Agroecology TPP

Madagascar country report on Measuring Agroecology and its Performance (MAP)

TAPE application in the context of the Global Programme "Soil Protection and Rehabilitation for Food Security" (ProSoil)

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The Transformative Partnership Platform on Agroecology (Agroecology TPP)

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The contents of this publication are the sole responsibility of GIZ and World Agroforestry (ICRAF) and do not necessarily reflect the views of the EU or BMZ.

Abbreviations and acronyms

Agroecology TPP	Transformative Partnership Platform on Agroecology
ANOVA	Analysis of variance
BMZ	Bundesministerium für wirtschaftliche Zusammenarbeit und Entwicklung (German Federal Ministry for Economic Cooperation and Development)
CAET	Characterization of Agroecological Transition
CIFOR	Center for International Forestry Research
CIRAD	Centre de coopération internationale en recherche agronomique pour le développement (French Agricultural Research Centre for International Development)
DeSIRA	EU initiative Development Smart Innovation through Research in Agriculture i
EU	European Union
FAO	Food and Agriculture Organization of the United Nations
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH
ICRAF	International Centre for Research in Agroforestry (World Agroforestry)
INRAE	Institut national de recherche pour l'agriculture, l'alimentation et l'environnement (National Research Institute for Agriculture, Food and the Environment)
IRD	Institut de Recherche pour le Développement (French National Research Institute for Sustainable Development)
K	kilo (thousand)
LDSF	Land Degradation Surveillance Framework
MAP	Measuring Agroecology and its Performance
NGO	Non-governmental organization
ProSilience	DeSIRA project "Enhancing Soils and Agroecology for Resilient Agri-food Systems in Sub-Saharan Africa", implemented by GIZ and embedded in ProSoil
ProSoil	Global Programme "Soil Protection and Rehabilitation for Food Security", implemented by GIZ
SDGs	Sustainable Development Goals
SOCLA	La Sociedad Científica Latinoamericana de Agroecología (Latin American Scientific Society for Agroecology)
Stats4SD	Statistics for Sustainable Development
TAPE	Tool for Agroecology Performance Evaluation
VA	Value added

Executive summary

Overview

In the framework of an agreement between ICRAF and CIRAD, the TAPE methodology was applied in Boeny Region, the intervention area of the Global Programme "Soil Protection and Rehabilitation for Food Security" (ProSoil) in Madagascar. ProSoil has been promoting the implementation of agroecology in 12 municipalities of this region since 2018. The first step was the adaptation of the TAPE questionnaire in three languages and soil health testing in the field, in collaboration with two experts and eight selected farmers, as well as non-governmental organizations (NGOs) involved in agroecology promotion and farmers' support. After brief training of six experienced enumerators by FAO, 200 farms were selected in four contrasting municipalities based on their environmental, social, and economic characteristics, using a previous socioeconomic survey (50 farms per municipality). In each household, both a man and a woman were interviewed for half a day. Next, a representative farm field was selected on a hand-drawn map for soil sampling and a participatory soil health survey.

Results

Local knowledge, traditions, and culture support agroecology

The results of Step 1 of TAPE, the Characterization of Agroecological Transition (CAET), from the 200 household assessments show a considerable variation among assessed households. While the average total CAET score of 52 implies that most farmers are at an incipient stage of transition, a considerable proportion of farms are yet to transition to agroecology. Others have already integrated the 10 elements of agroecology to an advanced degree. The average CAET scores are highest for the elements of Culture and food traditions, and Human and social values. This indicates that in the study locations, local knowledge, traditions, and culture are critical aspects of agroecological transitions that need to be conserved and strengthened. The agronomic and economic dimensions of agroecology seem less developed in the Boeny Region.

Agroecology can support sustainable development and reduce economic poverty

Regarding the performance of agroecology, the correlation of CAET scores with SDG-aligned performance indicators, indicating that agroecological transitions can contribute significantly to sustainable development in Madagascar.

Results show a positive correlation between the degree of agroecological integration (CAET score) and economic performance. Thus, on average, more agroecological households have a significantly higher overall farm productivity. Additionally, the results show a significantly positive correlation between CAET scores and household income yet no significant correlation between agroecological integration and value addition. This indicates that agroecology can be an effective approach to reduce economic poverty in rural Madagascar.

Agroecology can reverse soil and land degradation

Results show a highly significant positive correlation between CAET scores and agrobiodiversity indicators. More agroecological farms on average cultivated more crop species and varieties, and held more livestock species and breeds. They also had a higher Gini-Simpson index of diversity for crops and livestock, as well as for natural vegetation and pollinators. Further, more agroecological farms on average have significantly higher soil health scores, particularly for the indicators on presence of invertebrates, soil cover, and soil compaction. This demonstrates the value of agroecological approaches for reversing soil and land degradation.

Enhanced agroecology led to less food insecurity and more diverse diets

On average, perceived levels of lower food insecurity and improved dietary diversity among households with enhanced integration of the 10 elements of agroecology were highly significant. Further, more agroecological farmers also had a highly significant reduced exposure to pesticides. This suggests that agroecology is a highly effective approach for improving food and nutrition security and health parameters for rural populations in Madagascar.

Empowerment of both women and youth need to be strengthened

There is only a slightly positive correlation between CAET scores and the women empowerment indicators. For youth empowerment indicators, there is even a slightly negative correlation with CAET scores. This highlights the requirement to further strengthen gender equity and youth empowerment efforts in agroecological interventions to increase agroecology's contribution to sustainable development.

Land tenure does not constrain efforts to improve soil through agroecology

The Responsible governance performance was assessed mainly through land tenure characterization, including a gender approach. It showed that land security is not a major issue for men or women. Land tenure should thus not be a constraint for soil improvement through agroecological practices.

Recommendations

A national workshop was attended by over 70 stakeholders, including farmers, civil society organizations, research and education institutes, as well as representatives from governmental agencies and the private sector. Additionally, municipality-level workshops were attended by farmers previously interviewed, as well as local authorities and NGOs. The farmers and other stakeholders appreciated the evidence linking agroecological transitions with improved performance across economic, environmental, nutritional, and health domains. The stakeholders made the following recommendations:

- Prioritize creation of promising opportunities for youth to engage in agriculture and ensure sustainable livelihoods.
- Provide further support to farmers to transition to agroecology. The transition requires long-term investments to adapt to climate change and combat environmental degradation, which stakeholders saw as major threats to agricultural production.
- Increasingly engage policymakers, investors, and entrepreneurs in discussions about agroecology. Scaling agroecology requires an enabling environment and farmers' agency is limited.
- Take a non-dogmatic approach to agroecology. Many farmers considered synthetic pesticides and mineral fertilizers necessary to obtain sufficient yields to ensure food security and economic prosperity. Furthermore, many participants considered the locally available biopesticides were insufficiently effective.

1 Introduction

1.1 Objectives and milestones

There were two main objectives of these studies: to assess the degree of agroecological transition in the Boeny Region after 4–5 years of ProSoil activities and to analyse the correlation between agroecological integration and multidimensional performance on farm level. The milestones of this study are listed in Table 1, running from May 2023 to September 2024. The CIRAD team consisted of a senior agronomist (PhD), one national consultant (PhD), and six experienced enumerators who conducted a previous socioeconomic survey on behalf of GIZ in August 2023.

Table 1. Milestones of the TAPE study

Months	Main partners	Main points
May 2023	FAO	Workshop led by FAO onsite and online to update TAPE guidelines
June 2023	ICRAF, FAO, Stats4SD, GIZ	Inception workshop for the collaborative application of FAO TAPE in Benin, Ethiopia, Kenya and Madagascar in the context of ProSoil (including the integrated EU co-funded ProSilience)
November–December 2023	ICRAF	ICRAF-CIRAD agreement signed on 9 November
	NGOs, farms	Step 0: Local adaptation of the questionnaire and participatory soil health assessment
	FAO, farms	• National kick-off meeting on 6 December • Enumerator training • Step 1 & Step 2 on 100 farms
January 2024	ICRAF	Country meeting on January 19
	NGOs, farms	Step 1 & Step 2 on 100 farms
February 2024	Stats4SD	Stats4SD data management
	ICRAF	8 February webinar on agroecological case studies
March 2024	Stats4SD, ICRAF	Country meeting on 6 March for data management
	Stats4SD	Data availability
	Stats4SD	Country meeting on 21 March for statistical issues
April 2024	Stats4SD, FAO	Data treatment
	ICRAF, GIZ	Soil exportation documents
May 2024	GIZ, NGOs, farms	Step 3: Municipality and national validation workshops
	CIRAD-ArtDev	Step 0: Description of the geographical site and agricultural systems
June–July 2024	ICRAF, Stats4SD, FAO, GIZ	Amendment for ICRAF-CIRAD extension by 15 September Final report
September 2024	GIZ, CIRAD, NGOs	Madagascar workshop organized by representative of ProSilience on 19 September: *"Advances and limits of agroecology in the context of Madagascar"*
	GIZ, ICRAF	MAP project presentations in internal webinar for GIZ colleagues on 10 September

Source: Autfray 2023; Autfray 2024

1.2 The Global Pogramme “Soil Protection and Rehabilitation for Food Security” (ProSoil)

ProSoil aims to protect and rehabilitate degraded soils through a landscape approach – with close links to other development cooperation initiatives. As part of the global programme, the Madagascar component contributes to achieving the objectives of the BMZ special initiative “Transformation of Agricultural and Food Systems”, aimed at eradicating extreme poverty and hunger.

Embedded within ProSoil, the EU-co-funded Action “Enhancing Soils and Agroecology for Resilient Agri-food Systems in Sub-Saharan Africa” (ProSilience), also implemented by GIZ, aims to build on ProSoil outcomes by advancing agroecological transitions to enhance a climate-relevant, productive and sustainable transformation of agriculture and food systems in low- and middle-income countries.

In the Boeny Region, ProSoil aims to protect and rehabilitate 38,000 ha of degraded land or land threatened by degradation, and targets more than 25,000 direct beneficiary households. In June 2023, a total of 7,414 beneficiary farms were identified.

In Madagascar, the three outputs of ProSoil are:
- Field of action 1: Implementation of soil protection and land-rehabilitation measures
- Field of action 2: Political and institutional anchoring of soil protection and land rehabilitation
- Field of action 3: Management of knowledge relating to soil protection and land rehabilitation, and networking of the holders and potential beneficiaries of this knowledge

A total of 34 agroecological practices are promoted by ProSoil (Table 2) in collaboration with NGOs and pilot farmers. Twelve practices relate to crop and soil fertility management, seven to climate change adaptation, eight to soil tillage management, five to agroforestry systems, and two to pasture improvement (Grislain et al. 2024).

Regarding reforestation activities, ProSoil supports 58 nurseries, which produce 240,000 seedlings each year. ProSoil provides advice, training, forest seeds, plastic pots and some tools. Different valorisations are targeted for wood production, soil protection, livestock feeding, shading, and fertility transfer.

Table 2. The different scaling-out techniques by ProSoil through NGOs

Topic	Technique
Crop and soil fertility management	Cereal–legume mixed cropping
	“Milpa” cereal–legume–cucurbits mixed cropping
	Cassava basket composting
	Farmyard manure
	On-farm compost
	Liquid fertilizer
	Vermicompost
	Off-farm compost (company by-products)
	Upland rice–pigeon pea mixed cropping
	Crop rotation
	Crop residue conservation
	Improved fallow

continue to the next page

Table 2. Continued

Topic	Technique
Climate change adaptation	Early maize sowing
	Repellent plants for crop pests
	Botanical pesticides
	Orange sweet potato
	Improved lowland-rice management techniques
	Improved upland-rice varieties
	Sorghum
Soil management	Mulching
	Ploughing perpendicular to the slope
	Improved lowland irrigated rice management techniques
	Contour lines crop valorization
	Non-cultivated strip bands
	Cropping with contour lines
	Micro-barrier for soil erosion control
	Large barrier for soil erosion control
Forestry and agroforestry	Strip cropping with tree lines
	Forest tree plantation in pure stands
	Agroforestry (mixed)
	Fruit tree plantation
	Reforestation of summit areas
Pasture	Forage crops in pure stands
	Forage crops mixed with other crops

Source: Grislain et al. 2024

1.3 The Transformative Partnership Platform on Agroecology (TPP)

The Agroecology TPP aims to centre the co-creation of localized knowledge with national and local partners and to use this knowledge to inform global priorities and trajectories.

With funding secured from the CGIAR Research Program on Forests, Trees and Agroforestry and the French research institutions CIRAD, IRD and INRAE, World Agroforestry (ICRAF) has invested in the platform, helping generate considerable interest among a range of other bodies. The platform is overseen by a Steering Committee made up of representatives from supporting partner organizations and is guided by an Advisory Group. The Agroecology TPP has two co-convenors, and a Secretariat is provided by CIFOR-ICRAF.

1.4 The Tool for Agroecology Performance Evaluation (TAPE)

The tool has so far been used for individual assessments with various objectives:

- Ensure project design and baseline regarding agroecology and sustainable food systems.
- Generate evidence for policy discussions on agroecology.
- Promote participatory discussions on agroecology; inform and engage producers.
- Evaluate a project's impact on agroecological transitions over time.
- Assess multidimensional performance of agroecology.

TAPE could be mainstreamed as it is relevant not only to agroecology but to all evaluations of sustainable agriculture practices (Mottet et al. 2020; Lucantoni et al. 2021). TAPE has been applied in more than 45 countries – 70% of them in Africa – and specific country studies could be used as case studies (Lucantoni et al. 2022, 2023). The different steps for a TAPE assessment are presented below in Figure 1.

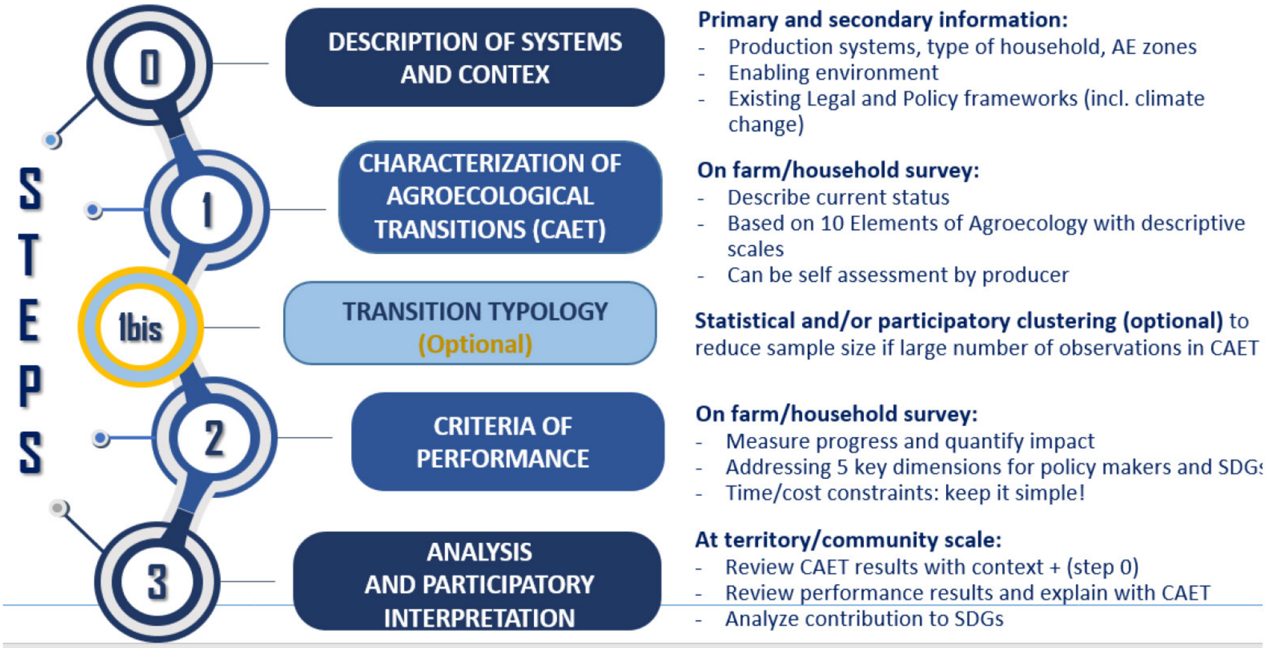


Figure 1. Stepwise approach of TAPE

Source: FAO 2021

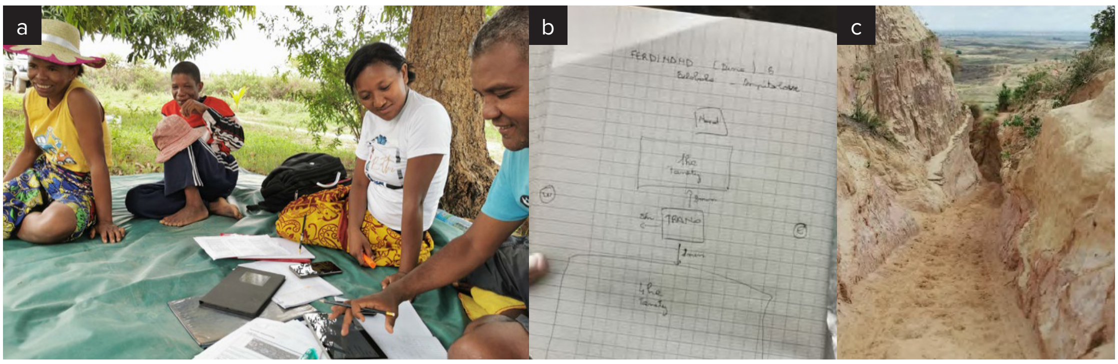
2 Methods

2.1 The TAPE questionnaire and its local adaptation

A standard FAO questionnaire in English was provided by Stats4SD from FAO. It was also translated into French and Malagasy to avoid misunderstandings. This local adaptation of the questionnaire was tested on eight farms over four days with the help of the researchers responsible for the survey.

Before beginning the survey, some issues were shared with Stats4SD and FAO (see Annex 1). The balance between cultivated and natural areas is addressed three times in: (i) the context description at the beginning, (ii) Step 1 “Synergies 2.4” and (iii) Step 2 “Natural vegetation trees and pollinators.” We understand that this aspect focuses on landscape level for Step 1, related to the farm environment, and on farm level for Step 2, related to the farm structure. The scoring data of these two criteria (indices) could be interpreted differently, so Stats4SD added the option “could not answer” to the “do not want to answer” response at our request. Also, FAO recognized that off-farm activities needed to be described in more detail. Time dedicated to Step 2 quality was constrained by the list of crops – this needs to be improved to avoid confusion. In the context of the study, pulses and vegetables play an important role in agricultural incomes, and only a clear reference to their scientific names would prevent time wasting.

The survey, which included 200 households, took place from 11 December 2023 to 22 January 2024. The draft list of survey households was adapted based on the availability of both the man and the woman of the household. As farmers have, on average, three different fields – often dispersed and far from the house – one field per farm was selected for soil health assessment with the help of a hand-drawn map. This map with cardinal points indicates the location, size and walking time from the house of different fields (Figure 2). This map will also be very relevant for preparing future questions on main land valorization (Step 1) and incomes (Step 2).



a) 4 to 6-hour survey on tablet with both the man and the woman of each household; b) Participatory hand-drawn map for fields’ location; c) Difficult access to field for soil sampling.

Figure 2. Tablet, map drawn by hand, and field access

Photos by Patrice Autfray

2.2 Selection of farms

For this TAPE farm sampling, we selected 200 households from the 400 households that were surveyed in August 2023 during the CIRAD ArtDev socioeconomic survey (Grislain et al. 2024). We selected the 200 households at random after filtering out those that did not fulfil the following conditions: (i) availability of both the man and the woman per household; (ii) a residency period of at least three years; and (iii) a minimum cultivated area of 0.2 ha. The idea was to link our TAPE survey to the previous study by keeping the same farm code.

These 200 households belong to four contrasting municipalities of three districts in eight villages. These villages differ in their level of progress in the agroecological transition, according to the experience of ProSoil, to ensure comparability 50 farms per selected per municipality.

2.3 Soil sampling and analysis

For each selected farm, a soil sampling was done on a systematic homogenous area of 1,000 m^2 at two depths: 0–20 cm and 20–50 cm (Figure 3).

Figure 3. Scheme of soil sampling according to ICRAF methodology

Photos by Patrice Autfray

A low-resolution photo of the soil samples had been taken of the 300–500 g of air dried and sieved 2 mm soil and uploaded to the ODK data collection tool. A KEPHIS import permit was obtained by CIFOR-ICRAF Soil and Land Health Laboratories in Nairobi, Kenya. To finish soil procedure exportation in Madagascar, it took around three months.

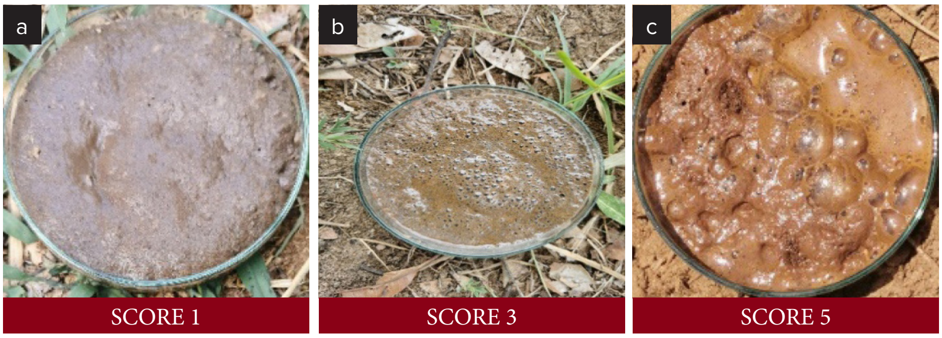
2.4 Soil health assessment

The soil health assessment from the Latin American Scientific Society for Agroecology (SOCLA) (Tittonell 2014) is based on applied methods to include farmers' participation. We adapted this methodology in advance with real tests involving five farmers to: (i) overcome weather conditions.

(i) the survey was conducted from the beginning of the full rainy season; (ii) be year-based; and (iii) add scientific knowledge. The assessment took around 45 minutes as some indicators required visual appreciation of the sampled soil. In Annex 2, there is a detailed description of the 10 soil health indicators applied in this study.

Table 3. The 10 soil health indicators

No.	Indicator	Assessment
1	Soil structure	Visual based
2	Soil compaction	By question
3	Soil depth	By question
4	Status of residues	By question
5	Soil colour	Visual based
6	Water retention	By question
7	Soil cover	By question
8	Erosion	By question
9	Invertebrates	By question
10	Microbiological activity	Visual based



a) No or very little soil effervescence in 1 minute; b) Medium soil effervescence in 1 minute;
c) Very high soil effervescence in 1 minute.

Figure 4. Soil health indicator N°10: In-situ soil peroxide test in petri dishes after a 2 mm topsoil sieving

Photo by Patrice Autfray

2.5 Data management and statistical analysis

The data treatment and analysis were conducted by Stats4SD, which provided a platform of all results from one month after applying the 200 questionnaires. Apart from a correlation between CAET scores and performance scores, households were analysed based on categories summarized in Table 4.

Table 4. The factors compared in the TAPE survey, their modalities and farm number

Factor		Number
CAET class	>60 (in transition to agroecology)	22
	50-60 (incipient transition)	46
	40-50 (low level)	94
	30-40 (very low level)	34
	<30 (non-agroecological)	4
Municipality	Belobaka	50
	Katsepy	50
	Manerinerina	50
	Tsaramandroso	50
Farm type	Small & young (SY)	56
	Small & intensive (SI)	44
	Medium & pluri-active (MP)	24
	Medium & high number of family members (MF)	60
	Large (LA)	16

Source: Patrice Autfray and Nasandratra Ravonjiarison

For the representation of the 10-dimension scores (Step 1), the box-violin plots were chosen to provide four major pieces of information:

- Distribution density, which could be compacted or spread.
- The interquartile range box showing the interval in which 50% of the data were concentrated.
- The median value.
- The vertical line shows 1.5 x interquartile range; dots show the extreme values.

All extreme values (or outliers) were conserved. Farm structure differed greatly – e.g. farm productive area from 0.2 ha to 35 ha, thus providing a large variation of values. All ANOVAs (analysis of variance), pair-wise comparisons of the two groups were performed on mean values, when possible, or on median values to avoid the impact of outliers. For CAET values linked with the performance (Step 2), we chose scatter plots to show the main correlations. On each adjustment, a statistical test was applied.

3 Results and discussion

3.1 Step 0

3.1.1 The agroecological zone

The Boeny Region (equivalent to a province) comprises 31,000 km^2. Mahajunga, its capital, is the fourth-biggest town in Madagascar, with about 250,000 inhabitants. Situated at the foot of Madagascar's highlands and open to the Mozambique Channel, the topographical configuration of the Boeny Region is based on the concentric bands of geological units that form vast tabular shapes (plateaus), with an average altitude of less than 800 m, and plains along the major rivers and the seacoast (CREAM 2013). These plains are along (i) the Betsiboka River (Madirovalo, Ambato-Boeny, the great plain of Marovoay); (ii) the Kamoro River (Anjiajia); and (iii) the Mahavavy River (the plains of Mitsinjo and Namakia). The sandstone massif of Ankarafantsika constitutes a major water tower for the Marovoay plain, where a natural forest covers an area of 135,520 ha. Thus, the hydrology of the Boeny Region is dominated by Lake Kinkony – Madagascar's second-largest lake after Lake Alaotra – which covers an area of 15,000 ha. There are also the following major rivers: Betsiboka (525 km), Mahavavy (165 km) and Mahajamba (300 km). Regarding land use, in 2016, the total surface area of natural ecosystems was estimated at 2,683,826 ha, or 88% of the region's total surface area. More specifically, in 2016, savanna occupied 65% of the region's total surface area, the forest ecosystem 15%, cultivated land 12% and mangroves 2%, while built-up areas represented less than 1% of the total surface area.

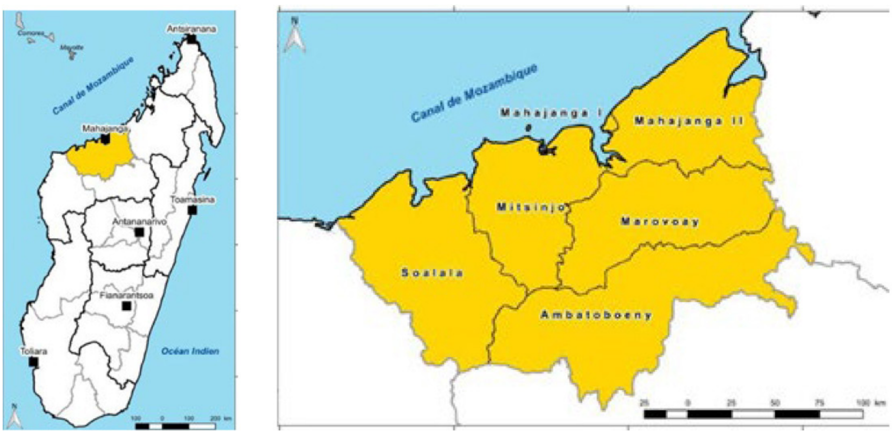


Figure 5. Location of the Boeny Region in Madagascar

Source: SRAT 2016

The region has a dry tropical climate, with a seven-month hot season and a five-month rainy season. The rainy season generally lasts from December to April, and the dry season from May to November. The average temperature is 26°C during the dry season, and 28°C during the hot and humid season. Total average rainfall varies from 1,000 mm to 1,300 mm with a gradient from the coast to inland areas (CREAM 2013).

Five main types of soil characterize the pedology of the region:
- the soils of the rainfed ferruginous domain on hillsides and plateaus
- the hydromorphic soils in lowlands and plains
- the *baiboho*, located between the lower hills and plateau and the rivers, are specific fertile colluvial and alluvial soils, with a surface area of 250,000 ha
- calcareous and lithic soils near the coast on gently sloped landscapes
- saline soils close to the coast

The Boeny Region offers fairly favourable natural conditions for cattle farming. It is made up of savanna plateaus, depressions containing numerous waterholes, coastal plains with grasslands, and *baiboho* areas offering vast pastures (CREAM 2013). The livelihoods of the local people, called *sakalava*, are mostly based on cattle rearing. Fishing activities are locally important and comprise industrial maritime fishing, coastal fishing, aquaculture, rice-fish farming and freshwater fishing.

Given the wealth of water resources, fish production in the Boeny Region plays an important role in the local economy. The coastal communities have almost 630 km of coastline. Inland water bodies account for 2.5% of the region's surface area, or 75,268 ha. The mean population density is low, at around 30 inhabitants per km^2 in 2018. This region is characterized by a high level of rural migrants coming from other parts of Madagascar. Roads, as in other regions in Madagascar, are particularly bad, so market access is subject to great variability among municipalities. Field access is often difficult outside the homesteads. Small farms dominate with a mean productive area of 1.5 ha with 5 persons and, on average, 2.5 active persons. Larger farms typically use workers from the smaller ones.

Lowland rice represents more than 50% of the total productive area. Rice is a staple food, as in other regions in Madagascar, and can be cultivated in three seasons with flooded conditions: the first from November to March, the second from March to May, and the third season from May to July only under irrigated schemes. Upland rice is barely cultivated. Bovines (on average, three animals per farm) are used mainly for field work and transportation. Free grazing dominates during the dry season, with access to crop residues for farms specialized in livestock production.

A wide range of pulses are cultivated and valorized, particularly in the temporarily flooded fertile areas. The three main species, each with diverse varieties, are:
- *Vigna unguiculata*, with the black-eyed variety dedicated to export in informal contract-farming schemes, and a red one typically for own consumption
- *Vigna radiata*, with small green grains and a short cycle, like *Vigna unguiculata*
- *Vigna umbellata*, with medium-size yellow or red grains and a long cycle

Pesticide use is common in annual commercial crops, mainly maize and pulses. On maize, fall armyworm (FAW) is the main pest, while different insects attack the *Vigna* pulses. Pesticide use could be seen as the main challenge for the agroecological transition as there is no administrative control of their quality. Insecticides are freely sold on the market without company tracking (Autfray et al. 2023).

The CIRAD-ArtDev socioeconomic survey provided useful information for agricultural systems' overall characterization (Grislain et al. 2024). The average number of annual plants cultivated per farm is, on average, four. Only a third of farms produce organic manure. One farm in two uses fertilizers – with an average amount of 10.8 kg ha^{-1} – and 85% of farms use pesticides. Biopesticides are applied on only 3% of the total area. The use of chemical fertilizer is scarce. As the quantities of organic matter available are low – on average, 800 kg to 850 kg per farm – soil fertility management is mainly based on natural processes during flooding events in lowlands, and during soil mining agriculture in the upland domain.

Livestock farming is an important part of the production system for many farms. The average value of livestock reared was around 4.1 million ariary (ca. USD 900) per farm.

For cattle, there are three main types of management linked to their size:
- *Sarety* – two animals, plow/cart; individual management household compound
- *asesy* – 3 to 30 animals, lowland rice preparation / savings; collective management village
- *tondraka* – 30 to 200 animals, mainly savings; outside the village, 39% of the fields and 38% of the area are cultivated on a land-lease basis.

Intensive cropping in the highland region is applied on lands and plots around farmers' homesteads or family compound homes. In these conditions, farms are specialized in vegetables and tree fruit production around more urbanized areas. Fruit trees are mainly mango trees. Various other trees were promoted by different environmental projects to counteract natural degradation for charcoal production. The three main genera are *Acacia, Albizia* and *Eucalyptus*.

3.1.2 Agricultural systems

Regional variation occurs within the four surveyed municipalities (communes) and eight selected counties (*fokontany*) with the following characteristics:
- Belobaka: The most intensive in terms of manure and fertilizer use, linked with agricultural incomes of fresh products (fruit trees and vegetables sold in the regional capital); also, the proximity of the city Mahajanga allows for free access to commercial organic products (e.g., from Madacompost) or organic by-products from sugarcane companies.
- Katsepy: Higher level of pluri-activity, mainly due to fishing. Therefore, the level of income from crops is low at less than 20% of total income (more than 50% for the three other municipalities).
- Manerinerina: Access to large areas of *baiboho* allows for the production of pulses for international and national markets; largest farms, some of which use motorization for land preparation.
- Tsaramandroso: The poorest municipality of the four studied, characterized by the dominance of medium-sized farms with high number of family members and lots of recent migrants; compared with Manerinerina, less access to fertile soils.

Pesticides are used on 74%, 57%, 98%, and 95% of the farms in the Belobaka, Katsepy, Manerinerina and Tsaramandroso municipalities, respectively. The recent CIRAD-ArtDev socioeconomic survey determined a farm typology based on 400 farms using a principal component analysis and a hierarchical ascendant classification of structural variables. It found five farm types, whose main characteristics are mentioned in Table 5. These types vary among the municipalities (Table 6).

Table 5. Main capital assets and annual incomes of the five farm types in the Boeny Region

Farm type		Small & young (SY)	Small & intensive (SI)	Medium & pluri-active (MP)	Medium & high number of family number (MF)	Large (LA)
% (n=400) CIRAD-ArtDev		45%	14%	12%	25%	4%
% (n=200) TAPE		28%	22%	12%	30%	8%
Human & social	Age: Head of the farm (male or female)	40	44	42	54	45
	Farm residency (years)	15	20	16	28	23
	Education level (years)	5	7	4	2	5
	Persons (number)	4	5	6	7	7
	Active persons in agriculture (number)	2	2	2	4	4
	Farmer organizations (number)	0.4	1.8	0.4	0.3	0.7
Natural	Productive area (ha)	1.11	1.37	1.50	1.85	7.04
	Productive rent area (ha)	0.56	0.43	0.59	0.55	1.45
	Productive area with pulses (ha)	0.27	0.25	0.45	0.53	2.88
	Lowland rice (ha)	0.56	0.56	1.06	1.09	4.77
Physical	Livestock value (K ariary)	1,824	3,699	5,835	5,296	28,289
	Machine value (K ariary)	195	504	361	453	3 501
Incomes	Off-farm incomes from agriculture (K ariary)	359	87	58	865	127
	Non-agricultural off-farm incomes (K ariary)	803	878	4 590	390	1 236
	On-farm incomes (K ariary)	2,568	5,370	5,020	4,239	20,145
	Total farm incomes (K ariary)	4,284	7,564	10,162	6,026	23,390

Source: Adapted from Grislain et al. 2024

Table 6. Farm types among the municipalities

Municipality	Small & young (SY) in %	Small & intensive (SI) in %	Medium & pluri-active (MP) in %	Medium & high number of family members (MF) in %	Large (LA) in %
Belobaka	50	29	5	16	0
Katsepy	41	15	31	11	1
Manerinerina	49	5	7	31	7
Tsaramandroso	35	10	13	38	1

Source: Adapted from Grislain et al. 2024

3.2 TAPE Step 1: CAET

With an average CAET score of 52.30, most of the assessed households are at an incipient stage of agroecological transition. This result is relatively homogenous across all 10 elements of agroecology (Figure 6). Higher CAET scores were only observed for the agroecology elements culture and food traditions, as well as for Human and social values (with average scores of 58.90 and 58.79, respectively). This indicates that the sociocultural dimension of agroecology is more prominent in Boeny than the agronomic and environmental aspects. The lowest average CAET score (46.91) was observed for the Co-creation and sharing of knowledge element. This suggests that additional efforts are needed to empower farmers to play a more important role in agroecological innovation and transmitting knowledge.

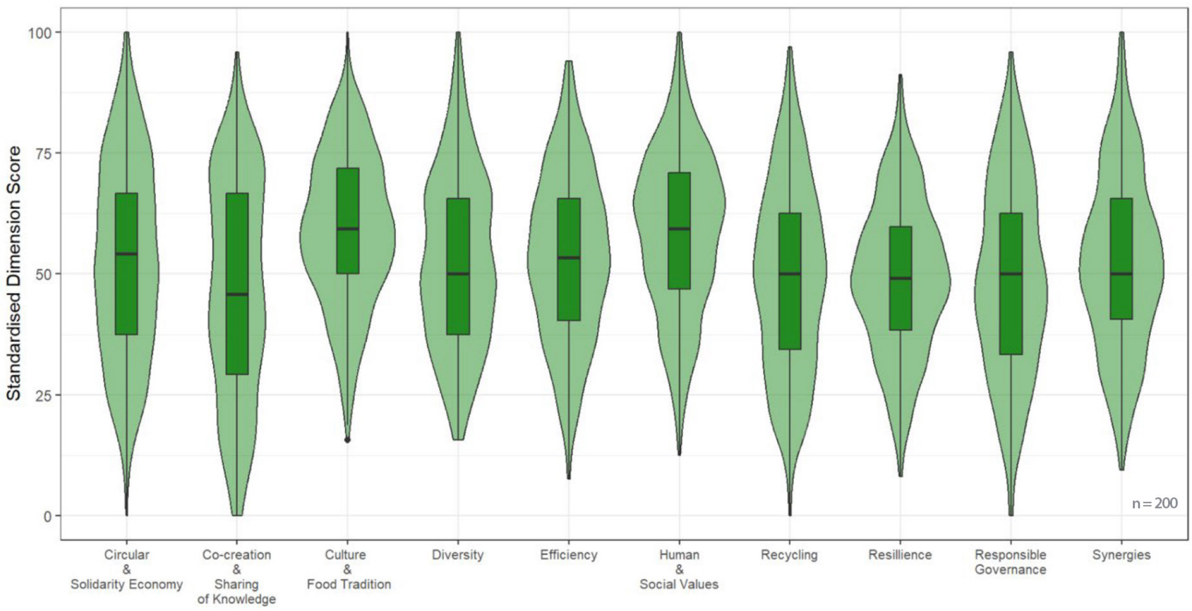


Figure 6. Violin plots of CAET scores for each of the 10 elements of agroecology

Source: Adapted from Alex Thomson

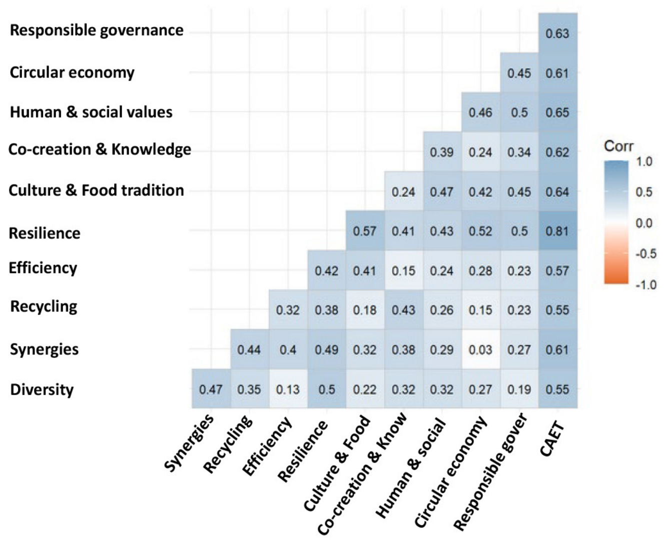


Figure 7. Correlations between the 10 elements of agroecology and the CAET scores

Source: Adapted from Alex Thomson

Figure 7 indicates that the 10 elements of agroecology are all positively correlated with the CAET score, showing correlation values ranging from 0.55 to 0.81. Interestingly, the Diversity element – which integrated crops, livestock, trees and farm activities – was more correlated with the Resilience element (0.50), which included farm behaviour stability, suggesting an impact of crop diversification on farmer livelihood stability. The Synergies element (synergies between crops, livestock, trees and natural areas) was more correlated (0.44) with Recycling (biomass, water, seeds and energy). The Recycling element was more linked with Co-creation and sharing knowledge (0.43). The Efficiency element based on crop inputs self-production at the farm level showed a stronger link with the Resilience element. The Culture and food tradition element was more linked with the Resilience element (0.57). The Human and social values and the Culture and food traditions elements were linked (0.47). The Circular and solidarity economy element was more linked with the Human and social values element. Finally, Responsible governance was more correlated with Resilience.

3.2.1 Effect of farm type

According to the farm typology established by the previous socioeconomic survey, significant differences among farm types showed that the SI type (Small intensive) had the highest scores (51.9) compared with the SY type (Small and young) (45.2), the MP type (Medium and pluri-active) (46.4) and the MN type (Medium and high number of family members) (45.9) (Table 7; Annex 2).

The LA type (Large) provided the highest scores for the elements Diversity (53.5) and Synergies (52.1), while the score was low (35.9) for the Recycling element. The elements Efficiency, Culture and food tradition, Human and social values, and Responsible governance did not show significantly different scores among the farm types. The SI type farms displayed high scores for the elements Recycling (45.7), Co-creation and sharing knowledge (49.9), and Circular and solidarity economy (51.1).

Table 7. Results of the ANOVAs on the CAET and the 10 TAPE elements among the types of farms for both the OG and PG

Element	p-value	Farm type				
		Small & young (SY)	Small & intensive (SI)	Medium & pluri-active (MP)	Medium & high family number (MF)	Large (LA)
CAET	0.001	45.2	51.9	46.4	45.9	48.9
Diversity	<0.0001	40.5	52.1	46.8	48.0	53.5
Synergies	0.014	45.6	53.1	48.4	46.5	52.1
Efficiency	0.352	54.5	53.6	55.7	51.0	47.9
Recycling	0	34.5	45.7	45.0	38.4	35.9
Resilience	0.005	45.6	52.1	45.8	45.6	49.4
Culture and food tradition	0.132	52.8	56.3	51.1	51.1	56.4
Co-creation and sharing knowledge	<0.0001	33.4	49.9	38.1	35.2	45.3
Human and social values	0.2	56.6	60.6	57.7	55.8	59.7
Circular and solidarity economy	0.045	43.8	51.1	36.6	45.6	44.5
Responsible governance	0.412	44.7	45.0	39.2	41.5	44.5

3.3 Step 2: The multidimensional performance of agroecology

3.3.1 CAET and economic performance

Overall, the results show a significantly positive correlation between agroecological integration and economic performance. On average, more agroecological households have a higher net income and higher overall farm productivity. The correlation between CAET scores and value added is not statistically significant, albeit also positive.

Figure 8 shows the significantly positive correlation between CAET score and productivity. This correlation is strongest for value of crops produced and value of livestock sold. No significant correlation was observed between CAET scores and the value of forestry products. This indicates that a more deliberate focus on the valorization of timber and non-timber forest products could further increase the contribution of agroecology to economic development in rural Madagascar. Regarding CAET scores for individual agroecology elements, it becomes apparent that the Diversity, Recycling, and Resilience elements – hence elements closely linked to agroecological farming practices – are particularly strongly correlated with increased productivity (Figure 8).

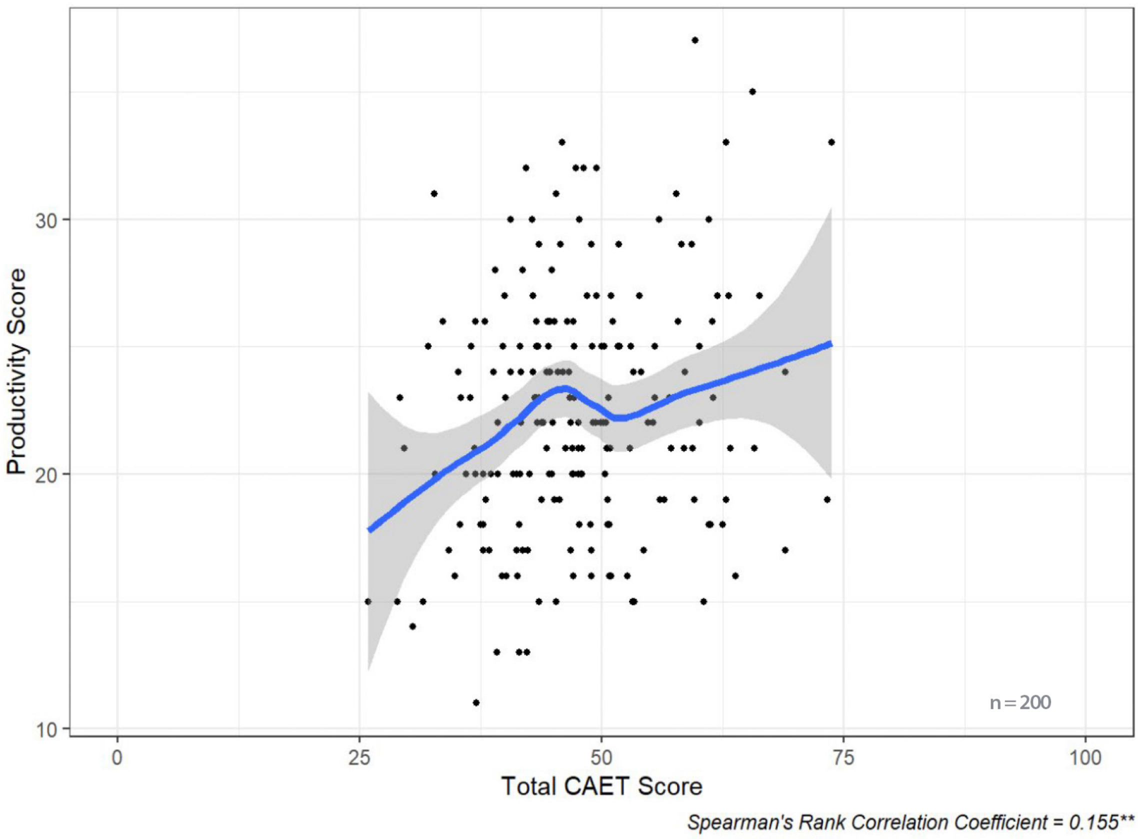


Figure 8. Correlation of CAET score with the composite productivity score, combining indicators for crop, livestock and forestry productivity

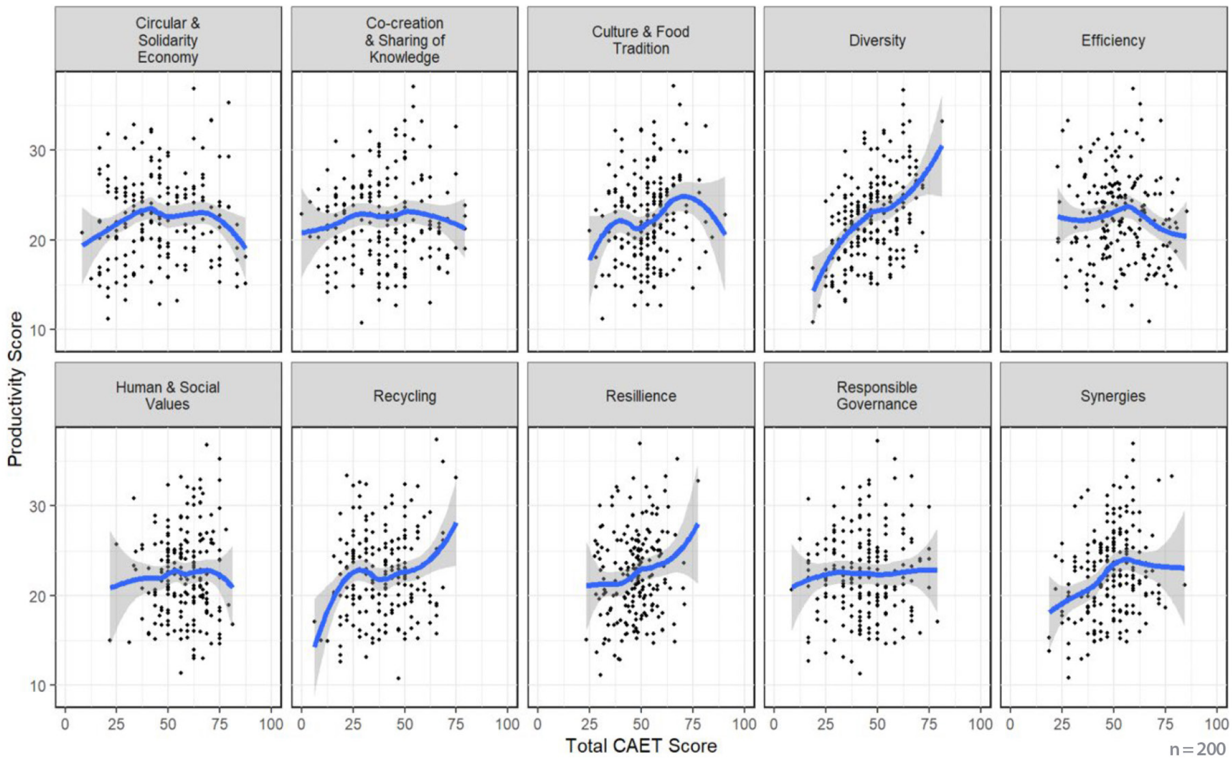


Figure 9. Correlation of CAET scores for each of the 10 elements of agroecology with the composite productivity score, combining indicators for crop, livestock and forestry productivity

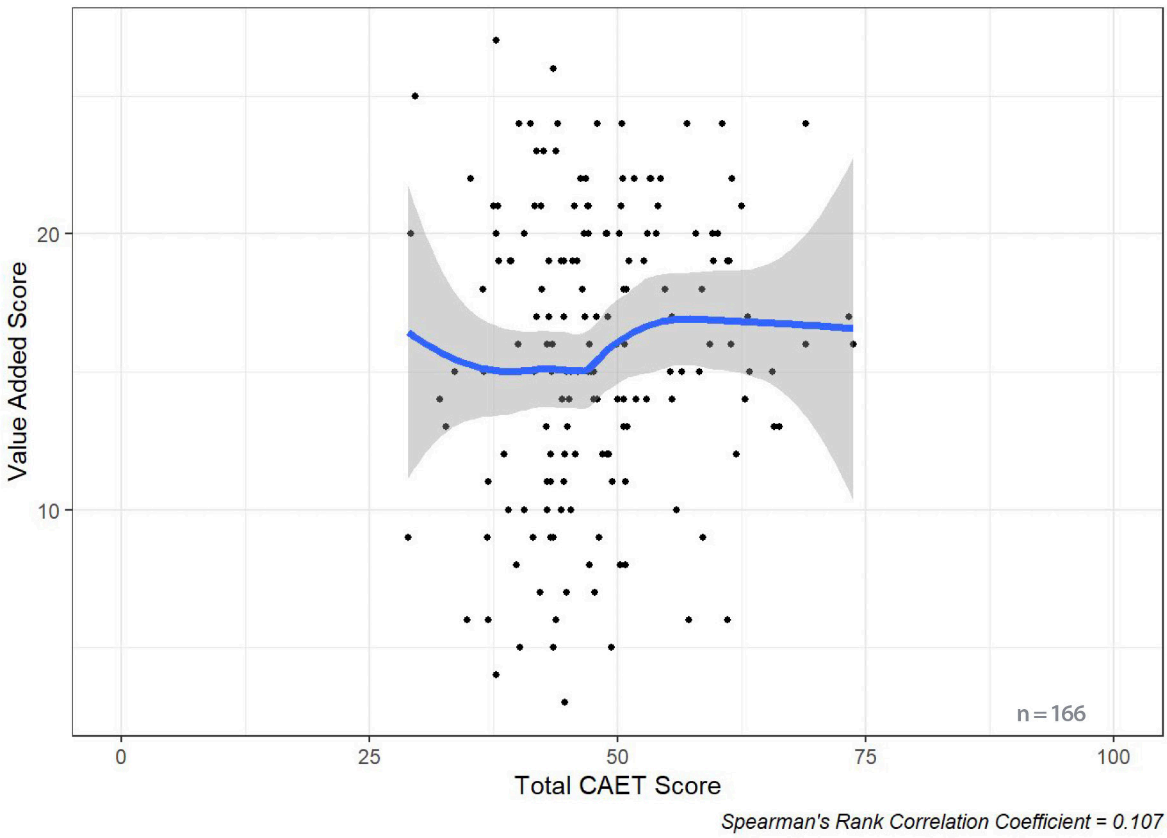


Figure 10. Correlation of CAET score with the composite value added score

The value added represents the gross value of agricultural production based on agricultural incomes and revenues from other household activities minus production cost. Some data were difficult to assess, and we retained 166 farms (34 missed out). This criterion was not significantly correlated with CAET scores (Figure 10). This notwithstanding, individual elements of agroecology – such as Efficiency, and Culture and food tradition – do show a significant positive correlation with the value added (Figure 11). On the other hand, Co-creation and sharing of knowledge appears to negatively affect value addition, possibly indicating that the time investment by farmers in knowledge generation does not pay off under the conditions prevailing in the Boeny Region.

By asking how farmers perceived their current value added compared with three years ago, we found values from 1.8 (farms with CAET score <30) to 2.8 (farms with CAET score >60) (Figure 12).

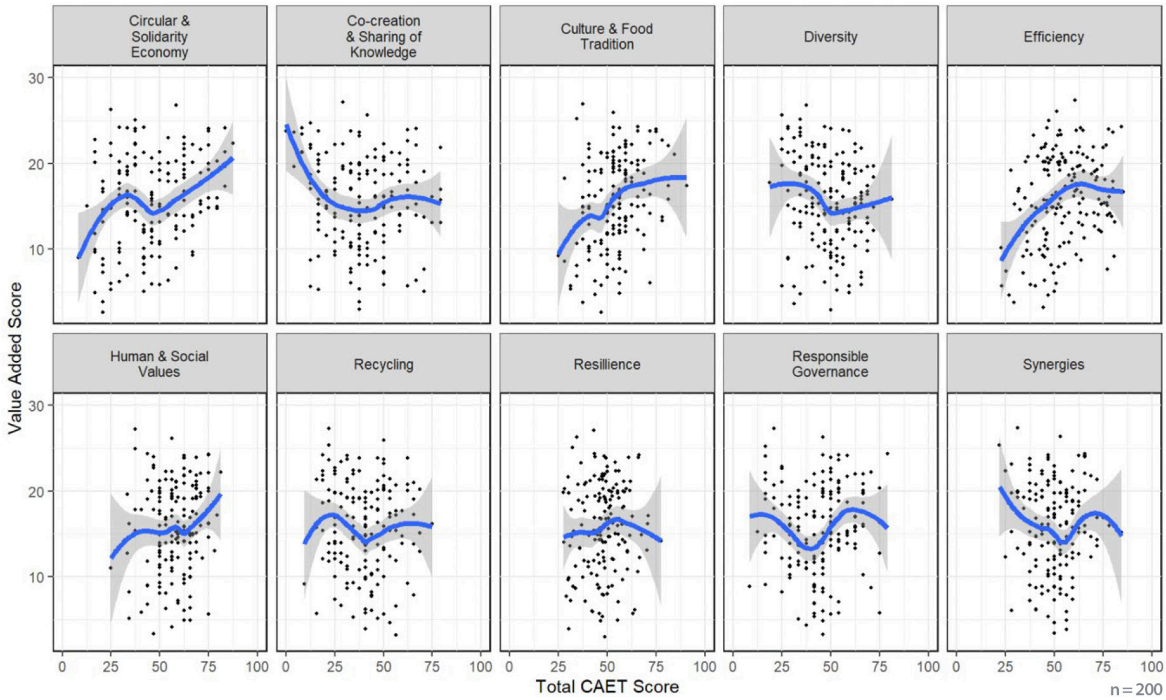


Figure 11. Correlation of CAET scores for each of the 10 elements of agroecology with the composite productivity score, combining indicators for cop, livestock and forestry productivity

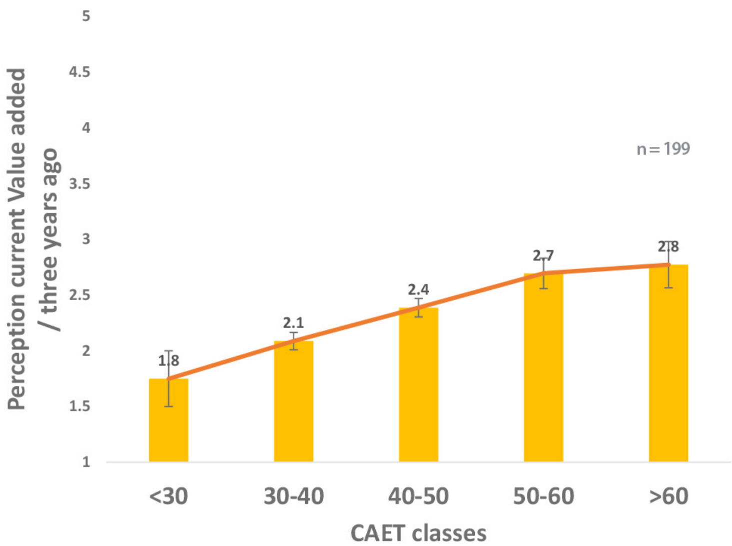


Figure 12. Perception of the current farm value added compared with the last three years among the five CAET classes; 1= much less, 2= less, 3 = same, 4= more, 5= much more

The four farms with a CAET <30 (non-agroecological) score are very small, with a mean area of 0.80 ha, while the mean area for the classes 30–40, 40–50, 50–60 and > 60 CAET were 2.59 ha, 2.46 ha, 2.05 ha and 4 ha, respectively. But no relationship was found between CAET and farm size.

Economic poverty is highly prevalent among rural farmers in the Boeny Region. Around 42% of the assessed households live below the international poverty line of USD 2.15 per day, which represents around 3,474 K ariary per year per person. Hence, it is particularly promising to see that the results show a significantly positive correlation between CAET scores and net household income (Figure 13). In particular, the elements of Diversity and Synergies contribute to this positive correlation (Figure 14). This suggests that optimizing synergies among diverse components of diversified farms is a viable approach to boost rural incomes in Madagascar.

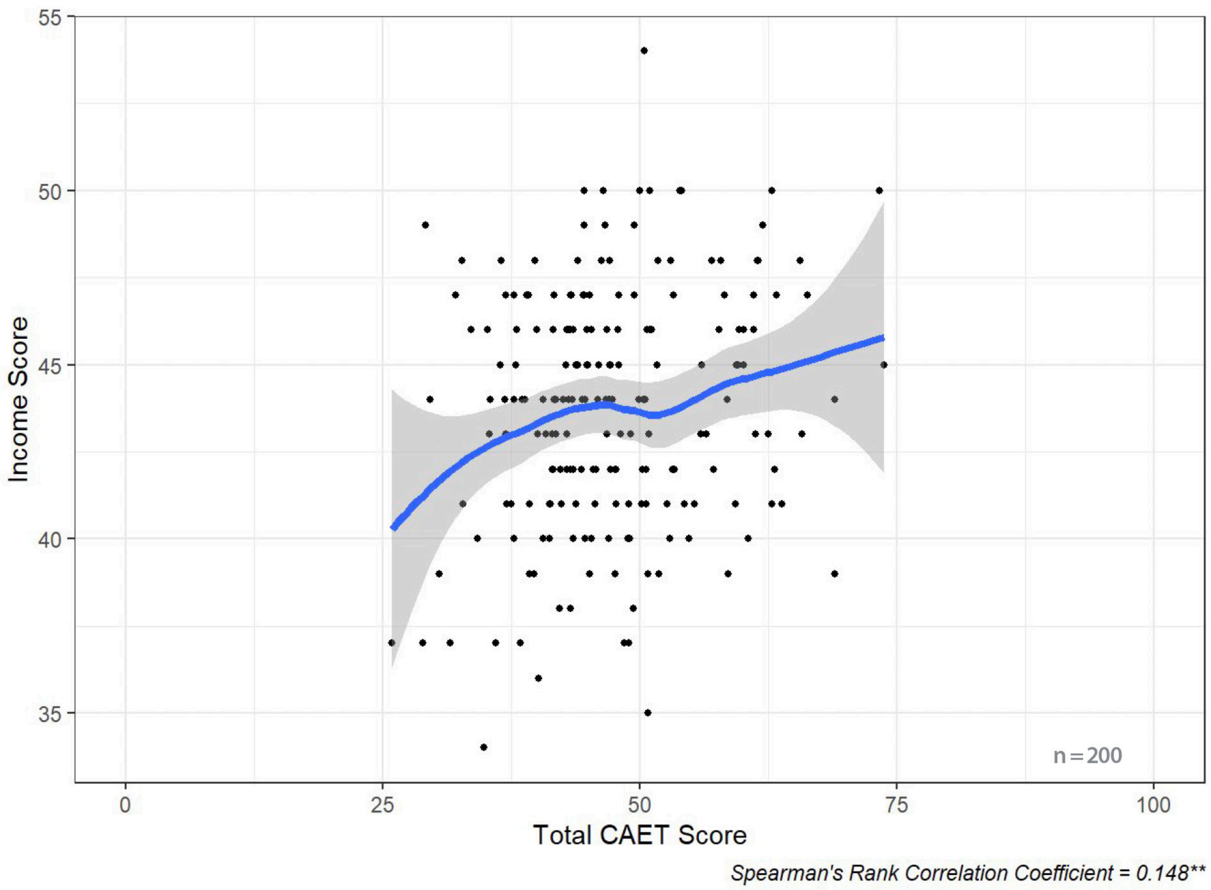


Figure 13. Correlation of CAET score with the composite income score, combining indicators for revenues from crop, livestock product, animal and forestry product sales with indicators income from other activities, total wages expenditures, depreciation and financial expenses

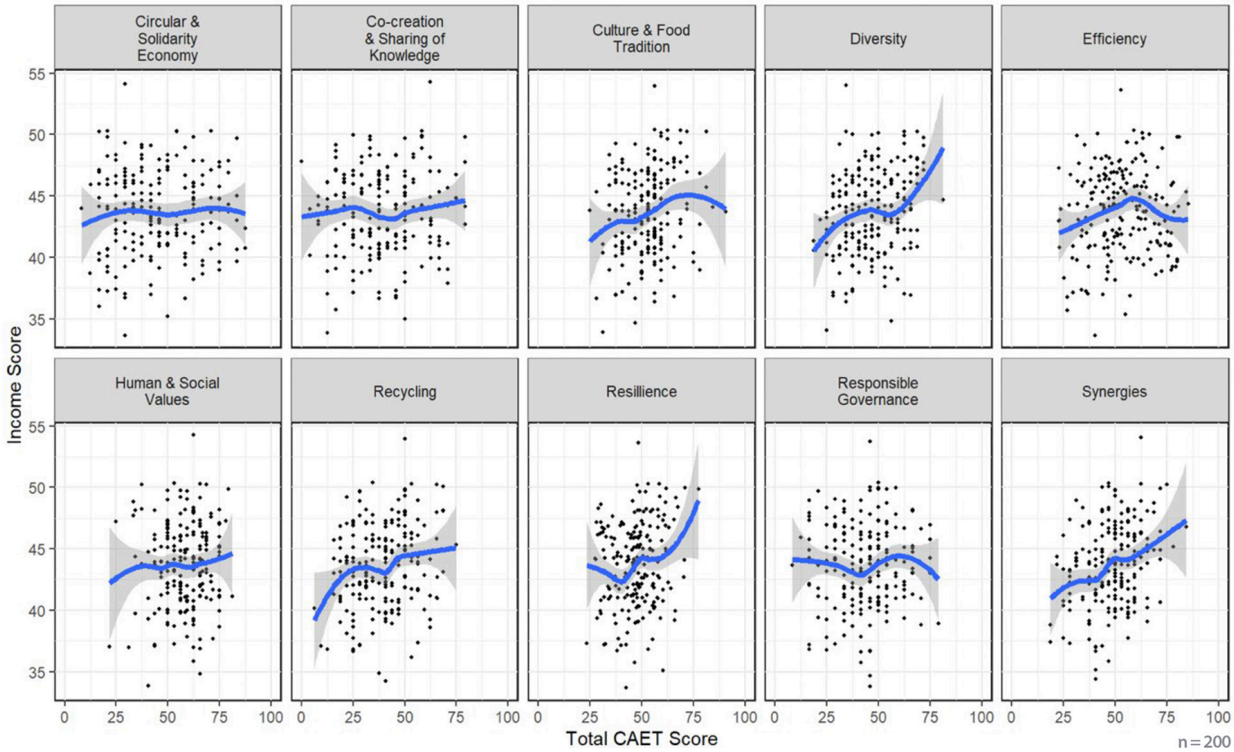


Figure 14. Correlation of CAET scores for each of the 10 elements of agroecology with the composite productivity score, combining indicators for revenues from crop, livestock product, animal and forestry product sales with indicators income from other activities, total wages expenditures, depreciation and financial expenses

3.3.2 CAET and environmental performance

The soil health assessment that was applied on a reference field on the farm was carried out using 10 in-situ indicators, with scores provided by the farmer on a scale from 1 (very bad) to 5 (very good). The occurrence of the 199 scores (one missing farm) for each soil indicator is presented in Figure 15, showing the dominance of Class 3, which represents a mean value.

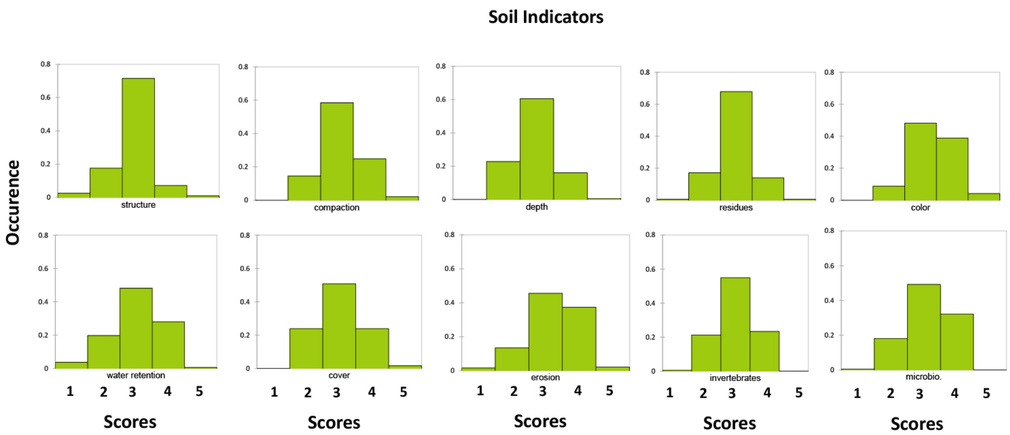


Figure 15. Occurrence of the 199 scores for each soil indicator

The correlation between CAET score and aggregate soil health score (Figure 13) and individual soil health indicators (Figure 14) shows a positive yet not statistically significant positive correlation. Thus, on average, farms with an advanced degree of agroecological integration showed reduced soil compaction and erosion while having improved water retention and a higher presence of invertebrates. Farms with a very low CAET score performed considerably worse than other farms on the status of residues, presence of invertebrates, and soil cover parameters. Overall, however, the correlation between CAET and TAPE soil health indicators is weak. Given that other performance indicators correlate significantly positively with CAET scores, the results from Madagascar suggest that agroecology is a viable approach for increasing farming system sustainability in rural Madagascar. Other approaches are similarly successful in achieving soil health but without creating other benefits such as increased economic viability, conserving agrobiodiversity, and improving food security and nutrition. Further, there may be a time lag between transitioning to agroecology and being able to measure significant improvements in soil health parameters. These conclusions are further substantiated by the results from the laboratory analysis of soil samples, which show no significant correlation between CAET scores and any of the physiochemical parameters assessed (Figures 16–21).

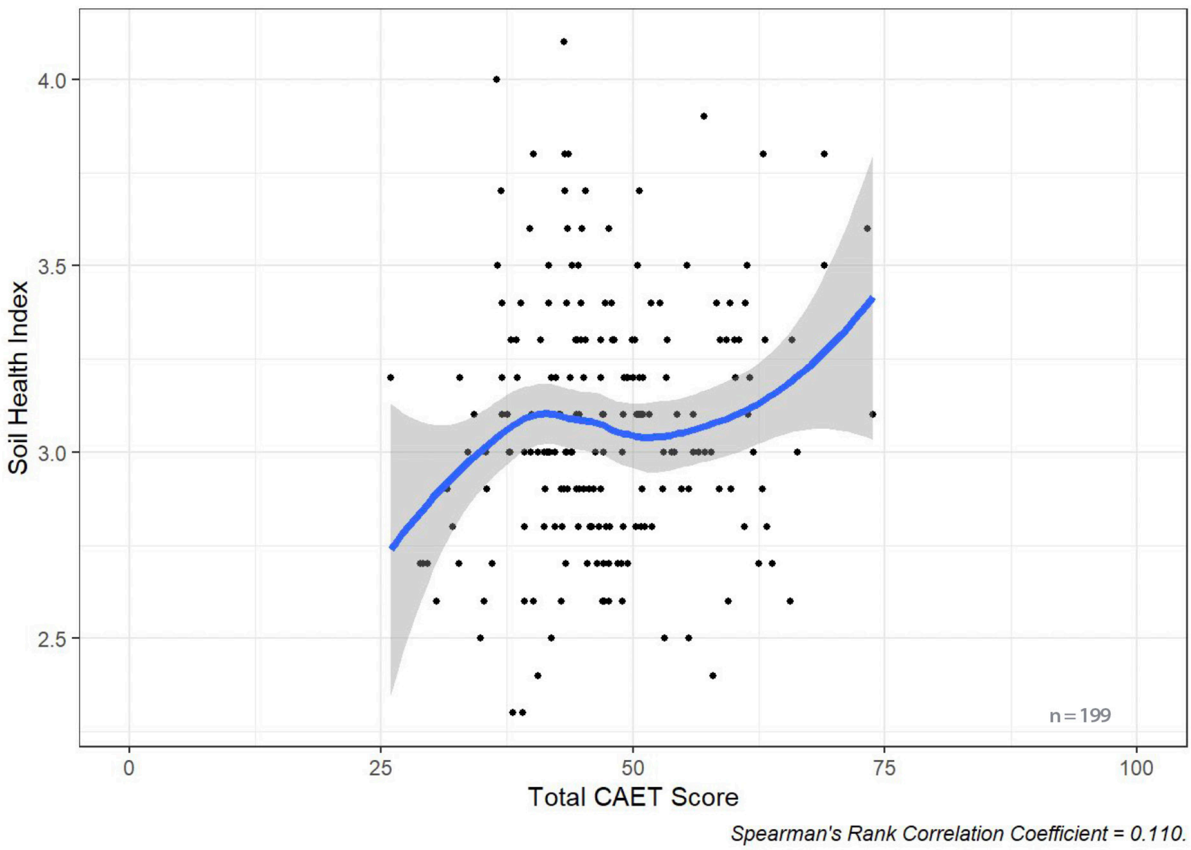


Figure 16. Correlation of CAET score with the composite soil health score, combining indicators for soil colour and odour; depth of superficial soil; microbiological activity; presence of invertebrates; soil compaction; soil cover; soil erosion; soil structure; status of residues; and water retention

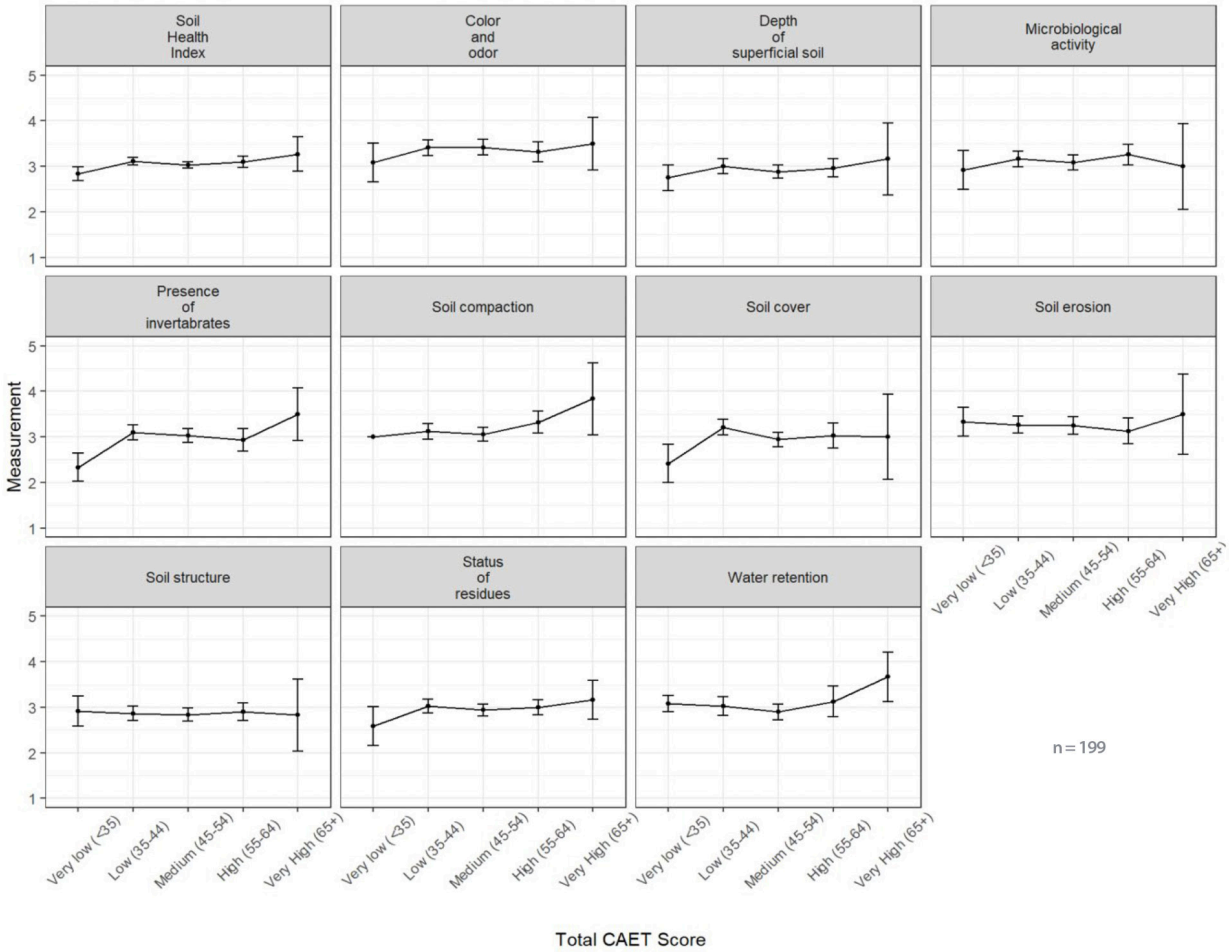


Figure 17. Correlation of CAET score with the individual soil health indicator scores of TAPE

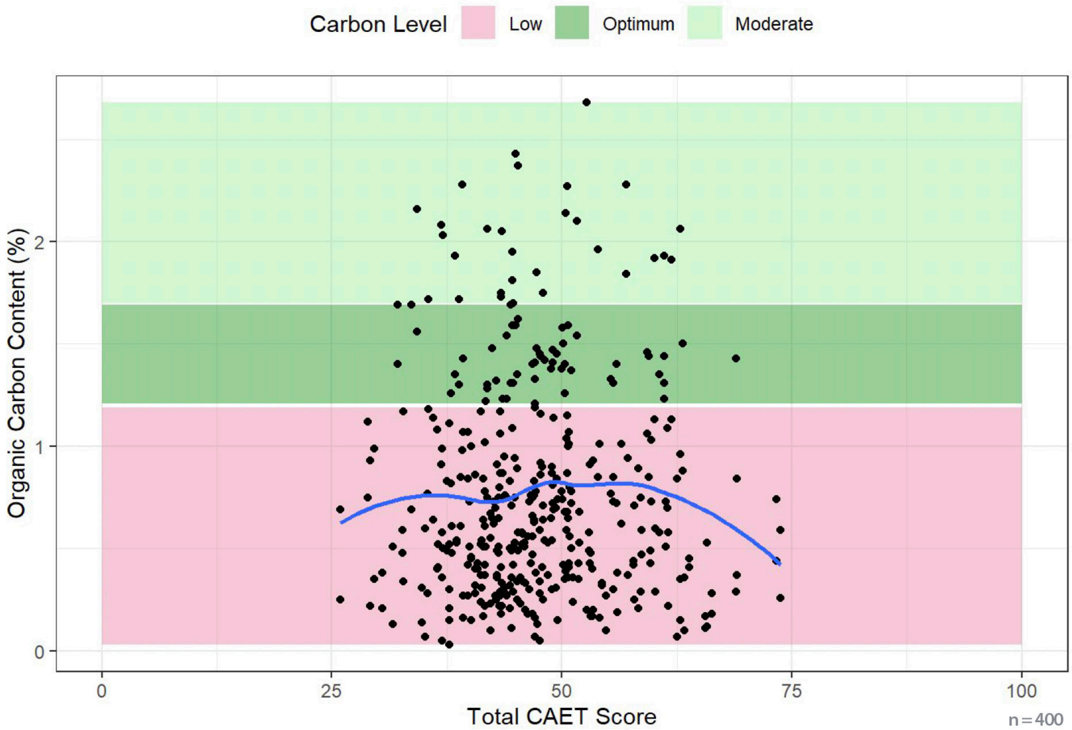


Figure 18. Correlation of CAET score with soil organic carbon content assessed through laboratory analysis following the LDSF protocol

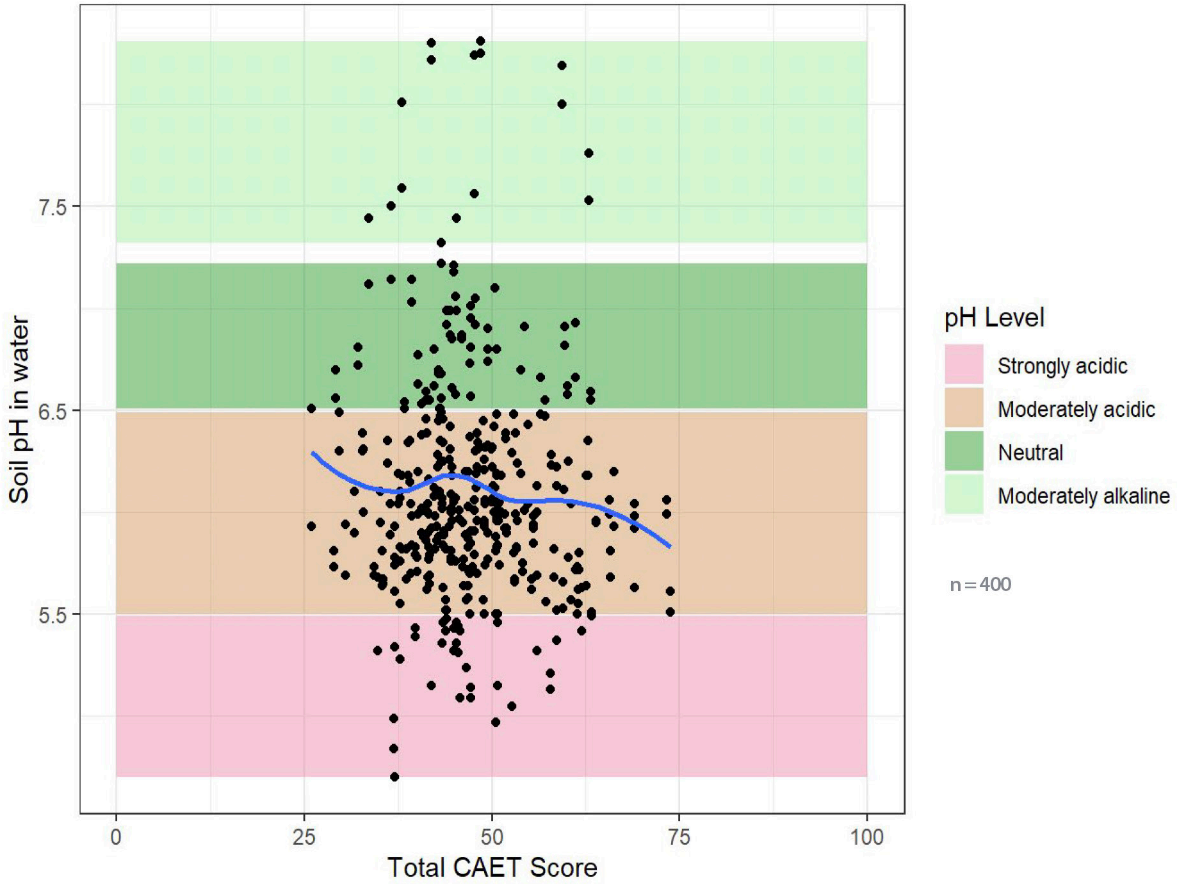


Figure 19. Correlation of CAET score with soil pH assessed through laboratory analysis following the LDSF protocol

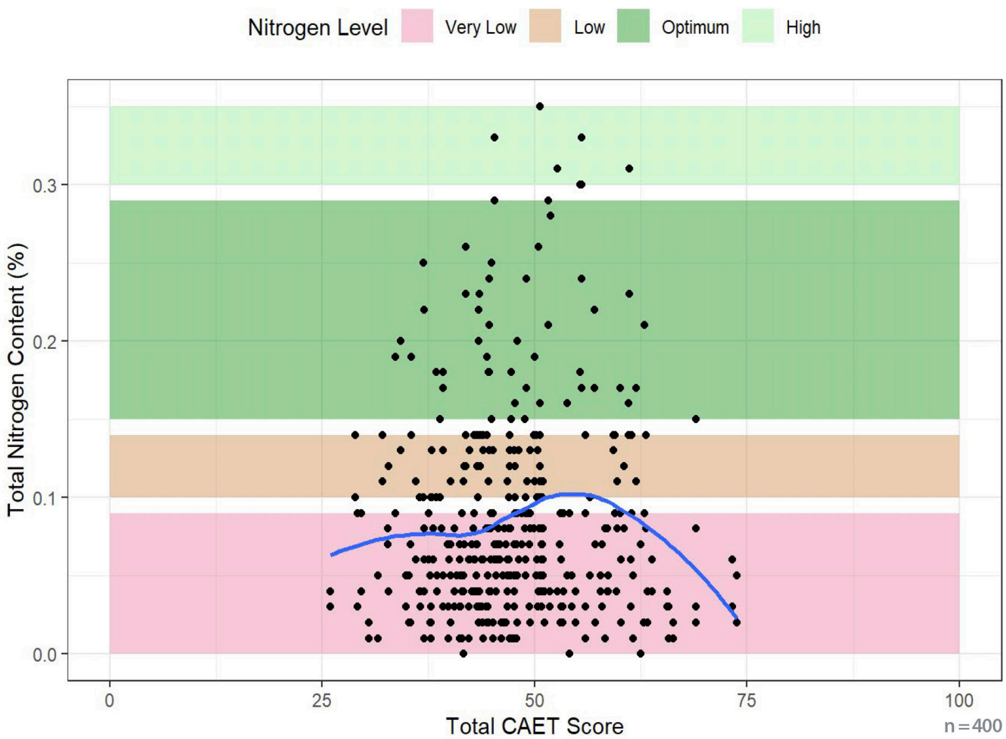


Figure 20. Correlation of CAET score with total soil nitrogen content assessed through laboratory analysis following the LDSF protocol

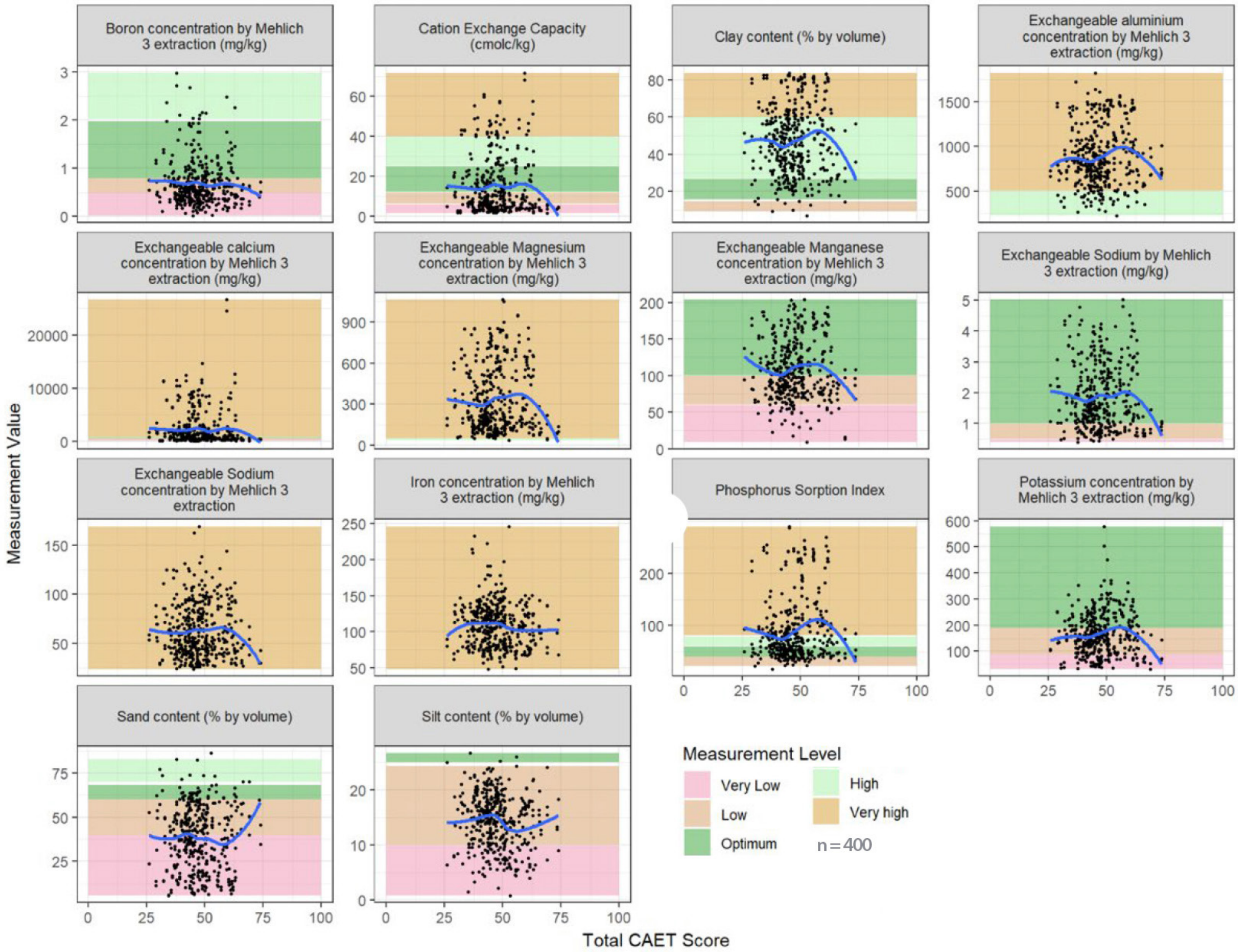


Figure 21. Correlation of CAET score with physiochemical soil health parameters assessed through laboratory analysis following the LDSF protocol

In addition to soil health TAPE assesses environmental performance through six indicators on agrobiodiversity. The aggregated results show a significantly positive correlation between CAET scores and farm performance on agrobiodiversity (Figure 22). Thus, on average, more agroecological farms have a significantly higher number of animal species and crop varieties as well as demonstrating significantly higher Gini-Simpson indices for crops, animals, and natural vegetation and pollinators. The composite agrobiodiversity score correlates significantly positively with the agroecology elements Diversity, Recycling, Resilience and Synergies. On farm level, the sociocultural and economic dimensions of agroecology appear to have limited correlation with protecting and restoring agrobiodiversity in the Boeny Region.

Figure 22. Correlation of CAET score with the composite agrobiodiversity score, combining indicators for crop, animal and natural vegetation diversity

3.3.3 CAET and social performance

Women's empowerment was assessed with the A-WEAI score (Abbreviated Women's Empowerment in Agriculture Index, IFPRI 2012). It measured the empowerment of women within the household according to their involvement in the following dimensions: productive decision making; decisions on income and assets; leadership; time use; and access to credit. While the results show a significantly positive correlation between CAET score and A-WEAI score, this is largely due to four households with a very low women's empowerment score that also show a very limited integration of agroecology (Figure 23). Among individual agroecology elements, Efficiency, Resilience, Human and social values, and Responsible governance show a positive correlation with women's empowerment (Figure 24). This highlights that the agency of women in farming is not just an important sociocultural concern but directly relates to agronomic dimensions as well. Results show no correlation between CAET scores and the Gender Parity Index (GPI; Figure 25), the youth emigration score or on youth employment score. This further highlights the importance of further strengthening gender equity and youth empowerment efforts in agroecological interventions to increase agroecology's contribution to sustainable development.

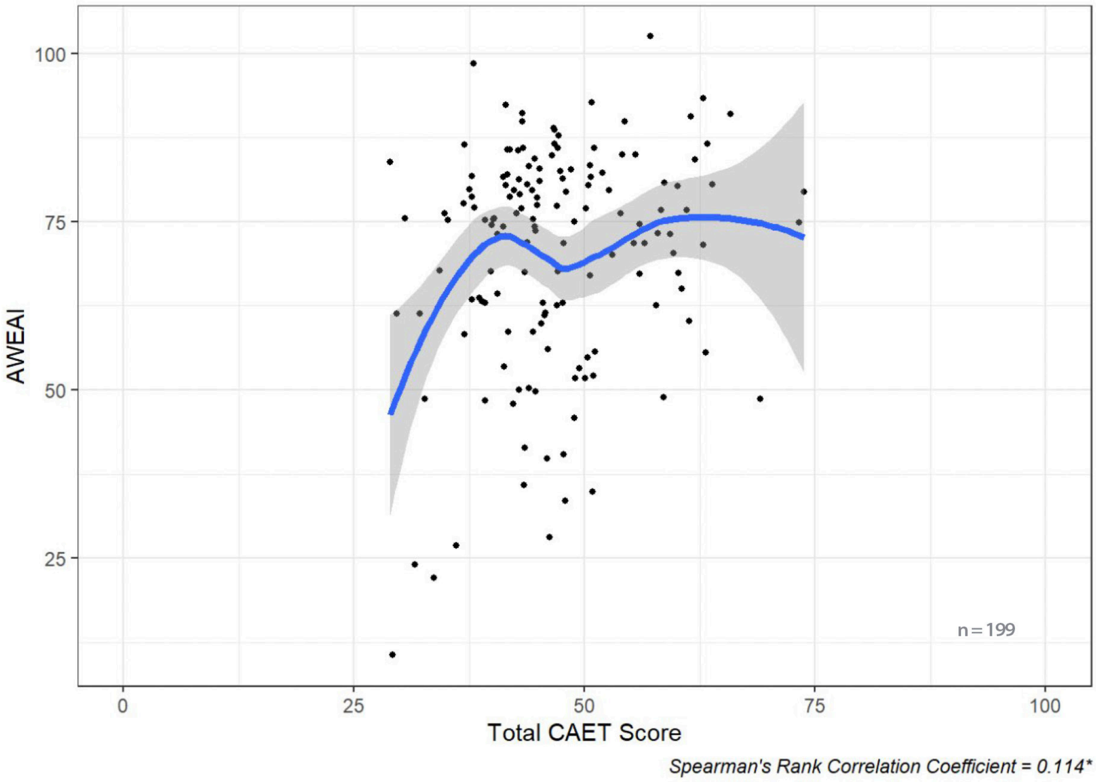


Figure 23. Correlation of CAET score with the Abbreviated Women's Empowerment in Agriculture Index (A-WEAI)

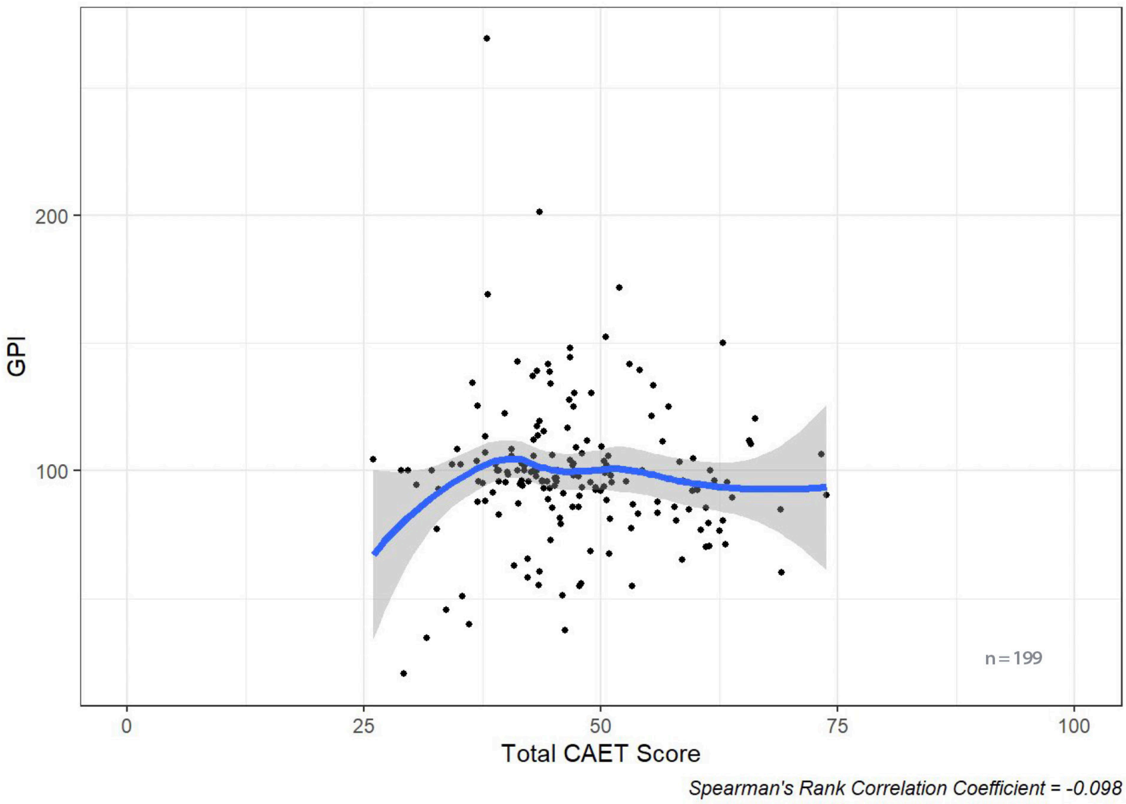


Figure 24. Correlation of CAET score with the Gender Parity Index (GPI), measures the relative access to education of males and females, with equality represented by a value of 100; more women's empowerment for values > 100; and less women's empowerment for values < 100

3.3.4 CAET and health and nutrition performance

Dietary diversity was estimated during an exhaustive, one-day inventory of eaten products on a scale of 0% to 100%. Further, food security was assessed through the Food Insecurity Experience Scale (FIES) module. Finally, we assessed food expenditure per capita. The results show a significantly positive correlation between CAET scores and dietary diversity and food security, yet no significant correlation with food expenditures (Figure 25). This indicates that supporting farmers' transition to agroecology is a highly successful approach for alleviating food and nutrition insecurity in rural Madagascar. In particular, the agroecology elements Efficiency and Resilience correlate significantly positively with improved food security and nutrition parameters.

Further, the results indicate health benefits of agroecology due to reduced exposure of farmers to pesticides, as there is a significantly positive correlation between CAET scores and TAPE's integrated pest management, ecological pest management, and pesticide toxicity scores (Figure 26). However, the total use of pesticides is not significantly correlated with CAET and spraying mitigation strategies appear to be very limited on all assessed farms.

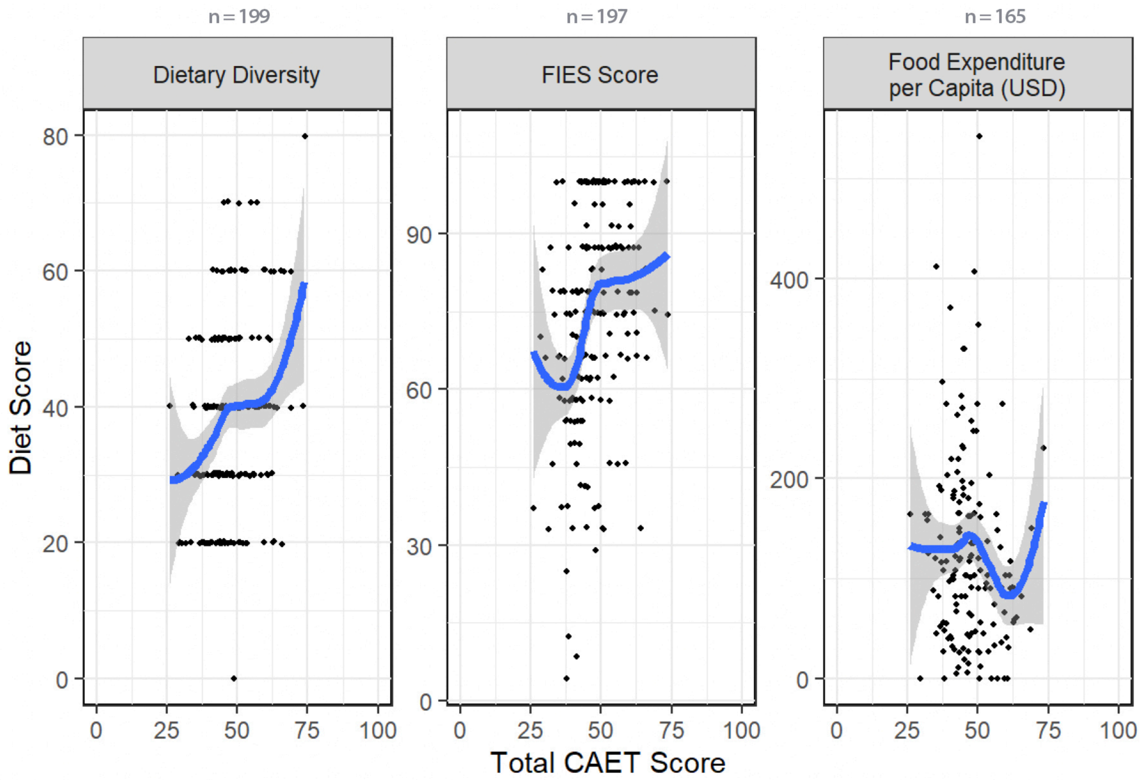


Figure 25. Correlation of CAET score with the dietary diversity score, the Food Insecurity Experience Scale (FIES) score, and the food expenditure per capita per year

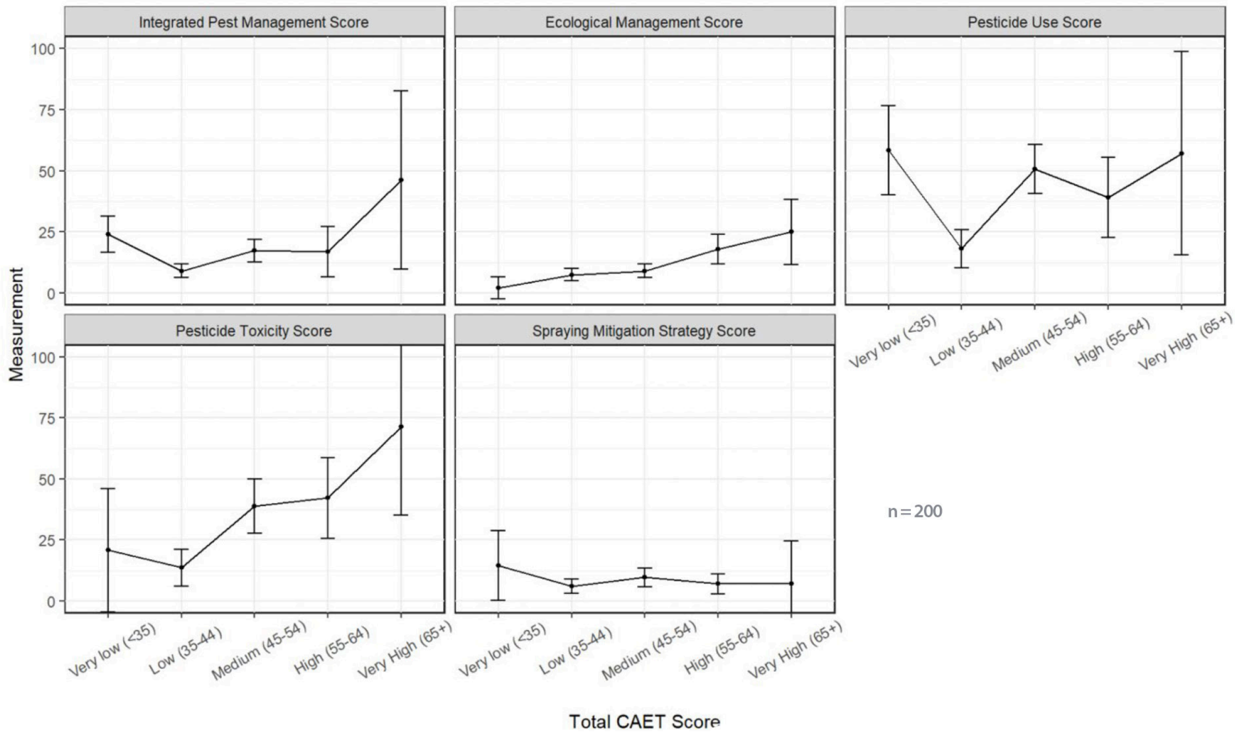


Figure 26. Correlation of CAET score with the exposure to pesticide indicators of TAPE

3.3.5 CAET and governance status

Land tenure issues were assessed with open questions, including a gender-segregated approach. No municipality effect was observed and Figure 27 shows there is no significant correlation between CAET scores and land tenure security.

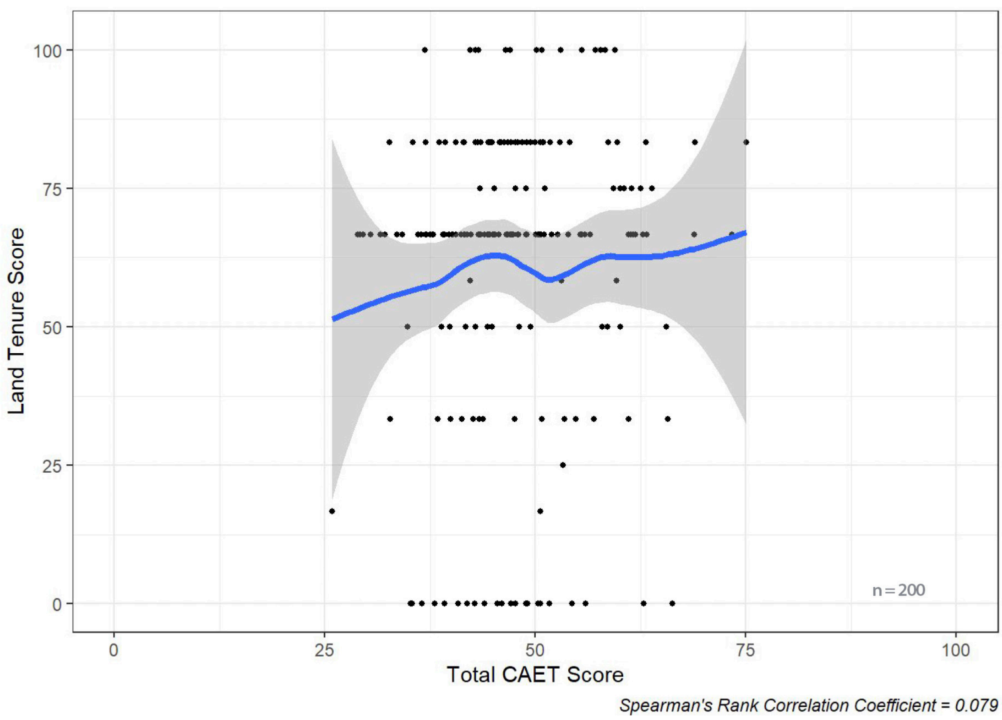


Figure 27. Correlation of CAET score with the composite land tenure score

The first question relating to legal recognition showed that most farmers do not have an official land-ownership certificate and that landowners are more frequently men (Table 8).

Table 8. Do you have any legal recognition of your land? (For pastoralists: Is your mobility legally recognized?)

Gender	Yes	No	No answer
Men	82	112	6
Women	18	169	13

The second question showed that land security is not a major issue for men or women, indicating that land tenure should not be a constraint for soil improvement through agroecological practices (Table 9).

Table 9. Do you perceive that your access to land is secure, regardless of whether this right is documented? (For pastoralists: Do you perceive that your mobility is secure?)

Gender	Yes	No	No answer
Men	162	27	11
Women	136	33	31

The third question, which related to the possibility of selling the land, confirmed the previous two questions, showing the absence of official land certificates and that landowners are more frequently men (Table 10).

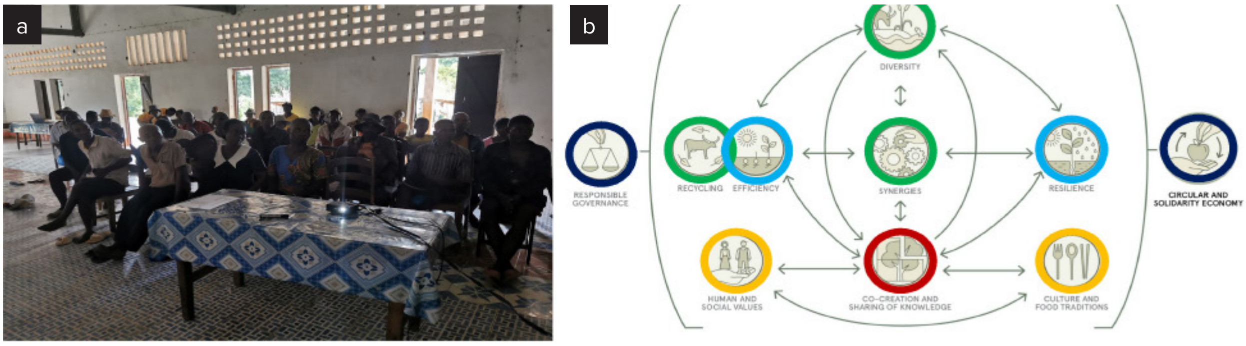
Table 10. Do you have the right to sell any parcels of the holding?

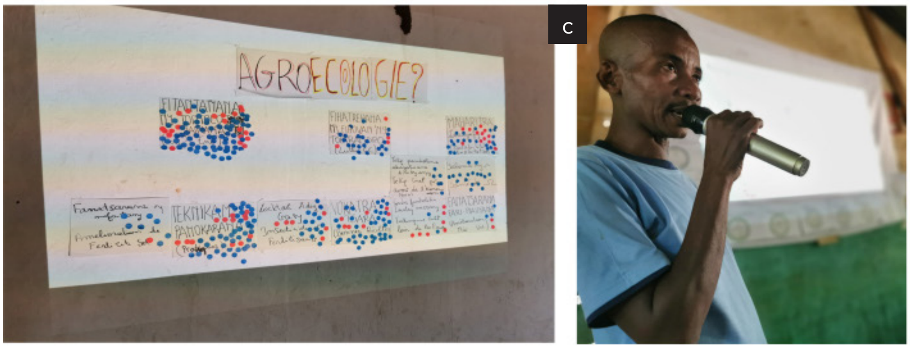
Gender	Yes	No	No answer
Men	102	93	5
Women	53	137	10

3.4 Step 3: Participatory interpretation of results

A national and regional validation workshop was held on 17 May 2024 at the regional office of ProSoil – with online communication with various international, national and regional actors (Annex 5). Further, validation workshops were also held in each of the four municipalities to enable participatory exchanges mostly between the research team, NGOs and farmers previously interviewed, with the inclusion of some municipality representatives. In each of the four municipalities, the same procedure was used during a full day working session from 9 am to 4 pm with a common lunch:

- main outputs of the previous socioeconomic CIRAD-ArtDev survey focused on adoption of agroecological practices
- presentation of the 10 elements of agroecology
- overall results of Step 1 and Step 2 as well as specific results for the respective municipality
- development of an agroecology vision through discussions, individual statements and voting on keywords





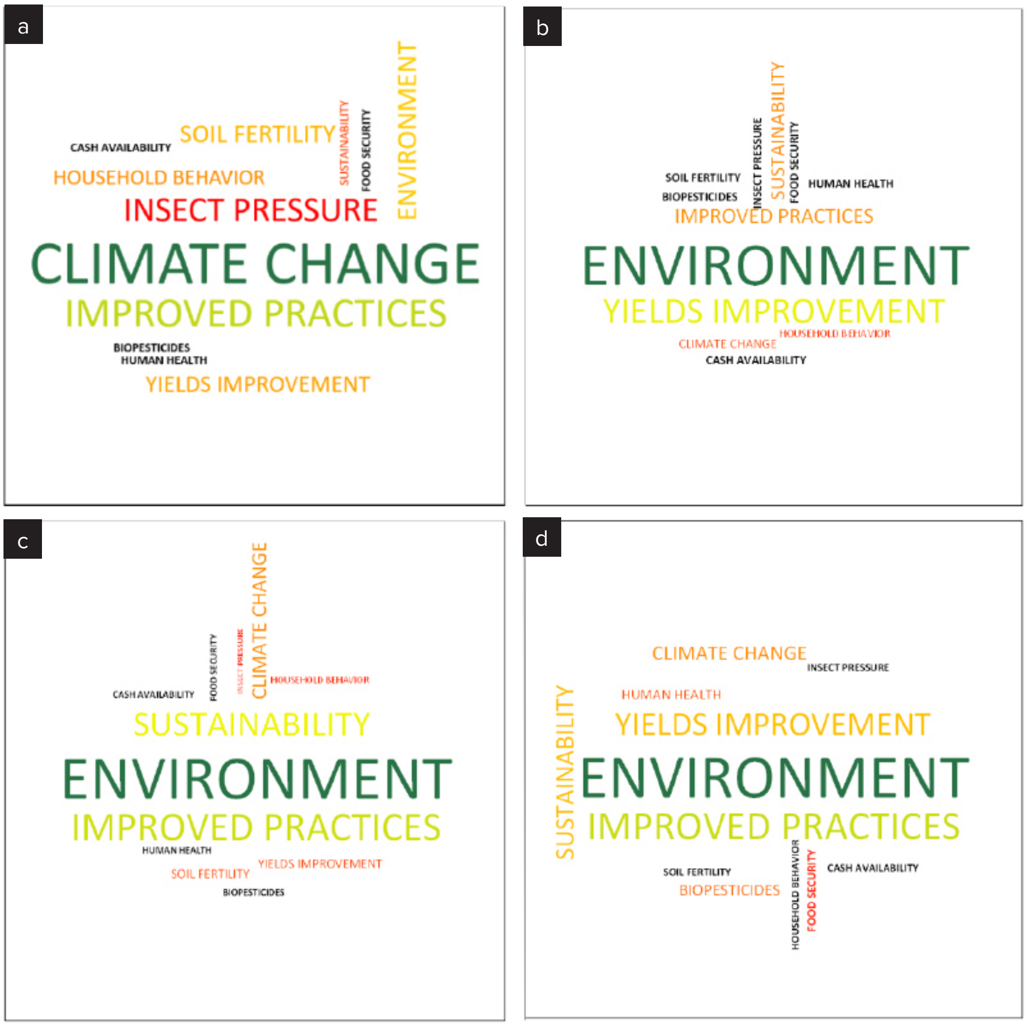
a) During the municipality validation workshop; b) The 10 elements were presented; c) Farmers were expected to outline their vision on agroecology.

Figure 28. Municipality restitution approach with interviewed farmers and NGOs, including collective exchanges and individual statements

Photos by Patrice Autfray

The different keywords chosen by the farmers were described and explained during collective sessions. The results are presented in Figure 29:

- Environmental concerns (283 votes) were deforestation and overall land degradation caused by regular uncontrolled fires and new crop fields; this degradation was seen as the main cause of climate change, creating droughts and floods; thus, agroecology is seen primarily as a long-term investment.
- Improved practices (157 votes) were often described as the only short-term way to counteract climate change.
- Household sustainability (115 votes) highlights the need to give youth a secure future.
- Yield improvement (112 votes) as a main objective for improved practices.
- Climate change (90 votes) adaptation as farmers understand that it is inevitable due to increasing temperatures.



a) Belobaka Municipality; b) Katsepy Municipality; c) Manerinerina Municipality; d) Tsaramandroso Municipality

Figure 29. Municipality results and the vision of agroecology for the four municipalities

The other keywords were:

- soil fertility improvement (30 votes)
- household behaviour improvement (27 votes)
- control of insect pressure (24 votes)
- availability of efficient biopesticides (20 votes)
- human health (17 votes)
- food security issues (9 votes)
- cash availability (6 votes)

The last three words were only selected in Tsaramandroso, highlighting higher social vulnerability in this municipality. The use of chemical fertilizers was sometimes considered necessary to obtain significant yields from rice and vegetables. Biopesticides are often seen as inefficient for the control of crop pests. Interestingly, farmers pointed out that all the elements of agroecology are interrelated and globally validated the holistic approach of TAPE (Lucantoni et al. 2021).

At these five workshops farmers and other stakeholders appreciated the evidence linking agroecological transitions with improved performance across economic, environmental, nutritional, and health domains. The stakeholders made the following recommendations:

- Prioritize providing promising opportunities for youth to engage in agriculture and ensure sustainable livelihoods.
- Provide further support to farmers to transition to agroecology, as this requires long-term investments to adapt to climate change and combat environmental degradation, which were seen as major threats for agricultural production by the stakeholders.
- Increasingly engage policymakers, investors, and entrepreneurs in the discussions about agroecology, as scaling agroecology requires an enabling environment and farmers' agency is limited.
- Take a non-dogmatic approach to agroecology, as many farmers considered synthetic pesticides and mineral fertilizers necessary to obtain sufficient yields to ensure food security and economic prosperity. The biopesticides locally available were considered insufficiently effective by many participants.

4 Discussion and conclusions

4.1 Multidimensional performance of agroecology

Near-natural ecosystems make up nearly 90% of the Boeny Region and only 12% of the land is cultivated, over half of which is dedicated to rice production. Vegetables and fruit trees are commonly grown for subsistence in home gardens and commercially around urbanized areas. Different legumes are grown commercially and for subsistence, particularly in the temporarily flooded fertile lowlands. Farmyard manure production is limited, and mineral fertilizer is applied scarcely. Thus, soil fertility management is mainly based on natural processes during floods in lowlands and soil mining is very common in the uplands. Unregulated pesticide use is common, particularly in maize and legume cultivation. In proximity to the regional capital, organic farming inputs are commercially available. The savanna ecosystem prevailing in the region is suitable for cattle farming and the livelihoods of the local Sakalava people largely depend on cattle rearing. The 630 km coastline and several freshwater bodies result in fishery, aquaculture, and rice-fish farming playing a major role in the local economy. While population densities are low, the region is characterized by high levels of rural migration from other parts of the country. Road infrastructure is poor, resulting in very limited market access and fields are often only accessible by foot. The enabling environment for agroecological transition in the Boeny Region is supported by ProSoil activities and other GIZ-implemented projects on land tenure, reforestation, and protected areas. These aim to counteract environmental degradation, informal contract farming, and uncontrolled pesticide use, as well as to support the establishment or strengthening of farmers' organizations.

The results from 200 household assessments with TAPE show considerable variation among assessed households. While the average total CAET score of 52 implies that most farmers are at an incipient stage of transition, a considerable proportion of farms are yet to transition to agroecology and others have already integrated the 10 elements of agroecology to an advanced degree. The average CAET scores are highest for the elements Culture and food traditions, and Human and social values. This indicates that in the study locations, local knowledge, traditions and culture are critical aspects of agroecological transitions that need to be conserved and strengthened. The agronomic and economic dimensions of agroecology seem less developed in the Boeny Region.

Economic performance

The results show a positive correlation between the degree of agroecological integration (CAET score) and economic performance. Thus, on average, more agroecological households have a significantly higher overall farm productivity. Additionally, the results show a significantly positive correlation between CAET scores and household income yet no significant correlation between agroecological integration and value addition (graphs not shown). This indicates that agroecology can be an effective approach to reduce economic poverty in rural Madagascar.

Environmental performance

The results show a highly significant positive correlation between CAET scores and agrobiodiversity indicators. More agroecological farms on average cultivated more crop species and varieties, held more livestock species and breeds, and had a higher Gini-Simpson index of diversity for crops and livestock, as well as natural vegetation and pollinators. Further, more agroecological farms on average have significantly higher soil health scores, particularly for the indicators on presence of invertebrates, soil cover, and soil compaction. This demonstrates the value of agroecological approaches for reversing soil and land degradation.

Social performance

There is only a slightly positive correlation between CAET scores and the women empowerment indicators. For youth empowerment indicators, there is even a slightly negative correlation with CAET scores. This highlights the requirement to further strengthen gender equity and youth empowerment efforts in agroecological interventions to increase agroecology's contribution to sustainable development.

Health and nutrition

On average, households with an enhanced integration of the 10 elements of agroecology have highly significantly lower perceived levels of food insecurity and improved dietary diversity. Further, more agroecological farmers also had a highly significant reduced exposure to pesticides. This suggests that agroecology is a highly effective approach for improving food and nutrition security and health parameters for rural populations in Madagascar.

In summary, this survey reveals the relevance of the holistic approach of TAPE (Mottet et al. 2020). The 10 elements of agroecology were seen to be interrelated in this study, as in other studies (Lucantoni et al. 2022). This point was highlighted at municipality level when these elements were presented one by one to the interviewed farmers. The TAPE survey could be seen as a future starting point for element interpretation, and there is a clear need for element-by-element studies, criteria by criteria. For example, one main added value often related to agroecology is the improvement of food security and nutrition (Bezner Kerr et al. 2021), which could be seen as important as soil aggradation.

4.2 Improvements for TAPE application

This survey highlights that application of the TAPE tool requires experience in different domains. The time dedicated to the questionnaire adaptation is crucial. It is important to balance the number of farms interviewed (minimum: 200) and the duration of interviews (minimum: half a day). Therefore, only an experienced team could achieve the objectives of a systemic assessment in a smallholder context.

Some proposed methodological improvements:
- A collective meeting with the selected farmers to present the questionnaire and to initiate a debate to anticipate misunderstandings and prepare data collection of expenditures and incomes (most farmers do not have a recording book).
- This meeting should include a debate on the meaning of the term "agroecology" to avoid confusion, and to explain ecological intensification principles (Tittonell 2014).
- For economic performance assessment, it would be important to have an idea of the level of values likely to be obtained in the questionnaire to directly detect typographical errors.

- The soil health survey in the field should be carried out after the household interview, during which a representative field is selected based on a hand-drawn map with main fields and crops cultivated throughout the year. This map also facilitates the economic assessment.
- Soil analysis interpretation requires more time to separate the different variables; for example, soil texture is recognized as having a great impact on soil organic matter and needs to be used as a co-variable.

The integration of the farm type factor in TAPE data analysis was also shown to be relevant, as mentioned in other studies (Lucantoni et al. 2023). In Annex 3, some figures explained this point.

4.3 Opportunities for scaling-up of agroecology

In the Boeny Region, the level of poverty is high, and around half of the farms were living below the international poverty line. The project works mainly with a scaling-out process based on the local diffusion of agroecological practices. An agroecological transition requires efforts at higher decision-making levels and needs scaling-up approaches. In Madagascar, some success stories from the private sector in the domain of organic agriculture of niche products were obtained in the smallholder farming context (Rahmann et al. 2017). Facilitating access to production factors, such as carts and draught animals, could be a way to improve farm living conditions and agroecology adoption globally. In this sense, performance should not be seen only as a consequence of the adoption of agroecology but also as a cause of its development. In this study, small intensive farms and large farms recorded the highest scores to a significant degree. The former propose an intensification on small areas based on the integration of crops and small livestock, as well as high-value crops (vegetables), while the latter look to agricultural tool mobilization based on draught animal power.

Our TAPE assessment revealed significant correlations between agroecological status and multidimensional performance, which could be linked to ProSoil activities focused on scaling agroecological techniques. Contrary to our hypothesis, land tenure status for migrant farms did not seem to be a major constraint for field fertility aggradation through agroecological practices. Land tenure should not be a constraint for soil improvement through agroecological practices, even though around 40% of fields are cultivated based on a land-use status. Soil fertility management is mainly based on natural processes during flood events in lowlands. In this region, lowlands represent different topographical locations and are preferably valorized.

Soil analysis interpretation will need to be more connected to the soil health assessment based on local perceptions in considering only the soil at a depth of 0–20 cm depth. In Annex 6, a description of local soil knowledge according to topography is proposed (Ravonjiarison et al. 2023) and should serve as a prerequisite for future analysis, including a multidimensional analysis (Annex 4).

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Annexes

Annex 1. TAPE Step 1 indices and Step 2 indicators

10 Elements of Agroeclogy – TAPE step 1 indices

10 Elements	36 CAET Indices
Diversity	• Crops • Animals, including fish and insects • Trees and other perennials • Diversity of activities, products, and services
Synergies	• Crop-Livestock-Aquaculture integration • Soil-Plants management system • Integration with trees (agroforestry, silvopastoralism, agro/silvopastoralism) • Connectivity between elements of the agroecosystem and the landscape
Efficiency	• Use of external inputs • Management of soil fertility • Management of pests and diseases • Productivity and household's needs
Recycling	• Recycling of biomass and nutrients • Water saving • Management of seeds and breeds • Renewable energy use and production
Resilience	• Stability of income/production and capacity to recover from perturbations • Mechanisms to reduce vulnerability • Environmental resilience and capacity to adapt to climate change
Culture and food tradition	• Average diversity • Appropriate diet and nutrition awareness • Local or traditional identity awareness • Use of local varieties/breeds and traditional knowledge for food preparation
Co-creation and sharing of knowledge	• Platforms for the horizontal creation and transfer of knowledge and good practices • Access to agroecological knowledge and interest of producers in agroecology • Participation of producers in networks and grassroots organizations
Human and social values	• Women's empowerment • Labor (productive conditions, social inequalities) • Youth employment and emigration • Animal welfare (if applicable)
Circular and solidarity economy	• Products and services marketed locally or in fair trade schemes • Networks of producers, relationship with consumers and presence of intermediaries • Local food system
Responsible governance	• Producers' empowerment • Producers' organizations and associations • Participation of producers in governance of land and natural resources

Dimensions of Sustainability - TAPE step 2 Indicators

Dimensions of sustainability	10 core criteria of performance	Indicators measured in the standard version of TAPE Step 2
Governance	Secure land tenure	• Existence of legal or traditional recognition of land • Existence of legal or traditional recognition of mobility for pastoral people • Perception of secure access to land (or secure mobility) • Right to sell / inherit / bequeath land
Economy	Productivity	• Quantity of crop and forestry products produced Quantity of animals and livestock products produced • Monetary value of agropastoral production • Gross value of the agricultural production (per ha and per person)
	Value added	• Total expenditures for the purchase of seeds, fertilizers, pesticides, machineries • Total expenditures for the purchase of livestock • Value added (per ha and per person) • Value added on Gross value of the production (VA/GVP)
	Income	• Revenue derived from crop and forestry products • Revenue derived from animals and livestock products • Revenue derived from other activities • Financial expenditures • Net revenue from agropastoral activities per person and per household • Net revenue from agropastoral activities after taxes and subsidies per person and per household • % of revenue derived from crops and livestock • % of people under poverty level • Depreciation • Expenditures for wages
Environment	Agrobiodiversity	• Gini-Simpson index of diversity for crops • Gini-Simpson index of diversity for animals • Index of diversity for natural vegetation and pollinators • Number of species and varieties/breeds of crops and animals • Livestock Unit
	Soil health	• 10 indicators of soil health (structure, compaction, depth of superficial soil, status of residues, color and odor, presence of organic matter, water retention, soil cover, erosion, and microbiological activity)
Health and nutrition	Exposure to pesticides	• Quantity of chemical pesticides used • Quantity of organic pesticides used • Level of toxicity of the pesticides used • Area of use of pesticides • Use of mitigation strategies when applying • Implementation of practices for the ecological management of pests
	Dietary diversity (and food security)	• Number of food groups consumed • Food Insecurity Experience Scale (FIES) • Expenditures for purchase of food per capita

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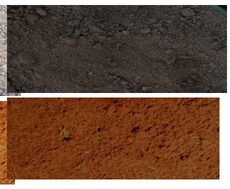
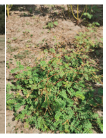
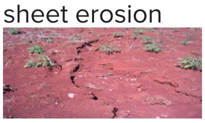
Dimensions of Sustainability - TAPE step 2 Indicators. Continued

Dimensions of sustainability	10 core criteria of performance	Indicators measured in the standard version of TAPE Step 2
Social	Women's empowerment	• Productive decision, Decision on income, Perception of decision making, leadership, time use, access to credit for both men and women • Gender Parity Index • % of women living and working on the farm • All social indicators disaggregated by sex
	Youth empowerment	• Youth employment opportunities • Youth emigration and willingness to emigrate or working in agriculture • % of youth living and working on the farm
	Others	• Number and composition of the household • % of the family employed on farm • % of elders working on farm

Annex 2. Critical main points concerning local adaptation of the TAPE questionnaire

Step	Criteria	Issue	Comments
0	Total area under natural vegetation	The balance between cultivated and natural areas are approached in Steps 1 and 2	Make a map with the farm at the beginning of the survey.
	"-99" answer	Means only "do not want to answer"	Add another option "could not answer".
1	1.4	The range of diversity of economic activities, products and services	Pluri-activity could be seen both as a factor favouring agroecology but also having a negative impact: external work for other farms, labour peak or greater non-agricultural opportunities.
	2.4	Connectivity between elements of the agroecosystem and the landscape	The "landscape mosaic" concept could use a simple image with contrasted colours.
	3.2	Management of soil fertility	The score, on average, was not so bad (2.8) despite the very low level of manure input; farmers prioritize fields with natural fertility regeneration through sedimentation during flooding periods. Thus, organic input is not necessary and may not make sense.
	4.2 & 4.4	Waste for energy and water fairly adapted to the context	The scores were low 1.39 and 1.0, respectively.
	8.4	Animal welfare	No answer for 44 farms.
2	Output and earning	The list of crops and fruits based on common names mix general names (e.g. vegetables, beans) and specific species (e.g. soybeans); it creates confusion and is an important risk for future earnings calculations	Group crops between main characteristics: cereals, tubers, legumes, etc. Use scientific names to be more precise.
	Soil health	The fields were often far from the houses, and the number of fields, on average, was three.	The time devoted to soil sampling creates work for the enumerators, and drudgery.

Annex 3. Soil health survey

Indicator	Formulation	Scores and illustrations		
		SCORE 1	SCORE 3	SCORE 5
Soil structure *Firafitry ny tany*	Importance of particles and aggregates			
Soil compaction *Fahamafisan'ny tany*	Adapted through the ability of the roots to colonize in depth the soil when humid and to be ploughed in depth by hand, draft power or mechanized tillage			
Soil depth *Halalin'ny nofo tany*	Adapted through the importance of humic black soil	Lack of black soil	15–20 cm humic black soil	40–50 cm thick humic black soil
Status of residues *Fotoana fahalovan'ny potika zavamaniry*	Adapted through the duration of plant or crop residue soil incorporation in humid conditions	Low incorporation	Medium	Residue quickly incorporated
Soil colour, odour, and organic matter *Lokon'ny tany*	Adapted only for colour, including the importance of organic matter through two levels of ferrous oxides (Munsell code)			
Water retention *Fitsikan'ny rano*	Adapted for water infiltration rapidity during rain events	Low water infiltration rapidity	Medium 	Very rapid water infiltration
Soil cover *Rakotra*	Adapted no soil cover during the entire year, as well as with natural or plant species, live or dead organic material			
Soil erosion *Riaka*	Importance of soil erosion during the rainy season	Severe erosion, presence of gullies or sheet erosion 	Evident, but low erosion signs (e.g. rill/ sheet erosion) 	No visible signs of erosion 

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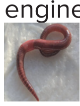
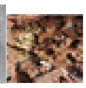
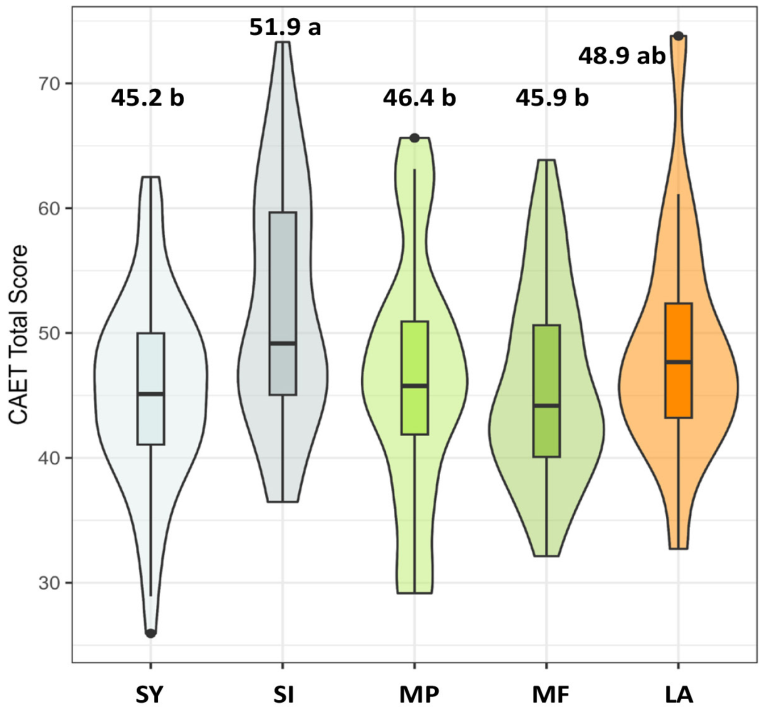
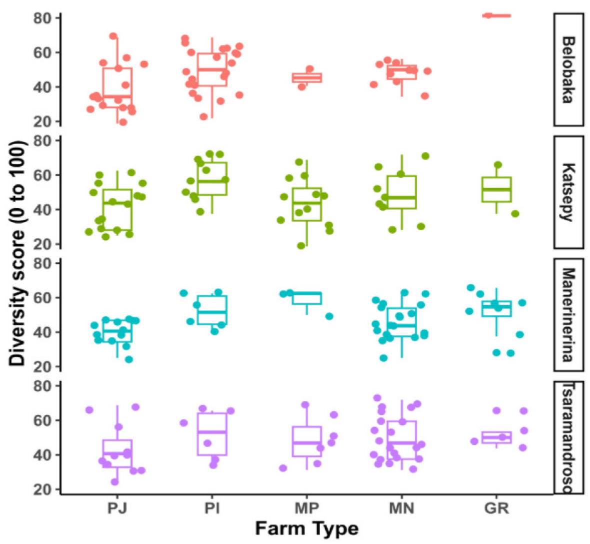
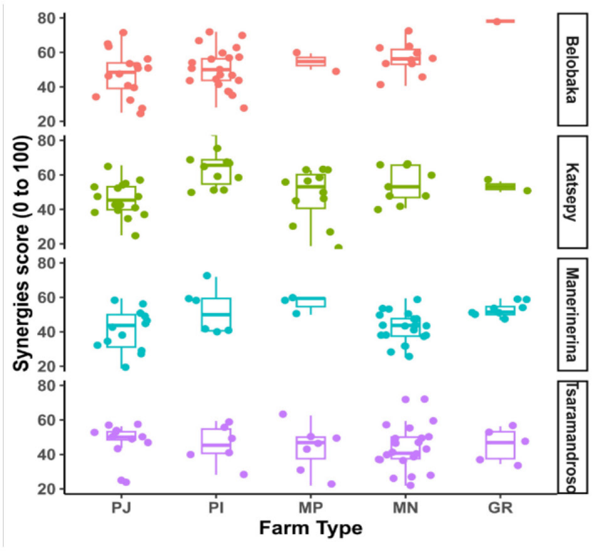
Annex 3. Continued

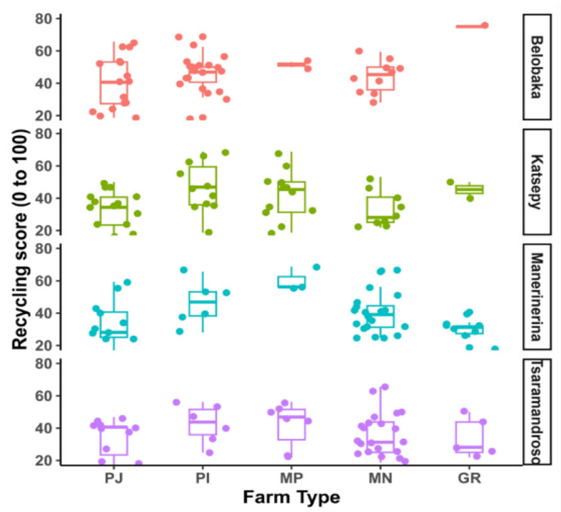
Indicator	Formulation	Scores and illustrations		
		SCORE 1	SCORE 3	SCORE 5
Presence of invertebrates *Biby kely manampy*	Adapting by specifying no-crop pest animals	No good invertebrates	Termites, earthworms engineers  	Plenty of good invertebrates
Microbiological activity *Akora organika*	Adapting by doing the test with a uniform volume of water peroxide and sieved soil for 1 minute in a petri dish	No effervescence 	Medium 	High effervescence 

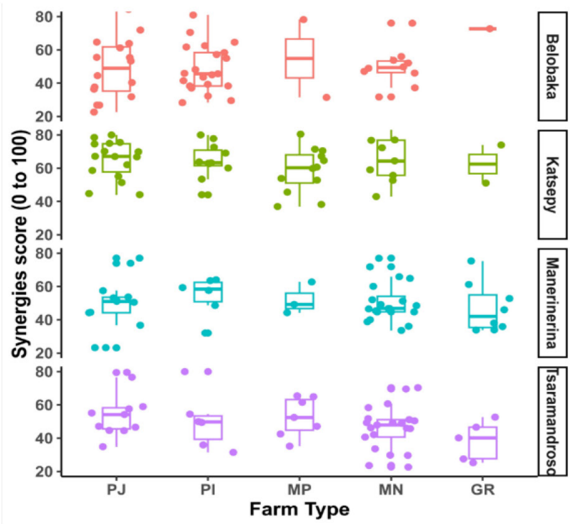
Annex 4. CAET and elements among municipality and farm type

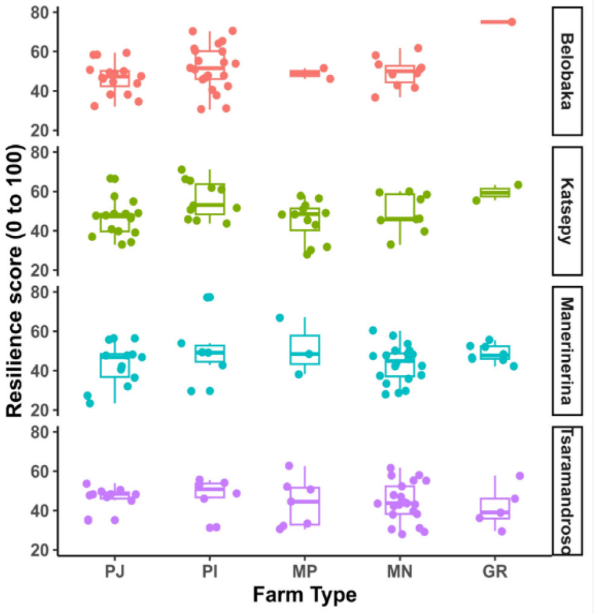


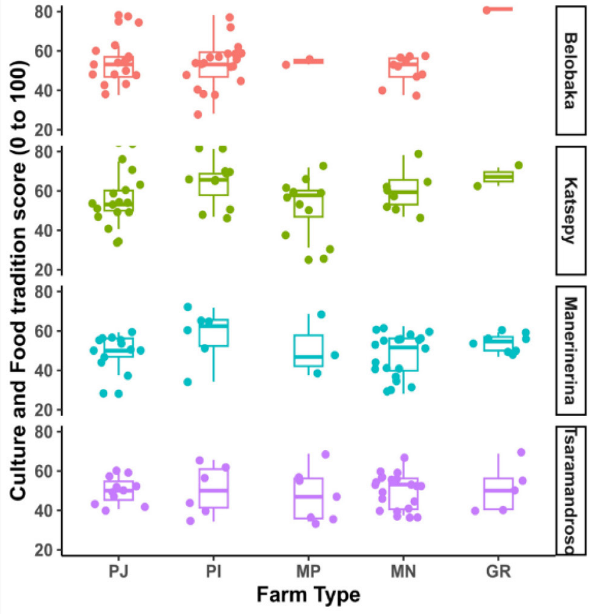


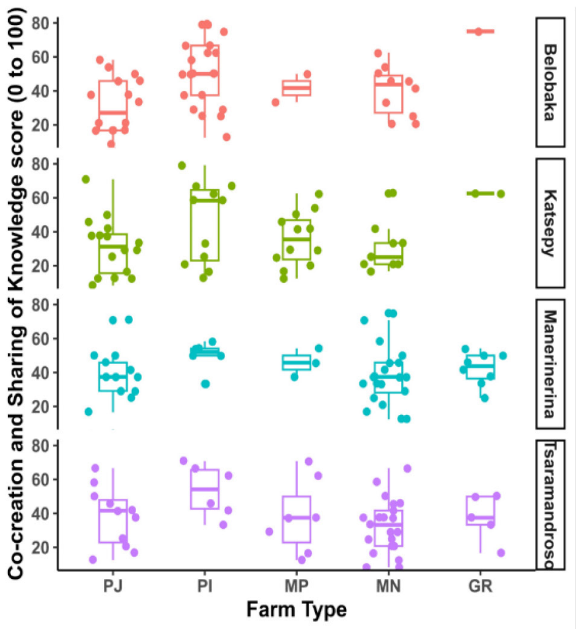


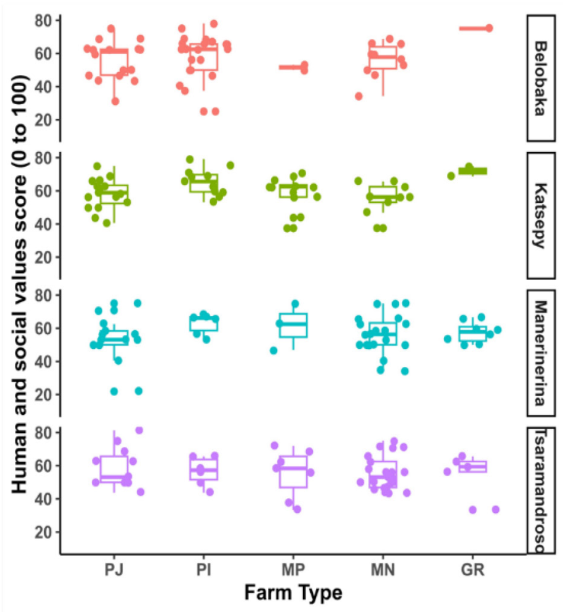


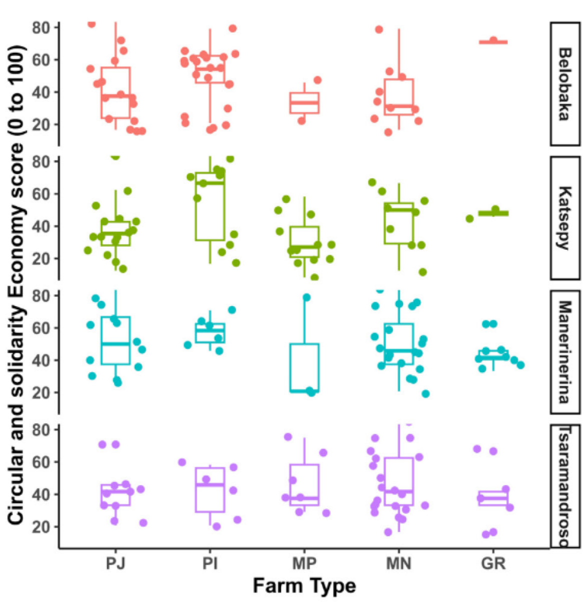


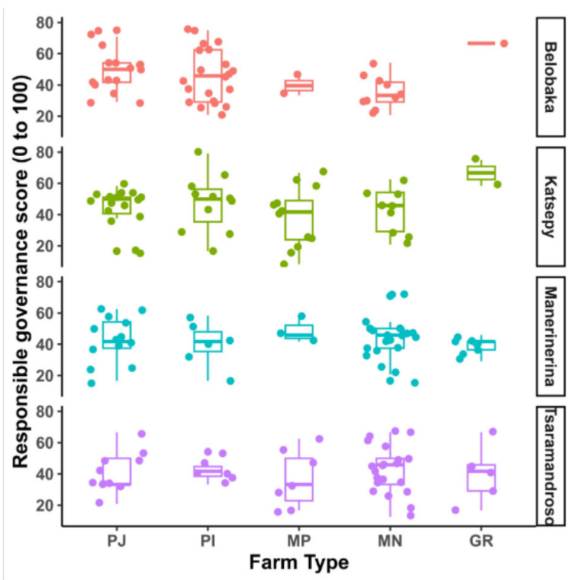

Resilience score (0 to 100)
Belobaka
Katsepy
Manerinerina
Tsaramandroso
PJ PI MP MN GR
Farm Type


Culture and Food tradition score (0 to 100)
Belobaka
Katsepy
Manerinerina
Tsaramandroso
PJ PI MP MN GR
Farm Type


Co-creation and Sharing of Knowledge score (0 to 100)
Belobaka
Katsepy
Manerinerina
Tsaramandroso
PJ PI MP MN GR
Farm Type


Human and social values score (0 to 100)
Belobaka
Katsepy
Manerinerina
Tsaramandroso
PJ PI MP MN GR
Farm Type


Circular and solidarity Economy score (0 to 100)
Belobaka
Katsepy
Manerinerina
Tsaramandroso
PJ PI MP MN GR
Farm Type


Responsible governance score (0 to 100)
Belobaka
Katsepy
Manerinerina
Tsaramandroso
PJ PI MP MN GR
Farm Type

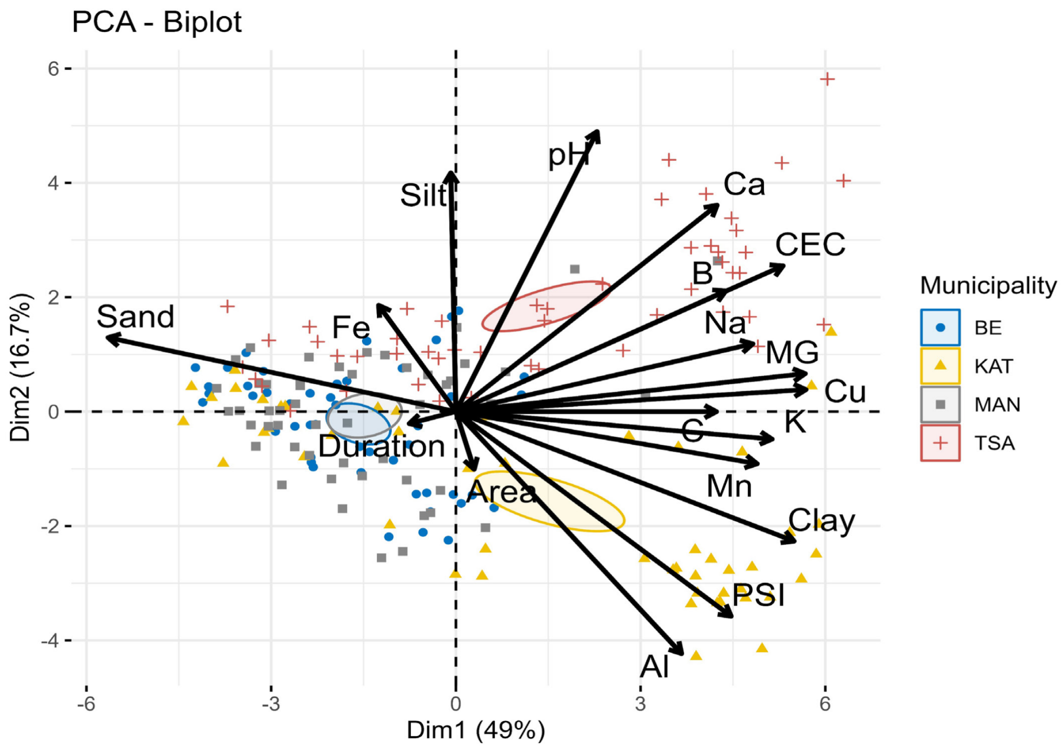
Annex 5. Soil chemical analysis

For both depths (n=400)

Soil Analysis chemical

Statistic	N	Min	Pctl(25)	Median	Mean	Pctl(75)	Max	St. Dev.	Interpretation based on the median
pH	400	4.7	5.7	6.00	6.1	6.4	8.3	0.6	Moderately acidic
SOC (%)	400	0.0	0.4	0.64	0.8	1.1	2.7	0.5	Very Low
TN (%)	400	0.0	0.0	0.07	0.1	0.1	0.3	0.1	Very Low
m3.Al (mg/kg)	400	226.9	664.4	839.81	889.5	1071.3	1826.6	329.0	Very High
m3.B (mg/kg)	400	0.4	0.57	0.87	0.8	0.9	3.0	0.5	Moderately Low
m3.C (mg/kg)	400	32.9	109.5	157.89	166.2	217.8	578.7	80.7	Moderately Low
m3.Ca (mg/kg)	400	36.6	396.9	921.23	1195.3	2326.5	3262.9	752.0	Very High
m3.Cu (mg/kg)	400	0.4	1.0	1.9	2.5	2.6	30.1	2.4	Optimum
m3.Fe (mg/kg)	400	38.5	82.8	107.74	109.0	127.3	246.4	30.4	Very High
m3.K (mg/kg)	400	20.3	36.6	50.79	59.9	70.1	201.1	23.6	Very High
m3.Mg (mg/kg)	400	9.0	79.3	101.89	108.3	137.1	204.1	40.1	Optimum
m3.Na (mg/kg)	400	0.1	0.3	0.4	0.5	0.6	1.8	0.3	Very High
m3.P (mg/kg)	400	1.5	4.3	8.7	9.4	13.5	71.8	14.2	Moderately Low
CEC (cmolc/kg)	400	5.2	9.5	14.7	19.9	20.9	50.4	9.8	Moderately High
PSI	400	10.4	19.7	29.42	33.3	40.9	77.8	15.6	Moderately High
Clay (%)	400	7.2	26.6	46.1	47.4	63.3	85.8	18.6	Moderately High
Silt (%)	400	10.4	14.88	14.3	17.9	20.6	35.6	5.0	Moderately Low
Sand (%)	400	5.6	23.3	39.05	38.3	52.6	86.3	18.0	

For the 0–20 cm depth



Annex 6. List of actors

Actor type	Organization	Name	Localisation
Administration	DRAEP	Gédéon Andriamahefarivo	Regional
Administration	DRAEP	Faramalala Randriamiharisoa	Regional
Administration	DRAEP	Marcelin Randrianombola	Regional
Administration	Mairie Amkirihitra	Rabemasoavina Olivier	Municipality
Administration	Mairie Manerinerina	Davy André	Municipality
Administration	MEDD	Malalatia RANDRIAMBAO	National
Administration	MINAE	Malalatia RALANDISON	National
Administration	ONN	Jules RAFALIMANANA	National
Administration	ONN	Jean Marie RABEARIVELO	National
Administration	ORN	Bathilde Rakotondratiana	Regional
Administration	Protected Area Katsepy	Roger Edmond	Municipality
Administration	Protected Area Katsepy	Naina	Municipality
Farm Organization	AFDI	Randriamalala Victor	Regional
Farm Organization	AFDI	Fanja Ralamboranto	National
Farm Organization	OP FITAMINO	RADANIELSON Juco	Municipality
Farm Organization	OP MIARA MIZOTRA	RANDRIAZAFISON Tsitohaina	Municipality
Farm Organization	OP TSIMIALONJAFY	RAHARISOA Lydia	Municipality
Funder	World Bank	AMBOARASOA Mampionona	National
International Organzation	FAO	Rémi Cluset	International
International Organzation	FAO	Herizo Rakotoniaina	National
International Organzation	FAO	Andry Rakotoharivony	National
National Agency	ANAE	Mihaja Randriamanantena	National
National Agency	ANAE	Tahina Rakotondralambo	National
NGO	APDRA	Philippe MARTEL	National
NGO	Agrisud	Adrien Lepage	National
NGO	AIM	Patrick Rakotoarisoa	Regional
NGO	AMADESE	Samuelson Andriamanohisoa	Regional
NGO	AMADESE	Jeremy Maharatse	Municipality
NGO	AMADESE	Heriniaina Hobiarivelo Rakotomalala	National
NGO	AVSF	Guillaume PARIZET	National
NGO	CTAS	Tolotra RANAIVOHARIMANANA	National
NGO	GSDM	Tahina Raharison	National
NGO	GSDM	RAKOTONDRAMANANA	National
NGO	MAZAVA	Narindra	Municipality
NGO	SDMAD	Ando Tafitasoaniaina	Municipality
NGO	SDMAD	Claude CHABAUD	National
Private sector	Consultant	Serge RAMPARANY	National
Private sector	LFL	Andriambololona Christomichael	Regional
Private sector	LFL	Rafanoharana Tojomamema	Regional
Private sector	MadaCompost	Mihajasoa	Regional
Private sector	Pulse company	Malde Kara	Regional
Private sector	Plate-forme Tojy	Randrianarijaona Bernard	Municipality

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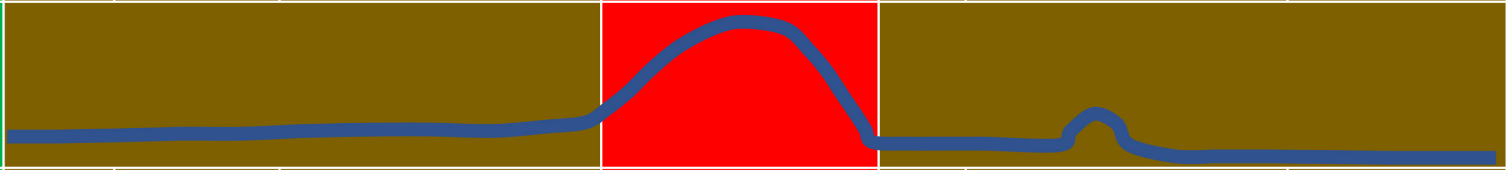
Annex 6. Continued

Actor type	Organization	Name	Localisation
Project	ECO Consult	Fabrice LHERITEAU	Regional
Project	ECO Consult	Roger RAFANOMEZANTSOA	Regional
Project	ECO Consult	Solofo RAHARINAIVO	Regional
Project	ECO Consult	Tahiry RARIVONANDRASANA	Regional
Project	ECO Consult	Mamy Tiam RAKOTOZAFY	Regional
Project	ECO Consult	Serge Ramparany	Regional
Project	ECO Consult	Serge RAKOTOZAFY	Regional
Project	ECO Consult	Miharitsoa RANDRIANTSARAFARA	Regional
Project	ECO Consult	Marie RALISON	Regional
Project	GIZ	Marc Spikerman	National
Project	GIZ	Alexis Randrianiaina	National
Project	GIZ	Arline Ramarosandratana	National
Project	GIZ	Oliver Zemek	Regional
Project	GIZ	Herimanga Nantenaina	Regional
Project	GIZ	Richette Rabenarson	Regional
Project	GIZ	Tiana Pickart	National
Research / Academic	CIRAD	Holy RAHARINJANAHARY	International
Research / Academic	CIRAD	Véronique ANCEY	International
Research / Academic	CIRAD	Perrine Burnod	National
Research / Academic	CIRAD	Bertrand MULLER	National
Research / Academic	CIRAD	Quentin Grislain	National
Research / Academic	FOFIFA	Dina Rahaingotsambatra	Regional
Research / Academic	FOFIFA	Safidy	Regional
Research / Academic	FOFIFA	Mbolarinosy RASOAFALIMANANA	National
Research / Academic	LlandDev	Harifidy RAZAFY RATSIMBA	National
Research / Academic	LRI	Tantely RAZAFIMBELO	National
Research / Academic	Université d' Antananarivo	RAZAFIMAHATRATRA Hery	National
Research / Academic	Université de Majunga	Heriniaina RAMAHEFARISON	Regional
Research / Academic	Université de Majunga	Hery Lisy Tiana Ranarijaona	Regional

Annex 7. Topography and local soil knowledge

BELOBAKA MUNICIPALITY Main Sedimentation dynamic	Negative	Positive		
Topograpy				
Soil name	Rainfed hilly soils (Tanety)	Rainfed clayish soils (Tanipako)	Temporary and permanent flooded soils (Tanimbary)	Saline soils (Tany sira)
Color	Light red and yellow red	Black	Dark red	Black
Texture and compaction	Strongly clayish and compacted soil	Clayish and compacted soil	Clayish and sandy soil / Sticky soil	Sandy and friable
Spontaneous species	Elionurus tristis (kofafa), Grasses (Bozaka), Heteropogon contortus (Ahidambo)	Cynodon dactylon (Fandrotrana), Hyptis suaveolens (Bemaimbo)	Specific species	Cyperus madagascariensis
Main crops	Maize and peanut	Rice, Maize and Cassava	Rice	Rice

KATSEPY MUNICIPALITY Main Sedimentation dynamic	Negative	Positive			
Topograpy					
Soil name	Sandy hilly soils (Vohitra fasihana)	Colluvial soils (Baiboho)	Lowland rainfed soil (Matsabory Asara)	Rice field with poor water control (Kapila vaky)	Temporary and permanent flooded soils (Tanimbary)
Color	Black / red / brown	Black / red / brown	Black	Black	Black - Grey
Texture, compaction and depth	Thin soil, friable and sandy	Thin soil, Clayish and sandy soil, lumpy	Thin soil, black sand	Sick soil - Clayish	Sick soil - Clayish, sticky
Spontaneous species	Stylosanthes Spp, Borera, Heteropogon contortus (ahidambo), Fandrotrana, teloravina	Manevika, ahidambo, teloravina, crotalaria	Ahidambo, Tsingatraka, Horefo, Fandrotrarana	Ahidambo	Ahidambo, Tenina, Imperata, Ahibita
Main crops	Maize, pulses, sorghum	All annual crops, tree fruit, sugarcane, banana	Trees	Rice	Rice

MANERINERINA MUNICIPALITY Main Sedimentation dynamic	Positive	Positive	Positive	Negative	Positive	Positive	Positive
Topograpy							
Soil name	Alluvial Sandy soils (Baiboho Fasihana)	Alluvial fertile soils (Baiboho Betro)	Ricefiled Alluvial fertile soils (Baiboho Tanimbary)	Sloped Hilly soil (Kirimpana)	Bassin soil (Deboka)	Rainfed clayish soils (Tanipako)	Rice field with poor water control (Kapila vaky)
Color	White, light color	Brown or Red	Dark grey	Red	Back or brown	Black or grey or brown	Black or grey or brown
Texture, compaction and depth	Sandy - good water infiltration	Very fine sand, friable; good water retention	Fine sand - Clay ; lumpy and good water retention	Clayish , hard soil	Sandy	Clayish, compact	Clayish, compact
Spontaneous species	Bozaka	Cynodon Dactylon (Fandrotrarana), Tsimitamita	Fandrotrarana, Andramavo	Paipaika, kofafa	Akata, Lavatanana, Abikia	Varinjanahary	Varinjanahary
Main crops	Pulses, Pumpkin, Maize	Rice, Maize, vegetables, pulses	Rice, Maize, pulses	-	Rice, Maize, Cassava	Rice	Rice

TSARAMANDROSO MUNICIPALITY Main Sedimentation dynamic	Negative	Positive				
Topograpy						
Soil name	Hilly soils (Tanety)	Sloped Hilly soil (Kirimpana)	Upand soil (Tanety marina)		Rice field (Tanimbary)	Colluvial soils (Baiboho)
Color	Black or red or brown	Yellow	Black Yellow	Black - brown	Black	Black - red
Texture, compaction and depth	Stony	Sandy	Variable	Sandy - Clayish	Clayish	Fine sand
Spontaneous species	Bozaka	-	Bozaka	Cynodon Dactylon	Varinjanahary	Varinjanahary
Main crops	Eucalyptus, Acacia	-	Maize, pulses	Rice, Corn, Cassava, bambara peas	Rice	Rice, pulses, cucumber

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The Agroecology TPP Working Papers contain preliminary or advanced research results on agroecology issues that need to be published in a timely manner to inform and promote discussion. This content has been internally reviewed but has not undergone external peer review.

The Measuring Agroecology and its Performance (MAP) project is a collaboration to generate evidence of how agroecology can contribute to societal goals. The project assessed the performance of agroecology in three of the six districts of the Boeny region in Madagascar (Mahajanga II, Ambatoboeny, Mitsinjo), which have been part of the GIZ global project, Soil Protection and Rehabilitation for Food Security (ProSoil), since 2018–2019. Analysts applied Tools for Agroecology Performance Evaluation (TAPE), as well as the Characterization of Agroecological Transition (CAET) on 102 farms that participated in the global project, and on 98 non-participating farms as a control group.

Overall, CAET scores indicated participating and non-participating groups had few significant differences. For some elements of agroecology, such as diversity, synergies, co-creation and sharing of knowledge, participating farms showed a positive trend. The number of farms below the poverty line, crop incomes and non-agricultural incomes were not significantly different between the two groups, while livestock income was higher in the participating group. Strong correlations were observed between crop incomes and the diversity score in both groups, and global scores for soil health were the same for both groups. On environmental and social performance, participating farms recorded higher livestock diversity and higher women's empowerment, respectively. Dietary diversity, pesticide use and the percentage of children working in agriculture were the same, or nearly the same, in both groups.

In all, the ProSoil project had a slight impact on the agroecology level and performance of farms. Nevertheless, CAET scores were positively correlated with different economic, environmental and social indicators, providing evidence for decision makers to sustain agroecology scaling-out and scaling-up for food security.

About the Agroecology TPP

The Agroecology TPP convenes a broad group of scientists, practitioners and policymakers working together to accelerate agroecological transitions. Since its official launch on 3 June 2021, the TPP has begun addressing knowledge gaps across eight domains that will support various institutions and advocacy groups in key decision-making processes. Its online COMMUNITIES are open to all, providing spaces for members to co-create knowledge, share insights and experiences on various agroecological themes, building collaborative networks with local communities and research bodies to drive agroecological progress for food systems transformation.