Maximum price	Number of farmers who have sold the specific crop	Share of households selling at least 1 bag of the kind
Sorghum	0.34	0.26	0.60	4	1.1 %
Maize	0.34	0.23	0.51	9	4.8 %
Millet	0.68	0.34	0.77	49	34.5 %
Beans	0.68	0.26	0.82	94	35.8 %
Groundnuts	0.30	0.13	0.53	121	88.5 %
Rice	0.36	0.16	0.60	8	95.0 %
Sesame	0.61	0.60	1.3	67	97.6 %
Average for all crops	0.47	0.13	0.6	400	100 %

*Median price was used when it corresponded to focus group findings, and there were extreme values skewing the mean.

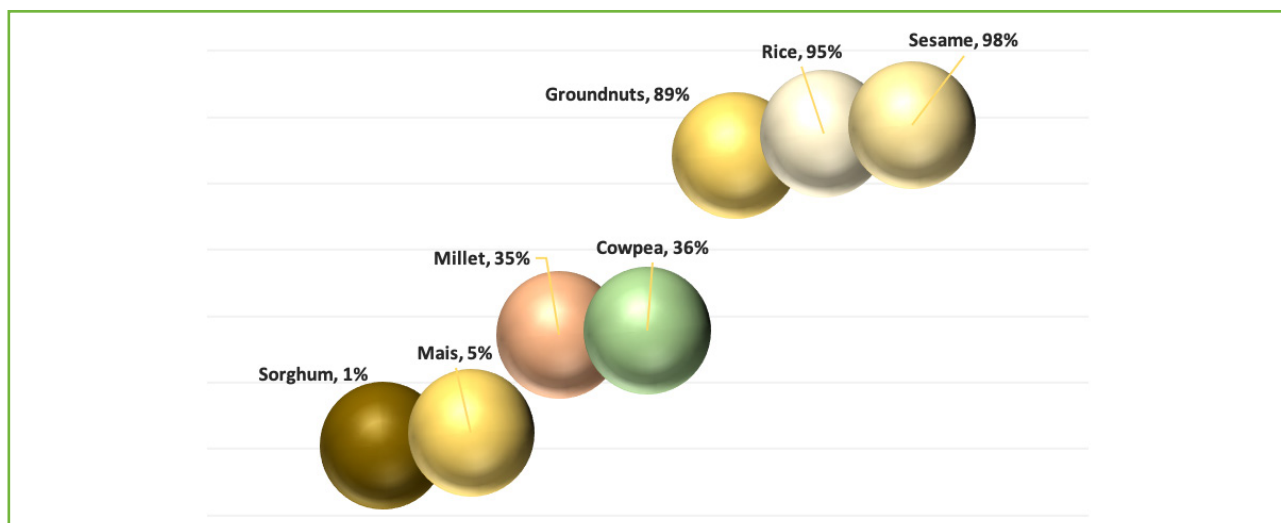


Figure 6: Subsistence versus cash crops: Percentage of households that have sold at least one bag of the kind

because there is an opportunity cost for the farmer of using that cart of manure or compost, in terms of foregone sales. Manure sells for approximately US\$2 per cart (CFA 1,000) and compost for US\$5 per cart (CFA 3,000)¹⁸. As for the use of fertilizers, three-quarters of farmers use manure and one-third use inorganic fertilizers.

4.5.3 Pesticides, Inorganic Fertilizers and Seeds

More than half of all farming households use pesticides of some kind, as well as herbicides. Average spending on pesticides is in the order of US\$15/ha (8,333 CFA/ha), which is substantial in the light of an average aggregate expenditure on all inputs and practices of US\$42 per ha. Farmers spend an average of US\$14 per ha on mineral fertilizers (farmers who purchase NPK use on average 28 kg NPK per ha, at a price of US\$25 per 50 kg bag). Across the whole sample, including farmers who do not buy mineral fertilizers, the average use rate is in the order of 10.6 kg (CFA 3,173), identical to the average national fertilizer consumption per hectare in Burkina Faso in 2016 (World Bank, 2016; Haider, 2018).

Table 11 shows where farmers obtained their seeds during the previous agricultural season. Only 15% of producers purchase seeds, half of them from other farmers and the other half from INERA (L'Institut de l'Environnement et de Recherches Agricoles du Burkina Faso), resulting in an average expenditure of US\$1 per hectare across the whole population, and US\$4.1

per ha among those that purchase seeds. In the vast majority of cases (97% of households), farmers simply use their own seeds. Table 12 summarizes the costs and revenues across the whole sample.

4.6 Revenue and Net Income from the Main Plot of Land

With an average yield of 825 kg/ha, a crop revenue of US\$346 per ha and a total average cost of US\$42 per ha, the average smallholder farmer has a net crop income of US\$304 per ha. Most of the produce from the main plot is consumed within the household, and only 28% of the produce is sold. Assuming that all inputs are purchased, this results in a net cash income of US\$56 per ha per year. Considering that manure and compost may be produced and collected at the farm household level (worth on average US\$25 per ha), the actual cash income could be higher than what is estimated here.

The distribution of net crop income within the sampled population ranges from negative -2.5 US\$/ha (for one farmer) to 1,082 US\$/ha (when deleting two outliers), which tells us that **there is a considerable potential for many farmers to improve their productivity and profitability**. In the next chapter of the report, we will look closely at what contributes to explaining the wide differences in yields and net crop income among farmers, and the role of conventional farming inputs and agroecological practices in explaining these.

¹⁸ As per focus group revelations. There is about 400 kg of compost or manure in one cart load.

Table 10: Services and inputs used in the farming system

	Rate of adoption	\$/ha among adopters	\$/ha full pop (std dev)	Services and inputs used in the farming system	Rate of adoption	\$/ha adopters	\$/ha full pop (std dev)
Plowing and tillage		\$26	\$3 (30)	Purchased seeds	15%	\$4.1	\$1 (3)
Mechanized	1.3%			Hiring of labor	7%	\$13.1	\$1 (6)
Animal traction	85%			NPK fertilizers**	33%	\$14.2	\$6 (21)
Manual traction	83%			Use of chemical pesticides	54%	\$15.3	\$8 (12)
Use of biopesticides & biofertilizers	1%	\$7.5	\$0.1 (0.5)	Herbicides	46%	\$15.7	
Compost	22%	\$12.7	\$9 (4)	Insecticides	30%	\$3	
Animal manure (USD/ha) *	74%	\$13.0	\$9 (12)	Fungicides	10%	\$1.3	

*Corresponding to an average of 11 carts/ha (4 T/ha) for advanced agroecological farmers, 3.3 carts/ha for farmers in early transition (1.3 T/ha) and 5.5 carts for the population as a whole.

**Corresponding to an average application rate of 28 kg NPK per ha.

Table 11: Seed Origin

How does your household access seeds?	Percentage
We purchase them from INERA	6.9%
We use our own seeds	97.5%
We purchase seeds from other farmers	7.4%
We exchange seeds with other farmers	1.5%
We obtain seed from the warrantage systems	0%
We obtain seeds from other farmers, who donate them to us	4.1%

Table 12: Yields, revenues and costs, and net crop income for the average farmer (the whole population)

US\$ per hectare	Average	Minimum-Maximum
Yield	825 kg/ha	167 – 3,756 kg/ha
Total revenue	\$346	\$37-1,165
Cash revenue	\$98	
Subsistence consumption	\$248	
Total cost	\$42	\$2-537
Net crop income per ha*	\$304	-\$2.5 to \$1,082
Net crop cash income ** (assuming 28% of crops sold)	\$56	

*Recalling equations 1 to 3: net crop income-ha = total revenue-ha – total cost-ha

**Net cash income = cash revenue – total cost

5. The Use of Agroecology in the Eastern Region of Burkina Faso

5.1 The Agroecological Practices Adopted by Farmers

Over the last 30 years, farmers, local NGOs, and agricultural researchers in Burkina Faso have tested and adapted a number of effective agroecological farming practices that have proven capable of improving land productivity and incomes for smallholder farmers. These include soil and water conservation techniques that build on traditional practices, such as *zaï* and *half-moon* micro-water catchment planting pits, and permeable rock contour barriers; the use of compost to increase organic matter in soils; legume-cereal associations and crop rotations; the promotion of farmer managed natural regeneration of trees; the use of local short-cycle seeds to cope with irregular rainfall and many more techniques (Batta & Bourgou, 2017).

According to farmers themselves, as noted in a focus

group in Gayeri, “agroecological techniques render our soils rich, and we produce a lot.”

A critical point of the ANSD approach to agroecology is that it does not involve the transfer of pre-determined packages of technologies. Instead, ANSD works with farmers to identify baskets of promising innovations used locally and enables each household to experiment with and apply the combination of agroecology practices that best suit their circumstances, as explained in Chapter 2.

Figure 7 shows all of the agroecological techniques adopted by farmers in the three districts, and the percentage of households that are adopting them. The highest adoption rate of most of these practices is within the department of Bilanga, which, not surprisingly, is where ANSD started their work in 2011 and has intervened the most.



Photo 3: An agroecological farm combining *zaï* pits, FMNR, contour barriers and manure and compost.
Credit: ANSD

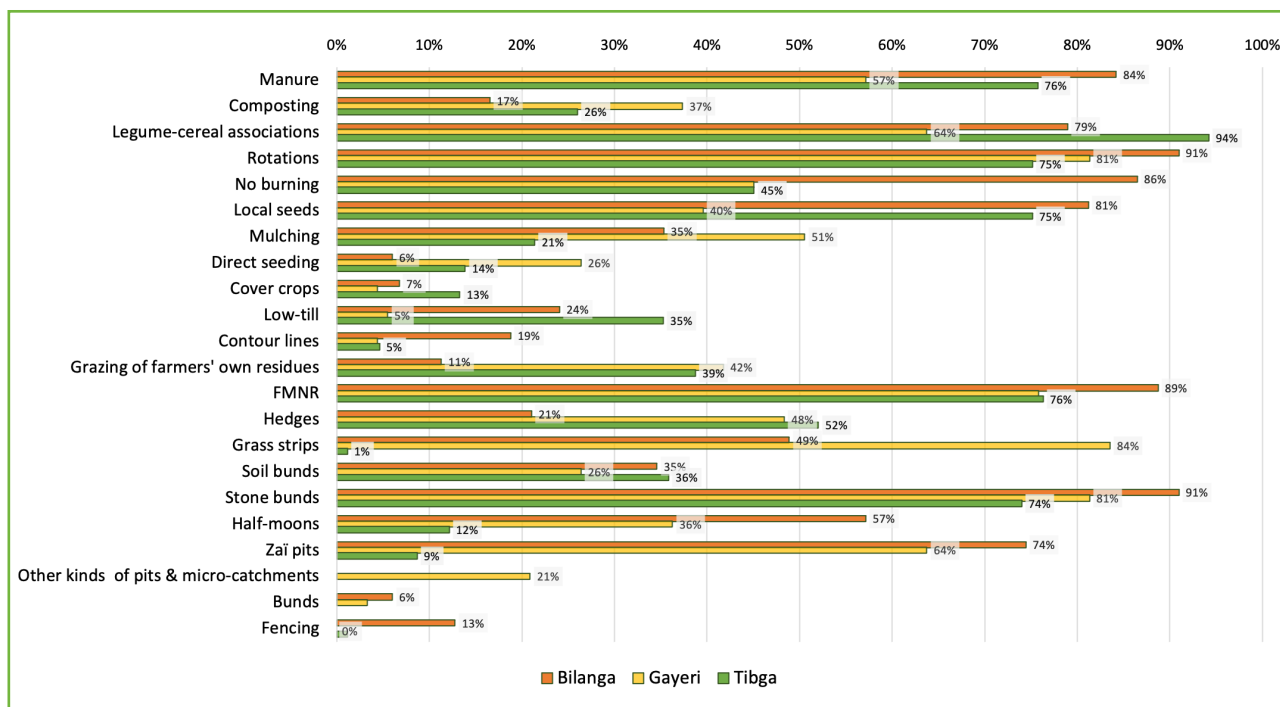


Figure 7: Agroecological practices and their adoption rate among households in Bilanga, Gayeri and Tibga

Figure 7 also reveals where there are potentially low-hanging fruit to be reaped in the respective departments. Many households in Gayeri, for example, use no manure, and only 64% intercrop legumes and cereals, while more than half of all smallholders (55%) in Gayeri and Tibga are still burning crop residues. Likewise, there is great potential for using more zaï in Tibga. The focus group in Bilanga revealed that zaï was their preferred agroecological technique because “it fertilizes our soils and gives reliable yields, even during dry spells and droughts” (Sagadou & Lankoande, 2024). Farmer managed natural regeneration of trees is also highly appreciated, but free-roaming livestock do pose a constraint to full-fledged scaling of this practice.

5.2 Adoption Rates of Agroecological Practices and Defining an Agroecological Farmer

ANSD defines an advanced agroecological farmer as someone who undertakes at least two agroecological practices. When inspecting the number of practices that farmers undertake, nearly everyone (95% of households) uses at least two practices on their main

plot, with an average of eight practices per household (Table 13). Thus, a more refined definition is necessary to truly understand the contribution of agroecology to land productivity and livelihoods.

The process of analyzing the drivers of increased yields for the purpose of this study led us to define an **advanced agroecological farmer as someone who combines at least three different agroecological practices**, out of a *basket of practices* which includes half-moons, zaï, FMNR, stone bunds, minimum tillage, and no burning of crop residue, in combination with cereal-legume intercropping in all cases¹⁹. Interestingly, the same farmer also turns out to use at least five carts of manure per ha (corresponding to approximately 2 tons/ha), because the on-farm availability of manure is increased due to the use of agroecology. **All other farmers can be considered as farmers in early transition**, because most of them have adopted some degree of agroecological practices, as shown in Table 13.

¹⁹ An advanced agroecological is coded as someone that simultaneously practice 1) zaï, stone barriers and uses at least 2 T of manure, cereal legume intercropping; or 2) zaï and half-moons, cereal legume intercropping and uses at least 2 T of manure or 3) minimum tillage, no burning of residues; cereal legume intercropping and least 2 T of manure.

Table 13: Characteristics of advanced agroecological farmers and conventional farmers in transition

	Average number of agroecological practices – (min-max)	Experience: Years since they started adopting agroecology	Adoption time 0-3 years	Adoption time 4-7 years	Adoption time 8 years or more
Whole sample	8 (0-14)	5.8 years	15%	43%	41%
Advanced agroecological farmer	10 (7-16)	6.7 years	9%	41%	50%
Farmers in transition	7 (0-14)	5.5 years	17%	44%	39%

5.3 Duration of the Adoption Journey Among Agroecological Farmers

Comparing the two groups of farmers, the advanced agroecological farmers adopt an average of 10 practices, with a minimum of 7. These practices have been adopted for an average of 6.7 years, contrary to farmers in early transition who adopt an average of 7 agroecological practices and have done so for an average of 5.5 years. The yields are distinctly different for the two groups, as is the share of produce that is sold versus consumed by the household.

In the following sections, we will analyze more closely the drivers of increased land productivity among agroecological farmers and the process that led to the definition of an advanced agroecological farmer.

5.4 The Role of Agroecological Practices in Driving Yields and Profitability

Farmers engage in various agroecological practices that are adopted progressively, as they access training, resources, and gain motivation to continue their adoption journeys.

To get a first-hand understanding of how agroecology impacts yields, we compared yields among farmers adopting a specific agroecological technique and those that did not. These showed that farmers who practice reduced tillage²⁰, crop rotations, no burning of residue, legume-cereal intercropping, and zaï have significantly higher yields, relative to those that do not adopt those specific practices (Figure 8).

The adopters of any specific practice enjoy 100 kg/ha to 300 kg/ha higher yields than the non-adopters. Stacking several practices together accelerates the im-

pact. For example, a farmer who practices zaï and half-moons together has yields in the order of 950 kg/ha, versus 783 kg/ha for those who practice zaï only. Also, those farmers who are able to apply more than 2 tons of manure per ha (5 carts/ha) enjoy, on average, 500 kg/ha higher yields, relative to those who apply less than 2 tons per ha. As we shall show, *higher manure used* is directly correlated to the adoption of agroecological practices. **Consequently, advanced agroecological farmers, adopting a bundle of agroecological practices as described above, and using a minimum of 2 T/ha of manure, attain an average yield of 1,230 kg/ha, nearly double that of farmers in transition (695 kg/ha).**

5.5 Explaining Land Use Productivity Using Production Function Modelling & Determinants of Improved Yields

As management practices and farmer conditions vary substantially in a given population, simple bivariate comparisons do not reveal the causal drivers of land productivity and the role of each practice in driving improved soil health. Indeed, the dispersion in yields and per-hectare incomes for any given plot is a combined result of:

1. The types of agroecological practices that farmers apply, the number of practices they apply, and the duration with which they have been applied.
2. Conventional and organic inputs that are used and their levels, as well as other factors of production, such as household labor and livestock holdings.
3. The underlying soil and ecosystem conditions that we cannot observe.

²⁰ Reduced tillage is performed on wet soil with a manga hoe or hand hoe, up to 5-cm depth, in contrast to conventional plowing, performed at 10-15 cm using animal traction (Korodjouma, n.d).



Figure 8: Bivariate comparisons of mean yields, with standard error

Note: Only practices for which there are statistically different yields in means are illustrated, unless otherwise stated²¹

²¹ Using a t-test and a Kruskal-Wallis non-parametric test

For example, yields may be higher among advanced agroecological farmers simply because they have more household members or are more educated. To control for such factors and explain the role of each agroecological practice and varying input levels, we undertook statistical production function modeling.

At first, we regressed yields on all possible management practices and relevant socio-demographic characteristics (use of pesticides, fertilizers, agroecological practices, education levels, number of household members and their age group). In doing so, we found that **mineral fertilizers, fungicides, and insecticides have no statistically significant impact on yields. In contrast, the use of herbicides had a positive impact, but only at low dosages.** Appendix 1 shows the scatter plot relationship between these inputs and yields.

Statistically significant factors that drive land productivity were found to be various agroecological practices, as well as key factors of production, including number of household members in the 14-64-year category (a proxy for labor availability), number of sheep units owned by the household, the use of manure, and the department of the household.

Manure is a particularly strong driver of increased yields, and when included in the full production function, it knocked out the significance of all the other agroecological practices. It turned out that this is because *use of manure* is highly correlated ($\text{corr}=0.5$) with the uptake of agroecological practices (resulting in so-called multicollinearity).

We retained three models to explain land use productivity and the use of manure:

- An “agroecology-yield-model”, explaining how agroecological practices impact yields and
- A second “input-yield” model, focusing on the role of fertilizers (organic and inorganic) and pesticides

- An “agroecology-manure model” to understand what exactly increases the availability and use of manure at the farm level.

The regression model specifications and detailed variable descriptions are provided in Appendix 2.

5.6 The Transformation Journey for an Agroecological Farmer

We hypothesize that:

1. All agroecological practices increase yields.
2. Household labor, fertilizers, and other farm inputs have an overall positive impact.
3. Agroecological practices, livestock ownership, and household labor enhance the use of manure.

These hypotheses were tested, and the **results of the agroecology-yield model²² are presented in Appendix 2.1.** With an adjusted R^2 of 0.31, the model fit is strong, explaining 31% of the variation in crop productivity in the area.

Our findings show that the regression coefficients for tree spacing density, zaï and half-moons, minimum tillage, legume-cereal intercropping, and no residue burning all have positive and significant coefficient estimates.

Higher tree density leads to higher yield, but at a decreasing rate as more trees are regenerated. With a coefficient of 0.14, yields increase by 0.14%²³ when tree canopy cover density increases by 1%. Or, as an example, when tree density increases from 1 to 15 per ha (+300%), yields increase by an impressive 21%²⁴.

The other agroecological practices are binary variables.²⁵ These reveal that the intercropping of cereals and leguminous crops is a particularly powerful intervention, increasing yields by 38% alone, keeping all other factors constant. Avoiding crop residue burning and conservation tillage allows for increasing yield by 14% and 16%. The harvesting of rainwater (and

22 The parameter values of agroecology-yield model, are as follows: $\ln(\text{Yield})_i = 5.5 + 0.15 \cdot \text{No residue burning}_i + 0.137 \cdot \ln(\text{tree density})_i + 0.32 \cdot (\text{legume-cereal intercropping})_i + 0.13 \cdot (\text{minimum tillage})_i + 0.06 \cdot (\text{Zaï \& half-moons})_i + 0.03 \cdot (\text{adult household members})_i + e_i$.

23 In a double-log function, the coefficient measures the estimated percent change in the dependent variable (yield) for a one percent change in your independent variable (number of trees per ha). This relationship is consistent with findings from Groundswell International partner organization CIKOD in the upper western region of Ghana, where a 1% increase in tree canopy cover, increases, increases crop revenues by 0.11%.

24 Interpreting the regression coefficients using the formula $(3+1^{0.14} - 1) \times 100 = 21\%$.

25 They are not logged. Therefore, to interpret the coefficient, we exponentiate the coefficient, which gives the multiplicative factor for every one unit increase in the independent variable.



Photo 4: An FMNR farmer demonstrating to other farmers how to select and prune trees within a field.

Credit: ANSD

manure) using *zai* and half-moons adds another 12% to yields after 7 years of adoption. Lastly, for every additional household member in the 14-64 age category, productivity increases by 3%.

As shown in Chapter 4, agroecological households have more adult household members. By controlling for this, we know that higher yields are attributable to agroecological practices and agricultural inputs, as opposed to agroecological farmers having more family members. For an average household residing in Tibga with eight members in the 14-64-year category, Figure 9 illustrates the resulting marginal effects of each additional new tree on crop yields, and how yields increase as more agroecological practices are added on the main plot at any level of canopy cover.

The graphic highlights that there is a theoretical potential for a farmer to increase yields from 400 kg/ha to 1,400 kg/ha, as farmers regenerate canopy cover from 5 to 100 trees per ha, and stack multiple agroecological practices. There is no specific order in which farmers implement these practices, with the exception that

avoided residue burning typically precedes regeneration of canopy cover.

For the sake of further illustration, Figure 10 shows the transformation journey using a waterfall diagram. Starting from a yield of 320 kg/ha under cereal monocropping, with no trees or other agroecological practices, yields increase to 510 kg/ha as crop residue burning is terminated, and canopy cover is regenerated to reach 50 trees per ha. Shifting from cereal cropping only to intercropping with legumes will further increase yields by 210 kg/ha. With legume-cereal intercropping, the use of micro-basins to collect runoff, and subsequent conservation tillage, a typical advanced agroecological farmer can expect 1,155 kg/ha. With increased maturity (after 7 years of adoption), the average advanced agroecological farmer can expect a yield of 1,420 kg/ha.

As such, our data reveals that a typical farming household can increase its yields by 340% (from 320 kg/ha to 1,420 kg/ha) through the adoption of multiple key agroecological practices.

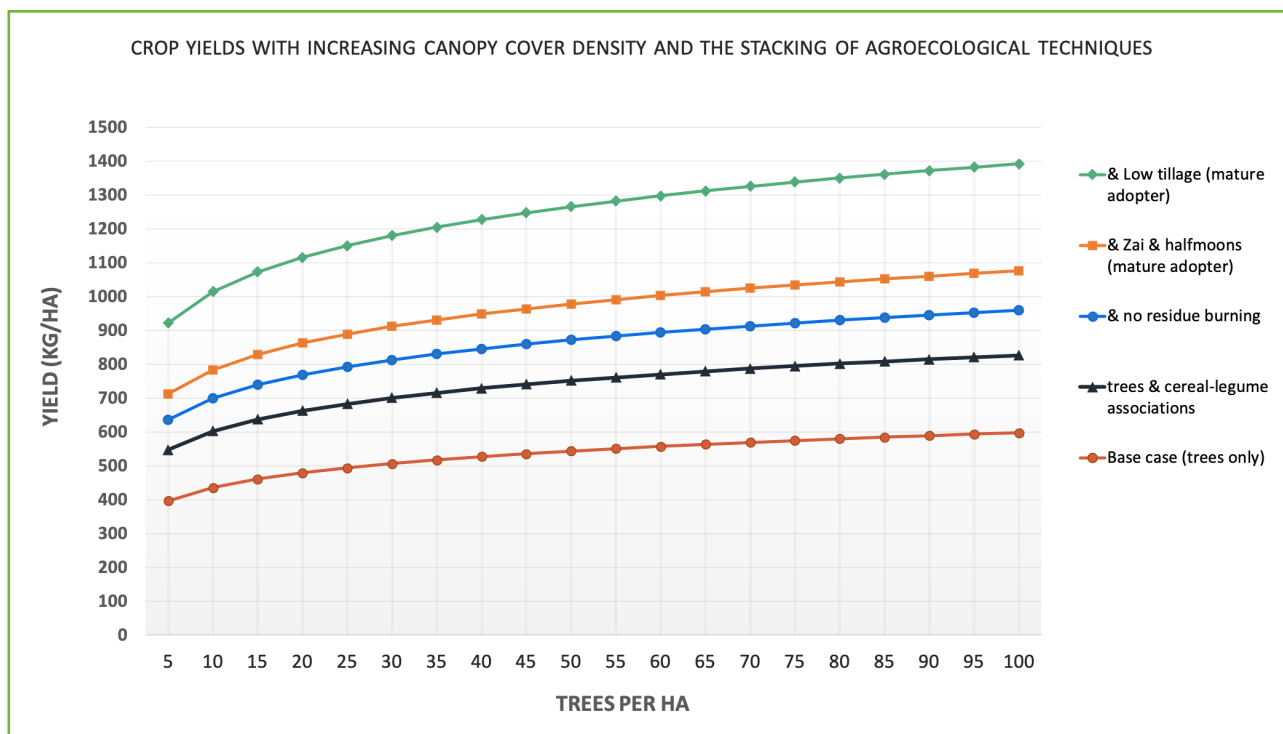


Figure 9: Crop yields with increasing canopy cover and stacking of agroecological practices

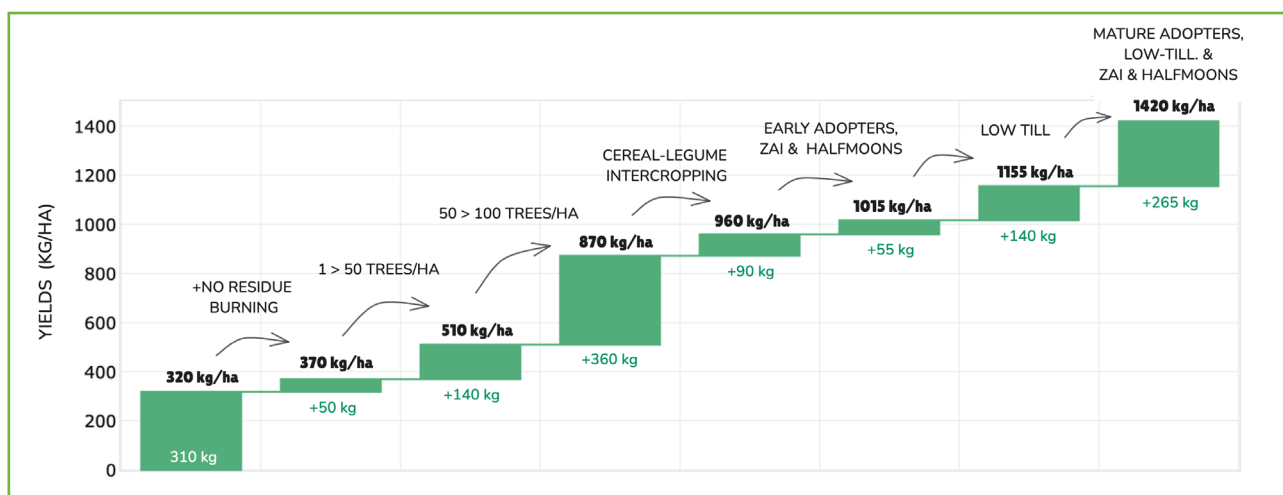


Figure 10: Illustration of how yields increase as more agroecological practices are adopted

This is a noteworthy transformation, and **challenges common claims of yields being low in the Sahelian zones** “due to inherent low soil fertility and unreliable rainfall” (Graef & Haigis, 2001; Schlecht et al., 2006; Stoorvogel & Smaling, 1990).

Under business-as-usual practices, however, yields are likely to be low. Millet yields, for example, are commonly in the order of 400 kg/ha in low-input smallholder farming systems, even though millet is adaptable to

harsh conditions and low soil fertility (Sivakumar & Sa-laam, 1999). Sorghum yields were recently measured to be in the order of 625 kg/ha in the Central Plateau (Kondombo et al., 2024).

During periods of low rainfall, e.g., between 1981 and 1985, yields of sorghum and millet averaged as low as 293 and 232 kg/ha in the Central Plateau, explaining why the majority of farm households had structural food deficits during this period (Kabore & Reij, 2004).

As such, our results show that **there is ample scope for overcoming low soil fertility with agroecological innovation. It should be noted, however, that potential yield increases from agroecology are not instantaneous**, recalling from Chapter 3 that the advanced agroecological farmer has implemented agroecological practices for an average of 6.7 years.

5.6.1 Caveats

As a note of explanation, regarding agroecological measures that are not included in the agroecology-yield model (stone barriers, composting, crop rotations, etc.), these are often practiced together with the other agroecological practices (zaï, FMNR, minimum tillage), and therefore cannot necessarily be assessed for their individual impact through a regression analysis, even while they still have a role in improving land use productivity.

5.7 The Input-Yields Production Function Model - The Role of Manure, Mineral Fertilizers and Pesticides

To understand more deeply the impact of organic and inorganic inputs on agricultural productivity, the results of the **input-yield regression model**²⁶ are pre-

sented in Appendix 2.2. Input use is measured in terms of US\$ worth of value (for manure²⁷) or spending on that input.

The regression model results in Appendix 2.2 show **no positive causality between yield and the use of inorganic fertilizers, insecticides, and fungicides**. As can be seen in the scatter plot in Appendix 1, a large proportion of farmers spend nothing on NPK fertilizers and yet achieve high yields. The production function, however, reveals a **slight positive relationship between herbicide use and yields**. With a 1% increase in spending on herbicides, yields increase by 0.04% (illustrated in Figure 11).

More importantly, manure is a strong driver of yields. For every 1% increase in the use of manure, yields increase by 0.13%. For example, by increasing manure use from just 0.4 T (1 cart) to 2 T (5 carts) per hectare (an additional US\$7 worth of manure), yields increase by 131 kg/ha, providing approximately US\$62 worth of additional crop revenues²⁸, and a benefit-cost ratio of 9 (US\$62/US\$7). As the farmer applies more manure, the benefit-cost ratio decreases, but remains positive within the whole spectrum of application rates applied by farmers (ranging from 0 to 14 T of manure per ha).

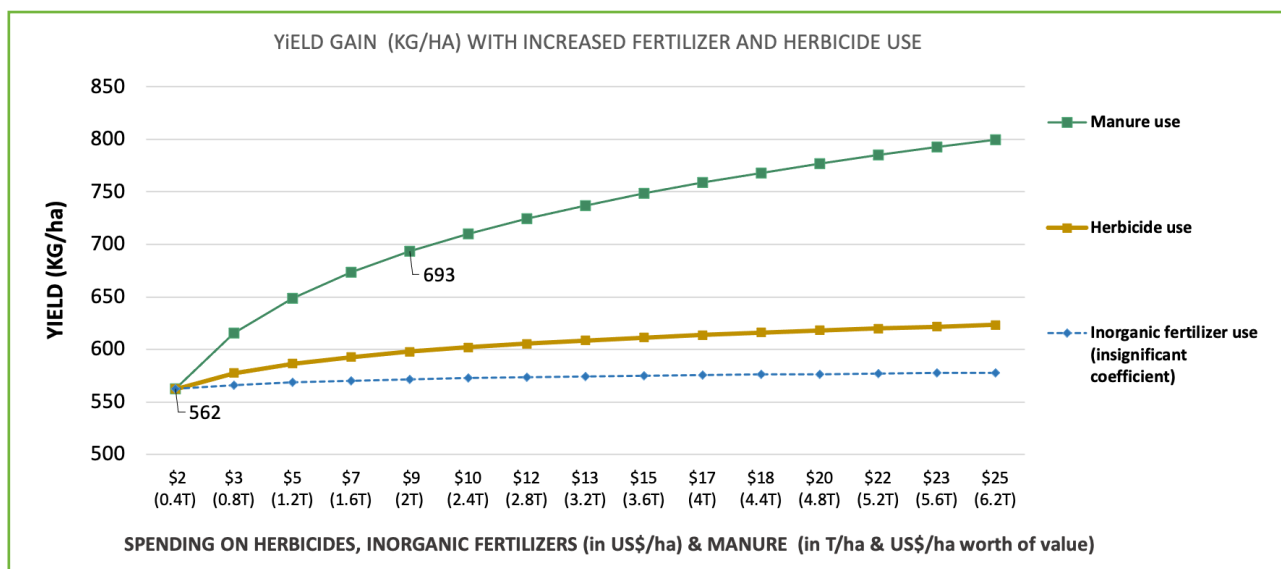


Figure 11: Yield gain with increasing spending on herbicides & manure combined*

*Illustrated for an average farmer in the region of Tibga, intercropping cereals and legumes, with eight household members in the 14–64-year category.

²⁶ $\ln(\text{Yield})_i = \alpha + 0.13\ln(\text{manure use in } \$/\text{ha})_i + 0.04\ln(\text{herbicide cost in } \$/\text{ha})_i + 0.29(\text{Legume-Cereal intercropping})_i + 0.02*(\text{adult household members})_i + 0.3*(\text{Bilanga})_i + 0.14*(\text{Tibga})_i + e_i$.

²⁷ Based on consensus value from two focus group revelations (1 cart with 0.4 T of manure is worth US\$1.7).

²⁸ With an average price per kg of produce of US\$0.47 for all crops (cowpea, sesame, sorghum, maize, millet) confounded.

For herbicide use, however, if farmers spend more than US\$8 per hectare, the additional revenues (of US\$1) hardly outweigh the additional cost (US\$1). Beyond US\$9 worth of herbicides, farmers are taking a loss as the incremental yield gain is minor. At very low levels of application, however, farmers can expect US\$3 to US\$6 of benefits for every US\$1 spent.

Table 14 below summarizes the impacts of agroecological practices and inorganic inputs, in relation to the three locations studied. Independent of manure use, intercropping with legumes and additional adult household members also increase yields (as we saw in the previous section as well). Interestingly, and confirming our hypothesis, land productivity in Bilanga and Tibga is higher than in Gayeri, keeping all factors constant. Yields in Bilanga are 35% higher, while yields in Tibga are 16% higher, no matter the level of inputs used. This result may be explained by the fact that agroecological technologies have properly permeated these departments.

5.8 How to Increase the Availability and Use of Manure?

The **agroecology-manure model**²⁹ (Appendix 2.3) has a very strong model fit, which explains an impressive 37% of the variation in the use of manure. The tree density coefficient is again positive and shows that with a 1% increase in tree canopy cover (e.g., from 10 to 11 trees), manure availability increases by 0.31%.

Not burning residues, in comparison to burning, also has a powerful impact, increasing manure availability by 60%. Stone contour barriers increase manure availability by 33%, while digging zaï and half-moons increase manure application by approximately 11% for the recent adopter, and 22% for the mature adopter (>7 years). For every additional Tropical Livestock Unit (TLU),³⁰ manure use increases by 0.02%. To harness the potential of the additional manure, household labor also plays a role. Specifically, for each additional household member in the 14-64-year category, manure use increases by 3%. Figure 13 illustrates how factors interact positively to increase access to and use of manure.

Figure 12 shows the respective role of each agroecological practice in increasing manure use, starting from the base case of an average household owning 3 TLU, with eight members in the 14-64 age bracket. As the farmer introduces various agroecological practices (at least 7 years of application) and increases his livestock holding by 5 TLU, the manure application rate will increase from 0.4 T/ha to 4.6 T/ha per year.

5.9 Creating a Reinforcing Positive Cycle and Synergy Between Crop and Livestock Production

The statistical analysis clearly demonstrates that the availability and use of manure are inherently promoted and boosted through the practice of agroecology.

Table 14: Summary - agroecological practices, inorganic inputs, location and their impact on yields

Impact of agroecological practices and location	Effect on crop yields
Cereal monocropping to Legume-cereal intercropping	+38%
Residue burning to No residue burning	+14%
Conventional tillage to Low till	+16%
Zaï and half-moon pits (after 7 years of implementation)	+12%
Yields in Bilanga relative to Gayeri	+35%
Yields in Tibga relative to Gayeri	+16%
Impact of changing input levels (examples)	Effect on crop yields
Canopy cover density 1 trees/ha to 15 trees/ha (+300%)	+21%
Manure use from \$2/ha to \$9/ha (or 4 T/ha to 2 T/ha) (400%)	+23%
Herbicide use from \$2/ha to 9 \$/ha (350%)	+6%

29 $\ln(\text{manure})_i = -0.37 + 0.29(\text{Stone barriers})_i + 0.47(\text{no residue burning})_i + 0.31\ln(\text{tree density})_i + 0.02\ln(\text{TLU})_i + 0.1(\text{Zaï \& half-moons})_i + 0.032(\text{adult household members})_i + e_i$.

30 One TLU (250 kg live weight) standardizes live animals by species mean live weight with the following conversion factors: cattle: 0.55; buffalo: 0.50; sheep and goats: 0.10; pigs: 0.20 to 0.25; and poultry: 0.01, following Pica-Ciamarra et al. (2011).

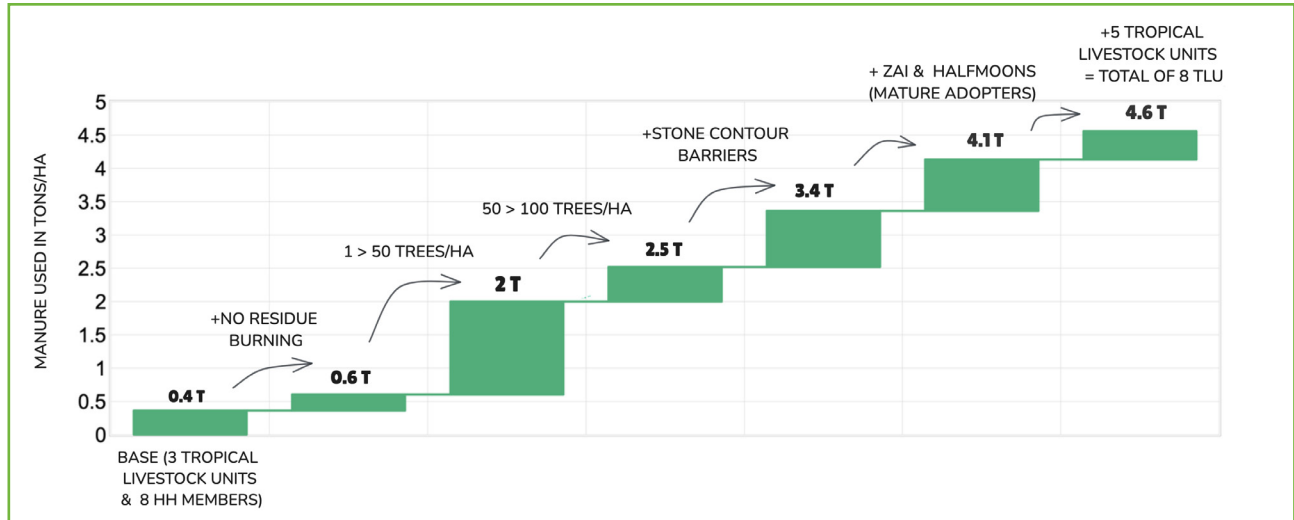


Figure 12: Examples of how manure use changes with increased uptake of agroecological practices, which can be applied in any order (2 T=5 CARTS)



Photo 5: Integrating livestock into farming systems increases access to manure and other benefits. Credit: Andrew Esiebo and The Gaia Foundation

Theoretically and practically, this is not difficult to explain. Agroecology practices increase biomass, forage, manure, and soil health, both directly and indirectly, thanks to:

- **Tree canopy cover species** such as *F. Albida* and *P. Reticulatum* (Bagnan) provide forage for animals. Other trees also provide shade that attracts animals (domesticated, or from other farms) and contribute to enhanced biomass through nitrogen fixation (Nair, 1984).
- **Animals return manure droppings** that are collected by farmers to be applied during land preparation and the tilling of the soil. Stone barriers and micro-catchments (half-moons and *zai* pits) trap manure in fields, so it is not flushed away with rainfall.
- **Grass strips** along the stone barriers that are harvested yearly are a source of forage and conserve soil and water.
- **Crop residues**, which otherwise were burned, now constitute an important part of the livestock diet. Higher yields, thanks to agroecological practices, also result in the production of additional crop residues, which can be used as forage, as well as compost.
- **Additional biomass and income from higher yields** allow farmers to purchase more livestock and keep more offspring.
- **Increased offspring and livestock holdings** increase the availability of manure from own livestock

holdings. Under conditions of strategic pasture management, livestock may also be viewed as an input into farming activities, with animal trampling enhancing soil structure by breaking up the hard soil crust (Savory Institute, 2015).

Therefore, in summary, more biomass and shade from trees:

- Increases manure droppings on the fields
- Increases livestock numbers
- Higher livestock numbers increase manure availability further
- Finally, enhanced manure availability increases yields, which increases residues and provides more forage

As highlighted by IFAD (2009), there is a beneficial synergy between crop and livestock production, whereby the outputs of one system act upon and provide inputs and resources for the other system. **Agroecology therefore creates a reinforcing positive cycle, in which people, plants, animals and soils work in symphony to exponentially increase yields (Figure 13).**

Independently of the use of manure, all other agroecological practices also increase land productivity, because they help retain soil moisture and build soil biology. Farm labor is fundamental to mobilize all these production factors. Consequently, agroecology has both a direct and indirect impact on land productivity.

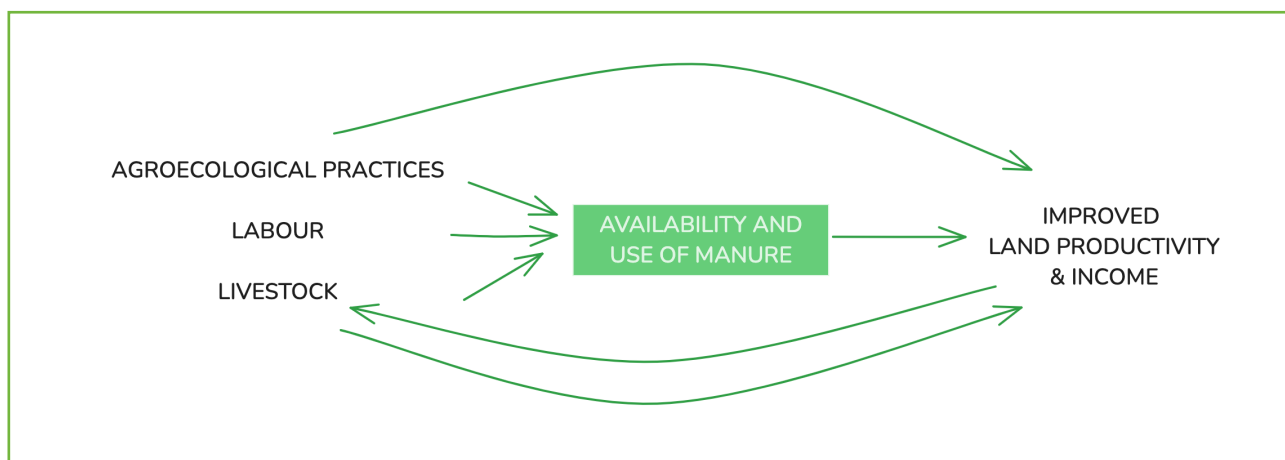


Figure 13: The self-reinforcing cycle of land productivity under agroecology

6. THE TYPICAL LAND USE BUDGET OF AN ADVANCED AGROECOLOGICAL FARMER VERSUS A CONVENTIONAL FARMER IN TRANSITION

In the previous section, we analyzed why some farmers are more successful than others and why advanced agroecological farmers can achieve double the yields compared to conventional and farmers in early transition to agroecology. Specifically, we saw how the role and duration of the adoption of agroecological practices, such as FMNR and tree canopy density, stone contour barriers, zaï and half-moons, and intercropping with legumes are driving higher yields. It is important to recognize, however, that higher yields do not always translate into higher net incomes, which is the ultimate goal for a farmer. In the following chapters, therefore, we dig into the farm-level economics of the two farmer segments. We estimate per-hectare incomes (this Chapter) as well as total household incomes to have a more holistic understanding of the well-being of farmers (Chapter 7). We also investigate how total household income compares to the Living Income benchmark for rural Burkina Faso, which is the annual income required for a typical rural household to afford a decent standard of living for all members of that household (Anker Institute, 2024).

6.1 Yields Among Advanced Agroecological Farmers and Farmers in Early Transition

The average yield for the whole population is in the

order of 825 kg/ha. In comparison, the average yield among advanced agroecological farmers is 1,230 kg/ha, with a minimum of 500 kg/ha and a maximum of 2,800 kg/ha (when removing one outlier of 3,700 kg/ha) and is 695 kg/ha among farmers in transition. Overall, the distribution of yields is shifted upwards for advanced agroecological farmers (Figure 14).

Higher yields translate into higher per ha revenues, but how are final bottom lines impacted for the two farmer categories when we account for input costs? In the following section, we analyze revenues and costs for the two categories of farmers, focusing on their main plots of land. We include revenue from the harvesting of fuelwood, timber, and NTFP from the main plot, before presenting the full land-use budgets.

6.2 Forest-Based Income from FMNR

Farmer Managed Natural Regeneration of trees (FMNR) is an innovative agroforestry system, which has made a significant impact starting in the Maradi region of Niger since yearly 1980s (Sendzimir et al., 2011; Haglund et al., 2011) and spreading across southern Niger, Burkina Faso, Mali and Senegal.

The success of FMNR has been widely documented, and more than 5 million ha of land have been restored, with

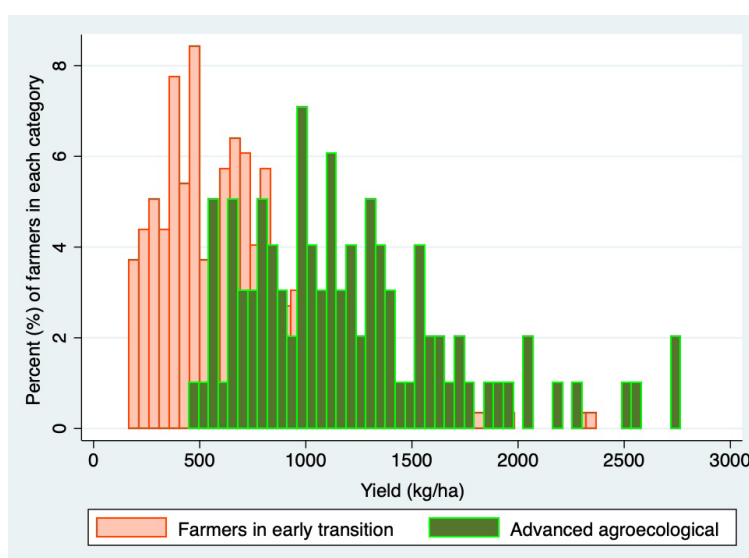


Figure 14: Distribution of crop yields for farmers in early transition and advanced agroecological farmers



Photo 6: Women farmer from Gayeri who processes and sells Non-Timber Forest Products. Photo credit: Steve Brescia

over 200 million trees re-established in Niger alone (Rinaudo, 2007; Pye-Smith, 2013). Overall, the changes brought about by FNMR include improved soil fertility and increased supply of food, fodder and firewood.

In the ANSD intervention area, 80% of all farmers claim to undertake FMNR. According to farmers in the Gayeri and Bilanga focus groups, “trees protect and regenerate our soils,” and “they fertilize our soils and provide reliable yields.” “Trees are typically spaced at 10-15-meter distances between them, with an average of 75 trees per hectare.”

Household survey results suggest that tree canopy cover density is in the order of 20 trees per ha for farmers in transition and 48 trees per ha among advanced agroecological farmers (Table 15). These are not *exact* measurements because they are based on farmers’ own assessments of the number of trees on their main plot of land. However, the statistically significant regression estimates in the previous Chapter give us confidence that farmer observations are not random and, as expected, advanced agroecological farmers have higher

tree canopy cover densities relative to farmers in transition.

The trees species that are most often occurring in the case-study area are *Piliostigma reticulatum* (or *bagnan* in local language), appreciated for animal forage; followed by *Lannea microcarpa* (*raisinier*), appreciated for its fruits; *Diospyros mespiliformis* (West African ebony) appreciated for its fruits, wood, fodder, medicinal purposes and construction (Gnonlonfin et al., 2022); *Adansonia digitata* (known for baobab fruits); *Balanites aegyptiaca* (desert date), that is harvested for its fruits, and used for oil production, sweets and jams; as well as *Ziziphus mauritiana* (*Jujubier*); *Acacia Nilotica*; Gum Arabic; and *Combretum micranthum* (*randga*); and finally *Faidherbia albida* (*Zaanga*) “the pearl of the Sahel” appreciated for its forage during the dry season (Le Houerou, 1985; Poschen, 1986). Legume species such as *F. albida*, *A. nilotica*, and *G. sepium* increase soil fertility by fixing atmospheric nitrogen in the soil.

The prevalence of these tree species on farmers’ main plots is shown in Figure 15 for advanced agroecological

Table 15: Tree canopy cover density per hectare

Tree density per ha	Mean	Min - Max
Average	26.5	0-150
Farmers in early transition	19.2	0-150
Advanced agroecological farmers	48.0	0-150

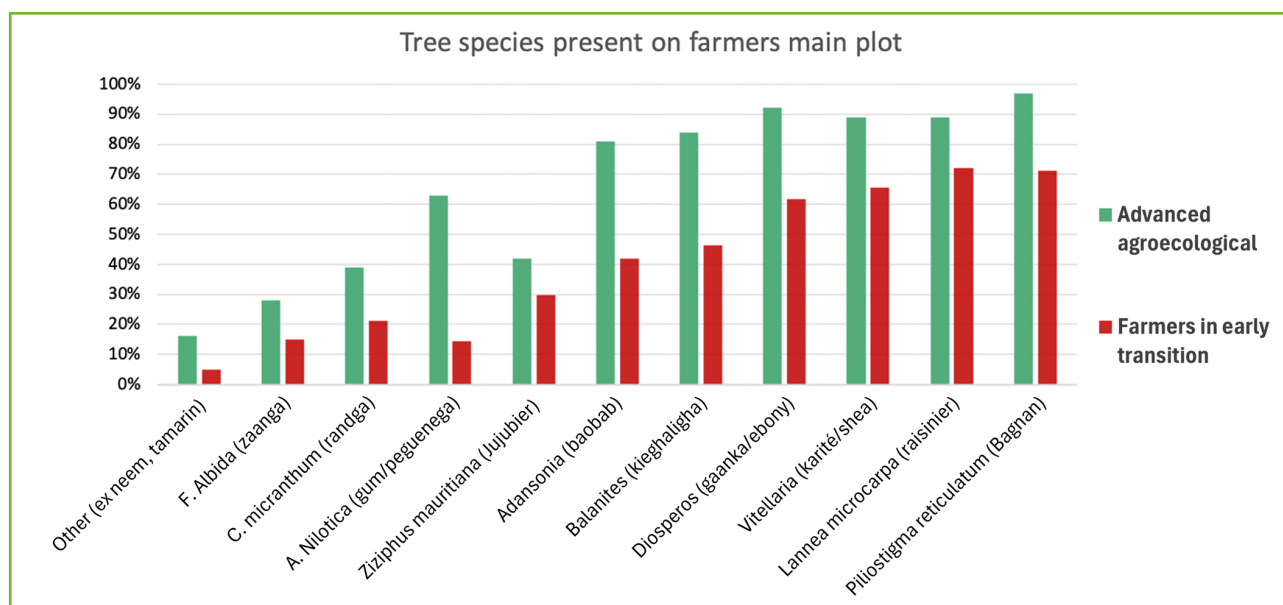


Figure 15: Proportion of households with the specific tree species present on their main plot

as well as farmers in transition. In general, any given tree, regardless of its species, is more likely to be present on the main plots of advanced agroecological farmers. (See also Appendix 3 for more details.)

6.2.1 The Collection and Harvesting of Forest Produce

Farmers reported collecting a diverse set of timber and non-timber forest products over the 12 months preceding the survey. The 2023/24 season, however, was a particularly poor year for shea production, so the figures presented here are conservative estimates of the true income that farmers enjoy in a typical year.

Table 16 shows the quantities for major forest products harvested from farmers' main plots of land. Timber and NTFPs are typically harvested and measured in bags of 50 kg or dishes (translated from *plats*, in French). Forage from bagnan ranks as the primary source of income (providing US\$46 per ha in income for the advanced agroecological farmers), followed by shea nuts, tamarind pods, baobab powder and African locust bean (nééré). Other produce which was harvested in smaller quantities (and sometimes processed for value addition) included: gum arabic, litres of balanites, bags of F. Albida pods (zaanga), dishes of ebo-

ny seeds, ebony fruits, balanites, bags of raisins, and jubube powder. The average total revenue from these products was in the order of US\$25 (CFA 14,520) per ha for advanced agroecological farmers, and US\$19 (CFA 11,200) per ha for farmers in early transition.

In terms of quantities of fuelwood harvested from farmers' main plots, the median estimates for advanced agroecological farmers versus conventional farmers (Table 16) are similar to the results derived from the focus group carried out in Ouagadougou in May 2024, giving confidence in the household survey results. **On the whole, the harvesting of fuelwood and NTFPs (in 2023/24) resulted in a median revenue of US\$68 per hectare for advanced agroecological farmers and US\$31 per hectare for farmers in early transition.**³¹

6.2.2 Origin of Non-Timber-Forest Products

The main plot is the most important location for the harvesting of forest produce for farmers in transition, whereas for the majority of advanced agroecological farmers, only about half of the NTFP derives from the main plot. This suggests that there is scope for farmers to extend FMNR practices to other plots on their farm (Table 17).

³¹ With the mean being above the median, average revenue, is pulled upwards, by some highly performing farmers, for that reason, the median is used for the land use budgets and in the calculation of total annual household income. It should be noted however, that NTFP harvest rates were low this year, due to an unfavorable shea nut season and insecurity, prohibiting some farmers from going to their fields frequently.

Table 16: Forest products harvested from farmers' main plots

Major NTFP items	Unit	Farm-gate price US\$ per unit	CFA per unit	Advanced agroecological		Farmer in early transition	
Quantity harvested on the main plot/ha				Quantity harvested	Revenue per hectare	Quantity harvested	Revenue per hectare
Bagnan	Plats	0.85	500	66	46	21	8
Shea nuts	Bags	35.7	21000	1.2	42	1.1	39
Tamarin pods	Plats	1.0	600	8	7.9	2	2.3
Baobab powder	Plats	0.5	300	6	2.9	3	1.7
Néré grains	Plats	4.0	2250	1	5	1	2.7
Néré powder	Plats	2.6	1500	0.5	0.6	0.5	0.8
Other produce	Mixed	NA		NA	25	NA	19
Fuelwood	Carts	5.1	3000	3.5	\$18	2.5	\$13
Total revenue				Mean	Median	Mean	Median
Total fuelwood and NTFP	US\$/ha			\$89	\$68	\$64	\$31
Total forest revenue	US\$			\$758	\$414	\$283	\$134

6.2.3 Challenges Imposed by Armed Conflict

Not surprisingly, advanced agroecological farmers collect more agroforestry produce relative to farmers in transition. However, it should be noted that within each of these farmer categories, there are still large differences between farmers' ability to collect forest products. This is not only related to the prevalence of trees, but also security concerns in some villages.

In Nassabdo in the department of Tibga, for example, farmers announced during the household survey that they were not able to go to their fields to harvest forest products, due to fear of terrorist attacks. For that reason, the actual revenue from forest produce is also currently lower than the true potential revenues (in the absence of security concerns).

Table 17: Share of forest produce obtained from farmers' main plot

Of all the forest produce you collect, what percentage, approximately, comes from your main plot versus other plots?	Average, full sample	Advanced agroecological	Conventional & in transition
100% comes from my main plot	38%	4%	47%
Three quarters	9.4%	1%	11%
50% half	38%	80%	24%
One quarter	1.5%	6%	2%
0% Nothing comes from my main plot	13.2%	9%	16%

6.3 The Land-Use Budget of the Advanced Agroecological Farmer and the Farmer in Transition.

Table 18 shows two land-use budgets comparing a farmer in transition (with a 694 kg/ha yield) and an average advanced agroecological farmer (with 1,231 kg/ha yield), with per-hectare revenues and costs broken down.

For the 2023/24 agricultural season, advanced agroecological farmers had an average expenditure of US\$69 per ha, against US\$33 per ha for farmers in transition. However, with crop and forest-based reve-

nues in the order of US\$558 per ha for advanced agroecological farmers and US\$328 for conventional farmers in transition, **the per-hectare net income for the advanced agroecological farmer amounts to US\$489 against US\$293 for a conventional farmer.** Moreover, a larger proportion of their agricultural output is sold by agroecological farmers, so in terms of actual cash, agroecological farmers also enjoy much higher cash-on-hand crop-based revenues (of US\$197/ha against US\$57 /ha for farmers in transition for agricultural crops).³² The budgets for the two farmer segments are also illustrated in Figure 16.

Table 18: Land use budgets for advanced agroecological farmers vs farmers in early transition

\$USD per ha	Advanced agroecological farmer	Farmers in transition
Yield (kg per ha)	1,230 kg/ha	695 kg/ha
Total revenue	\$ 558	\$ 328
Revenues from forest produce	\$ 68	\$ 31
Crop-based revenue	\$ 490	\$ 297
Crop-based revenue from sale (cash)	\$57	\$197
Costs (US\$ per ha)		
Manure and compost*	-42*	-17*
Chemical pesticides	-10	-8
Chemical NPK fertilizer	-11	-5
Hired labor, plowing & seeds	-6	-5
Total cost	-69	-35
Net crop and forest income	\$489	\$293
Share of produce sold	40%	19%

*The survey elicited the quantity of manure (in 400 kg carts of manure) used by the farming households. The carts were valued according to their market price, corresponding to an average of 11 carts/ha (4 T/ha) for advanced agroecological farmers, and 3.3 carts/ha for farmers in early transition (1.3 T/ha). In reality, however, much of the manure is not purchased, but rather collected by farmers from their fields or stalls, before being applied prior to planting. Therefore, the true *cash* cost of manure use is arguably lower than what is reported here.

³² We do not know the share of agroforestry produce that is sold versus home-consumed and therefore do not account for that in the cash-based income.

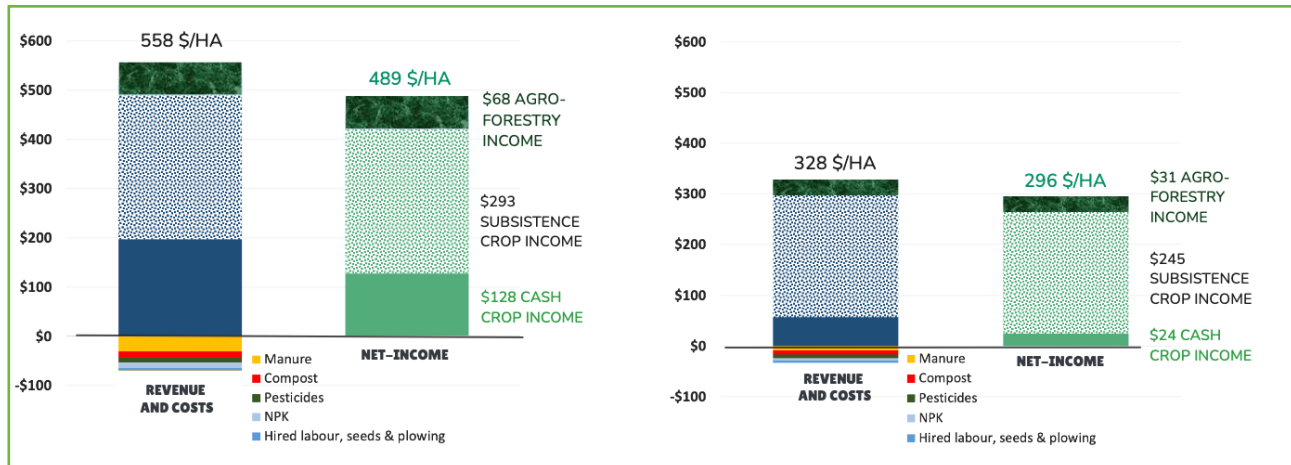


Figure 16: Land use budgets, advanced agroecological farmer vs farmer in transition

7. Total Household Incomes: Toward the Closing of the Living Income Gap

There is an increasing recognition of the need to ensure better livelihoods for smallholder farmers around the world. The principle that farmers deserve a decent standard of living has gone from niche to mainstream, as civil society, regulators, investors, consumers, and companies are recognizing that achieving *living incomes* is an essential human right and a vital step towards a world where people and nature thrive together (Fairtrade International, 2025; Ducett et al., 2022; Sustainable Brands, 2022). **A living income is defined as sufficient income to afford a basic, but decent standard of living for all household members – including a nutritious diet, clean water, decent housing, education, health care and other essential needs, plus a little extra for emergencies and savings (Rainforest Alliance, 2019)**

The Living Income Benchmark for rural areas in Burkina Faso was estimated to be in the order of US\$2,112 in 2024 for an average-sized family. In the following section, we estimate total household income by farmer segment and investigate whether smallholders in the region can generate enough income to reach the Living Income Benchmark. In doing so, we account for net farm income (livestock, crops, forest produce, vegetable gardens) as well as other/off-farm incomes, including enterprise income, remittances, retirement payments, etc. The detailed accounts for all of these income sources are provided in Appendix 4.

7.1 Income from Annual Crops, Domestic Animals, Forest Produce and Other

Livestock plays an important role in the smallholder farming systems of sub-Saharan Africa, beyond just providing manure (e.g., as sources of diverse food and nonfood products, such as milk, meat, wool, leather

and eggs). Moreover, ruminants are able to transform resources not used for human consumption, such as grass and fodder, into edible products, in addition to manure. Farmers also use livestock for traction and often sell animals to buy food when crop harvests fail, acting as an insurance for vulnerable families and communities (Soussana et al., 2015). For eastern Burkina Faso, **Table 19 reveals that a significantly larger proportion of advanced agroecological farmers sold or consumed their livestock during 2023/24 relative to farmers in transition. This result is in accordance with expectations, considering that advanced agroecology allows farmers to have more livestock.**

Farmers hold diverse types of livestock, including pigs, cows, goats, sheep, and donkeys, to mention a few. The vast majority of animals sold and consumed are chickens and guinea fowl. Standardizing live animals by species according to live weight, advanced agroecological farmers consumed or sold an average of 1.4 TLU (or 13.5 sheep units), while farmers in early transition consumed or sold 0.52 TLU. 9% of all households also sourced milk from their livestock. Details on the number and kinds of livestock sold, and revenues by farmer segments, are provided in Appendix 4.1.

In the absence of data on livestock keeping costs, it is assumed that cash-based expenditures are in the order of 20% of total revenue, which is a maximum since the most cost-intensive component is the gathering of fodder and the moving of livestock utilizing family labor, which has a low opportunity cost and is treated as sweat equity in the analysis (Steinfeld & Mack, 1995).

Livestock maintenance costs are negligible for poultry birds that can survive on 30-50 grams of feed per day,

Table 19: Advanced agroecological vs farmers in transition- sale of livestock

	Whole sample	Advanced agroecological	Farmers in early transition
Household consumed or sold animal produce in the previous 12 months?	59%	85%	50%
Ownership of livestock in Sheep Units	48.0 (4.8 TLU)	76 (7.6 TLU)	39 (3.9 TLU)
Sale of livestock in Sheep Units	7.4	13.5	5.2
Income from livestock	\$243	\$478	\$163

obtained by scavenging and feeding on kitchen waste. Large ruminants, on the other hand, need fodder equal to about 10 % of their body weight (e.g., 30 to 40 kg for an adult cow). For large ruminants, farmers usually gather residues in their fields or forage from fodder trees (Pica-Ciamarra et al., 2011).

7.2 Own Business Income

Farmers also generate income from their own businesses, which could include running a small kiosk, a barber shop, engaging in artisanal mining, rental of livestock for traction, or using a motorcycle as a taxi. Appendix 4.2 shows own-business categories and the income earned from these over the last 12 months. Interestingly, advanced agroecological farmers also reap more income from their businesses relative to farmers in early transition (Table 20). Finally, some farmers also have access to collective vegetable garden plots, and others have income from remittances, NGO support, compensation payments (from mining activities), dividends, etc. (the magnitude and sources of these other incomes are provided in Appendix 4.3 to 4.5.) Wage income was negligible for the farmers surveyed

and, therefore, not accounted for.

7.3 Total Annual Household Income – Own Business Income

When aggregating the various income sources, there is a substantial difference in total household income when comparing advanced agroecological farmers and farmers in transition, especially when it comes to income from livestock, crop, and forest products. The advanced agroecological smallholder farmer has an average annual income of US\$2,981 against US\$1,341 for farmers in transition. With 5.1 and 4.1 adult household members respectively, this translates into **US\$580 per adult household member among advanced agroecological farmers, against US\$261 per adult household member for farmers in transition**. The GDP per capita for Burkina Faso was in the order of US\$908 in 2024 (IMF, 2025).

The Living Income Benchmark for Burkina Faso was US\$2,112 in 2024³³ (Medinaceli et al., 2024). Therefore, with a mean annual household income of US\$1,734 per household, the average household in the departments

Table 20: Total household income- advanced agroecological farmers vs farmers in transition

Total household income (cash and non-cash)	Average	Advanced agroecological (n=100)	Conventional farmers in transition (n=296)
Crop income from the farmers' main plot	\$933	\$1,544	\$757
Income from all other plots	\$185	\$287	\$155
Agroforestry income from the whole farm (lower bound)	\$224	\$414	\$134
Income from livestock produce	243	478	163
Income from vegetable gardening	\$3.2	\$1.5	\$3.8
Enterprise income	\$127	\$183	\$108
Miscellaneous income (NGO support, dividends from a local enterprise, compensation payments, retirement)	\$19	\$44	\$10
Average annual household income	\$1,734	\$2,951	\$1,331
Living income gap*	-378	839	-781
Approximate cash income**	593	1318	352

*The updated Anker Living Income Reference Value for rural Burkina Faso for 2024 is CFA 107,006 (USD 176) per month, equivalent to an average annual income of **USD 2,112** ** Based on the assumption that 50% of livestock and forest produce, are consumed at home, that the majority (90%) of produce from other plots are sold and that the fraction that is sold from the main plot, is according to section 6.3.

33 To be able to pay for food, education, medical expenses, and unexpected events. To calculate the gap to the Living Income Benchmark, we need the total income of the household (including farm and off-farm incomes, as done above), net of agricultural production costs, including inputs and paid labor, as we have comprehensively done (Tyszler & Carlos De Los Ríos, 2020).

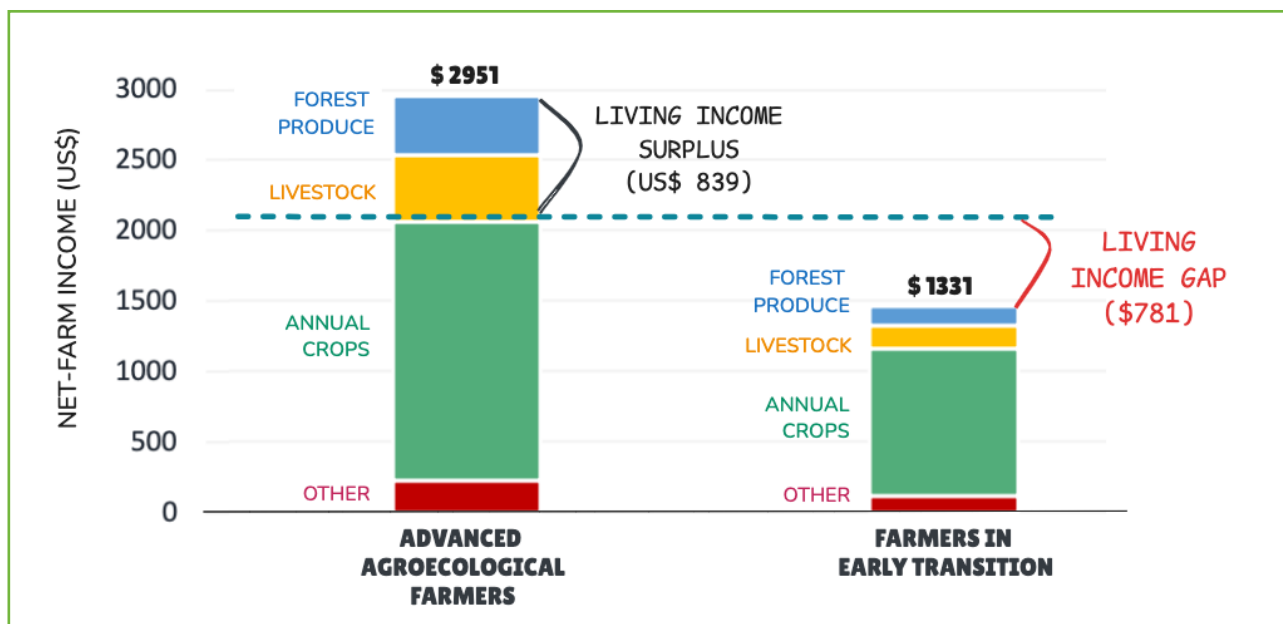


Figure 17: Total household income and living income surplus/gap for advanced agroecological farmers and farmers in early transition

of Tibga, Bilanga, and Gayeri is earning 80% of what is required to have a living income to meet a basic, but decent, standard of living. Advanced agroecological farmers, however, diverge by entirely generating a living income surplus, while farmers in transition are still 37% short of meeting the living income target.

For context, in 2020, seasonal farmworkers at the Fruiteq mango exporter in Burkina Faso earned the legal minimum wage, which amounted to approximately 26% of what would be required to earn a Living Wage (Lieffering, 2020). In that sense, **farmers in our case study area are significantly better off than seasonal workers who are only making the minimum legal wage.**

In the next Chapter, we consider the business case for investing in advanced agroecology. Considering the upfront costs, what are the expected returns over a 10 to 15-year period, and what is the pay-off period?

Subsequently, Chapter 9 presents farmers' appreciation of the successes they have achieved, the perceived reasons for land degradation and land regeneration, implications of agroecology on food security and bankability, and finally, we triangulate our economic household results with remote sensing data.

8. The Business Case for Advanced Agroecology Based on Zaï, Stone Bunds & Farmer Managed Natural Regeneration

8.1 Cost-Benefit Analysis

The analysis above has provided a one-year insight into the income differentials of advanced agroecological farmers in early transition based on expenditures and revenues during the 2023/2024 cropping season. However, there are upfront investment costs associated with advanced agroecological interventions, while gains pertain to the future. In order to meaningfully compare the gains with the immediate outlays of the project, it is necessary to convert all the future gains into today's value. To do so, all money spent and received in the future is discounted into present value (PV) terms. The Net Present Value (NPV) benefit, associated with transitioning to an advanced agroecological farming system, is simply the additional revenues (crop yields, fodder, forest products) in PV terms, less the additional costs in PV terms, as explained in Chapter 3, equations 5 and 6. The investment is considered worthwhile if the discounted value of the stream of additional revenues exceeds the additional costs. Here we assess the NPV and other relevant financial criteria, involving a popular package of practices, including zaï, stone barriers & FMNR.

The NPV is estimated over a 10-year and 15-year time horizon to capture the benefits that accrue incrementally over time. Full soil function capacity, for example, can take up to 15 years or longer to achieve, after restoration activities begin (Bado et al., 2018; Silva Olaya et al., 2025). Such time horizons are also consistent with traditional agricultural land management systems, where soil fertility regeneration was based on a relatively long fallow period of 10-15 years (Bado et al., 2018).

8.2 The Interest Rate and Cost of Capital

From an economic perspective, the cost of investing in agroecology today is the value that the dollar would have produced with an alternative investment. Therefore, for advanced agroecology to be socially worthwhile, the invested capital should grow more than the extra dollar invested elsewhere. This expectation is reflected through the use of positive interest rates when

evaluating Net Present Values (NPV). Considering that many of the benefits of advanced agroecology accrue to the greater public (soil health regeneration, carbon sequestration, etc.), a 4.5% discount rate was used, representing Burkina Faso's average real interest rate, for the previous 10 years.³⁴

8.3 The Technical Itinerary

As we have seen above, advanced agroecological farmers combine different agroecological practices. A popular package includes zaï, stone contour barriers with grass strips, and FMNR, as revealed from the data and a focus group with agroecological farmers. These practices are not implemented in any standard sequence and are rarely initiated all in the same year. In the cost-benefit analysis, it is assumed that FMNR is implemented in the first year, followed by stone contour barriers in the second year, and zaï pits in the 3rd year. According to household survey results, 20% of farmers (76 farmers out of 397) currently use this combination.

In May 2024, a focus group was held in Ouagadougou with eight agroecological farmers at different stages of the agroecological transition journey. The group also included members from agroecological committees and farmer innovators. In the following section, we share key insights from the focus groups undertaken in each department (Mano, 2024; Sagadou, J., & Lan-koande, A., 2024; Tambiga, C., 2024) and in Ougadougou with innovative producers (Table 4). Where there were data gaps (e.g., in relation to income from the harvesting of NTFPs), household survey results were used.

8.4 Implementation Costs

Implementation costs refer to costs directly associated with starting land restoration activities. For example, ANSD typically donates equipment to each village in which they are intervening (such as shovels, pick-axes, cutlasses, wheelbarrows, and an A-frame level for drawing contour lines on sloping land) at a total cost of US\$595 (350,000 CFA). In a typical village with some 250 households (and 3,000 inhabitants), this amounts to US\$2.3 per household. Farmers will typically acquire some equipment at their own cost,

³⁴ Burkina Faso's real interest rate averaged 4.23 percent from 2010 until 2024, reaching an all-time high of 5.5% in December of 2023. <https://data.worldbank.org/indicator/FR.INR.LEND?locations=BF>

such as cutlasses (CFA 2,500, or US\$4.40), pickaxes and shovels (each CFA 2,000, or US\$3.52), a wheelbarrow, or spend on maintaining of existing equipment. Approximate private investment costs are in the order of US\$20 (12,000 CFA).

8.5 Farmer Managed Natural Regeneration Pruning and Thinning: Costs and Benefits

Farmer Managed Natural Regeneration of Trees (FMNR) involves the systematic selection, management and pruning of tree shoots, so as to regenerate “the hidden underground forests of stumps and roots (Bourgou, 2024)” into agroforestry systems and with the potential to rapidly regenerate tree canopies. Tree stumps and shoots are identified by farmers according to desired species and spacing, allowed to regenerate, and pruned in the first three years to allow them to develop into trees. Effective pruning requires an average of 10 man-days³⁵ per hectare in the first three years, followed by thinning as of the fourth year, estimated at five man-days per hectare. As above, these are multiplied by the minimum wage (CFA 500 per day) that workers would be willing to accept to perform a given activity.

According to a separate focus group held in Tibga, FMNR farmers typically strive to have 75 trees per hectare, spaced at 10 to 15 meters distance, and 45 to 80 trees per hectare according to groups from Yassombo and Bilanga, in the department of Bilanga. Within three years, two carts of fuelwood may be collected through pruning and thinning (in comparison to only one under low canopy cover), selling at US\$5.1 (CFA 3,000) per cart. As of the fourth year, three carts of fuelwood have been generated. The resulting average annual income from fuelwood under FMNR systems is US\$15.3 per ha. This number is very close to the estimates derived from the household survey for advanced agroecological farmers (of US\$14.9 per ha, section 6.2), confirming the relative accuracy of the information provided from the focus group. Note that non-FMNR farmers still have some canopy cover, and therefore also enjoy revenues from the harvesting of fuelwood (in the order of US\$6.4 per ha as per the household survey results).

The regenerated canopy cover also allows for the production of diverse fruits (baobab, ebony), nuts (shea), animal forage, leaves for medicinal purposes, and bio-pesticides (such as neem). The average annual income

from such forest products under advanced agroecological farming is in the order of US\$49 per ha (against US\$12 for non-advanced farmers), according to household survey results. It is assumed that such benefits are achieved as of the seventh year, in accordance with the typical duration for which farmers in our sample have undertaken advanced agroecological farming (Table 13, Chapter 4).

8.6 Constructing and Maintaining Stone Contour Barriers

Stone contour barriers are constructed where rainwater usually passes, to reduce its speed and impact on soil erosion, and to allow for the water to infiltrate into the soil. Plowing (when land is not too degraded) is also done perpendicular to the direction that water flows. In addition, grass strips are typically planted on contour lines that are perpendicular to the slope. Runoff water is slowed down, and the erosive impact of the water on the arable soils is reduced. Stone barriers are spaced at a minimum of 50 meters each, and 2-3 barriers are recommended on land with a gentle slope of less than a 5-degree angle, and 4-5 on steeper land. Two truckloads of stone are required for three stone lines. The unsubsidized cost of the stones in one truckload is US\$136 (CFA 80,000). With five rows on one hectare, the per-hectare cost of materials is in the order of US\$272. After five years, grass strips and regenerated trees can provide the services that the stones originally provided. At this stage, the stone rows are therefore moved to new fields to serve a similar purpose. The associated cost of moving them is about a third of the initial investment cost.

Transportation costs for one day of driving are US\$255. Typically, 10 trips can be done in one day, and enough stones for three rows can fit in each truckload. Thus, 3.3 hectares of stone contour barriers can be carried in one day of driving, resulting in an average transportation cost of US\$77 per ha. The total unsubsidized cost of implementing stone barriers is thus in the order of US\$349 per ha in the first year (and one-third the cost, 5 years later, when they are moved to another place on the farm).

In terms of direct benefits, it is possible to harvest six bundles of forage grasses per hectare per year along the stone contour barriers. Each bundle (natte) is worth about CFA 200 (\$3.4). It is important to note that stone

35 Man-day describes a day of work completed by one person in one work day.



Photo 7: A farmer digging zai pits and half-moon water catchment and planting pits on his land. Credit: ANSD

costs are often subsidized by the government (thereby costing farmers US\$51 instead of US\$272).

8.7 Digging of Zai Pits

To construct zai pits, the main cost item is the labor effort required during the first year. One person can make 80 pits in one day, and as there are up to 15,600 pits on one hectare of land (corresponding to 125 x 125 pits), some 78 days of human labor are required. According to focus group revelations, the typical daily labor cost for the digging of zai pits is in the order of CFA 600 (US\$1) per day, yielding a total labor cost of US\$66 (CFA 39'000) per ha.

The pits are also filled with manure or compost, requiring approximately 45 carts per hectare. The estimated average cost per cart is US\$3.52 (CFA 2,000), assuming that farmers use a mixture of manure and compost. Land is too degraded to be tilled at this time, and it would destroy the pits. After the fifth year, soil health has been regenerated, and farmers can again begin to till the land, requiring a minimum of 5 carts of compost

and/or manure. Conventional farmers and farmers in transition who do not have zai pits need to continue to use organic fertilizers to maintain yields (every year). There is thus an avoided cost from the second year (when implementing zai) that we account for. Beyond the fifth year, the recommended quantities are the same for zai and non-zai implementers (and therefore not accounted for). Recall that only the additional costs, revenues, and savings are accounted for in the CBA when estimating the net benefit of transitioning to advanced agroecology (Table 21).

8.8 Benefits to Crop Yields

According to farmers in the Ouagadougou focus group, the zai-stone contour barriers-FMNR packages allow for increasing yields from 6 bags on degraded lands to 26 bags (=2,600 kg/ha). For the CBA, however, we prefer to use conservative figures, stipulating that yields increase from 600 kg/ha to an average of 1200 kg/ha within 7 years. This corresponds to information derived from the household survey on the typical dura-

tion for which advanced agroecological farmers have been implementing agroecological practices, and the average yields of both farmers in transition and advanced agroecological farmers. Beyond 7 years, it is assumed that yields continue to increase moderately (at a rate of 90 kg/ha/year) until the tenth year, after which yields stabilize at 1380 kg/ha.

We believe, however, that this remains a conservative estimate of the possible benefits of adopting agroecology, based on focus group revelations and because household survey results demonstrate that at least 10% of agroecological farmers are obtaining yields in the order of 2,000 kg/ha. Moreover, as explained in Section 6.2, income from the harvesting of NTFPs is usually higher than that of the 2023/24 season, upon which our economic estimates are based. The projected flow of revenue from additional crops, fuelwood, grasses, NTFPs and tree-based forage, and the outflows under *early transition* and *advanced agroecological* farming are shown in the cash flow, in Appendix 5.

8.9 Cost-Benefit Analysis Results - The Case for Adopting Advanced Agroecological Practices

Figure 18 shows the net benefits of adopting advanced agroecological farming over a 15-year time horizon. In the first three to four years, the cash flow is negative, reflecting the additional costs that farmers face when pruning, thinning, digging zaï pits, acquiring equipment, and constructing stone contour barriers. However, the flow of income from crop revenues, forage grasses and agroforestry produce increases rather rapidly, allowing for paying off the implementation costs within 5.4 years. At the end of the fifteenth year, farmers will have earned an additional net income of US\$2,308 per hectare in present value terms, equivalent to an average of US\$154 per year per hectare (Table 21). In an earlier study from the Upper Western region of Ghana (with Groundswell International partner NGO CIKOD)³⁶, it was found that an advanced FMNR provided the typical farmer with an additional income of EUR 102 per hectare in present value terms, thus providing similar returns.

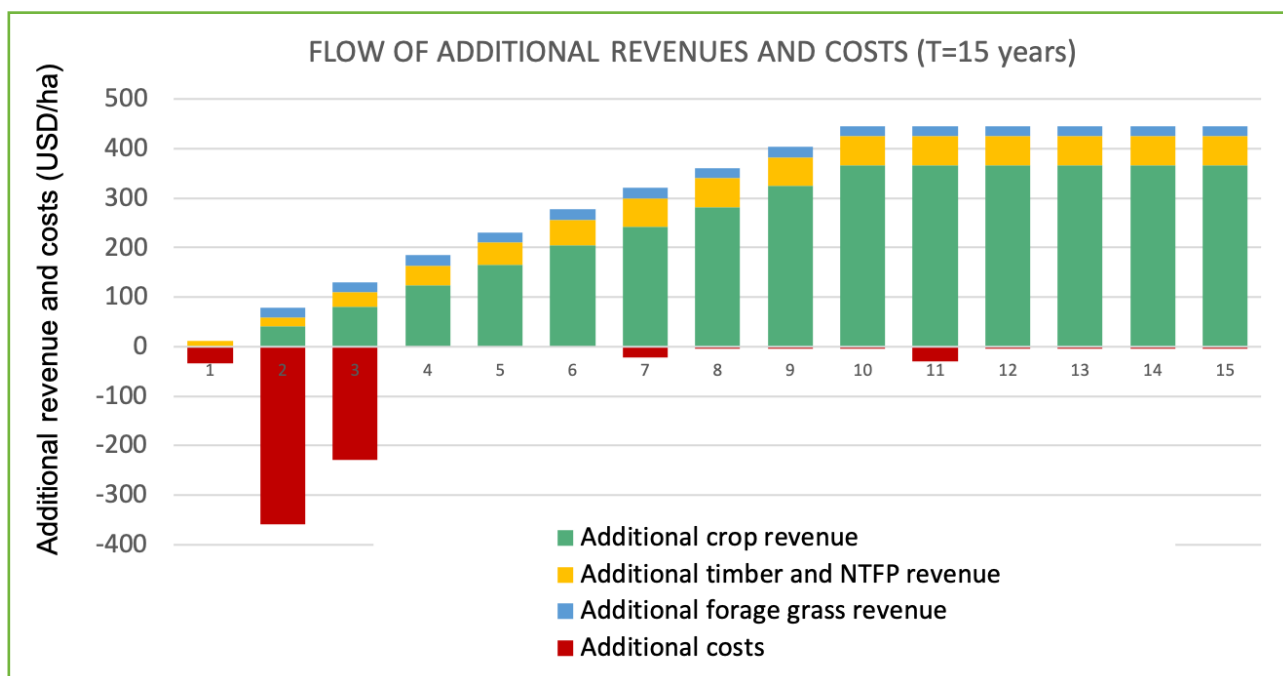


Figure 18: Flow of additional costs & revenues when transitioning to advanced agroecology, an example of zaï, stone barriers and FMNR in combination.

36 The study can be found at <https://www.groundswellinternational.org/wp-content/uploads/2020/04/ELD-PB-1-Ghana-web.pdf>.

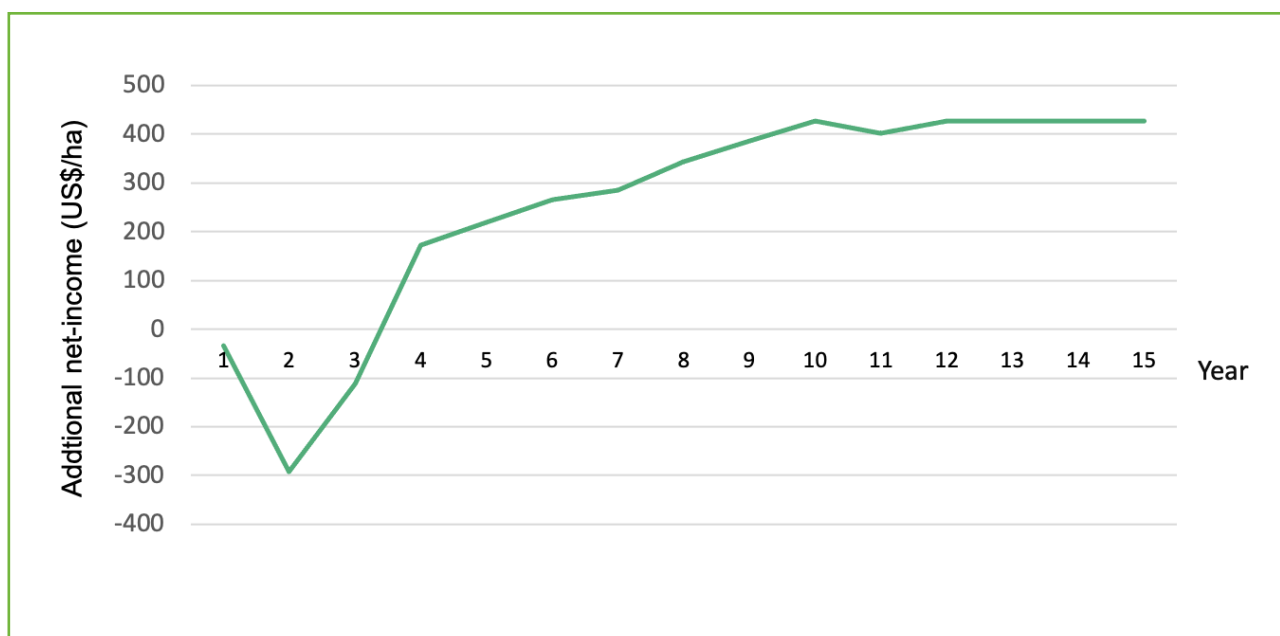


Figure 19: Additional per hectare net income, year-on-year from the adoption of zai, stone barriers and FMNR.

Table 21: CBA results per ha farmland when transitioning to advanced agroecology, an example of a zai pits, stone barriers and FMNR in combination (discount rate of 4.5%, 15 year time horizon)

	Without subsidies	With subsidies for stone contour barriers
Evaluation criteria (T=15)	r=4.5 %	r=4.5 %
Net Present Value (US\$/ha)	\$2,308	\$2,464
Average annual net-benefit (US\$/ha)	\$154	\$164
Benefit Cost Ratio (BCR)	4.8	6.4
Implementation costs (US\$/ha), first 3 years	\$621	\$451
Payback period in years	5.4	4.5
Internal Rate of Return (IRR)	43%	61%
Return on Investment (ROI)	540%	746%

* Representing Burkina's Faso's average real interest rate, for the previous 10 years.

The expected compound annual rate of return earned by the farmer when investing in advanced agroecology is 43%. Also known as the Internal Rate of Return (IRR), this is the maximum discount rate that the investment can take before it stops creating value. With

interest rates ranging from 2-3% among development finance institutions (e.g., IBDR³⁷), to 5.5% under government lending,³⁸ and 10-30% with rural development banks (Chapter 9), the cost of capital is lower than IRR in all cases, which implies that advanced agroecol-

37 With International Bank for Reconstruction and Development (IBRD), applying a rate of 2.2 % for Nature Based Solutions under flexible loans for Burkina Faso, comprising a 1.56% real rate of interest based on the 10-year Treasury Inflation Protected Securities yield from U.S. bonds along with a 0.64% lending margin based on IBRD flexible loans for Burkina Faso (Carlucci & Guzzetti, 2024).

38 World Bank (n.d.) Lending Interest Rate (%) – Burkina Faso. Extracted from International Financial Statistics database, International Monetary Fund (IMF).

ogy is profitable under all financing options. However, the pay-off period³⁹ is rather long from a smallholder perspective, notably 5.4 years, against, for example, 3.3 years for the FMNR system implemented by Groundswell partner CIKOD in Ghana (Westerberg et al., 2020). The longer pay-off period is due to the capital-intensive investments associated with the construction of stone barriers and zaï pits, relative to the implementation of FMNR alone. So, while the overall returns are higher, the barrier to adoption may be greater for a cash or labor-constrained farmer who cannot access patient capital. As shown in Figure 24 (Chapter 9), farmers typically have loan terms of a maximum of two years, not long enough for the benefits to pay off the outlays.

8.10 Previous Subsidies for Agroecology

Under previous government-funded initiatives, such as the *Programme National de Gestion des Terroirs – Phase 2* running from 2002 to 2007 (PNGT2), the implementation of agroforestry and soil and water conservation techniques was subsidized (Gouvernement du Burkina Faso, 2019). The typical subsidy for contour barriers amounted to US\$170 per ha, as per focus group discussions in Ouagadougou, May 2024, reducing the per-hectare implementation costs, for a typical combination of using zaï, stone barriers, and FMNR, from US\$349 to US\$179. A subsidy of this kind decreases the payback period from 5.4 to 4.5 years (Table 21).

8.11 CBA Sensitivity Analysis

For some farmers, 15 years is a long timeframe for planning and conceiving projects. We therefore also evaluate net benefits from a 10-year perspective (Table 22). The results show that farmers still stand to benefit significantly from the agroecological investments. Namely, for every US\$1 invested, the smallholder can expect nearly US\$3 of additional revenues. Suppose the construction of stone contour barriers is subsidized (as

per previous experiences). In that case, farmers can expect an additional US\$4 for every US\$1 invested and an average additional income of US\$127 per hectare of farmland, in present value terms.

8.12 Well-Established and Demonstrated Successes from the Zaï-Stone Barriers-FMNR Combination

This Chapter has shown that the combination of zaï, stone bunds and FMNR is a highly worthy investment, even when using conservative estimates of benefits from yields and NTFP harvest quantities. The technique has also proven itself elsewhere. In the North of Ouahigouya in Burkina Faso, farmers were able to double their yield of sorghum, achieving 1,500 kg/ha compared to 700 kg in the control sites without any soil and water conservation structures (Hien 2015 in Bado et al., 2018). The three techniques work in synergy:

- **Stone bunds counteract water erosion**, improve water infiltration, and accumulate organic matter and manure upstream.
- **Zaï pits concentrate fertility**, reduce evaporation losses and act as small water-catchment pools.
- **Trees improve soil fertility** and increase the supply of food, NTFPs and firewood. Trees like *Acacia albida* or *Piliostigma reticulatum* provide fodder during the dry season.

The overall effect is an increase in cereal yields that can exceed 100% (according to Bado et al., 2018), with increased soil organic matter levels, a windbreak effect, and reduced soil temperature. Not surprisingly, this agroecological combination is also popular in central and northern regions of Burkina Faso, as well as Senegal (Kaffrine, Tabacounda, Villigara), Mali (Kayes, Segou, Mopti) and Niger (Tahoua).

Table 22: Economic returns using a 10-year project span

10-year time horizon	10 years r=4.5 %	10 years r=4.5 %with subsidies
Net Present Value (NPV)	\$1,114	\$1,269
Average annual net benefit	\$74	\$127
Benefit-Cost Ratio (BCR)	2.9	4.0

39 The amount of time required for revenue inflows generated by the adoption of agroecological to offset the initial cash outflow.

9. Other Impacts of Agroecology and Perceived Successes

In this final Chapter, we consider farmers' own-reported appreciation of changes in soil quality and successes of agroecological interventions. We also assess differences in food security and bankability of farmers in transition versus advanced agroecological farmers, and finally, we use remote sensing data to assess land use productivity for the different farmer segments, and triangulate results from our household data.

9.1 Farmers' Perceptions of the Changes in Soil Quality and Reasons Thereof

Over the last 5 years (2019-2024), more farmers (50%) have observed a degradation of soil quality, relative to an improvement (44%) (Table 23). The story is very different, however, from the farmer segment. Specifically, the majority of advanced agroecological farmers (72%) consider that soil fertility has increased, and only 18% have observed a decline in soil fertility. In comparison, 62% of the conventional farmers in early transition have noticed a decline in soil quality.

The quasi-totality of those who have experienced an increase in soil fertility attribute this to their agricultural practices (97%), and nearly 75% also consider that the presence of trees has led to an improvement in soil health. Only 6% consider that it is because of favorable weather. Among those having experienced a decline in soil health, poor weather conditions (floods, droughts, fire) are considered a reason among 71% of farmers, followed by agricultural practices (41%) and the loss of trees (40%). Only 3% think that trees are to blame for reduced land productivity (Figure 20).

Overall, it is striking that such a large proportion of agroecological farmers consider land to have improved, despite the fact that half of all the sampled farmers consider land to have degraded. **The results suggest that it is indeed agricultural practices and the regeneration of soil health among agroecological farmers that have led to higher land productivity among this group.**

Table 23: Farmers' perception of soil quality changes

Have you noticed a change in the quality of your soil on your main plot over the last 5 years?	All Farmers	Advanced Agro-ecological	Farmers In Early Transition
Degradation (-)	50%	18%	62%
Improvement (+)	44%	72%	33%
No noticeable change	6%	10%	5%

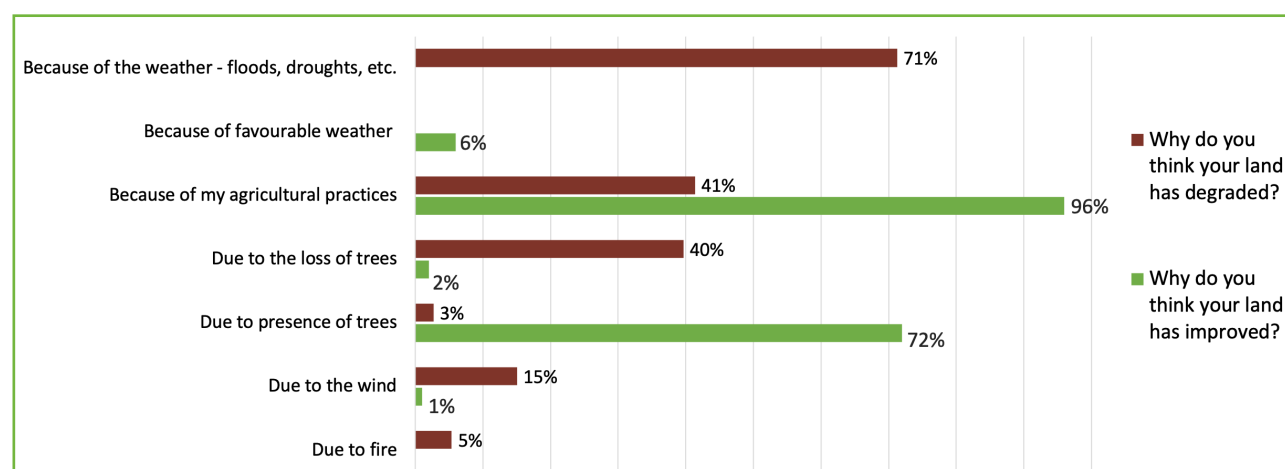


Figure 20: Perceived reasons for changes in soil health. "For those having noticed a loss of soil quality, and for those having noticed an improvement in soil quality, it is due to..."

9.2 Perceived Success of Agroecology Among Farmers

The above analysis of the farmers' land use budgets clearly demonstrates that advanced agroecological farmers are reaping higher net incomes per hectare of land, relative to all others (conventional farmers and those in transition). It is relevant to put such results in perspective with respect to farmers' own appreciation of agroecological farming. In this regard, Figure 21 shows that the overwhelming majority (87+2+7=91%) state that they plan to expand agroecology to all their plots, or they have already done so. In terms of

the success of agroecology to provide food all year round, while improving incomes and soil fertility, 89% (64+25) consider agroecology as successful or very successful (Figure 22).

In terms of income changes, 80% of farmers have experienced an increase in their agricultural income after applying agroecological practices (Table 24), and for the most part (82%), they attribute this to higher volumes of produce (Figure 23). In selected cases (3% to 6% of farmers), higher prices, reduced pressure from pests, more resources for working, and training are also mentioned as factors leading to increased incomes.

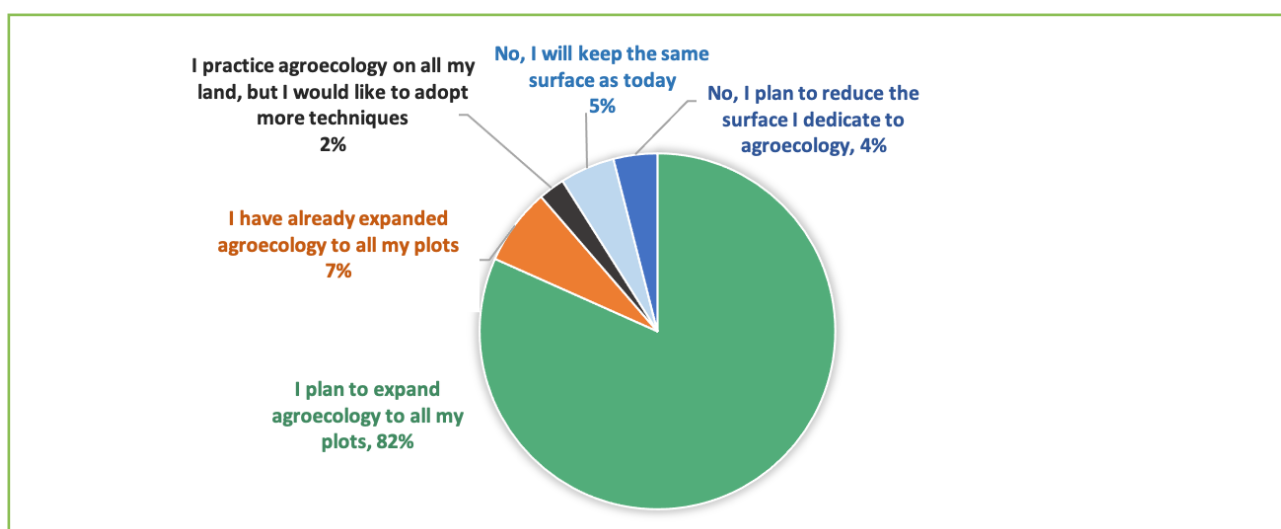


Figure 21: Are you considering extending agroecological practices to all your plots?

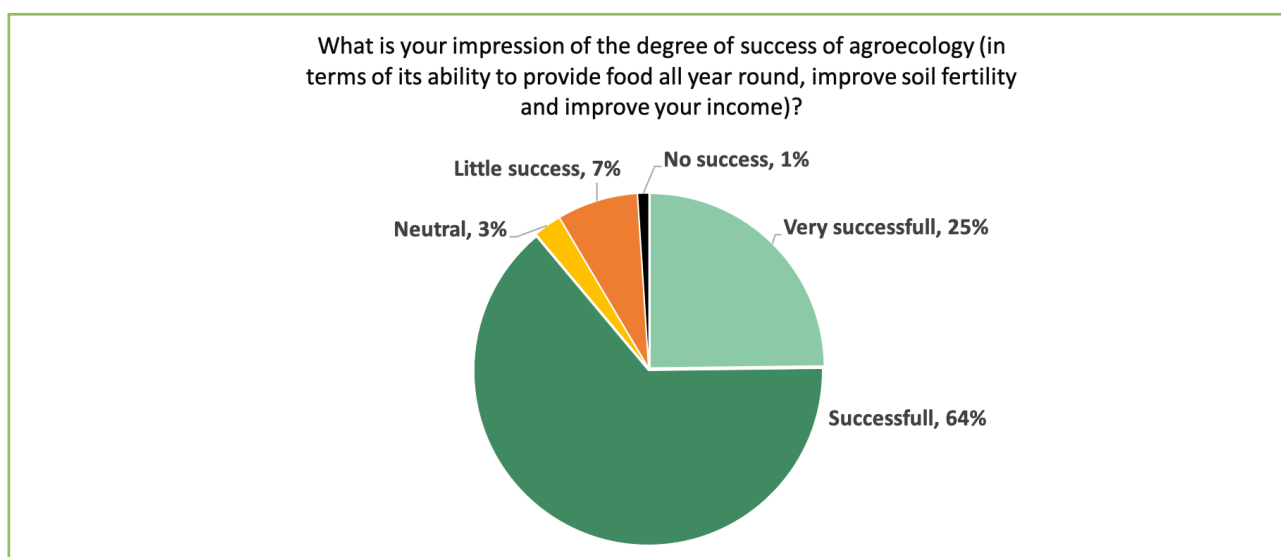


Figure 22: What is your impression of the degree of success of agroecology (in terms of its ability to provide food all year round, improve soil fertility and improve your income)?

A very small fraction of households (13 out of 397) have observed a decrease in agricultural income, and they attribute this to lower yields and lack of adapted equipment (such as carts, pickaxes, shovels, wheelbarrows and donkeys for traction) (Table 25). For those experiencing lower yields, this may be due to the fact that they are in the very early transition period, and soil biology has not yet had a chance to kick in. That said, overall, there are no signs in our data that yields decline (even temporarily) during the transition period. The challenge is that some upfront costs need to be recovered. The cost-benefit analysis above shows this in detail.

9.4 Food Security

There are noticeable differences between advanced

agroecological and transitional farmers in terms of food security and food and dietary diversity. Among conventional farmers in transition, three-quarters of all the respondents (60% + 16% = 76%) had consumed a maximum of two different food ingredients in the 24 hours preceding the interview, against 55% among advanced agroecological farmers who had exceeded two different food ingredients (Table 26).

Moreover, at the time of the interview, agroecological farming households had an average dry food stock of 300 kg, compared to 100 kg for farmers in early transition (consulting the median). In other words, **the typical agroecological farming households had a food stock that was three times higher relative to conventional farmers** (Table 27).

Finally, when using a few questions from the FAO Food

Table 24: Changes in incomes as a result of agroecological uptake

Has your agricultural income changed since you started applying agroecological practices?	Frequency	Percentage
Decrease (reason: lack of adapted equipment and reduced yields)	13	3.5 %
No change	47	12.5 %
Increase	300	79.6 %
I don't know	17	4.5 %

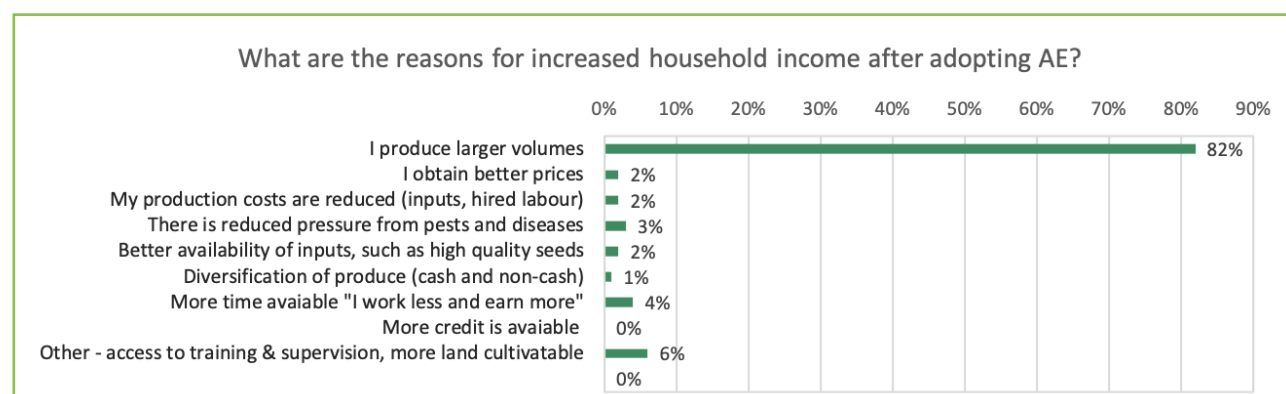


Figure 23: Perceived reasons for increased household income after adopting agroecology (AE)

Table 25: Reasons for decreased income after adopting agroecology

If you have noticed a decrease in your household income, what are the reasons? Check as many boxes as necessary	Frequency
Lower yields	9 (2%)
Costs of inputs are higher, and/or the labor effort is higher	0
There is a lack of adapted equipment	7 (2%)

Table 26: How many different food products (vegetables, legumes, fruits, cereals) did you eat in the last day and night (24 hours)?

Number of different products	Advanced agroecological (n=100)	Farmers in transition (n=293)	Average
1-2	55%	76%	71%
3 or above	45%	24%	29%
Average number of products*	2.4	2.1	2.2

*statistically significant difference in means



Photo 8: A farmer with her peanut harvest. Credit: Andrew Esiebo and The Gaia Foundation

Table 27: Food stock availability in the household

At this moment, what is your stock of food? (June-July, some 6-8 months, after the harvesting season)	Advanced agroecological	Farmers in early transition	Population wide
Mean (per household)	627 kg	329 kg	405 kg
Median (per household)	300 kg	100 kg	200 kg
Minimum-maximum	0-30,000 kg	0-7,000 kg	0-1,646 kg

*T-test and Krystal Kwalist tests confirm statistically different means between advanced agroecological and farmers in transition.

Insecurity Experience Scale (FIES), we also see statistically significant differences in the level of food security: 45% of farmers in early transition had experienced running out of food in the 12 months prior to the interviews, against only 13% of advanced agroecological households. Moreover, one-fifth of the transitional farm households have gone a whole day without eating due to lack of resources, against only 5% for advanced agroecological households (Figure 24).

9.5 Access to Credit and Lending

It is no secret that **financing is a critical barrier for smallholder farmers** to access materials, technologies, and other inputs that are needed to improve land use productivity. Whether we talk about the ability to take a loan, the interest rate or the loan duration, the lack of patient capital is a barrier to agroecological adoption.

Considering this, it is relevant to understand farmers' access to finance in the region. Here, we also see noticeable differences between advanced agroecological farmers and those in transition. **An impressive 43% of advanced agroecological households claim they can borrow money from a rural bank**, against only 4% for farmers in transition. A larger proportion of farmers in early transition (48%), however, are able to borrow from family and friends.

The interest rates, however, tend to be higher among credit unions and rural banks (Table 29). As for the duration of the loans that farmers have taken, there is no difference between farmers in early transition and advanced agroecological farmers (Table 28). Figure 26 shows the duration and interest rates of the loans that are taken out by farmers. In some selected, rare situations, penalizing interest rates of 50% to 100% have

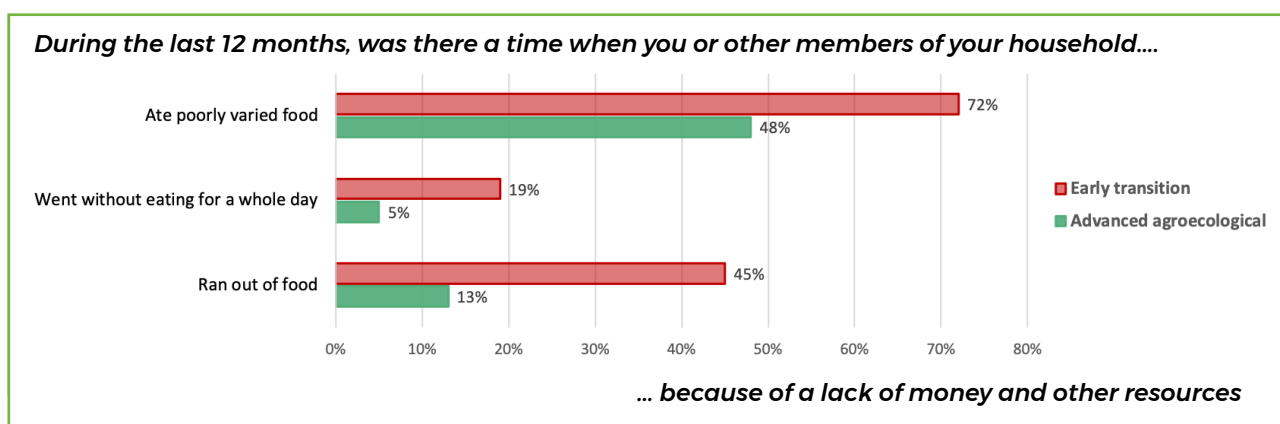


Figure 24: Experienced food security using selected questions from the FAO FIES survey module

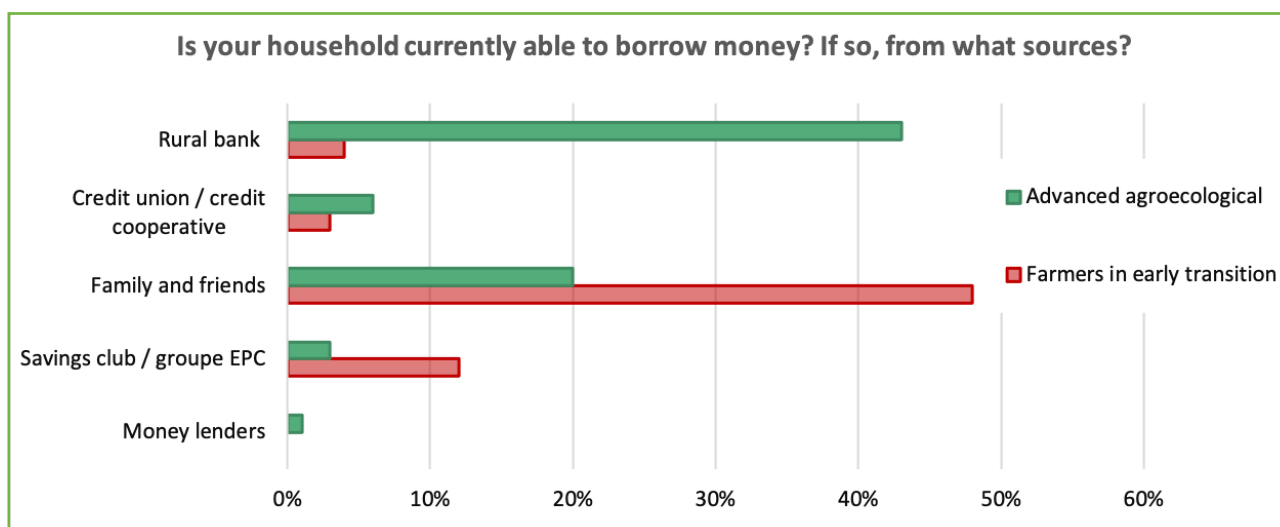


Figure 25: Availability of credit among advanced agroecological farmers and farmers in transition

been applied for short-duration loans. These rates are not uncommon among moneylenders (Mentz-Lagrange & Gubbels, 2018).

Finally, in terms of outstanding significant debt (>30,000 CFA) at the time the household survey was undertaken, we see again noteworthy differences among advanced agroecological farmers and farmers in transition. Namely, a higher proportion of farmers in transition have a loan of significant magnitude, result-

ing in an average debt of US\$35 (across the full population) against US\$8 for advanced agroecological farmers (Table 30).

The above results prove that agroecology does more than improve yields and per-hectare net income. **Mature and advanced agroecological farmers have a higher level of food security, better access to finance, lower debts, and substantially higher total household income.**

Table 28: Availability of credit for farmers

Is your household currently able to borrow money? If so, from what sources?	Population Average	Advanced agroecological	Farmers in early transition
Rural bank	15%	43%	4%
Credit union/credit cooperative	4%	6%	3%
Savings club/group EPC	10%	3%	12%
Family and friends	40%	20%	48%
Money lenders	0.3%	1%	0%
Not sure they can borrow	30%	27%	33%
Average loan duration (months)	12.2 months	12.2 months	12.2 months

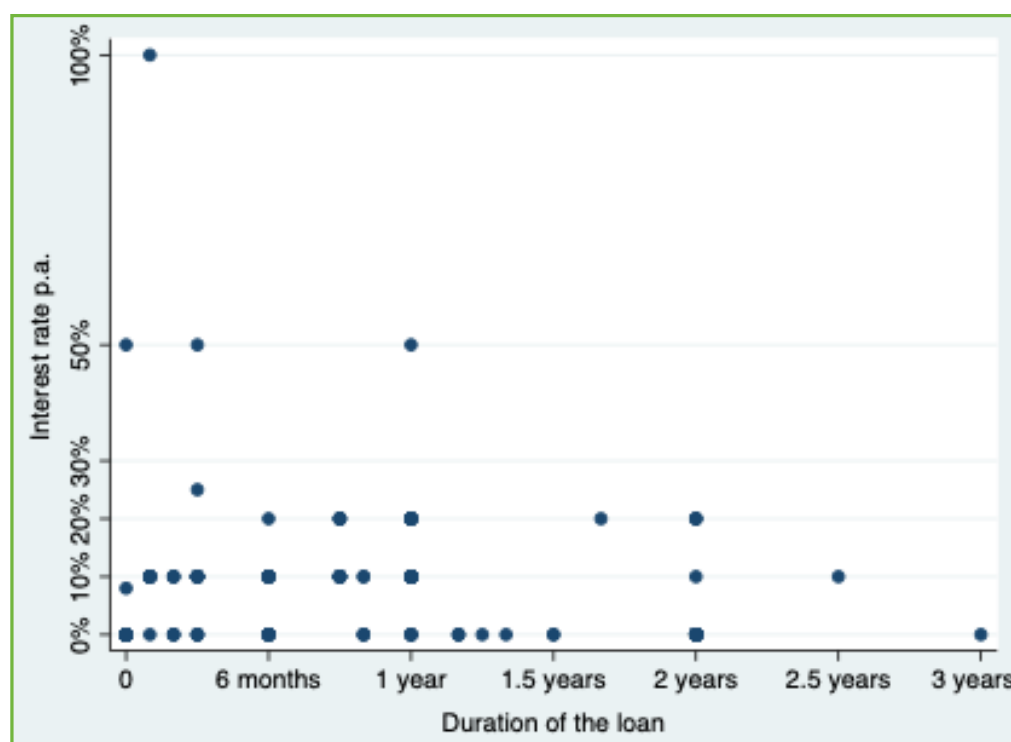


Figure 26: Interest rates and loan duration

Table 29: Interest rates available to farmers

Most common interest rates per annum (0 to 20 %)	i=0% frequency	i=10% frequency	i=20% frequency	Average Interest rate per annum
When lending from family and friends (n=132)	75%	21%		6%
When lending from rural banks (n=50)		61%	34%	13%
When lending from a credit union (n=13)		50%	42%	15%
Interest rate, when lending from a savings club/group EPC (n=21)	43%	52%	5%	9%

Table 30: Loan debt for advanced agroecological farmers vs farmers in early transition

Does the household have debt above US\$85 per household?	Existing debt			
	Mean those with a loan	Mean (st dev) Across the whole population	Maximum	Share of households with a loan > \$85
Debt levels				
Average household	\$193	\$28	0-2550	19 %
Advanced agroecological farmer	\$158	\$8 (51)	0-510	5 %
Conventional farmer in transition	\$197	\$35 (101)	2550	17 %

10. Discussion and Conclusion

Since the early 1980s, Burkina Faso, and in particular the eastern and northern regions, have witnessed expanding cultivation on lands marginal to agriculture, declining rainfall, low and declining cereal yields and degradation of vegetation. This situation led farmers and NGOs to start experimenting with agroecological techniques to improve soil and water conservation (Reij et al., 2005; Ilboudo-Nébié, 2020). Their major objective was the rehabilitation of land productivity through better control of rainfall and runoff, as well as through improved soil fertility management and reforestation. ANSD started working in the East Region in 2011, in the departments of Bilanga, Gayeri and Tibga.

10.1 Main Results

The study presented here demonstrates the remarkable impact of these interventions on land use productivity and farmer livelihoods.

- At the most basic level, a conventional farmer household, monocropping cereals and using no manure or agroecological techniques, has the de facto opportunity to increase his/her yields from 320 kg/ha to 1,400 kg/ha by implementing at least five key agroecological techniques.
- A farmer who is already on the transition journey towards advanced agroecology can expect to increase his/her crop yields from approximately 700 kg/ha to 1,230 kg/ha. The associated net income rises from US\$293 to US\$489 per ha, including revenue from fuelwood, forage grasses and other NTFPs.
- In terms of the drivers of those yield gains, agroecological practices have very significant positive impacts. As tree canopy cover increases by 1%, yields increase by 0.14%. So, for example, by increasing tree canopy cover from 5 to 20 trees per ha (+300%), yields increase by 21% (or 112 kg/ha) on average, holding all other factors constant. Legume-cereal intercropping increases yields by 38%; avoided crop residue burning and conservation tillage, by 14% and 16%; and zaï and half-moons by an additional 12%.
- Furthermore, agroecological practices increase farmers' use of manure by enhancing the availability of fodder biomass, crop residues, and trapping of manure within the field. As the farmer introduces stone contour barriers, zaï pits, FMNR, and the farming system matures, the use of manure increases from 0.4 T/

ha to 4.6 T/ha per year.

- Increased use of manure provides a significant boost to yields. For each 1% increase in manure, yields increase by 0.13%. For example, by increasing manure use from 0.4 T to 2 T/ha (400%), yields increase by 23%.
- More forage and biomass also allow farmers to have larger livestock holdings and therefore income from their livestock. Advanced agroecological farmers generate livestock-derived income in the order of US\$478 per household, against US\$163 for farmers in transition.
- Inorganic fertilizers have no demonstrable positive impact on yields. This is arguably thanks to the extensive soil health improvements with agroecology, since agronomic efficiency is low when inorganic fertilizer is applied on fertile soil (Vanlauwe et al., 2010).
- Chemical herbicide use increases yields, but only at low levels of application. For any spending beyond US\$8 per hectare, the additional cost is greater than the value of the incremental yield, generating a net loss to the average farmer.

10.2 Situating the Role of Organic and Mineral Fertilizers Within Other Case Studies from the Sahel

Our results echo that of other studies such as the article *From the Central Plateau of Burkina Faso*, Stöber et al., (2024) concluded that “the application of composted manure and improved seed is lifting the rural population out of food insecurity in record time, with a of tripling yields” and the more agroecological practices that are pursued, the better the yields (Stöber et al., 2024). A study based on field experiments in Nigeria, published in the journal *Nature*, Adekiya et al. (2020), found yield increases of okra pods in the order of 58%, 36%, 39% from cow dung, poultry manure and green manure. In contrast, NPK fertilizers increased yield by only 3.2%. The addition of 5 T/ha of manure doubled millet yields, as compared with control plots, near Parc W in Niger (Bationo & Mkwunye, 1991). At Saria in Burkina Faso, continuous cultivation was associated with a rapid decrease in organic matter and the contents of the exchangeable bases (Ca, Mg and K), which further resulted in a progressive acidification of the soil. With manure applications, however, the situation

Table 31: Summary - agroecological practices and inorganic inputs, and their impact on yields

Impact on yields	Effect on crop yields
Cereal monocropping to Legume-cereal intercropping	+38%
Residue burning to No residue burning	+14%
Conventional tillage (15 cm depth) to Low till (5 cm depth)	+16%
Zaï and half-moon pits (after 7 years of implementation)	+12%
Examples of changing input levels	Effect on crop yields
Canopy cover density 1 trees/ha to 15 trees/ha (+300%) - as an example	+21%
Manure use from \$2/ha to \$9/ha (or 0.4 T/ha to 2 T/ha) (400%)	+23%
Herbicide use from \$2/ha to \$9/ha (350%)	+6%

was rapidly reversed (Pichot, 1981).

Regardless of the potential dramatic positive outcomes of agroecology, limited crop production in Sahelian agroecological zones are typically blamed on inadequate soil nutrient supply and insufficient rainfall (Morris, 2007; Ibrahim et al., 2015; Ahmad et al., 2022), and some scholars argue that continued use of mineral fertilizers in Sub-Saharan Africa is necessary because nutrients, such as phosphorus and potassium, are not provided by nitrogen fixing legumes, and the use of animal manure will simply *“lead to a transfer of nutrient from grazing areas to cultivated areas, which gradually reduces fertility in grazing areas”* (Falconnier et al., 2023).

In our case-study areas however, agroecological farmers produce more forage, and have more live-stock (on average 7.6 TLU against 3.9 TLU for farmers in transition) and often contract Fulani (Peul) to keep their animals during the rainy season and recover them during the dry season when there is less of risk that they damage crops (Bourgou, 2025). As such, there is not a transfer of animals from grazing land to cropland, but rather an increase in livestock numbers altogether (that benefits both grasslands and farm-lands). This finding is in line with study findings from the Central Plateau in Burkina Faso, where soil and water conserving practices were also shown to increase the availability of manure (Reij et al., 2005).

10.3 Mineral Fertilizers are Used Inefficiently

Moreover, others argue that due to the high cost of inorganic fertilizers and the need for their repeated use, NPK fertilizers will continue to remain out of reach for

poor farmers (Olowoake, 2014). Consequently, most smallholder farmers do not use the recommended dose of mineral fertilizers (Jayne et al., 2018). Lastly, the biophysical environment can constrain the effectiveness of mineral fertilizer inputs. For example, **fields that lack secondary nutrients and micronutrients, or are already fertile, are typically unresponsive to NPK fertilizers** (Nziguheba et al., 2021; Vanlauwe et al., 2010). This latter effect is what we believe to see in our case study area in the East Region of Burkina Faso. In either case, the agronomic use efficiency of fertilizer application depends on the dose and how it combines with other farming inputs and practices. If site-specific contexts are not taken into account when applying inorganic fertilizers, there will be non-optimal use of that input, on the part of the farmer and the organizations subsidizing that input.

10.4 The Case for Rethinking Mainstream Agricultural Policies and their Global Costs

Increasing the use of *modern* chemical inputs has been a policy aim in many countries of sub-Saharan Africa since their independence (Ibrahim et al., 2015) and the Abuja Declaration on Fertilizer in 2006 (Haider, 2018; Smale & Theriault, 2019). In 2008, Burkina Faso introduced fertilizer subsidies, and these are still in vigor for rice, maize and cotton.

For the 2024-25 Burkinabe cotton campaign, for example, subsidies for conventional inputs **amounted to US\$67.2 million** (Minute.bf, 2024b). With an output of 286,623 tons (Minute.bf, 2025b), the magnitude of the subsidy was in the order of **US\$0.23 per kg of cotton produced**. That is a staggering amount, corresponding to 30-50% of the retail price for cotton, which ranged

from US\$0.41 to US\$0.70 in 2025 (Selina Wamuccii, 2025). In contrast, under previous rural development initiatives, such *PNGT2 programme* subsidies for contour barriers were in the order to US\$170 per ha (as per focus group discussions in Ouagadougou, May 2024), resulting in a grant value of approximately US\$0.02 per kg of food crops produced⁴⁰ corresponding to approximately 4% of the average farmgate market price (see Table 9) for staple crops in the case-study area. Moreover, unlike conventional inputs, agroecology provides positive co-benefits to wider society in terms of biodiversity enhancements, water cycle restoration and climate change mitigation and adaptation. As such, Burkina Faso is better off investing in agricultural systems with higher economic returns, drawing upon locally sourced organic materials as a means to improve and sustain the productivity of soils and arable crops (Adekiya et al., 2020).

Fundamentally, while input subsidies may increase agricultural productivity in areas devoid of agroecological practices and fertile soils, we need to look at profitability from the perspective of the farmer and the society. **What is the value of those additional yields, relative to the cost of those inputs to farmers and the public treasury?** This study provides evidence that enhanced yields from herbicides do not compensate for the additional costs beyond US\$8 per hectare, and that there are no gains to be reaped from inorganic fertilizer use in our case-study area, where the use of agroecological practices is widespread. As such, the benefit-cost ratio is negative.

There is also ample evidence that input subsidies for conventional crop production are indirectly fueling land degradation. By virtue of its *subsidized costs*, farmers are expanding crop production over forestland, pastures and marginal lands that would otherwise not be economically viable to exploit for crop production (Nelgen et al., 2024; Westerberg et al., 2019). The clear-cutting of vegetable woody biomass, together with the shortening of fallow periods, significantly impacts ecosystem functions and the provision of ecosystem services, reducing the availability and quality of

water, plant, and animal resources for society, primary production, and economic sectors (Salih, 1993; Akhtar et al., 1994). These very tendencies have led a region such as Gedaref in Sudan to lose its status as a major food production center (Glover & Elsiddig, 2012).

10.5 The Public and Private Case for Investing in Agroecology

Instead, the government should seek to co-invest in strategies that improve the profitability of farming and reduce farmers' dependence on recurrent expenditures on inputs, which make them particularly vulnerable to fluctuations in yields.

Popular combinations of agroecological practices, such as combining zai, stone barriers and FMNR, offer an annual rate of return of 43% and a benefit-to-cost ratio of 5.6 over 15 years. The challenge, however, remains the upfront technology adoption costs. Without subsidies, these amount to approximately US\$621, assuming that all additional labor effort is met with hired labor.

10.6 Investing in Nature-Positive Farming Makes Business Sense Using Blended Finance

Granular data of financial flows provided in this study shows that the economic returns from agroecological investments are of such a magnitude that it is feasible to leverage on commercial return-seeking capital to mobilize investments into agroecology. But with seasonal and irregular cash flows, the perceived credit risk is a key barrier to financing smallholder farmers and the agri-food sector overall (OECD, 2022). Agroecology, however, allows farmers to increase and diversify their income sources (as shown above), thus improving farmers' risk-return profiles.

Going forward, additional risk mitigation instruments - such as repurposed subsidies for agroecology, index-based insurance, credit guarantees, catalytic first-loss capital, concessionary loans, as well as enhanced collateral through agri-tech, along with technical assistance by NGOs such as ANSD - should be used in

⁴⁰ With a material stone cost of US\$272 per ha using market-prices, against US\$102 per ha with the subsidy, resulting in a subsidy of \$170. The Zai-Stone barriers-FMNR combination increases yields from 600 kg/ha to 1380 kg/ha, which generates an additional crop output of at least 3870 kg/ha over 10 years, over and above the baseline of 6000 kg/ha. The subsidy amount is thus in the order of US\$ 0.017\$ per kg crop produced (= \$170/9870 kg) for a 10-year horizon. The subsidy is a one-off investment, unlike subsidies for conventional inputs, which are typically applied every year.

blended finance mechanisms⁴¹ to leverage private capital for agroecological scaling.

10.7 Improving the Trade Balance and Making Savings to the Public Treasury

The repurposing of subsidies (for conventional inputs) toward the spread of agroecological farming

would also create savings for the public treasury of Burkina Faso and improve the country's trade balance. In 2024, Burkina Faso imported US\$87.3 million worth of mineral fertilizers (and US\$118 million in 2023), corresponding to about 0.5-1% of Burkina's total imports (Agrisud International, 2020).

10.8 Aligning Agricultural Policies with International Policy Commitments and Targets

Supporting agroecology is also in alignment with several of Burkina Faso's Nationally Determined Contributions, such as restoration of degraded land at the rate of 30,000 ha/yr, increasing FMNR by 800,000 ha in rural communities, and participatory development of sustainable land management technologies (World Bank, 2024b). Burkina Faso's additional commitments include reaching land degradation neutrality by 2030 by restoring 5 million ha of degraded lands;

ending deforestation by 2030; recovering 300,000 ha of bare land, improving the productivity of 2.5 million ha of degrading savannas and cultivated lands, and improving carbon stocks in 800,000 ha to reach a minimum of 1% of organic matter (i.e., adding of 5T of organic matter per hectare every 2 years) (GM-UNCCD, 2018).

For the latter, we have demonstrated that agroecology is the answer. Advanced agroecological farmers use an average of 4.4 T/ha/year (11 carts) of manure, against only 1.3 T/ha/year (3.3 carts for farmers in early transition). Simple techniques, such as increased tree densities, stone contour barriers, and no residue burning, increase manure use by 2.8 T/ha per year (7 carts).

10.9 Boosting Agroecological Adoption through Appropriate Tools and Equipment

Widespread scaling of agroecology also requires a reduction in the implementation costs, which may happen by reducing labor efforts, through **machinery and equipment that is adapted to agroecological farming techniques**. On the other hand, **inappropriate mechanization** can be destructive to fragile agroecosystems by accelerating soil erosion and compaction, promoting forest and rangeland destruction, and

Table 32: Examples of equipment that can accelerate the adoption of agroecological practices

Tool	Challenge/Costs
Carts drawn by donkeys	Transporting rocks for contour barriers or timber products
Wheelbarrows	For the transportation of organic matter (compost, manure, forage)
Pick axes	Zaï, half-moons & contour barriers
Tools and oxen	Mechanizing the digging of zaï holes with small tools by animal traction
Hand pushed seeders	Seeding
Cutlases	Cutting grass for organic matter/compost (organic fertilizer)
Roller-crimpers	Termination of cover crop, without the use of herbicides
Small tractors (that can navigate between trees) with relevant implements	Land preparation, harvesting, collection of crop residues, incorporation of crop residue and other organic wastes into the soils.
Vallerani	Designed for large-scale restoration to restore highly degraded lands for afforestation and silvopastoral purposes, and for the direct seeding of grass, shrubs and tree species.

⁴¹ Blended finance refers to the combination of capital that has commercial risk-return expectations with funding that is concessionary in some form (typically from the public sector), in order to generate additional measurable developmental impact (ODI, 2019).

encouraging the over-use of chemical inputs.

With this recognition, there is a movement towards the implementation of sustainable agricultural mechanization strategies that encourage the adaptation to (and mitigation of) climate change, led by primary examples from Southeast Asia (see Mrema et al., 2014).

Examples of desirable equipment include smaller tractors and cultivators that can navigate between trees, one-row or handheld planters, wheelbarrows for transporting organic material, roller-crimpers for avoiding herbicide use, bullock plows using animal traction, as well as simple equipment such as cutlasses, rain boots, shovels, pickaxes for pruning, and protective gear. Table 32 provides examples of such tools and equipment. As for how to make such tools available, local manufacturers (or the emergence of manufacturers) should be supported where feasible, as they can provide implements adapted to local conditions and better technical and repair services. The Burkina Faso public sector can be a key player here, in promulgating enabling policies, building technical and business management skills, and stimulating demand through subsidies for such equipment and by enabling the financial and infrastructural environment (Sims & Kienzle, 2016). Group ownership, e.g., at the level of agroecological village committees, and custom hire service provision are promising models to follow (Mrema et al., 2014).

10.10 Agroecology and Conflict Resolution

Since the end of 2018, like much of the rest of Burkina Faso, the eastern region has witnessed an increase in the rate of violence driven by Jihadist armed groups such as al-Qaeda and ISIS affiliates, undermining agroecology and rural development on many fronts.

Decades of poor governance, limited state investment in education, health and governance, have led to feel-

ings of neglect, and the socio-economic marginalization of the rural population and youth in particular. Moreover, intercommunal tensions have been fueled by increasing population growth, land degradation, changing laws governing land property sales,⁴² the reinforcement of protected natural areas and hunting areas,⁴³ as well as implicit incentives (via agricultural subsidies) to expand cropland over *marginal* grazing lands. As mentioned in Noria Research (2020), the associated grievances have created conditions for extremist recruitment, and “joining an armed group can be perceived as a factor of upward mobility for undervalued youth.”

Agroecology and re-greening initiatives in the Sahel, however, hold the pillars for the prevention and mitigation of conflicts. Farmers can produce more on existing land, thus reducing pressures on arable cropland expansion. New income streams create enhanced resilience and well-being within farming households (as already witnessed in the ANSD intervention area).⁴⁴ By creating favorable conditions for livestock, agroecology enables farmers to have larger livestock holdings. These are often entrusted to the Fulani (Peul population) through a guardianship contract, during the rainy season, thus increasing their income base and enhancing synergies between farmers and pastoralists.

More broadly, agroecology may offer opportunities to integrate peacebuilding into existing community-led land restoration programs, which, by their participatory design, grasp local dynamics and provide a nuanced understanding of local conflict. This kind of design, ensures local relevance and ownership, reducing external intervention risks, and fosters enhanced community buy-in.

As witnessed by Groundswell International and ANSD, community-based agroecology committees

42 Law 0034, which came into effect in 2009, has allowed farmers to sell their cropland to the highest bidder, rather than requiring the transmission through the family. This has led to a process of concentration of landownership, at times, at the expense of the younger generation that are deprived from accessing farmland and has encouraged the emergence of a landowner class that is often deemed to be close to the central state. It is also believed that pressure brought about by the restriction has accentuated agricultural activity moving towards transhumance areas (Noria Research, 2020).

43 Thereby reducing the ability of locals to reach arable land and fishing and hunting areas. The central state, in the shape of Forestry and Water Commission officials, may also extort locals or “demand 100,000 Francs for a few branches cut down in a park.” Also, since 2017, in the Pendjari park on the border with Benin, private security guards started pushing out locals from protected zones. The land-use policies lead to reducing the food-producing areas available to the rural population and social frustration is all the greater since these privatized zones are generally monopolized by groups and individuals who are labelled by locals as being foreigners (Noria Research, 2020).

44 During the focus group in Ouagadougou in May 2018, we talked with a farmer, who had been displaced 2 years ago, but had rebounded fast in a new village – he said, thanks to agroecology – allowing him to generate impressive yields, in synergy with high livestock holdings.

and governance frameworks also build trust and credibility, nourish relationships between communities and program implementers, and may offer forums for discussing and preventing conflicts over land and resources. Peacebuilding and land restoration may offer synergies to address the root causes of conflicts (poverty, competition over resources, lack of governance). Such efforts would require effective facilitation to build a common understanding and strategy among the government, civil society, and community-based organizations.

10.11 Conclusion

ANSD, with the support of Groundswell International, is using agroecological principles to work toward large-scale, cost-effective scaling of agroecology in eastern Burkina Faso, by focusing on the depth of on-farm agroecological practices, the horizontal spread of practices from farmer to farmer, and the vertical adaptation of agroecology through layers of government and civic organizations. Agroecological spread in Tibga, Gayeri is already transforming the livelihoods of rural households through increased yields, the diversification of income streams, earning a living income, and the feasible doubling of total household income, from agroforestry, livestock and

arable cropping.

Increased resilience, in turn, leads to enhanced food security and bankability of farmers. As we embrace these results, we need to conceive additional strategies for accelerating the spread of agroecology in an ecosystem where diverse forces come together, from farmer-led innovation and knowledge sharing to policy instruments that incentivize nature-positive and profitable land use systems, and to strengthen local market linkages, NGO assistance, and blended finance solutions that can help farmers overcome the transition costs. Integration of peacebuilding activities may contribute to a more stable context and improve the spread of community-driven agroecological strategies and their benefits.

It is our aspiration that this study will be instrumental in providing evidence and recommendations for policies and strategies to galvanize resources for agroecological transformations, so as to reverse the degradation of soils and biodiversity, reduce poverty and hunger, improve livelihoods, and build climate resilience. Burkina Faso can create this future and be a powerful example to other nations in the West African Sahel.

REFERENCES

- Adekiya, A. O., Ejue, W. S., Olayanju, A., Dunsin, O., Muiyiwa Aboyeji, C., Aremu, C., Adegbite, K., Akinpelu, O. (2020). Different organic manure sources and NPK fertilizer on soil chemical properties, growth, yield and quality of okra. *Scientific Reports*, 10, 16083. <https://doi.org/10.1038/s41598-020-73291-x>
- Agegnehu, G., Amede, T., Desta, G., Erkossa, T., Legesse, G., Gashaw, T., Van Rooyen, A., Harawa, R., Degefu, T., Mekonnen, K., & Schulz, S. (2023). Improving fertilizer response of crop yield through liming and targeting to landscape positions in tropical agricultural soils. *Heliyon*, 9(6), Article e17421.
- Agence Nationale de la Statistique et de la Démographie (ANSD). (2015a). *Intégration des technologies agro-écologiques pour la gestion de la fertilité des sols: Cas de Lankoandé Djingri Jaquest de Bilanga-Yanga*.
- ANSD. (2015b). *Intégration des technologies agro-écologiques pour la gestion de la fertilité des sols: Cas de Lankoandé Nakou de Bandikidini*.
- ANSD. (2015c). *Intégration des technologies agro-écologiques pour la gestion de la fertilité des sols: Cas de Woba Koubilenla*.
- ANSD. (2015d). *Intégration des technologies agro-écologiques pour la gestion de la fertilité des sols: Cas de MANO Assibidi*.
- Agrisud International. (2020). *L'agriculture familiale agro-écologique pour des systèmes alimentaires durables*. RMT Alimentation Locale.
- Ahmad, S., Smale, M., Theriault, V., & Maiga, E. (2023). Input subsidies and crop diversity on family farms in Burkina Faso. *Journal of Agricultural Economics*, 74(1), 237–254. <https://doi.org/10.1111/1477-9552.12504>
- Akhtar, M., Mensching, H. G., & Domnick, I. (1994). Methods applied for recording desertification and their results from the Sahel region of the Republic of Sudan. *Desertification Bulletin*, 25, 40–47.
- Amejo, A. (2024). Resilience, sustainability, and the role of livestock in rural food systems: A case study from Ethiopia. <https://doi.org/10.5772/intechopen.1006055>
- Bado, B. V., Savadogo, P., & Sanoussi Manzo, M. L. (2018). Restoration of degraded lands in West Africa Sahel: Review of experiences in Burkina Faso and Niger. ICRIAT and CGIAR. https://www.worldagroforestry.org/sites/agroforestry/files/output/attachments/Niger_Experiences%20in%20Regeneration%20of%20Degraded%20Lands_ICRIAT_2016_uploaded.pdf
- Bationo, A., & Mokwunye, A. U. (1991). Role of manures and crop residues in alleviating soil fertility constraints to crop production: With special reference to the Sahelian and Sudanian zones of West Africa. *Fertility Research*, 29, 117–125.
- Bationo, A., Kihara, J., Vanlauwe, B., Waswa, B., & Kimetu, J. (2007). Soil organic carbon dynamics, functions and management in West African agroecosystems. *Agricultural Systems*, 94(1), 13–25.
- Batta, Y., & Bourgou, T. (2017). From oases to landscapes of success: Accelerating agroecological innovation in Burkina Faso. In *Fertile Ground: Scaling Agroecology from the Ground Up*. https://archive.foodfirst.org/wp-content/uploads/2017/01/BurkinaFaso_final2.pdf
- Belay, W. A., Besha Bedada, T., & Berhan, G. (2019). Patterns of Lake Beseka catchment land use dynamics: Implication on soil organic carbon and pH properties. In A. M. Melesse, W. Abtew, & G. Senay (Eds.), *Extreme Hydrology and Climate Variability* (pp. 223–235). Elsevier. <https://www.sciencedirect.com/topics/earth-and-planetary-sciences/shrubland>
- Bourgou, T. (2025). Personal communication. West Africa Regional Coordinator for Groundswell International.
- Brescia, S. (Ed.). (2024). *Fertile ground: Scaling agroecology from the ground up* (2nd ed., 220 pp.). Groundswell International; Food First Books.
- Carlucci, E., & Guzzetti, M. (2024). *Sustainable asset valuation of land restoration and climate-smart agriculture in Burkina Faso*. NBI Report. International Institute for Sustainable Development and United Nations Industrial Development Organization. Retrieved from <https://nbi.iisd.org/wp-content/uploads/2023/04/nbi-burkina-faso.pdf>

- Cervigni, R., & Morris, M. (Eds.). (2016). *Confronting drought in Africa's drylands: Opportunities for enhancing resilience* (Africa Development Forum series). World Bank. <https://doi.org/10.1596/978-1-4648-0817-3>
- Citypopulation. (2022). Burkina Faso, municipal divisions. <https://citypopulation.de/en/burkinafaso/communes/admin/>
- Dawson, N., Martin, A., & Sikor, T. (2016). Green revolution in Sub-Saharan Africa: Implications of imposed innovation for the well-being of rural smallholders. *World Development*, 78, 204–218. <https://doi.org/10.1016/j.worlddev.2015.10.008>
- Dianou, A. (2024). Executive Secretary for ANSD. (Personal communication).
- Ducett, A., Stoikova, A., & Steer, A. (2022). Living wage and living income: Essential elements of corporate responsibility in global supply chains. Accountability Framework. <https://accountability-framework.org/news-events/news/living-wage-and-living-income-essential-elements-of-corporate-responsibility-in-global-supply-chains/>
- Fairtrade International. (2025). Fairtrade strives for living incomes. <https://www.fairtrade.net/en/why-fairtrade/why-we-do-it/decent-livelihoods/living-income.html>
- Falconnier, G. N., Cardinael, R., Corbeels, M., Baudron, F., Chivenge, P., Couëdel, A., Ripoche, A., Affholder, F., Naudin, K., Benaillon, E., Rusinamhodzi, L., Leroux, L., Vanlauwe, B., & Giller, K. E. (2023). The input reduction principle of agroecology is wrong when it comes to mineral fertilizer use in sub-Saharan Africa. *Outlook on Agriculture*, Advance online publication. <https://doi.org/10.1177/00307270231199795>
- FAO, ECA, & AUC. (2020). *Africa regional overview of food security and nutrition 2019*. FAO. <https://doi.org/10.4060/CA7343EN>
- FAOLEX. (2024). *Stratégie nationale de développement de l'agroécologie 2023–2027 au Burkina Faso*. <https://www.fao.org/faolex/results/details/en/c/LEX-FAOC217823>
- Food and Agriculture Organization (FAO). (2015). *Agroecology to reverse soil degradation and achieve food security*.
- Food and Agriculture Organization (FAO). (2025). *Action against desertification: Burkina Faso*. <https://www.fao.org/in-action/action-against-desertification/countries/africa/burkina-faso/ar/>
- Global Landscape Forum. (n.d.). *Factsheet: Forest and landscape restoration in Burkina Faso*. https://www.cifor-icraf.org/publications/pdf_files/factsheet/6984-GLF_Factsheet.pdf
- Global Mechanism of the UNCCD (GM-UNCCD). (2018). *Country profile of Burkina Faso: Investing in land degradation neutrality—Making the case*. <https://www.unccd.int/sites/default/files/inline-files/Burkina%20Faso.pdf>
- Gnonlonfin, L., Onsavi, & Olawale, E. (2022). *Ethnobotanical survey of less-known indigenous edible tree Diospyros mespiliformis (Ebenaceae) in Benin, West Africa*. XW World Forestry Congress. Seoul, South Korea. <https://openknowledge.fao.org/server/api/core/bitstreams/30b969eb-0769-4993-a0e5-709f6ef4ba97/content>
- Gouvernement du Burkina Faso. (2019). *Sur le chemin du développement local: Les acquis du PNGT2 au Burkina Faso*. PNGT2, Banque Mondiale, GEF, KIT.
- Graef, F., & Haigis, J. (2001). Spatial and temporal rainfall variability in the Sahel and its effects on farmers' management strategies. *Journal of Arid Environments*, 48 (2), 221–231. <https://doi.org/10.1006/jare.2000.0747>
- Haglund, E., Ndjeunga, J., Snook, L., & Pasternak, D. (2011). Dry land tree management for improved household livelihoods: Farmer managed natural regeneration in Niger. *Journal of Environmental Management*, 92(7), 1696–1705.
- Haider, H., Smale, M., & Theriault, V. (2018). Intensification and intrahousehold decisions: Fertilizer adoption in Burkina Faso. *World Development*, 105, 310–320. <https://doi.org/10.1016/j.worlddev.2017.12.030>
- HLPE. (2019). *Agroecological and other innovative approaches for sustainable agriculture and food systems that enhance food security and nutrition*. A report by the High Level Panel of Experts on Food Security and Nutrition of the Committee on World Food Security. Rome, Italy. Retrieved from <https://openknowledge.fao.org/server/api/core/bitstreams/ff385e60-0693-40fe-9a6b-79bbef05202c/content>
-

- Ibrahim, A., Abaidoo, R. C., Fatondji, D., & Opoku, A. (2015). Hill placement of manure and fertilizer micro-dosing improves yield and water use efficiency in the Sahelian low input millet-based cropping system. *Field Crops Research*, 180, 29–36. <https://doi.org/10.1016/j.fcr.2015.04.022>
- Ilboudo-Nébié, E. (2020, January 21). Burkina Faso study shows link between land degradation and migration. *The Conversation*. <https://theconversation.com/burkina-faso-study-shows-link-between-land-degradation-and-migration-130006>
- International Fund for Agricultural Development (IFAD). (2019). *Investing in rural people in Burkina Faso*. Retrieved March 5, 2025, from https://www.ifad.org/documents/48415603/49797297/burkino_faso_e_web.pdf
- International Fund for Agricultural Development (IFAD). (2023). *IFAD and Burkina Faso sign new financing agreement to build resilience of small-scale farmers to climate change and other shocks*. Retrieved March 5, 2025, from <https://www.ifad.org/en/web/latest/-/le-fida-et-le-burkina-faso-signent-un-nouvel-accord-de-financement-pour-renforcer-la-resilience-des-petits-exploitants-aux-changements-climatiques-et-a-d-autres-chocs>
- International Monetary Fund (IMF). (2025). Burkina Faso datasets. *World Economic Outlook (April 2025)*. Retrieved April 2, 2025, from <https://www.imf.org/external/datamapper/profile/BFA>
- Jayne, T. S., Mason, N. M., Burke, W. J., & Ariga, J. (2018). Taking stock of Africa's second-generation agricultural input subsidy programs. *Food Policy*, 75, 1–14. <https://doi.org/10.1016/j.foodpol.2018.01.003>
- Kabore, D., & Reij, C. (2004). The emergence and spreading of an improved traditional soil and water conservation practice in Burkina Faso. EPTD discussion papers 114, International Food Policy Research Institute (IFPRI). Retrieved from: <https://ideas.repec.org/p/fpr/eptddp/114.html>
- Komonsira, D. (2025). Personal communication. West Africa Coordinator for Action Learning & Advocacy, Groundswell International.
- Kondombo, C. P., Kaboré, P., Kambou, D., & Ouédraogo, I. (2024). Assessing yield performance and stability of local sorghum genotypes: A methodological framework combining multi-environment trials and participatory multi-trait evaluation. *Heliyon*, 10(4).
- Korodjouma, O. (n.d.). *Global Yield Gap Atlas: Burkina Faso*. Global Yield Gap Atlas. <https://www.yieldgap.org/burkina-faso>
- Le Houerou, H. N. (1985). *Le rôle des arbres et arbustes dans les pâturages sahéliens*. Ottawa: IDRC.
- Lieffering, G. (2021). *Taste the sweetness of living wage mangoes from Burkina Faso*. Living Wage. <https://www.livingwage.eu/en/taste-the-sweetness-of-living-wage-mangoes-from-burkina-faso>
- Mano, D., & Mano, L., (2024), compte rendu du focus groupe, from Gayéri, September 2025. Undertaken and transcribed by Mano David and Mano Lamoussa.
- Medinaceli, A., Andersen, L. E., Delajara, M., Anker, R., & Anker, M. (2024). *2024 Update Report: Living Income Reference Value for Rural Burkina Faso*. Anker Research Institute. <https://www.ankerresearchinstitute.org/burkina-faso-reference/livingwage-nonmetroargentina-2020-emhn8-6k6ew-59zrl-etamz-dzkjn-lrzgj-rr5rf-wgeth-8cwff-wsw2x-csj6e-pkw7m-4adj>
- Mentz-Lagrange, S., & Gubbels, P. (2018). *A case study report on strengthening the capacity of local governance structures as a vital dimension of initiatives to improve the resilience of dryland farm communities. Integrating equity into agroecology to improve the resilience of dryland communities in the Sahel*. Groundswell International, USAID, Sahel Eco. <https://www.groundswellinternational.org/wp-content/uploads/2020/03/case-study-local-governance-4-web.pdf>
- Ministère de l'Environnement, de l'Economie Verte et du Changement Climatique du Burkina Faso (MEEVCC). (2018). *Rapport final, Programme de Définition des Cibles de la Neutralité en matière de Dégradation des terres (PDC/NDT), Burkina Faso*. Ouagadougou, Burkina Faso.
- Minute.bf. (2024). *Burkina/Campagne cotonnière 2024–2025: Une subvention de 10 milliards accordée aux producteurs pour l'achat des intrants*. Minute.bf. Retrieved March 5, 2025, from <https://www.minute.bf/burkina-campagne->

cotonniere-2024-2025-une-subvention-de-10-milliards-accordee-aux-producteurs-pour-lachat-des-intrants/

Minute.bf. (2025). *Burkina/Campagne cotonnière 2024-2025: La production en baisse de 26% malgré les subventions (Bilan à mi-parcours)*. Minute.bf. Retrieved March 5, 2025, from <https://www.minute.bf/burkina-campagne-cotonniere-2024-2025-la-production-en-baisse-de-26-malgre-les-subventions-bilan-a-mi-parcours/>

Minute.fr. (2024). *Burkina: Stone bunds and grassy strips, agroecological practices that combat erosion*. Minute.mf. Retrieved March 5, 2025, from <https://www.minute.bf/burkina-le-cordon-pierreux-et-la-bande-enherbee-ces-pratiques-agroecologiques-qui-luttent-contre-lerosion/>

Minute.fr. (2025). *Performances agroécologiques: Les acteurs réajustent l'outil de validation TAPE*. Minute.fr. Retrieved March 5, 2025, from <https://www.minute.bf/performances-agroecologiques-les-acteurs-reajustent-loutil-de-validation-tape/?noamp=available>

Morris, M. L. (2007). *Fertilizer use in African agriculture: Lessons learned and good practice guidelines*. World Bank Publications.

Mrema, G., Soni, P., & Rolle, R. (2014). A regional strategy for sustainable agricultural mechanization. In *Sustainable mechanization across agri-food chains in Asia and the Pacific region* (p. 74). Food and Agriculture Organization of the United Nations.

Nair, P. K. R. (1984). *Soil productivity aspects of agroforestry (Science and Practice of Agroforestry Series No. 1)*. International Council for Research in Agroforestry (ICRAF).

Nelgen, S., Charré, S., & Pacheco, P. (2024). *Turning harm into opportunity: Repurposing agricultural subsidies that destroy forests and non-forest natural ecosystems*. WWF. Retrieved from <https://wwfint.awsassets.panda.org/downloads/wwf-turning-harm-into-opportunity---summary-final.pdf>

Nkonya, E., Mirzabae, A., von Braun, J. (2016). *Economics of Land Degradation and Improvement - A Global Assessment for Sustainable Development*. Springer Open. <https://link.springer.com/book/10.1007/978-3-319-19168-3>

Noria Research. (2020). *Les racines locales de la violence dans l'Est du Burkina Faso: La concurrence pour les ressources, l'État et les armes*. Noria Research. Retrieved March 5, 2025, from <https://noria-research.com/africas/fr/les-racines-locales-de-la-violence-burkina-faso/>

Nziguheba, G., van Heerwaarden, J., & Vanlauwe, B. (2021). Quantifying the prevalence of (non)-response to fertilizers in sub-Saharan Africa using on-farm trial data. *Nutrient Cycling in Agroecosystems*, 121, 257-269. <https://doi.org/10.1007/s10705-021-10174-1>

ODI. (2019). *Blended finance in the poorest countries—The need for a better approach*. ODI Global. Retrieved from <https://www.odi.org/sites/odi.org.uk/files/resource-documents/12666.pdf>

OECD. (2022). *Scaling up blended finance in developing countries*. ODI Global. Retrieved March 5, 2025, from https://www.oecd.org/content/dam/oecd/en/publications/reports/2022/11/scaling-up-blended-finance-in-developing-countries_4d47ff2c/2fb14da0-en.pdf

Olowoake, A. A. (2014). Influence of organic, mineral and organomineral fertilizers on growth, yield, and soil properties in grain amaranth (*Amaranthus cruentus* L.). *Journal of Organic Agriculture and Environment*, 1(1), 39-47.

Pica-Ciamarra, U., Tasciotti, L., Otte, J., & Zezza, A. (2011). *Livestock assets, livestock income and rural households: Cross country evidence from household surveys*. FAO and World Bank. Retrieved from <https://www.fao.org/4/as294e/as294e.pdf>

Pichot, J., Sedego, M. P., Poulain, J. F., & Arivets, J. (1981). Evolution de la fertilité d'un sol ferrugineux tropical sous l'influence des fumures minérales et organiques: Analyse des résultats d'un essai en place depuis 1952 sur sols ferrugineux tropicaux au Burkina Faso. *Agronomie Tropicale*, 36(1), 1-15.

Poschen, P. (1986). An evaluation of the A. albida based agroforestry practices in the Hararghe highlands of Eastern Ethiopia. *Agroforestry Systems*, 4: 129-43

Pye-Smith, C. (2013). *The Quiet Revolution: How Niger's farmers are re-greening the parklands of the Sahel*. ICRAF Trees for Change no. 12. Nairobi: World Agroforestry Centre.

Rainforest Alliance. (2019). *Driving better livelihoods: Why the fight for a living wage and income is essential to creating sustainable supply chains*. Rainforest Alliance. <https://www.rainforest-alliance.org/insights/driving-better-livelihoods-why-the-fight-for-a-living-wage-and-income-is-essential-to-creating-sustainable-supply-chains/>

Reij, C., Tappan, G., & Belemvire, A. (2005). Changing land management practices and vegetation on the Central Plateau of Burkina Faso (1968–2002). *Journal of Arid Environments*, 63(3), 642–659. <https://doi.org/10.1016/j.jaridenv.2005.03.010>

Rinaudo, T. (2007). *Managed Natural Regeneration*. LEISA Magazine 23.2. <http://fmnrhub.com.au/wpcontent/uploads/2013/09/Rinaudo-2007-Development-of-FMNR.pdf>

Sagadou, J., & Lankoande, A., (2024), compte rendu du focus groupe, from Bilanga, September 2025. Undertaken and transcribed by Adama Lankoande and Josué Sagadou.

Salih, A. A. (1993). Sustainability and profitability of intensive cropping techniques on the dryland vertisols of the Sudan: A simulation approach with EPIC. Ph.D. Thesis. Lafayette, USA: Purdue University

Savory Institute. (2015). *Restoring the climate through capture and storage of soil carbon through holistic planned grazing* [White paper]. Savory Institute.

Schlecht, E., Buerkert, A., Tielkes, E., & Bationo, A. (2006). A critical analysis of challenges and opportunities for soil fertility restoration in Sudano-Sahelian West Africa. *Nutrient Cycling in Agroecosystems*, 76(2), 109–136. <https://doi.org/10.1007/s10705-005-1670-z>

Selina, W. (2024). *Burkina Faso cotton prices*. Selina Wamuccii. Retrieved May 3, 2025, from <https://www.selinawamuccii.com/insights/prices/burkina-faso/cotton/>

Shanmugavel, D., Rusyn, I., Solorza-Feria, O., & Kamaraj, S.-K. (2023). Sustainable SMART fertilizers in agriculture systems: A review on fundamentals to in-field applications. *Science of The Total Environment*, 904, 166729. <https://doi.org/10.1016/j.scitotenv.2023.166729>

Silva-Olaya, A. M., España-Cetina, G. P., Cherubin, M. R., Rodríguez-León, C. H., Somenahally, A., & Blesh, J. (2025). Restoring soil multifunctionality through forest regeneration in abandoned Amazon pasturelands. *Restoration Ecology*, 33(3). <https://onlinelibrary.wiley.com/doi/10.1111/rec.14358>

Sims, B., & Kienzle, J. (2016). Making Mechanization Accessible to Smallholder Farmers in Sub-Saharan Africa. *Environments*, 3(2):11. <https://doi.org/10.3390/environments3020011>

Smale, M. & Theriault, V. (2021). Input subsidy effects on crops grown by smallholder farm women: the example of cowpea in Mali. *Oxford Development Studies*, 1–15.

Soussana, J.-F., Tichit M., Lecomte P., Dumont, B. (2015). Agroecology: integration with livestock. In: *Agroecology for Food Security and Nutrition Proceedings of the FAO International Symposium 18-19 September 2014* (pp. 225–249). Food and Agriculture Organization (FAO). ISBN 978-92-5-108807-4

Statista. (2023). *Burkina Faso country report*. Statista. Retrieved May 3, 2025, from <https://www.statista.com/statistics/448893/burkina-faso-gdp-distribution-across-economic-sectors/>

Statista. (2025). *Burkina Faso GDP distribution across economic sectors*. Statista. Retrieved May 3, 2025, from <https://www.statista.com/statistics/448893/burkina-faso-gdp-distribution-across-economic-sectors/>

Steinfeld, H., & Mack, S. (1995). Livestock development strategies. *World Animal Review*, (84/85), 18–24.

Stöber, S., Ouattara, G., Kalaydjian, S., Shawon, M. S., & Heie, J. (2024, September 11–13). Transforming sorghum farming in semi-arid Burkina Faso through agroecological intensification [Conference presentation]. *Tropentag 2024*. <https://www.tropentag.de/2024/abstracts/full/756.pdf>

Stoorvogel, J. J., & Smaling, E. M. A. (1990). *Assessment of soil nutrient depletion in Sub-Saharan Africa: 1983–2000* (Report No. 28, Vol. 1). Wageningen, The Netherlands: The Winand Staring Centre for Integrated Land, Soil and Water Research.

- Sustainable Brands (2022). *10 Global Companies Take Action Towards Living Wages*. *Sustainable Brands blog post*. Sustainable Brands. Retrieved May 2, 2025, from <https://sustainablebrands.com/read/idh-10-global-companies-take-action-towards-living-wages>
- Sylla, M. B., Dimobe, K., & Sanfo, S. (2021). *Burkina Faso – Land, climate, energy, agriculture and development: A study in the Sudano-Sahel Initiative for regional development, jobs, and food security* (ZEF Working Paper Series No. 197). University of Bonn, Center for Development Research (ZEF). <https://www.econstor.eu/bitstream/10419/246466/1/ZEF-Working-Paper-197-Burkina-Faso.pdf>
- Tambiga, C. (2024). *Focus group report from Tibga, September 2024*. ANSD.
- The Global Economy. (2025). *Burkina Faso: Cereal crop yield by hectare*. The Global Economy.com. https://www.theglobaleconomy.com/Burkina-Faso/cereal_yield/
- Tyszler, M., & de los Ríos, C. (2020). *KIT_LIVINGINCOME: Stata module providing tables and bar charts of the gap to the living income benchmark* (Statistical Software Components S458819). Boston College Department of Economics. <https://ideas.repec.org/c/boc/bocode/s458819.html>
- UNCCD – Global Mechanism. (2018). *Burkina Faso – LDN country profile*. United Nations Convention to Combat Desertification. Retrieved May 3, 2025, from <https://www.unccd.int/sites/default/files/2022-12/Burkina%20Faso.pdf>
- United Nations Development Programme (UNDP). (2019). *Burkina Faso country profile*. Human Development Reports. Retrieved March 5, 2025, from <https://hdr.undp.org/en/countries/profiles/BFA>
- United Nations Environment Programme (UNEP). (2024). *Global environmental outlook for Burkina Faso*. Nairobi: UNEP Publications.
- USAID (2022). *Burkina Faso Factsheet*. USAID. Retrieved September 10, 2024, from <https://www.usaid.gov/sites/default/files/2022-05/BF%20Fact%20Sheet%20-%20Ag%20%26amp%3B%20FS%201215.pdf>
- Vall, E., Dugué, P., & Blanchard, M. (2006). Le tissage des relations agriculture-élevage au fil du coton. *Cahiers Agricultures*, 15(1), 72-79.
- Vanlauwe, B., Bationo, A., Chianu, J., Giller, K.E., Merckx, R., Mokwunye, U., Ohiokpehai, O., Pypers, P., Tabo, R., Shepherd, K.D., Smaling, E.M.A., Woomer, P.L., Sanginga, N. (2010). Integrated soil fertility management, operational definition and consequences for implementation and dissemination. *Outlook on Agriculture* 39(1), 17-24. <https://doi.org/10.5367/000000010791169998>
- Vanlauwe, B., Kihara, J., Chivenge, P., Pypers, P., Coe, R., & Six, J. (2011). Agronomic use efficiency of N fertilizer in maize-based systems in sub-Saharan Africa within the context of integrated soil fertility management. *Plant and Soil*, 339(1), 35-50. <https://doi.org/10.1007/s11104-010-0462-7>
- Westerberg, V. (2017). *The economics of conventional and organic cotton production: A case study from the Municipality of Banikoara, Benin*. Economics of Land Degradation (ELD) Initiative, Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ).
- Westerberg, V., Doku, A., Damnyag, L., Kranjac-Berisavljevic, G., Owusu, S., Jasaw, G., & Di Falco, S. (2019). *Reversing land degradation in drylands: The case for Farmer Managed Natural Regeneration (FMNR) in the Upper West Region of Ghana*. Economics of Land Degradation Initiative. www.eld-initiative.org
- Wezel, A., & Soldat, V. (2009). A quantitative and qualitative historical analysis of the discipline of agroecology. *International Journal of Agricultural Sustainability*, 7(1), 3-18.
- Wezel, A., Herren, B. G., Kerr, R. B., Barrios, E., Gonçalves, A. L. R., & Sinclair, F. (2020). Agroecological principles and elements and their implications for transitioning to sustainable food systems: A review. *Agronomy for Sustainable Development*, 40, 40. <https://doi.org/10.1007/s13593-020-00646-z>
- WFP. (2025, March). *Burkina Faso in focus: Country brief*. World Food Programme. Retrieved May 3, 2025, from <https://www.wfp.org/countries/burkina-faso#:~:text=Over%20the%20past%20years%2C%20the,to%202.7%20million%20in%202024>

World Bank (n.d.). *Lending Interest Rate (%) – Burkina Faso*. World Bank. Retrieved from <https://data.worldbank.org/indicator/FR.INR.LEND?locations=BF>

World Bank. (2021). *Poverty & Equity Brief: Burkina Faso, Africa Western & Central*. World Bank. https://databankfiles.worldbank.org/public/ddpext_download/poverty/987B9C90-CB9F-4D93-AE8C-750588BF00QA/AM2020/Global_POVEQ_BFA.pdf

World Bank. (2023). *Burkina Faso poverty and equity brief*. World Bank. Retrieved March 5, 2025, from https://databank.worldbank.org/data/download/poverty/33EF03BB-9722-4AE2-ABC7-AA2972D68AFE/Archives-2023/Global_POVEQ_BFA.pdf

World Bank. (2024a). *Burkina Faso climate smart agriculture investment plan*. The World Bank Group. Retrieved March 5, 2025, from <https://documents.worldbank.org/en/publication/documents-reports/documentdetail/>

World Bank. (2024b). *Burkina Faso: Macro Poverty Outlook – Country-by-Country Analysis and Projections for the Developing World*. The World Bank Group. <https://documents1.worldbank.org/curated/en/099515510142426393/pdf/IDU15a8b166612c8e14130181ae1054846575f71.pdf>

World Bank. (2024c). *World Bank, Intended Nationally Determined Contributions (INDCs) database*. The World Bank Group. Retrieved May 1, 2025, from <http://spappssecext.worldbank.org/sites/indc/Pages/INDCHome.aspx>

World Bank (2025). *The World Bank in Burkina Faso. Overview*. The World Bank Group. Retrieved from Accessed through URL: <https://www.worldbank.org/en/country/burkinafaso/overview#>:

Zida, M. (2018). *Reshaping the terrain: Forest and landscape restoration in Burkina Faso*. Bogor, Indonesia: Center for International Forestry Research (CIFOR). <https://hdl.handle.net/10568/112502>

Appendix 1. Scatterplots of Organic and Inorganic Input Use and Yield

Figures A1.1 through A1.6 show simple scatter plots of the use of major inputs against the yields that farmers have obtained. Use of NPK fertilizers, fungicides and insecticides (Figures A1, A3 and A5) has no statis-

tically significant impact on yields (the fitted lines are dotted), as revealed in the regression models (Appendix 2). For these inputs, it can be seen that a very large proportion of farmers spend nothing yet achieve high

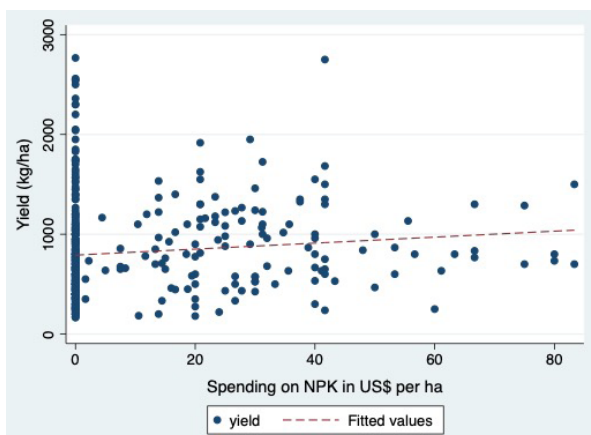


Figure A1.1: NPK use (in US\$/ha) against yields

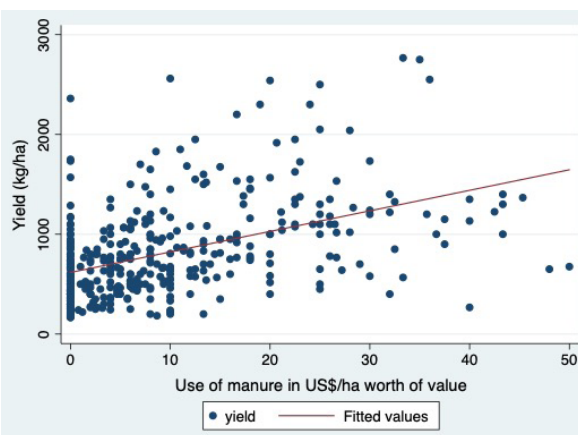


Figure A1.2: Manure use in US\$/ha value against yields

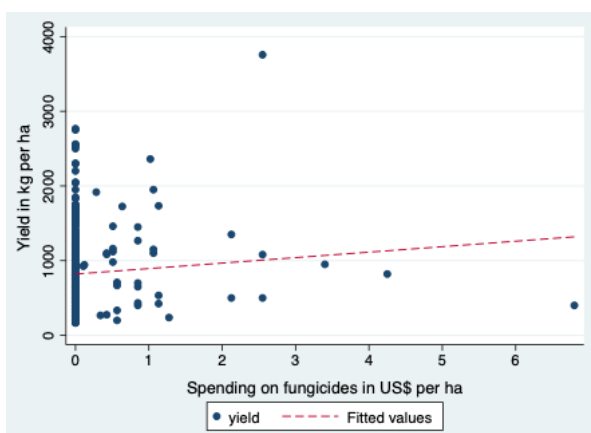


Figure A1.3: Fungicide use (in US\$/ha) against yields

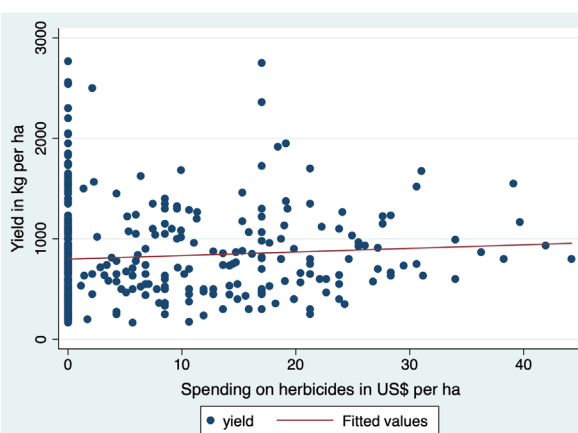


Figure A1.4: Herbicide use (in US\$/ha) against yields

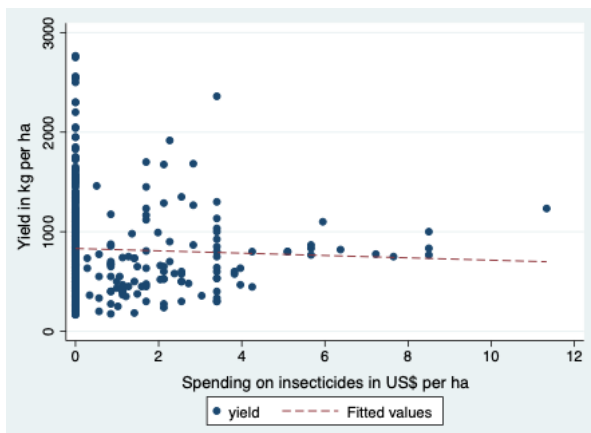


Figure A1.5: Insecticide use (in US\$/ha) against yields

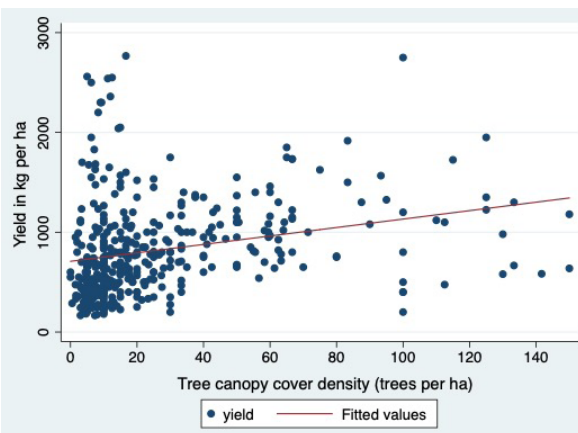


Figure A1.6: Tree density (trees/ha) against yields

*Dotted fit, because there is no statistically significant fit when controlling for cofounding factors.

yields. The use of manure and tree canopy density, however, appears to be strongly correlated with crop yields. However, the potential relationship between inputs and yields is influenced by other factors that are driving yields, such as legume-cereal intercropping,

the region in which the farmer finds himself (which has different levels of agroecological penetration), or 'adult household size' as a proxy for labor effort. It is therefore important to control for these influences as we do in Appendix 2.

Appendix 2. Production Function Model Specifications and Results

To understand how agroecological practices are impacting crop yields, in the agroecology-yield model, we use a combination of double-log and semi-log functions to achieve the best model fit, as per equations A1 to A3. **The agroecology-yield model** analyses the impact of tree density and agroecological practices on crop yields.

eq A1) $\ln(\text{Yield})_i = \alpha + \beta_1 \ln(T)_i + \beta_2 \ln(L)_i + \beta_3 \ln(AE)_i + \beta_4 \ln(L)_i + \beta_5 \ln(HH)_i + e_i$

The **input-yield model (equation A2)** demonstrates the extent to which increased use of organic and inorganic inputs influences yields.

eq A2) $\ln(\text{Yield})_i = \alpha + \beta_1 \ln(M)_i + \beta_2 \ln(INO)_i + \beta_3 \ln(L)_i + \beta_4 \ln(HH)_i + \beta_5 \ln(D)_i + e_i$

Finally, the **agroecology-manure model (eq A3)**, captures the main drivers of increased manure availability and use at the farm household level

eq A3) $\ln(\text{manure})_i = \alpha + \beta_1 (AE)_i + \beta_2 \ln(T)_i + \beta_3 \ln(SU)_i + \beta_4 \ln(L)_i + \beta_5 \ln(HH)_i + e_i$

Where the outcome variable **ln(yield)** represents kg of all crops confounded of each farmer *i* and is in log form, allowing us to observe nonlinearities.

In the agroecology-yield model (eq. A1), variable *T* represents the tree density on the main plot. *T* is logged to capture the fact that yield increases, but at a decreasing rate, as more trees are integrated. *L* represents cereal-legume intercropping, and *AE* is a set of other agroecological practices. *HH* captures household members in the 14-64 age category. As shown in Chapter 3 of the main report, agroecological households have more adult household members. Thus, by controlling for this, we know that higher yields are attributable to agroecological practices and agricultural inputs, as opposed to agroecological farmers having more family members.

Table A1: Detailed variable descriptions of the variables used in the production function

Variable	Explanation	mean	St dev	min-max
Tree density	Number of trees per hectare	26	28	1-150
Zaï and half-moons	Use of both half-moons and zaï pits. Two levels. 1= for less than 6 years. 2 for 7 years or more	0.49	0.84	0-2
Low-till	Minimum tillage. Two levels: 1=for less than 6 years (early adopter). 2=for 7 years or more (mature adopter).	0.34	0.63	0-2
Legume-cereal intercropping	Farmer undertakes legume-cereal intercropping (binary). As opposed to cropping sorghum only, or associating sorghum with millet, for example.	0.8	0.38	0-1
No residue burning	No residue burning for 3 years or more 0=residue burning, 1=no-residue burning	0.6	0.49	0-1
Household members (working age)	Household members in the age bracket of 14 to 64	7	4.5	0-32
Stone contour lines	Use of stone contour lines on main plot	0.8	0.39	0-1
Sheep Units	Number of cows, pigs, sheep, chickens, converted to sheep units* (or Tropical Livestock Units = SU/10)	48.2	56.1	0-430
Manure	Number of 400 kg carts of manure applied per hectare	5.5 (2.2 T)	7.01	0-36
Manure \$	Use of manure in \$/ha worth of value	\$13	11.1	0-61
NPK \$	Spending on NPK fertilizer per hectare (logged)	\$5.4 (28 kg)	9.9	0-\$59
Herbicides \$	Spending on herbicides per hectare (logged)	\$83	11.7	0-\$45

* Live animals by species mean live weight were standardized into Tropical Livestock Units (TLU) and Sheep Units (SU = TLU/10), using the following conversion factors, where 1 TLU (250 kg live weight), cattle: 0.55; buffalo: 0.50; sheep and goats: 0.10; pigs: 0.20 to 0.25; and poultry: 0.01, following Pica-Ciamarra et al., (2011).

In the Input-yield model (eq. A2), *M* represents the use of manure, measured in carts per hectare. *INO* is a set of inorganic inputs, including herbicides, fungicides and insecticides, that the farmer uses. They are all logged to generate linearity in parameters and reflect the fact that any input tends to increase yields, but at a decreasing rate. Variable *D* are departmental dummy variables representing Tibga, Bilanga and Gayeri. Bilanga and Tibga are analyzed relative to Gayeri, where ANSD's interventions have a lower penetration rate (especially since conflicts broke out four years ago). For this reason, the location variables are correlated with the agroecological practices in

the agroecology-yield model and therefore are not included. But we control for 'location' in the input-yield model to ensure that the impact of inorganic inputs is estimated independently of those agroecological practices that have permeated throughout the landscapes. In the **agroecology-manure model (eq. A3),** the outcome variable *manure* measures the carts of manure used per hectare of land on the farmer's main plot (logged). In addition to previously explained variables, *SU* measures the number of animals owned by the household, all converted into sheep units. All variable descriptions are included in Table A1.

Production Function Modelling Results

Appendix 2.1 The Agroecology-Yield Model Results

Agroecology - yield model (logged)	Coef.	t	P>t	Marginal impact*
Trees per hectare (logged)	0.137	4.73	0.00***	0.14%
ZAI and halfmoons (1=early & 2=mature adopter, 7 years at least)	0.057	1.82	0.06*	6-12%
Minimum tillage	0.129	2.85	0.00***	14%
Legume-cereal intercropping	0.324	4.77	0.00***	38%
No residue burning	0.149	2.4	0.017**	16%
Number of HH members between 14 and 64	0.030	3.96	0.00***	3%
Constant	5.524	57.18	0.00***	250 kg/ha
Regression fit	N=391; Adj R² = 0.31; Root MSE = 0.49; Prob > F=0.000			

* Marginal impact from a one 'unit' increase in the independent variable / from a 1% change in the independent variable when logged
Significant at the ***99% **95% and * 90% confidence level.

Appendix 2.2 Regression Results of the Input-Yield Model

Input use - yield model (logged)	Coef.	t	P>t	Marginal impact*
Manure use in USD/ha worth of value (logged) ^M	0.13	5.62	0.00***	0.13%
Spending on NPK fertilizers in USD/ha (logged)	0.01	0.48	0.63	NA
Spending on insecticide in USD/ha (logged)	-0.04	-0.85	0.40	NA
Spending on herbicide in USD/ha (logged)	0.038	1.72	0.09*	0.04%
Spending on fungicides in USD/ha (logged)	-0.01	-0.07	0.94	NA
Legume-cereal association	0.29	4.24	0.00***	34%
Household members	0.02	3.98	0.00***	2.4%
Bilanga	0.30	3.73	0.00***	35%
Tibga	0.14	2.13	0.03**	16%
Constant	5.71	75.6	0.00***	301 kg/ha
Regression fit	N=390; Adj R² = 0.33; Root MSE = 0.47; Prob > F=0.000.			

^M 1 T of manure = USD 4.25

* Marginal impact from a one 'unit' increase in the independent variable / from a 1% change in the independent variable when logged
Significant at the ***99% **95% and * 90% confidence level.

Appendix 2.3 Regression Results of the Agroecology-Manure Model

Agroecology - manure use model (logged)	Coef.	t	P>t	Marginal impact*
Trees per hectare (logged)	0.31	6.76	0.000***	0.31%
Stone contour barriers	0.29	2.48	0.014**	33%
No residue burning	0.47	4.86	0.000***	60%
Zaï and half-moons (1=early & 2=mature adopter, 7 years at least)	0.10	1.90	0.059*	11%-22%
Household members (14-64 yrs)	0.032	2.92	0.004***	0.032%
Tropical Livestock Units	0.02	2.26	0.025**	0.02%
Constant	-0.37	-2.32	0.021**	0.7 carts
Regression fit	N=395; Adj R2 = 0.37; Root MSE = 3.21; Prob > F=0.000			

* Marginal impact from a one-unit increase in the independent variable / from a 1 % change in the independent variable when logged.

Appendix 3 – Tree Species Present on the Main Plot

Kind of tree species present on farmer's main plot	Latin name	All farmers	Advanced agroecological (n=100)	Conventional and in transition (n=296)
Zaanga	Faidherbia albida	18%	28%	15%
Randga	Combretum micranthum	26%	39%	21%
Peguenega fomentosa	Acacia Nilotica, Gum arabic.	27%	63%	14%
Jujubier Mugunuga	Ziziphus mauritiana	33%	42%	30%
Baobab	Adansonia digitata	52%	81%	42%
Kieghaligha	Balanites aegyptiaca, desert date.	56%	84%	46%
Gaanka	Diospyros mespiliformis. Ebony	69%	92%	62%
Karité	Vitellaria paradoxa	71%	89%	65%
Raisinier	Lannea microcarpa	76%	89%	72%
Bagnan	Piliostigma reticulatum	78%	97%	71%
Other	Neem, tamarind, Gliricidia Sepium	8%	16%	5%

Appendix 4 – Details on Total Farm Household Income Sources

Appendix 4.1 Income from Domestic Livestock

Livestock consumed or sold in the 12 months preceding the interview	All farmers	Advanced agroecological (n=100)		Conventional and in transition (n=296)	
	Units sold or consumed	Units	Revenue	Units sold	Revenue
Chickens, ducks, guineafowl	14.8	35.8	\$122	7.8	\$27
Sheep	1.8	4	\$275	1	\$67
Goats	2.0	4	\$84	1.5	\$29
Animals for traction (donkeys or oxen)	0.2	0.1	\$22	0.2	\$32
Mixed (Pigs, calves, cows, lambs)	0.5	0.7	\$93	0.4	\$48
Milk in Liters (from cows, goat or sheep)	1.6	1.9	\$1	1.5	\$0.8
Income from the sale or consumption	\$258		\$507		\$173

*Assuming that livestock costs are in the order of 15 % of gross income.

Appendix 4.2 - Own Business Income

Share of households having their own business within the following categories	Average	Advanced agroecological (n=100)	Conventional and in transition (n=296)
Agriculture (ex, shea butter making)	33%	45%	29%
Breeding (ex, fodder supplier)	13%	34%	6%
Mining (ex, gold mining)	7%	12%	6%
Crafts (ex, furniture maker)	1%	2%	0%
Shop owner, repair service, tailor	3%	1%	2%
Family enterprise, other	26%	34%	23%
Average enterprise income	\$127 (302)	\$183 (270)	\$108 (290)

Appendix 4.3 - Produce and Income from All Plots, Other than the Main Plot

Other plots	Average	Advanced agroecological (n=100)	Conventional and in transition (n=296)
Millet	140 kg	280 kg	100 kg
Sorghum	200 kg	300 kg	180 kg
Maize and other	108 kg	130 kg	90 kg
Total	448 kg	710 kg	370 kg
Revenue (USD)	\$211	\$334	\$174
Net income*	\$185	\$287	\$155

*Since we do not have detailed cost data for inputs that are used on farmers' other plots (i.e., those that do not belong to the main plot), we assume that the ratio of the cost of production to total revenue is the same as that of the farmer's main plot. Advanced agroecological farmers have a total cost per hectare equivalent to 14% of total revenue. Farmers in early transition have costs in the order of 11% of their total crop revenue from the main plot, using the average price of \$0.48 per kg, for all the produce that was sold during the 2023/24 season.

Appendix 4.4 - Miscellaneous Income

Other sources of income	Average	Advanced agroecological (n=100)	Conventional and in transition (n=296)
Remittances	\$5.1	\$5.8	\$4.9
NGO support	\$1.9	\$2.9	\$1.6
Dividends ex: from a local company	\$6.9	\$15.0	\$4.3
Compensation payments	\$4.3	\$17.0	\$0
Retirement	\$0.9	\$3.4	\$0
Vegetable gardening*	\$3.2	\$1.5	\$3.8
Total other income*	\$23	\$46	\$15

*Only 16% of households are practicing vegetable gardening. Income per household is averaged across the whole population.

Appendix 4.5 - Income from Vegetable Gardening

	All farmers (n=396)	Advanced agroecological (n=100)	Conventional and in transition (n=296)
Vegetable gardening Kg of produce, full sample	2.12 kg	1 kg	2.5 kg
Among those (16 %) with access to a vegetable garden	13.4 kg	12.2 kg	13.5 kg
Income for those with access to a vegetable garden (based on an average price of USD 1.5 per kg)	\$20.0	\$18.3	\$20.3
Income across the whole population	\$3.2	\$1.5	\$3.8

Appendix 5 – Detailed Cash Flow and CBA Results

Appendix 5.1 Assumptions Used in the CBA

	CFA	USD
Daily labor cost (CFA)	600	\$1.02
Price per natte/mat	2000	\$3.4
Price per cart of fuelwood	3000	\$5.1
Price per 100 kg bag of crop produce (averaged)	27700	\$47.1
Cost per cart of manure (CFA)	1000	\$1.7
Cost per cart of compost (CFA)	3000	\$5.1
Cost per truckload of stones (unsubsidized)	80000	\$136
Cost per truckload of stones (unsubsidized)	30000	\$51
Cost of moving the stone barriers	1/3rd of the initial cost	
USD: CFA exchange rate	0.0017	

Appendix 5.2 Cost-Benefit Analysis of the Transition from Early Agroecological Adopter to Advanced Agroecology

Table A5.2.1 Flow of benefits, costs, and net benefits of implementing zaï, stone barriers and FMNR

COST BENEFIT ANALYSIS														
FARMERS IN EARLY TRANSITION														
Crop yields (100 kg bags)	6	6	6	6	6	6	6	6	6	6	6	6	6	6
Crop revenue	283	283	283	283	283	283	283	283	283	283	283	283	283	283
Revenue from firewood - HH survey 'conventional & in transition'	6.4	6.4	6.4	6.4	6.4	6.4	6.4	6.4	6.4	6.4	6.4	6.4	6.4	6.4
Revenue from NTFPs -HH survey 'conventional & in transition'	12	12	12	12	12	12	12	12	12	12	12	12	12	12
Total revenue	301	301	301	301	301	301	301	301	301	301	301	301	301	301
ADVANCED AGROECOLOGY														
Additional yield	0	86	171	257	343	429	514	600	690	780	780	780	780	780
Yield (bags) "average"→ advanced agroecological farmer	6	6.9	7.7	8.6	9.4	10.3	11.1	12.0	12.9	13.8	13.8	13.8	13.8	13.8
Crop Revenue	283	323	363	404	444	484	525	565	607	650	650	650	650	650
Bundles of forage grass (antropogon)	0	6	6	6	6	6	6	6	6	6	6	6	6	6
Revenue from forage grass strips	0.0	20.4	20.4	20.4	20.4	20.4	20.4	20.4	20.4	20.4	20.4	20.4	20.4	20.4
FMNR - Forest products														
Carts of firewood	0	0	2	3	3	3	3	3	3	3	3	3	3	3
Revenue from firewood (Advanced agroecological)*	6.4	6.4	10.2	15.3	15.3	15.3	15.3	15.3	15.3	15.3	15.3	15.3	15.3	15.3
Revenue from NTFPs	12	18	25	31	37	43	49	49	49	49	49	49	49	49
Total revenue crops and & FMNR produce	301	368	419	470	517	563	609	650	692	734	734	734	734	734
ADVANCED AGROECOLOGY COSTS (ADDITIONAL)														
FMNR														
Equipment costs														
Private: Cutlasses, pruning knife, sickles, shovels	20.4													
ANSD subsidy per household	2.38													
Pruning year 1-3														
Man days	10	10	10											
Pruning labour cost	10.2	10.2	10.2											
Thinning from year 4														
Man days	0	0	0	5	5	5	5	5	5	5	5	5	5	5
Thinning labour cost	0	0	0	5.1	5.1	5.1	5.1	5.1	5.1	5.1	5.1	5.1	5.1	5.1
Total equipment, thinning and pruning cost	32.98	10.2	10.2	5.1	5.1	5.1	5.1	5.1	5.1	5.1	5.1	5.1	5.1	5.1
CORDON PIEURREUX (field with a strong slope)														
Number of cordons	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Length across one ha (800/3 meters)		5												
Length of grass strips/bandes enherbées (meters)		267												
Quantity of stones required		130												
Cost per truckload of stones (subsidised)		51												
Cost per truckload of stones (unsubsidised)		136												
Number of stone-rows per truckload		3												
> Required number of truckloads per ha (rounded up)		2												
Material (stone) cost per ha (subsidised)		102												
Material (stone) cost per ha (unsubsidised)		272	0	0	0	0	0	0	0	0	0	0	0	0
Transport costs of stones														
Cost of one day of driving		255												
Number of trips in on one labour day		10												
Ha of stone rows from one day of transport		3.3												
Transport cost per hectare		77	0	0	0	0	26	0	0	0	26	0	0	0
Total additional unsubsidised cost - Stone barriers	0	349	0	0	0	0	26	0	0	0	26	0	0	0
ZAI														
Construction of Zai pits														
Number of pockets (125 x 125)			15600											
Pockets per person per day			200											
Number of labour days			78											
Labour cost per day			0.9											
ZAI labour implementation cost			66											
Organic inputs														
Charettes of manure/compost (mixed)			45											
Total cost from manure/compost application			153											
Avoided cost of manure application			0	-8.5	-8.5	-8.5	-8.5	0	0	0	0	0	0	0
Total additional ZAI related implementation costs	0	0	219	-8.5	-8.5	-8.5	-8.5	0	0	0	0	0	0	0
NET-BENEFIT														
Additional revenue (base→ advanced agroecological farmer)	0	67	117	169	215	262	308	348	391	433	433	433	433	433
Additional cost (base→ advanced agroecological farmer)	33	359	230	-3	-3	-3	22	5	5	5	31	5	5	5
Net-benefit	-33	-292	-112	172	219	265	286	343	386	428	403	428	428	428
Total additional revenue (undiscounted)	4477													
Total additional cost (undiscounted)	699													
Additional revenue (discounted)	0	64	107	148	181	210	237	256	275	292	279	267	255	244
Additional cost (discounted)	33	343	210	-3	-3	-3	17	4	4	3	20	3	3	3
Net-benefit (discounted)	-33	-279	-103	151	184	213	220	252	271	288	259	264	252	242
Cumulative cashflow	-33	-312	-415	-264	-80	133	352	604	876	1164	1423	1687	1939	2181

Table A5.2.2 Cost-Benefit Analysis results, when implementing zaï stone barriers and FMNR advanced agroecology.

Financial criteria T= 15 years, r=4.5 %	
Net Present Value	\$2,308
Average annual net-benefit	\$154
Present Value Revenue	\$2,918
Present Value Cost	610
Benefit-Cost Ratio	4.8
Implementation costs (first 3 years)	\$621
Internal Rate of Return	43%
ROI	540%
Annualized ROI	18%
Pay-back period	5.4 years



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Photography: Cover and back cover photo by Andrew Esiebo and the Gaia Foundation
Design/Layout: Leslie Shaw Design

