Agroecology TPP

Measuring Agroecology and its Performance (MAP)

Key findings from applying the FAO Tool for Agroecology Performance Evaluation (TAPE) in Benin, Ethiopia, Kenya, and Madagascar in the context of the Global Programme Soil Protection and Rehabilitation for Food Security (ProSoil)

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WORKING PAPER 8

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The Transformative Partnership Platform on Agroecology (Agroecology TPP)

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Abbreviations and acronyms

Agroecology TPP	Transformative Partnership Platform on Agroecology
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	Development Smart Innovation through Research in Agriculture initiative of the EU
EU	European Union
FAO	Food and Agriculture Organization of the United Nations
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit (German development agency)
ICRAF	International Council for Research in Agroforestry (World Agroforestry)
LDSF	Land Degradation Surveillance Framework
MAP	Measuring Agroecology and its Performance
ProSilience	DeSIRA project Enhancing Soils and Agroecology for Resilient Agri-food Systems in Sub-Saharan Africa implemented by GIZ and embedded in ProSoil
ProSoil	GIZ global project Soil Protection and Rehabilitation for Food Security
Stats4SD	Statistics for Sustainable Development
TAPE	Tool for Agroecology Performance Evaluation

Acknowledgements

The Measuring Agroecology and its Performance (MAP) project is a collaborative initiative aimed at fostering agroecological transitions by generating evidence of agroecological contribution to societal goals. The MAP project is funded by the German Federal Ministry for Economic Cooperation and Development (BMZ), co-funded by the European Union (EU) and supported by the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH. The Tool for Agroecology Performance Evaluation (TAPE) was applied in Benin, Ethiopia, Kenya and Madagascar in the context of the Global Programme "Soil Protection and Rehabilitation for Food Security" (ProSoil) with the GIZ-implemented EU DeSIRA project 'Enhancing soils and agroecology for resilient agri-food systems in Sub-Saharan Africa' (ProSilience).

The application of the Tool for Agroecology Performance Evaluation (TAPE) was made possible through the support of the Food and Agriculture Organization of the United Nations (FAO), which provided comprehensive training to project members and community facilitators. We also appreciate the invaluable contribution of the Center for International Forestry Research and World Agroforestry (CIFOR-ICRAF) Soil and Land Health team, who played a crucial role in soil sample collection and analysis. The entire data management process was efficiently conducted using an online data management platform, thanks to Statistics for Sustainable Development (Stats4SD), which was also responsible for data cleaning, analysis, and quality assurance. The project implementation was conducted by the French Agricultural Research Centre for International Development (CIRAD) in Madagascar, and World Agroforestry (ICRAF) in Benin, Ethiopia and Madagascar.

Above all, we extend our gratitude to the farmers and community members who participated in this study; to the community facilitators; key informant interview partners; and to the numerous workshop participants in all four countries. Without their cooperation, this report would not have been realized.

1 Key findings, conclusions and recommendations

In this collaborative project of the Transformative Partnership Platform on Agroecology (Agroecology TPP), FAO's Tool for Agroecology Performance Evaluation (TAPE) was applied to 839 farming households in Benin, Ethiopia, Kenya and Madagascar. The study was carried out in the context of the global programme Soil Protection and Rehabilitation for Food Security (ProSoil) to understand the degree to which ProSoil activities fostered agroecological transitions among participating households, and how these differing degrees of agroecological integration correlate with multidimensional performance. To address these questions, in each of the four countries, half of the assessed households had actively participated in ProSoil activities (constituting the 'ProSoil group') previously. The other half (the 'comparison group') shared the general socioeconomic, environmental and agricultural characteristics but had not participated in previous ProSoil activities.

Regarding ProSoil's contribution to agroecological transitions, the results indicate that ProSoil activities supported farmers' transitions to agroecology in a holistic sense, as households from the ProSoil group had consistently higher agroecology scores across all 10 elements of agroecology than the households from the comparison group. Only in Madagascar, the average agroecology scores of farms in the ProSoil group are not significantly higher than those of the comparison group. This may be due to ProSoil activities having started three years later in Madagascar than in the other three countries. Further, for Madagascar, it is likely that former beneficiaries or those who benefited from training or from neighbourhood and family effects, without being in the project database, were present in the comparison group and thus have led to similarly advanced agroecological transitions for both groups. By contrast, in Kenya, the difference in average agroecology scores between ProSoil and comparison groups is more pronounced than in the other three countries, but the farmers of both groups in Kenya are less advanced in their agroecological transition than their counterparts in the study locations in Benin, Ethiopia and Madagascar. This may indicate that projects with a particular focus on agroecological farming practices are most effective in the early stages of agroecological transition. At more advanced stages, a more deliberate food systems approach with a strong focus on the sociocultural, economic and political dimensions of agroecology may be more relevant. This is substantiated, as this study found no effects of ProSoil activities on the TAPE score for land tenure but a highly significant correlation between the land tenure score and the agroecology score. This highlights that secure access to land is a key precondition for farmers to take decisions to invest in agroecological practices for long-term sustainability.

In the case of ProSoil, the degree of agroecological integration on project level had previously been assessed, and strategic adjustments were subsequently carried out. This demonstrates that a systematic approach to evaluating a project's contribution to agroecology is a valuable exercise for ensuring a holistic contribution to agroecological food system transformations. Donors and implementing agencies interested in supporting agroecological transitions are therefore recommended to use TAPE at project design stage or to make use of the diverse tools and frameworks available for such purposes,[1] particularly the common framework endorsed by the Agroecology Coalition.[2]

Regarding performance of agroecology, it may not come as a surprise that the results of this study show a strong positive correlation between the degree of agroecological integration and environmental performance. Across the four countries, households with higher agroecology scores also tend to have higher scores for biodiversity and soil health performance. The index of diversity of natural vegetation and pollinators is the only agrobiodiversity indicator that does not show a significant positive correlation with agroecology scores. This suggests that more deliberate efforts to raise awareness on the importance of functional agrobiodiversity, and to support its conservation, could further enhance farm sustainability and agroecology's contribution to national and international biodiversity targets. As the sociocultural dimensions of agroecology correlate strongly with agrobiodiversity performance, the results indicate that focusing efforts on building cultural awareness, promoting local collaborative breeding, and developing more localized food systems can be a promising approach for enhancing agrobiodiversity. Similarly, the co-creation and sharing of knowledge is among the agroecology elements with the strongest correlation with soil health performance. This highlights the importance of co-learning as well as knowledge exchange and dissemination to foster agroecological transitions and sustainability.

Despite the dedicated focus on soil health and fertility management by ProSoil, there is no significant difference in soil health performance between the ProSoil and comparison groups. Yet the higher agroecology scores in the ProSoil group are associated with much better performance in other core criteria. Hence, it seems that through ProSoil interventions in the study sites, farmers are supported in adopting soil management practices that are more sustainable overall. It is also possible that there is a time lag between implementing agroecological soil management practices and being able to measure meaningful differences in biological, chemical and physical soil-health attributes. Further, it is important to note that the present study is not an evaluation of ProSoil, and the comparison group is not a control group. This implies that many farmers in the comparison group also apply agroecological soil-health management practices. Some households may also have benefitted indirectly from ProSoil activities through spillover effects, and most have been engaged in other related projects, as several projects (past or active) in all the study locations have focused on soil fertility management.

While agroecology's contribution to environmental performance indicators is expected and desired, environmental issues in the vulnerable study locations are often only of secondary concern because they are overshadowed by immediate livelihood challenges, particularly hunger, malnutrition and economic poverty. It is therefore encouraging to see that the results show a highly significant positive correlation between increased agroecology scores and decreased perceived food insecurity scores. Among participants of ProSoil activities, a similarly strong correlation between agroecology scores and dietary diversity is also observed. This suggests that the ProSoil interventions enabled participating households to increase the diversity of production and consumption of food products. By contrast, for farmers not participating in ProSoil activities, agroecology engagement results in better food security but not necessarily in improved dietary diversity.

1 See Geck et al. (2023) for an overview of tools and approaches for assessing agroecology and its performance with diverse objectives and on different scales: https://journals.sagepub.com/doi/abs/10.1177/00307270231196309?journalCode=oaga
2 See Moeller et al. (2023): https://online.ucpress.edu/elementa/article/11/1/00042/197669/Measuring-agroecology-Introducing-a-methodological

Arguably the most important finding of this study is that there is a positive correlation between agroecology scores and economic performance. This means that – contrary to a common narrative – the environmental benefits of agroecological farming practices do not seem to come at the cost of reduced productivity and profitability. On the contrary, in the study locations in Benin, Ethiopia, Kenya and Madagascar, the promotion of farmers' agroecological transitions appears to be an effective strategy for boosting households' net incomes and for significantly increasing the overall productivity of farming systems. This is substantiated by other applications of TAPE in Africa,[3] which also found positive correlations between agroecology scores and economic performance, as well as by a global meta study on the socioeconomic performance of agroecology[4] and a separate independent study mandated by ProSoil – in the context of its EU co-funded project ProSilience – on the economic benefits of agroecological soil management practices.[5] Interestingly, households participating in ProSoil activities, and households with higher agroecology scores generally, do not demonstrate higher productivity regarding forestry products. This indicates that a more dedicated focus on timber and non-timber forest products, including through agroforestry, could further improve the productivity of agroecology in the study locations. Net income among agroecological farmers is enhanced particularly by lower financial expenditures and increased revenues from animal and livestock product sales, highlighting the importance of diversification, recycling, and optimizing synergies for economic gains. However, among ProSoil beneficiaries with advanced levels of agroecological transition, the agroecology element 'responsible governance' (assessed through indicators on producers' empowerment, networks and associations, as well as producers' participation in land and natural resource governance) also correlates closely with higher income. Again, this highlights that agroecology should not be limited to a series of farming practices when assessing its performance. Agroecology emphasizes reduced dependency on commercial inputs through production on farms and through cooperatives. Yet, the results of this study show that agroecological households generally incur higher expenditures for inputs, possibly because ecological inputs tend to be more costly in the study locations. This implies that deliberate efforts to decrease the costs of ecological and organic farming inputs are required to foster agroecological transitions.

Based on this cumulative evidence, we recommend that donors and funders increasingly channel their investments towards the transformation of agri-food systems, structured by the 10 elements and 13 principles of agroecology. The results of the collaborative MAP project clearly demonstrate that it is important not to limit such investments to agroecological farming practices but rather to view agroecology holistically – including its social, cultural, economic and political dimensions – in order to harness its full potential. Further, we recommend that policymakers, private sector investors, extension service providers, and civil society actors in the four countries – and beyond – collaborate to create more enabling environments for farmers and other food system actors to transition to agroecology. The results show a particular importance of supporting the development of local agroecological businesses that can produce ecological farming inputs at an accessible price. Finally, we recommend that all relevant actors take diverse dimensions of performance into account when assessing the performance of farming and food systems. This is to ensure that the inherent multifunctionality of such systems is adequately addressed, and that synergies and trade-offs between different performance dimensions are acknowledged.[6] Regarding the assessment of agroecology specifically, we strongly recommend that its performance be evaluated based on a holistic understanding of agroecology characterized by the 10 elements or 13 principles, and not on its agronomic dimension alone.

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3 See for instance:
- Lucantoni et al. (2022), who applied TAPE to 200 households in Lesotho: https://openknowledge.fao.org/server/api/core/bitstreams/575a093c-6a3a-4db6-a467-2cc08e2863e5/content;
- Lucantoni et al. (2023), who applied TAPE to 233 households in Mali: https://www.sciencedirect.com/science/article/abs/pii/S0308521X22001354?via%3Dihub;
- Wordofa et al. (2024), who applied TAPE to 619 households in Ethiopia: https://www.tandfonline.com/doi/full/10.1080/21683565.2024.2370316;

4 Mouratiadou et al. (2024): https://link.springer.com/article/10.1007/s13593-024-00945-9

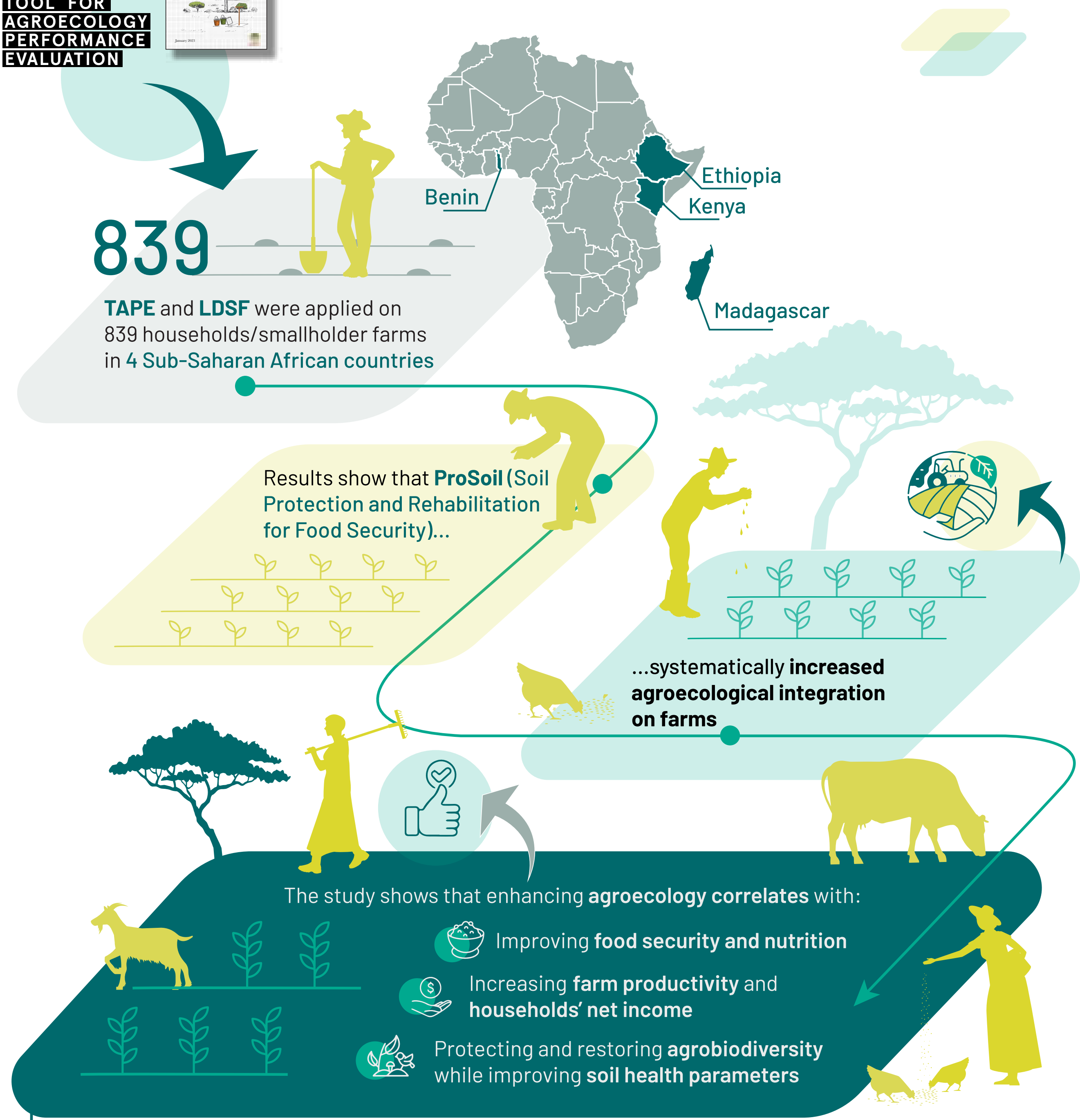
5 https://www.giz.de/en/downloads/giz2024-en-measuring-economic-benefits-of-agroecology.pdf

6 See Lamanna et al. (2024) for guidance on holistic agri-food system assessments: https://www.cifor-icraf.org/knowledge/publication/9081/

TOOL FOR AGROECOLOGY PERFORMANCE EVALUATION

The LDSF Field Manual

The results of the MAP project suggest that in the study sites in Benin, Ethiopia, Kenya, and Madagascar, agroecology is a highly effective approach for improving food security and nutrition, increasing farm productivity and households' net income, as well as protecting and restoring agrobiodiversity and improving soil health parameters. Yet, the results also show that the majority of households participating in this study are still at an incipient stage of agroecological transition.



Further efforts are required to enhance the multidimensional performance of farms, particularly regarding social performance dimensions such as women's and youth empowerment. The evidence suggests that impact, effectiveness, and relevance of agroecological interventions can be enhanced through a focus on improving land tenure security especially for women, integration of trees in agricultural landscapes and value addition for timber and non-timber forest products, as well as the support for local business development.

The Measuring Agroecology and its Performance (MAP) project is a collaborative initiative aimed at fostering agroecological transitions by generating evidence of agroecological contribution to societal goals. The MAP project is funded by the German Federal Ministry for Economic Cooperation and Development (BMZ), co-funded by the European Union (EU) and supported by the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH.

2 Context and methodological approach

Commissioned by the German Federal Ministry for Economic Cooperation and Development (BMZ), the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH implements the global programme Soil Protection and Rehabilitation for Food Security (ProSoil) in seven countries, namely Benin, Burkina Faso, Ethiopia, India, Kenya, Madagascar and Tunisia. With a programme duration from 2014 to 2027, ProSoil focuses on assisting partner countries in the "(…) widespread implementation of agroecological approaches that conserve soil and rehabilitate infertile soil in climate-smart, environmentally friendly ways."[7] In addition to providing training and guidance for farmers and agricultural consultants, ProSoil engages with government entities as well as research organizations, civil society and the private sector to create a more favourable environment for agri-food system change. It also supports the integration of agroecological soil-management approaches in curricula, while promoting knowledge sharing among countries and organizations involved in the programme.

Embedded in ProSoil is the DeSIRA (EU initiative Development Smart Innovation through Research in Agriculture) project Enhancing Soils and Agroecology for Resilient Agri-Food Systems in Sub-Saharan Africa (ProSilience), co-funded by the EU and BMZ. With a project duration from 2021 to 2024, ProSilience aims "(…) to enhance the agroecological transition towards sustainable agri-food systems (…)" in four of the ProSoil partner countries, namely Benin, Ethiopia, Kenya and Madagascar.[8] In each of the four countries, ProSilience is implemented in a context-specific manner to enhance the integration of agroecological principles in ongoing activities holistically at farm, agroecosystem, market and policy levels. During the design of ProSilience, GIZ assessed the degree of agroecological integration with the help of the Agroecology Criteria Tool (ACT).[9] At project level, the ACT makes it possible to rapidly appraise the degree of agroecological integration, but it does not combine this with a performance assessment.[10] One of the cross-country activities of ProSilience is the assessment of the ecological and socioeconomic impacts of agroecological practices.

In this context, the Measuring Agroecology and its Performance (MAP) project operates in a collaborative manner between GIZ, FAO, Stats4SD, CIRAD and CIFOR-ICRAF, under the umbrella of the Agroecology Transformative Partnership Platform (TPP).[11] The MAP project started in May 2023 and ended in September 2024. Data collection took place from October 2023 to March 2024. The MAP project aimed to develop partners' capacities to assess the multidimensional performance of agroecology, and to facilitate agroecological transitions through multistakeholder dialogues and the provision of evidence-based recommendations. However, the primary objective of the MAP project was to assess the degree to which ProSoil activities resulted in an enhanced integration of agroecology in participating households, and to evaluate how agroecological integration correlates with the multidimensional performance of farms. For this purpose, the Tool for Agroecology

7 https://www.giz.de/en/worldwide/129677.html
8 https://capacity4dev.europa.eu/projects/desira/info/prosilience_en
9 https://www.agroecology-pool.org/methodology/
10 https://journals.sagepub.com/doi/abs/10.1177/00307270231196309?journalCode=oaga
11 https://glfx.globallandscapesforum.org/topics/21467/page/TPP-home

Performance Evaluation (TAPE)[12] was applied to a total of 839 households in Benin, Ethiopia, Kenya and Madagascar. It was the first time that TAPE was applied in a comparable way across the four countries. The main implementing organizations were CIRAD in Madagascar and CIFOR-ICRAF in Benin, Ethiopia and Kenya. Given the focus on sustainable soil-management practices in ProSoil, the standard soil-health module of TAPE was complemented with robust soil sampling and laboratory analysis, following the methodological approach of the Land Degradation Surveillance Framework (LDSF).[13] Further, through the MAP project, Stats4SD developed an innovative data-management platform for TAPE, which has been piloted and refined in this collaborative project and will be available for future TAPE users.

TAPE, as a global analytical framework on agroecology, has been developed through a multistakeholder process under the auspices of FAO and incorporates key attributes of previous frameworks. TAPE consists of four steps:

- Step 0, the description of systems and context, was carried out in each of the four countries, largely building on existing analyses by ProSoil and complemented by key informant interviews as well as in-country kick-off meetings with key stakeholders.
- Step 1, the Characterization of Agroecological Transition (CAET), assesses the degree of integration with the 10 Elements of Agroecology (diversity, co-creation and sharing of knowledge, synergies, efficiency, recycling, resilience, human and social values, culture and food traditions, responsible governance, circular and solidarity economy)[14] on each assessed farm through a series of survey questions on 36 indicators.
- Step 2 assesses 10 Core Performance Criteria (secure land tenure, productivity, value added, income, agrobiodiversity, soil health, exposure to pesticide, dietary diversity and food security, women's empowerment, youth empowerment) – which are aligned with the United Nations Sustainable Development Goals (SDGs) – in five dimensions of sustainability (governance, economy, environment, health and nutrition, social) through 57 indicators. Step 2 was complemented by on-farm soil sampling following the LDSF method. The soil samples were analysed in the laboratories of CIFOR-ICRAF in Nairobi, Kenya, for physiochemical properties.
- Step 3, the joint analysis of Steps 1 and 2 and participatory interpretation, was carried out in each country through a multistakeholder workshop, where the key results, conclusions and recommendations were presented, discussed and refined.

In each of the four countries, Steps 1 and 2 were carried out by community facilitators who had undergone extensive training on TAPE and LDSF as part of a collaborative effort by CIRAD/CIFOR-ICRAF, FAO, GIZ and Stats4SD. In this cross-country report, we focus on the results of Steps 1 and 2. For the results of Steps 0 and 3, readers are kindly referred to the detailed country reports of the MAP project.[15] For a detailed description of TAPE and the indicators assessed in Steps 1 and 2, please refer to the FAO's official publication of the tool.[16]

To assess the contribution of ProSoil to agroecological transitions in the four countries, a purposive sampling strategy was chosen. For each country, around 100 households were randomly chosen from those that had actively participated in ProSoil activities previously, constituting the 'ProSoil group.' Around 100 additional households per country constituted the 'comparison group,' which were chosen at random from the communities that were targeted through ProSilience and had not actively participated in previous ProSoil activities. A collaborative effort between GIZ and CIRAD/CIFOR-ICRAF ensured that the agroecological and socioeconomic characteristics of the ProSoil and comparison groups were as similar as possible. Table 1 gives a brief overview of the study sites in the four countries. This approach was chosen because the before-and-after comparison was not possible to make due to time constraints. For a more detailed description, please refer to the country reports of the MAP project.[17]

12 https://www.fao.org/agroecology/tools-tape/en/
13 https://www.cifor-icraf.org/knowledge/publication/35961/
14 https://www.fao.org/agroecology/overview/overview10elements/en/
15 https://glfx.globallandscapesforum.org/topics/21467/page/measuring-agroecology-and-its-performance
16 https://openknowledge.fao.org/items/8511c796-c7d1-4a04-895d-a28115731ce0
17 https://glfx.globallandscapesforum.org/topics/21467/page/measuring-agroecology-and-its-performance

Table 1. Brief overview of the study sites in the four countries where TAPE was applied through the MAP project

Country	Context summary of study sites
Benin	A total of 240 households (120 each in ProSoil and comparison groups) in the departments Borgou, Collines and Zou, spread across Sudanian, Sudano-Sahelian, and Sudano-Guinean ecoregions, with mean annual precipitation of 800–1,500 mm. Mostly mixed subsistence farming and agropastoral systems (on average 5 ha agricultural land, 2 ha natural vegetation, and 0.6 ha pasture per household). Major crops: rice, sorghum, corn, yam, beans, peanuts, cassava and cotton. Livestock: mostly sheep and cattle. Agroforestry systems with fruit and timber trees common.
	Key ProSoil interventions: dissemination of innovative techniques for integrated management of soil fertility, in particular the introduction of combinations of agroecological practices and the use of legumes in rotations as well as the use of organic matter and super-granulated urea. Fostering value chain of agroecological outputs - such as biochar, seeds and small-scale mechanisation - as well as promotion of agroecological practices through farmer field schools and relay farmer approach.
Ethiopia	A total of 198 households (99 each in ProSoil and comparison groups) in Hula, Sodo-Zuria and Walmara districts in the Sidama, Southern and Oromia regions, respectively. Midland and highland zones, at an altitude of 1,500–3,190 m above sea level, characterized by mean annual precipitation of 800–1,900 mm and experiencing a mean annual temperature of 16°C to 19°C. Rainfall distribution is bimodal, with short rains received in March and April and the main rainfall from June to September. The latter is the main cropping season. The short rains are often variable in distribution and amount and can fail completely. Mixed subsistence smallholder farming system. Average farm holding size per district: 0.9 ha (Sodo-Zuria), 1.9 ha (Hula) and 2.2 ha (Walmara). Major crops: wheat, teff, barley, maize, sorghum, faba bean, peas, chickpea, lentils, beans, fruits, vegetables, root and tuber crops. Cash crops: coffee, sugarcane, ginger (Sodo-Zuria), khat, and eucalypt (Walmara). Livestock: cattle, sheep, goats, chickens and pack animals (donkeys, horses and mules). Population growth contributes to land shortages, deforestation and land degradation. Soil acidity, reduced soil organic matter, and limited access to inputs (seeds, fertilizers, pesticides) are among the main production constraints. Limited access to markets. Highly structured top-down and centralized public extension system. Generally, policies provide a favourable enabling environment for agricultural development, though coordination and follow-up on implementation are important gaps. Key ProSoil interventions: capacity development and training on integrated soil fertility management (ISFM); crop-livestock-forestry nexus to reduce nutrient losses; temporal and spatial farm diversification as well as water harvesting and management approaches. Introduction of improved fodder, fruit trees and livestock breeds; support for biogas production; small-scale mechanization services and liming.
Kenya	A total of 201 households (101 in ProSoil group and 100 in comparison group) in Bungoma, Kakamega and Siaya counties in western Kenya. Lower midland zones, characterized by reliable mean annual precipitation (650–1,900 mm) at an altitude of 790–1,500 m above sea level and experiencing a mean annual temperature of 21.8°C to 24°C. Mixed subsistence smallholder farming (average farm size 0.77 ha), surplus mostly sold locally. Major crops: maize, beans, vegetables, bananas, sweet potatoes, fruits. Major livestock: cattle, chickens, goats, sheep. 68% of farmers live below the international poverty line. Limited access to markets and poor physical infrastructure. Public subsidies for mineral fertilizers and procurement of tractors. County-level policies that are supportive of agroecological transitions are being drafted. Key ProSoil interventions: The project focuses on enhancing agroecological practices through key interventions, such as the training of farmers in agroecological measures aimed at protecting and rehabilitating degraded soils both on farm and off farm. The project also tests and generates evidence on agroecological innovations and supports farmer-led research to encourage private sector engagement. Additionally, it supports the development of soil management curricula, as well as national and county-level policies aimed at promoting agroecology, while advocating for policy changes through dialogue on soil management to create a supportive environment for sustainable agriculture. Furthermore, the project undertakes knowledge management to ensure that lessons learned during implementation are shared.

continue to the next page

Table 1. Continued

Country	Context summary of study sites
Madagascar	A total of 200 households (102 in ProSoil group and 98 in comparison group) in Belobaka, Katsepy, Manerinerina and Tsaramandroso municipalities in the Boeny Region. Tropical semi-arid area with a mean annual precipitation of 1,200-1,300 mm in a five-month period. Tabular shapes (plateau), with an average altitude always less than 800 m, and plains along the major rivers and the seacoast. Low population density with large proportion of rural migrants coming from other parts of Madagascar. Mixed subsistence smallholder farming (average farm size 1.5 ha), with surplus usually sold informally through middlemen. Dominated by lowland rice cultivation (around 50% of cultivated land). Variety of pulses grown in temporarily flooded areas. Fruit trees, particularly mango, are common. Cattle (on average, three animals per household) are common for fieldwork and transportation, with limited farmyard manure production. Poor physical infrastructure and low level of institutional support. Pesticide use is frequent for cash crops (pulses, maize, vegetables). Key ProSoil interventions (project began three years later than in the other three countries): training on soil protection and land rehabilitation measures; promotion of agroecological practices through NGOs and pilot farmers; support for planting forestry and fruit trees; political and institutional anchoring of soil protection and land rehabilitation; policy dialogue to secure land tenure in common pasture areas; management of knowledge relating to soil protection and land rehabilitation, and networking of the holders and potential beneficiaries of this knowledge.

The statistical analysis of results was carried out by Stats4SD in close collaboration with the other project partners. For this cross-country report, the data from the four countries are treated as a single dataset. Detailed results on Steps 1 and 2 of TAPE can be found in the annexes. CAET scores, both overall and the individual elements, are plotted using a combination of boxplots and violin plots to show the distribution of scores across the two groups. These are accompanied by a table of results from multiple t-tests to assess whether the difference in means between the ProSoil and comparison groups is statistically significant. These means are additionally plotted on a radar plot comparing the two groups. Composite scores to represent Step 2 performance are presented first at an overall level on a scatterplot with a moving average line; Spearman's rank correlation coefficients are also included. Scores are then shown disaggregated on a similar scatterplot along with combined box and violin plots as well as a table showing the mean, median, standard deviation and interquartile range of the composite scores. Additional scatterplots are provided showing the composite score against each of the 10 CAET element scores, as well as plots of the overall CAET score against the individual indicator scores that contribute to the composite score. In most cases, the latter shows the raw values of the specific indicators, but for monetary indicators, the quantile scores that are used in the composite score calculation are applied instead. Finally, the overall CAET scores are split into five groups ranging from very low (<40) to very high (70+). For each individual indicator and the composite score, the means are plotted across these five CAET score groups. These means are plotted with 95% confidence intervals.

3 ProSoil's contribution to agroecological transitions

Step 1 of TAPE focuses on evaluating the level of agroecological transition – meaning the integration of the 10 elements of agroecology – in the assessed farms and households. On average, across the four countries, households actively participating in ProSoil activities are at significantly more advanced stages of agroecological transition than comparison households (Figure 1). However, also in the ProSoil group, most households are still at an incipient stage of transition (CAET scores between 50 and 60) and only a few households are at an advanced transition stage (CAET scores above 75).

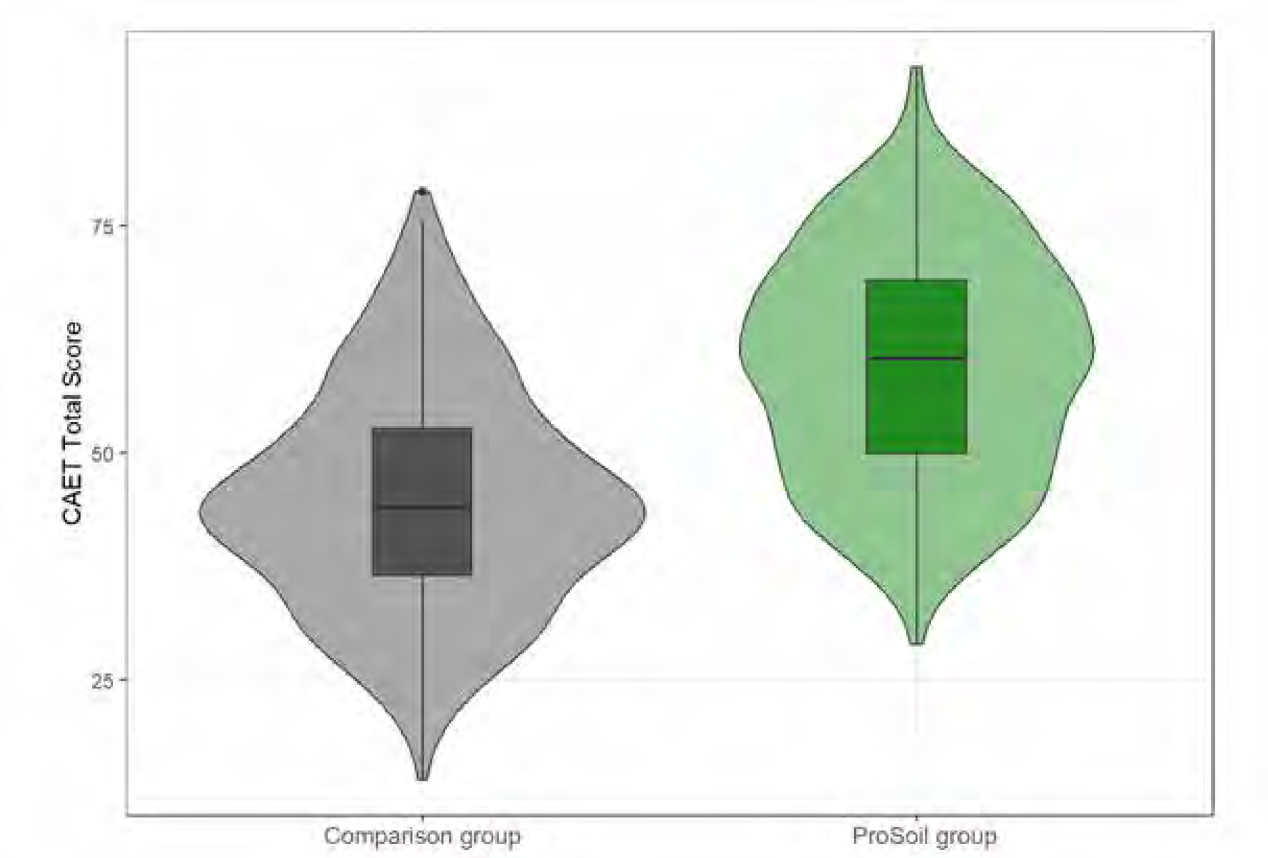


Figure 1. Results across the four countries included in this study of TAPE Step 1, i.e. the Characterization of Agroecological Transition (CAET), comparing households (n=839) that actively participated in ProSoil activities with the comparison group.

The households in the ProSoil group consistently showed higher average CAET scores across all 10 elements of agroecology than the households in the comparison group (Figure 2). The difference between the two groups is most pronounced for the agroecology element 'co-creation and sharing of knowledge.' This suggests that – apart from enhancing knowledge and capacities for farming practices relating to the agroecology elements efficiency, diversity, recycling and synergies – ProSoil gave considerable support to farmers in their agroecological transitions by establishing or strengthening social mechanisms for horizontal knowledge creation and sharing; raising awareness on agroecology among communities; and facilitating the increased participation of farmers in networks and associations. Further, the significantly higher average CAET scores of the ProSoil group on sociocultural, economic and political elements of agroecology suggest a holistic contribution of ProSoil to agroecological transitions in the study sites, going beyond the household level and encompassing broader areas of food system change.

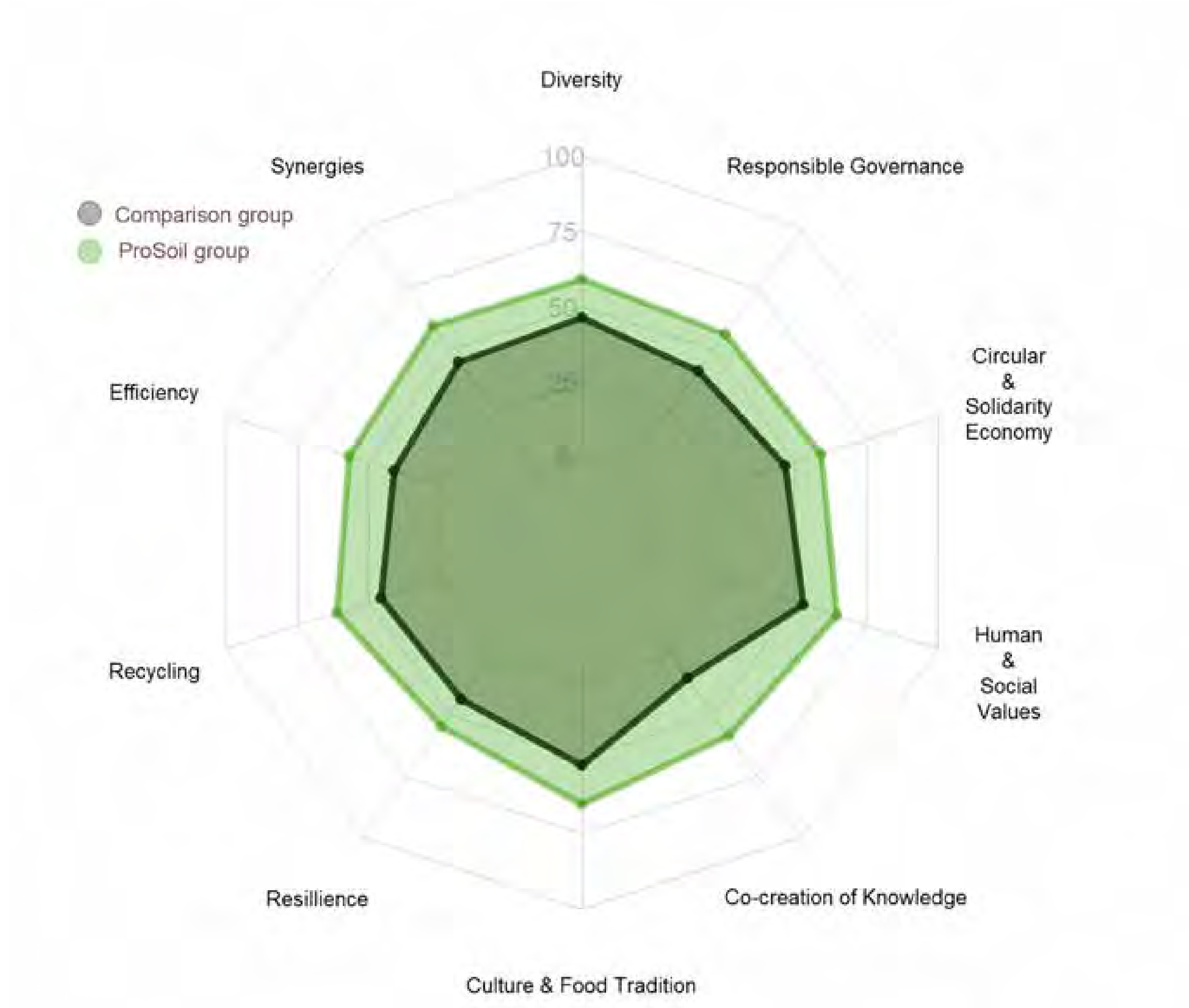


Figure 2. Results of TAPE Step 1, i.e. the Characterization of Agroecological Transition (CAET), across the four countries included in this study comparing households that actively participated in ProSoil activities with the comparison group for each of the 10 elements of agroecology.

While the average total CAET score is higher for the ProSoil group than for the comparison group in Benin, Ethiopia, Kenya and Madagascar, there are marked differences between the four countries (Figure 3). In Benin, Ethiopia and Kenya, the ProSoil group shows higher average CAET values across all 10 elements of agroecology. In Madagascar, only in the elements diversity and synergies does the ProSoil group show significantly higher average CAET scores. This may be because ProSoil activities began three years later in Madagascar than in the other three countries. Further, this could indicate that, in Madagascar, former beneficiaries or those who benefitted from training or from neighbourhood and family effects – without being in the project database – were present in the comparison group and thus have led to similarly advanced agroecological transitions for both groups. Additionally, it could imply that, in Madagascar, the activities of ProSoil had a less holistic contribution to farmers' agroecological transitions than in the other three countries. In Madagascar, there was a particular focus on farm diversification and the enhancing of synergies between different components of the farm and agroecosystem.

It is also noteworthy that, in Kenya, the difference in average CAET scores between the ProSoil and comparison groups is more pronounced than in the other three countries, but the farmers of both groups in Kenya are less advanced in their agroecological transition than their counterparts in the study locations in Benin, Ethiopia and Madagascar. This suggests that the interventions of ProSoil are more effective in fostering agroecological integration at incipient stages of agroecological transition. In contexts of more advanced starting points of agroecological transition, such as in the Ethiopian study sites, a more deliberate food system approach focusing on the enabling environment – including policies and institutions, market development, business and investment environments, as well as research and extensions systems – may be required to further foster agroecological transitions.

Figure 3. Average CAET scores for each of the 10 elements of agroecology for the ProSoil and comparison groups in each of the four countries included in this study.

4 Performance of agroecology in the context of ProSoil

By correlating Steps 1 and 2 of TAPE, it is possible to draw conclusions on the performance of agroecology in the context of the global programme ProSoil in Benin, Ethiopia, Kenya and Madagascar. Further, the results of Step 2 of TAPE make it possible to identify the core criteria of assessed performance, with a pronounced difference between the ProSoil and comparison groups. The results below are structured according to the five dimensions of sustainability for Step 2 in TAPE. Health and nutrition performance is included in the social dimension for the purposes of this report.

Regarding the governance dimension of sustainability, which is assessed by four indicators on secure land tenure in TAPE, no major differences were observed between the ProSoil and comparison groups. This might be because the assessed indicators fall outside the direct scope of ProSoil's activities. There is, however, a significant positive correlation between the degree of agroecological integration (CAET score) and the performance in this dimension (see Annex 2). This correlation is particularly significant for the indicator on legal recognition of land, in the case of both female and male heads of households. Overall, however, women have a slightly lower score for secure land tenure, which indicates the need to increase gender equity in land rights in the study locations. Legal recognition of land is a key precondition for enabling agroecological transitions on farms. The positive correlation between secure land tenure and CAET scores is particularly pronounced for the agroecology elements resilience, synergies, and diversity but also for co-creation of knowledge. This highlights the importance of tenure security in farmers' decisions to invest in agroecological practices for long-term sustainability and also to engage in time-consuming co-creation of knowledge activities.

4.1 Economic performance

TAPE assesses the economic performance of farms in terms of productivity, value added and income. It is particularly noteworthy that the results show a highly significant positive correlation between agroecological transition (CAET scores) and both farm productivity and household net income. There is no significant correlation between CAET scores and composite 'value added' scores, nor is there any marked difference in this core criterium of performance between the ProSoil and comparison groups. Total expenditure for the purchase of seeds, fertilizers, pesticides and machinery is the only TAPE indicator for value added that showed a clear correlation with CAET. The results suggest that, in the study locations, increased levels of agroecological transition come at the cost of higher expenditures for inputs. This is a surprising finding, given that agroecology aims at reducing farmers' dependency on commercial inputs by enhancing on-farm production, recycling and synergies. However, the results show that agroecological farmers do require access to ecological off-farm inputs. In the study locations, these are often considerably more expensive than conventional inputs. This implies that deliberate efforts to reduce the costs of ecological and organic farming inputs are required to further foster agroecological transitions. The detailed results for the value added criterium can be found in Annex 4.

4.1.1 Productivity

On average, across the four countries, there is a significant positive correlation between the degree of agroecological integration and overall productivity (Figure 4 and Annex 3). This finding is very important, as it contrasts sharply with the common perception that agroecology leads to environmental benefits at the cost of reduced productivity. This narrative is often used to justify investments in intensified agriculture based on an increased reliance on monoculture and on external synthetic inputs, as the alternative might be further conversion of natural ecosystems for agricultural purposes. The results here suggest that agroecological intensification – relying on diversification, recycling and optimizing synergies – is a viable alternative for increasing productivity in the study locations, potentially offering social and environmental benefits, such as enhanced biodiversity in agricultural landscapes aligned with the land-sharing paradigm.[18]

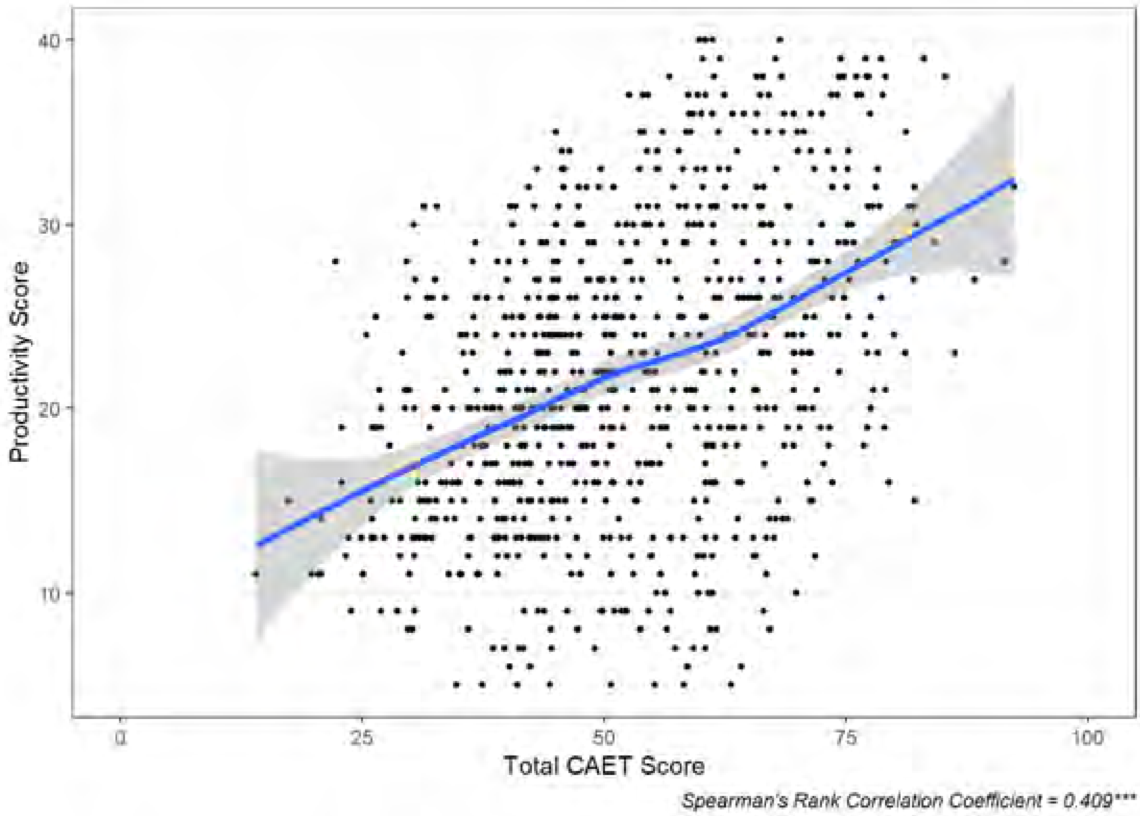


Figure 4. Correlation between degree of agroecological integration (CAET score) and composite productivity score, combining the four TAPE indicators for productivity: quantity of crop and forest products produced; quantity of animals and livestock products produced; monetary value of agropastoral production; and gross value of the agricultural production (per ha and per person). Scatterplot with a moving average line; a Spearman's rank correlation coefficient is also included.

With regard to how individual elements of agroecology correlate with productivity, it is noteworthy that not only the production-related elements – such as diversity, recycling and synergies – but also two sociocultural elements (human and social values as well as culture and food traditions) show significant positive correlations. This shows that it is important not to limit agroecology to farming practices when assessing its economic performance.

18 See https://www.chathamhouse.org/2022/05/sustainable-agriculture-and-food-systems/03-version-2-agroecology-and-land-sharing and https://tabledebates.org/building-blocks/table-summary-series-land-sparing-sharing for an overview of the role of agroecology in the debate about land sparing and land sharing.

Interestingly, the positive correlation between CAET score and productivity can be observed for each of the individual indicators for productivity, but with one exception: when forestry products are considered in addition to crop production, the productivity is fairly stable across CAET scores. This indicates that a more dedicated focus on timber and non-timber forest products, including through agroforestry, could further improve the productivity of agroecology in the study locations.

4.1.2 Income

While less pronounced than for the 'productivity' core criterion of performance, Figure 5 shows that also for the aggregated income score, there is a highly significant positive correlation with the degree of agroecological integration. In general terms, this trend holds true for all four countries but is less pronounced in Ethiopia and Madagascar (Figure 6). Whereas in Kenya and Madagascar the households with the highest CAET scores are also among those with the highest income, in Ethiopia the three most agroecological households have a comparably low income. These results indicate that in the study locations, support for agroecological transitions is likely to result in higher household incomes, but this will not automatically be the case and can also result in lower incomes under certain conditions. This interpretation is further substantiated when comparing the ProSoil and comparison groups, as households from the ProSoil group with CAET scores above 50 are overrepresented among households with the highest income but also among households with the lowest income (Figure 7).

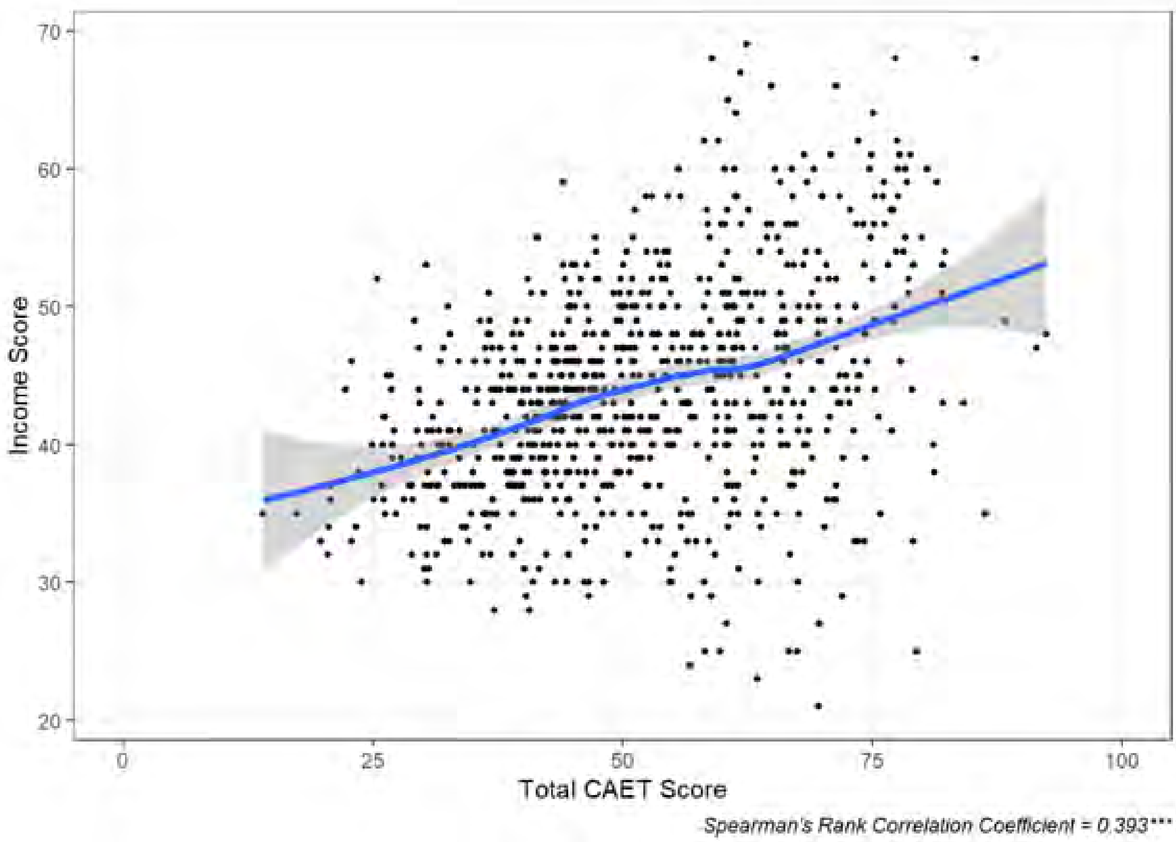


Figure 5. Correlation between degree of agroecological integration (CAET score) and composite income score, combining the 10 TAPE indicators for productivity: revenue derived from crop and forestry products; revenue derived from animals and livestock products; revenue derived from other activities; financial 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 below the poverty level; depreciation; and expenditure for wages. Scatterplot with a moving average line; a Spearman's rank correlation coefficient is also included.

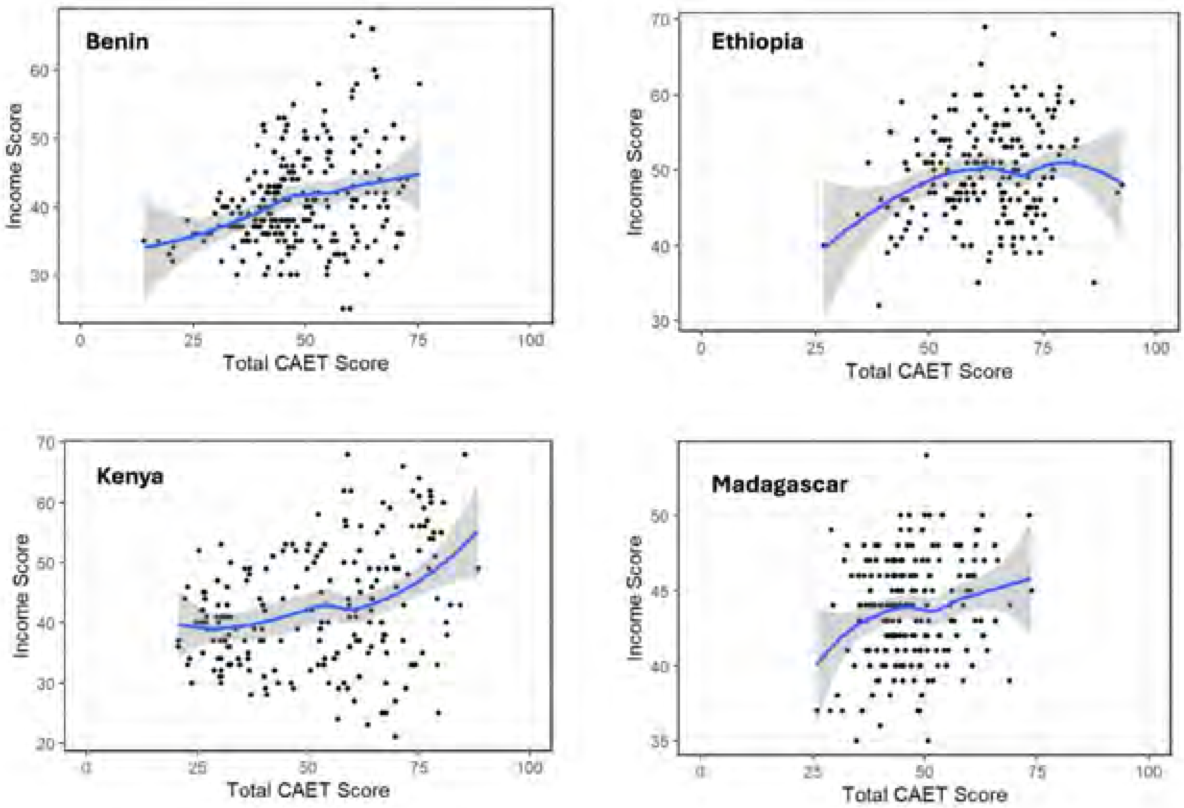
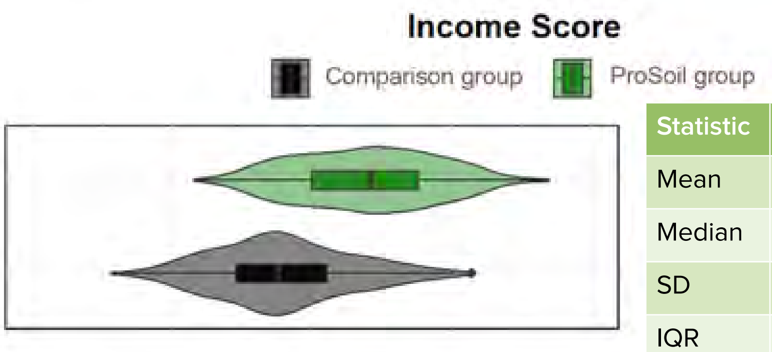


Figure 6. Correlation between degree of agroecological integration (CAET score) and composite income score per each of the four countries included in this study.



Statistic	Comparison group	ProSoil group
Mean	42.7	45.2
Median	42	45
SD	6.3	8.8
IQR	38.0-47.0	40.0-51.0

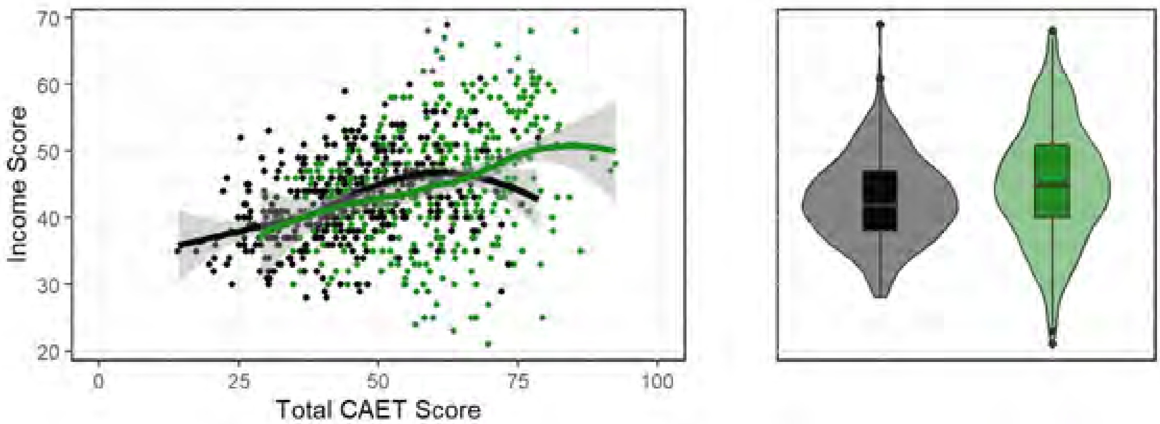


Figure 7. Correlation between degree of agroecological integration (CAET score) and composite income score across the four countries disaggregated by the ProSoil and comparison groups. Scores are disaggregated by the ProSoil and comparison groups on a scatterplot along with combined box and violin plots as well as a table showing the mean, median, standard deviation and interquartile range of the composite scores.

A closer look at the individual indicators contributing to the aggregated income score (Annex 5) shows that higher CAET scores are particularly correlated with lower financial expenditures and increased revenues from animal and livestock product sales. This indicates that, in the study locations, the financial benefits of agroecology are predominantly through reducing production costs and through diversifying income sources by an enhanced integration of livestock in mixed farming approaches. This is underlined by the fact that the agroecology elements diversity, recycling and synergies are of particular relevance in contributing to the positive correlation between CAET scores and net income. Further, in households from the ProSoil group with advanced levels of agroecological integration, the element 'responsible governance' (assessed through indicators on producers' empowerment, networks and associations, as well as producers' participation in land and natural resource governance) has a strong positive correlation with higher net income. Again, this highlights how important it is not to limit agroecology to a series of farming practices but also to support the integration of the sociocultural and political dimensions of agroecology in order to render farms more sustainable and profitable.

4.2 Environmental performance

Agroecology is often defined as an environmentally friendly approach to food and farming systems, which is underlined in the results of TAPE, showing clear correlations between the degree of agroecological integration and improved biodiversity and soil health. The results of TAPE are partially substantiated by the complementary assessment of physiochemical parameters of soil health based on laboratory analysis.

4.2.1 Agrobiodiversity

Given that on-farm diversification is a crucial element of agroecological transitions, it is not particularly surprising that the results of this study show a highly significant positive correlation between CAET and agrobiodiversity scores (Figure 8). The index of diversity of natural vegetation and pollinators is the only agrobiodiversity indicator that does not show a significantly positive correlation with CAET scores (Annex 6). This suggests that more deliberate efforts to raise awareness about the importance of functional agrobiodiversity and support for its conservation could further enhance farm sustainability and agroecology's contribution to national and international biodiversity targets. Among individual elements of agroecology, particularly the elements diversity and synergies, are closely correlated with increased agrobiodiversity (Annex 6). The sociocultural dimensions of agroecology, such as human and social values as well as culture and food traditions, also appear to be a major contributing factor to increased agrobiodiversity. Hence, the results indicate that focusing efforts on building cultural awareness about food traditions and diets; promoting local collaborative breeding; and developing more localized food systems can be a promising approach for enhancing agrobiodiversity.

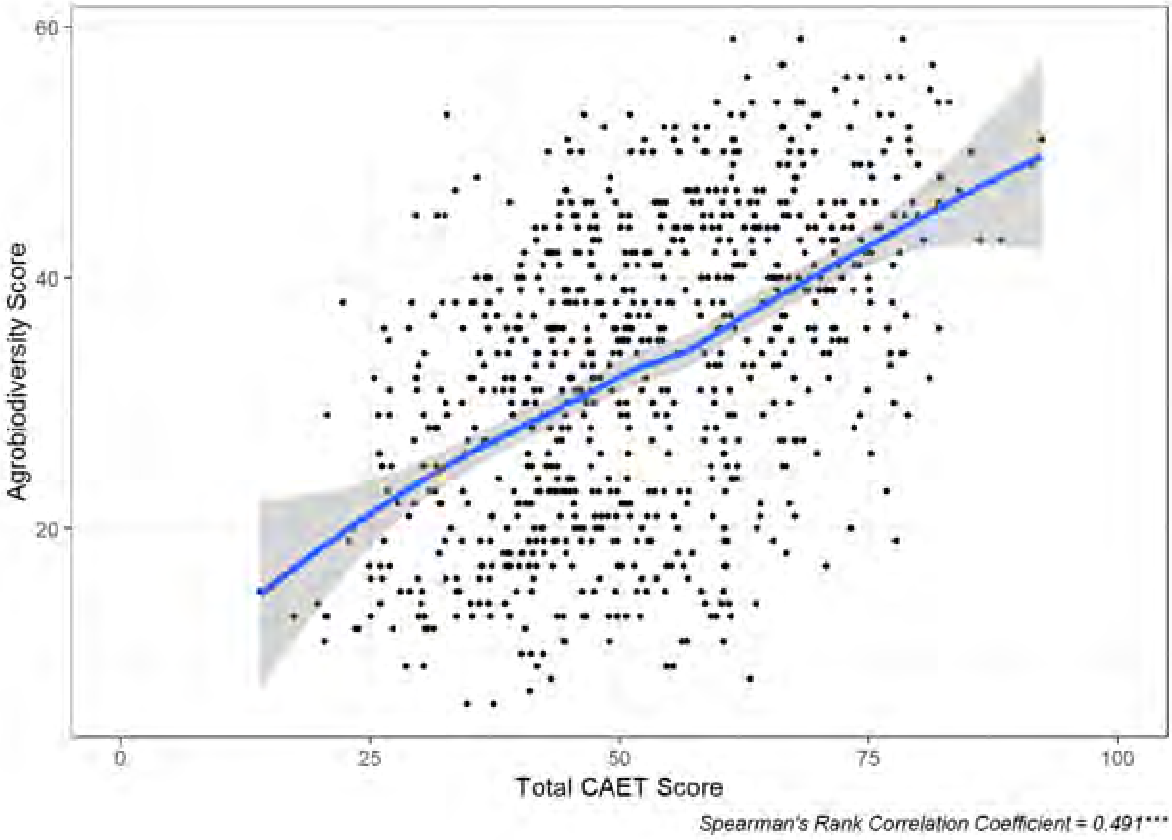


Figure 8. Correlation between degree of agroecological integration (CAET score) and composite agrobiodiversity score, combining the six TAPE indicators for agrobiodiversity: Gini-Simpson index for diversity of crops, Gini-Simpson index for diversity of animals, index of diversity of natural vegetation and pollinators, number of species and varieties of crops, number of species and breeds of animals, total number of livestock units. Scatterplot with a moving average line; a Spearman's rank correlation coefficient is also included.

The overall trend holds true for both the ProSoil and the comparison groups, with households actively participating in ProSoil activities demonstrating higher agrobiodiversity, on average (Annex 6). Interestingly, however, farms from the comparison group, on average, have a higher number of total livestock units. This could indicate that the diversification efforts of the ProSoil group come at the expense of quantity of animals. As the results in Section 4.1 show, this does not lead to lower income from animals and livestock products for the ProSoil group. On the other hand, households from the ProSoil group – when they are in the advanced stages of agroecological transition – tend to cultivate considerably more crop species and varieties than households from the comparison group.

4.2.2 Soil health

The standard soil health assessment in TAPE is based on 10 indicators assessed jointly on the farm by the community facilitators and the interview partners. In the MAP project, this was complemented by soil sampling and laboratory analysis. As ProSoil is a programme focusing on soil health, soil protection and soil rehabilitation, it is of particular importance to provide evidence regarding its impact on soils. The TAPE results show a highly significant positive correlation between the degree of agroecological integration (CAET scores) and soil health (Figure 9). Production-related agroecology elements – such as efficiency, recycling and synergies – show a clear positive correlation with soil health scores, but only at more advanced stages of agroecological transition (CAET scores above 75). This indicates that soil-health benefits manifest themselves largely when different agroecological farming practices are combined. The co-creation and sharing of knowledge is among the agroecology elements with the strongest correlation with soil health performance (Annex 7). This highlights the importance of co-learning as well as knowledge exchange and dissemination to foster agroecological transitions and sustainability.

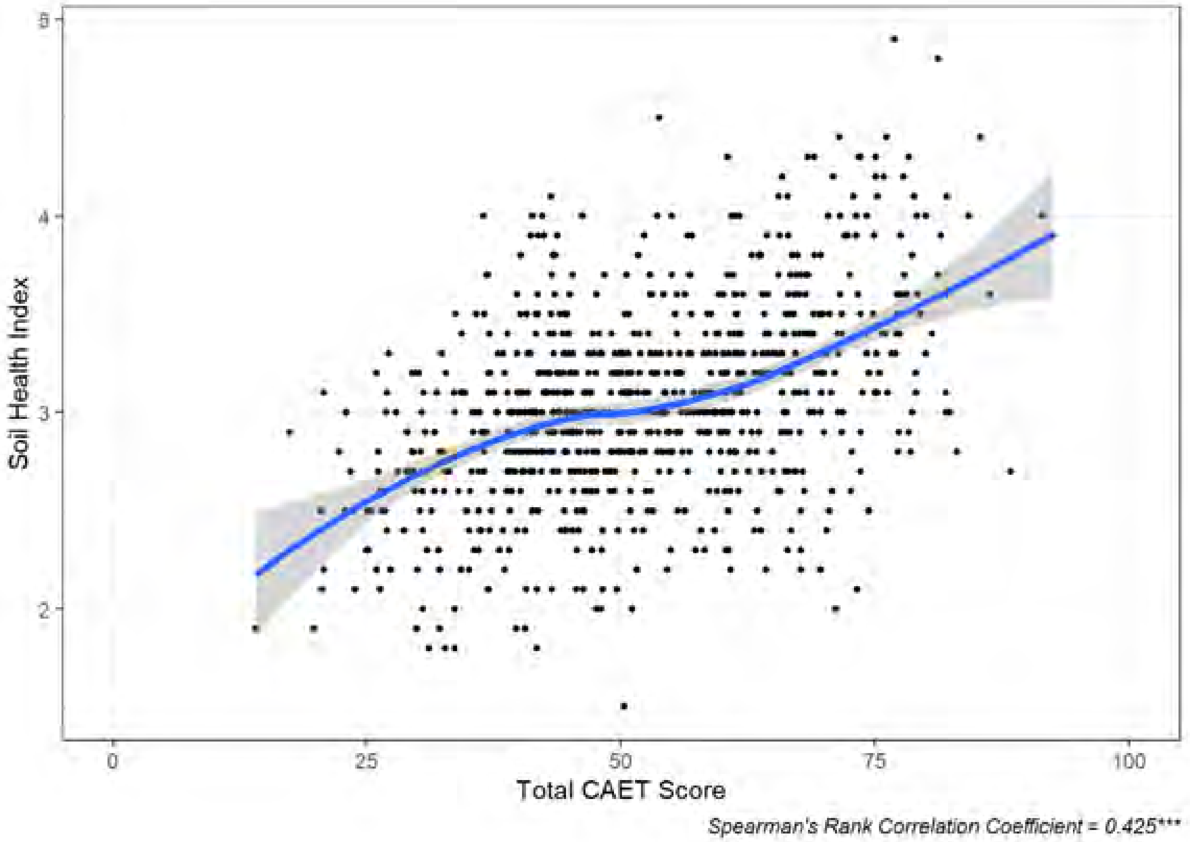


Figure 9. Correlation between degree of agroecological integration (CAET score) and composite soil health score, combining the 10 TAPE indicators for soil health: structure, compaction, depth of superficial soil, status of residues, colour and odour, presence of organic matter, water retention, soil cover, erosion, and microbiological activity. Scatterplot with a moving average line; a Spearman's rank correlation coefficient is also included.

Regarding the individual TAPE indicators for soil health, particularly microbiological activity, colour and odour, soil cover, and soil erosion show a significantly positive correlation with CAET scores (Figure 10). It is likely that these soil characteristics respond quickly to changes in soil management practices, such as the adoption of cover cropping and the addition of organic matter. For depth of superficial soil, water retention, and status of residues, only at higher CAET scores (above 60) can a positive correlation be observed, indicating that several agroecological practices need to be combined in synergistic fashion and probably over a sustained period to affect these soil characteristics. Finally, soil compaction and structure do not appear to be correlated with CAET scores in the study locations, whereas presence of invertebrates appears to decline slightly at higher degrees of agroecological integration. However, the latter negative correlation can only be observed in farms of the comparison group (Figure 10).

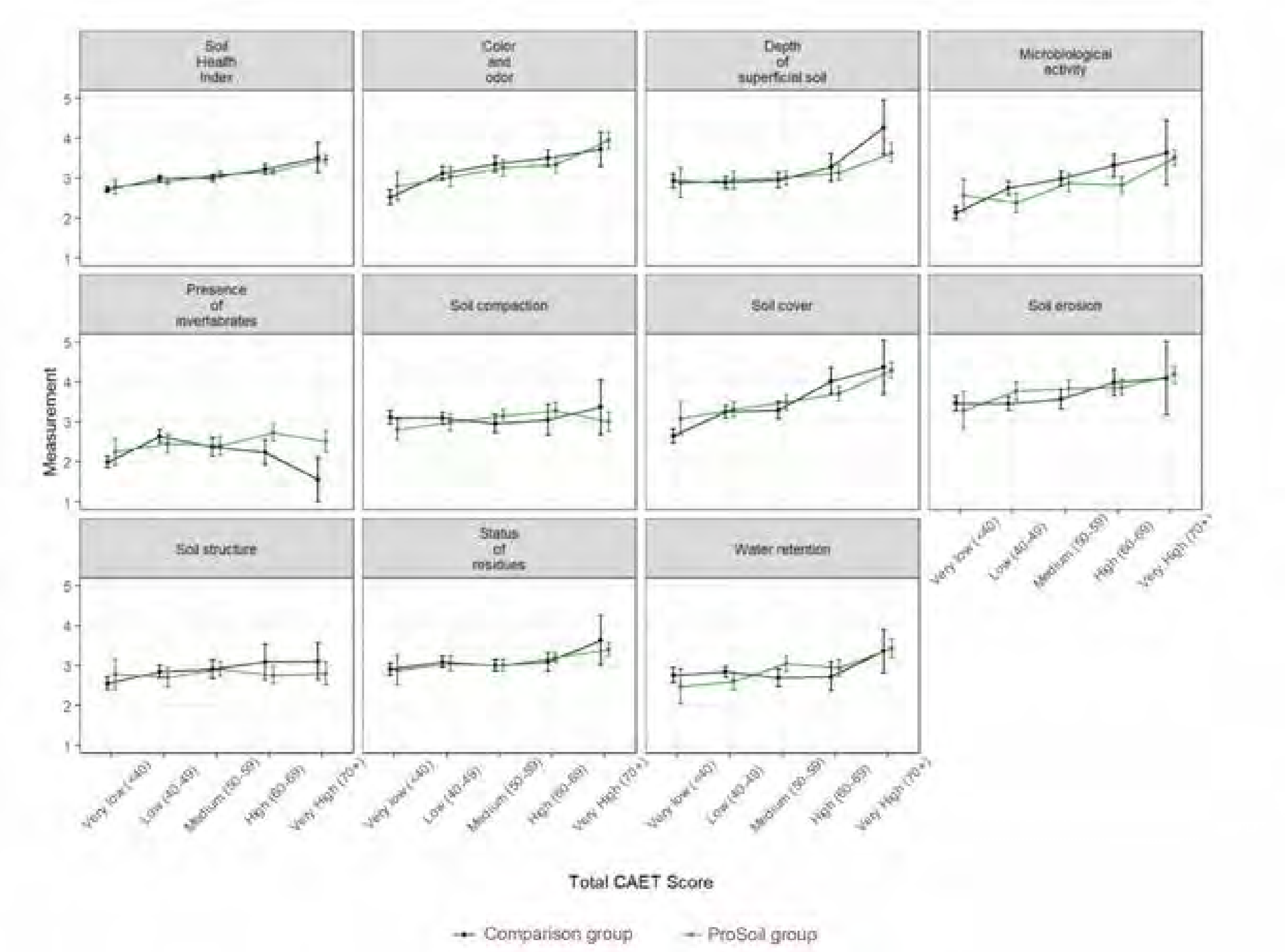


Figure 10. Overview of correlations between degree of agroecological integration (CAET score) and composite soil health index, as well as each of the 10 individual TAPE indicators for soil health. The overall CAET scores are split into five groups from very low (<40) to very high (70+). For each individual indicator and the composite score, the means are plotted across these five CAET score groups. These means are plotted with 95% confidence intervals.

For all of the 839 assessed households, the standard soil health assessment through TAPE was complemented by laboratory analysis of soil samples based on the LDSF methodology (Annex 8). The LDSF results partially substantiate the TAPE assessment showing a positive correlation of CAET scores with soil health parameters. Yet the broad diversity of soil characteristics makes generalizations difficult. Most of the assessed soils are low in soil organic carbon (SOC) but there is a clear correlation between CAET scores above 50 and increased SOC content, indicating the potential to continue to increase SOC with appropriate management (Figure 11). There are considerable differences between the four countries. While in Ethiopia and Kenya most farms have optimal to moderately high SOC levels, in Benin and Madagascar nearly all assessed soils are low in organic carbon in both topsoil (0–20 cm depth) and subsoil (20–50 cm) (Annex 8). Soil organic carbon is a key indicator of soil health, as it responds to management practices.

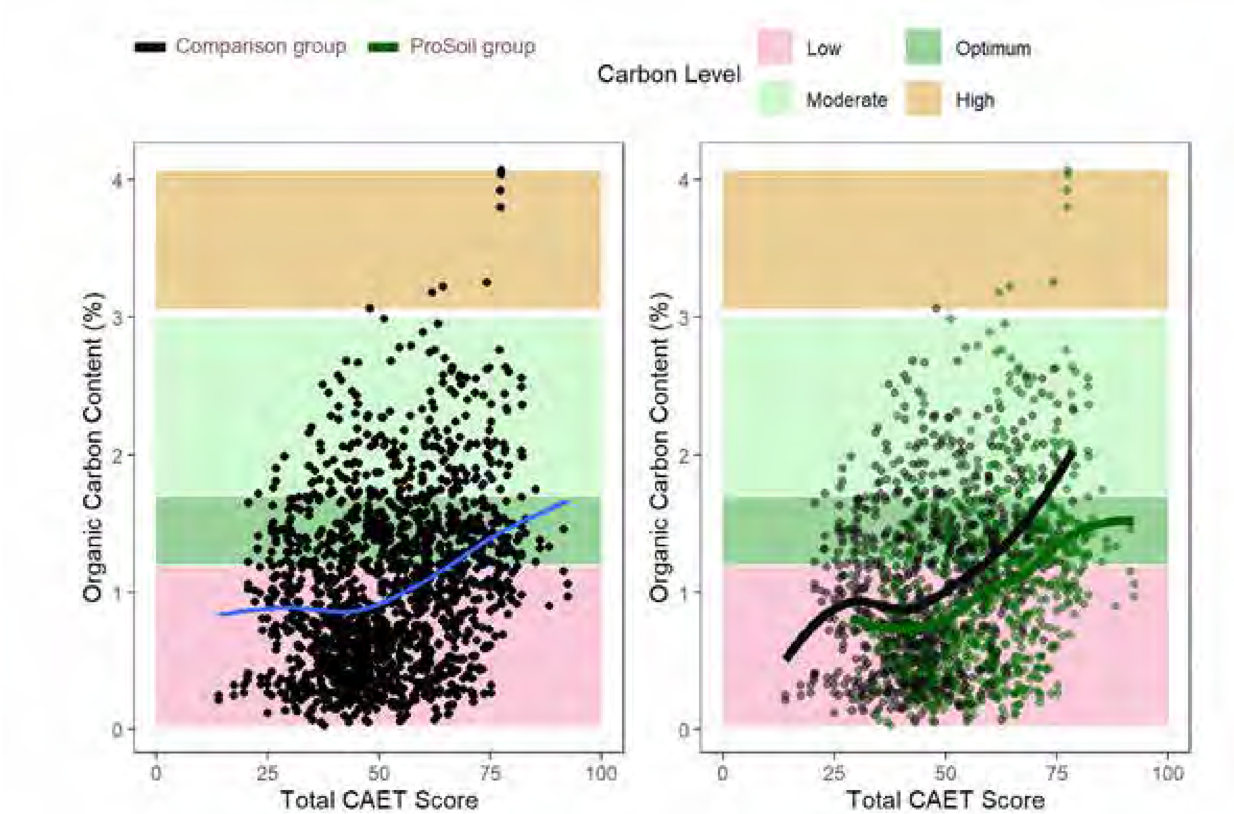


Figure 11. Correlation of degree of agroecological integration (CAET scores) with soil organic carbon content for the total dataset (left) and disaggregated by ProSoil and comparison groups (right). The categorization of low, optimum, moderate and high is based on critical levels.

The total nitrogen content in the assessed soil samples tends to be low or very low (Figure 12). However, the highly significantly positive correlation between CAET scores above 50 and increased nitrogen content indicates that agroecology provides a viable option for increasing soil fertility in the study locations once a certain level of agroecological integration is reached. The data suggest, however, that the soil management practices applied by agroecological farmers of the comparison group are slightly more effective in increasing nitrogen content than those applied by farmers of the ProSoil group. This might be explained by a potential use of mineral fertilizer in the comparison group. Similar trends for positive correlations between CAET scores and soil health parameters can be observed for cation exchange capacity and potassium concentration, yet without clear differences between the ProSoil and comparison groups (Annex 8).

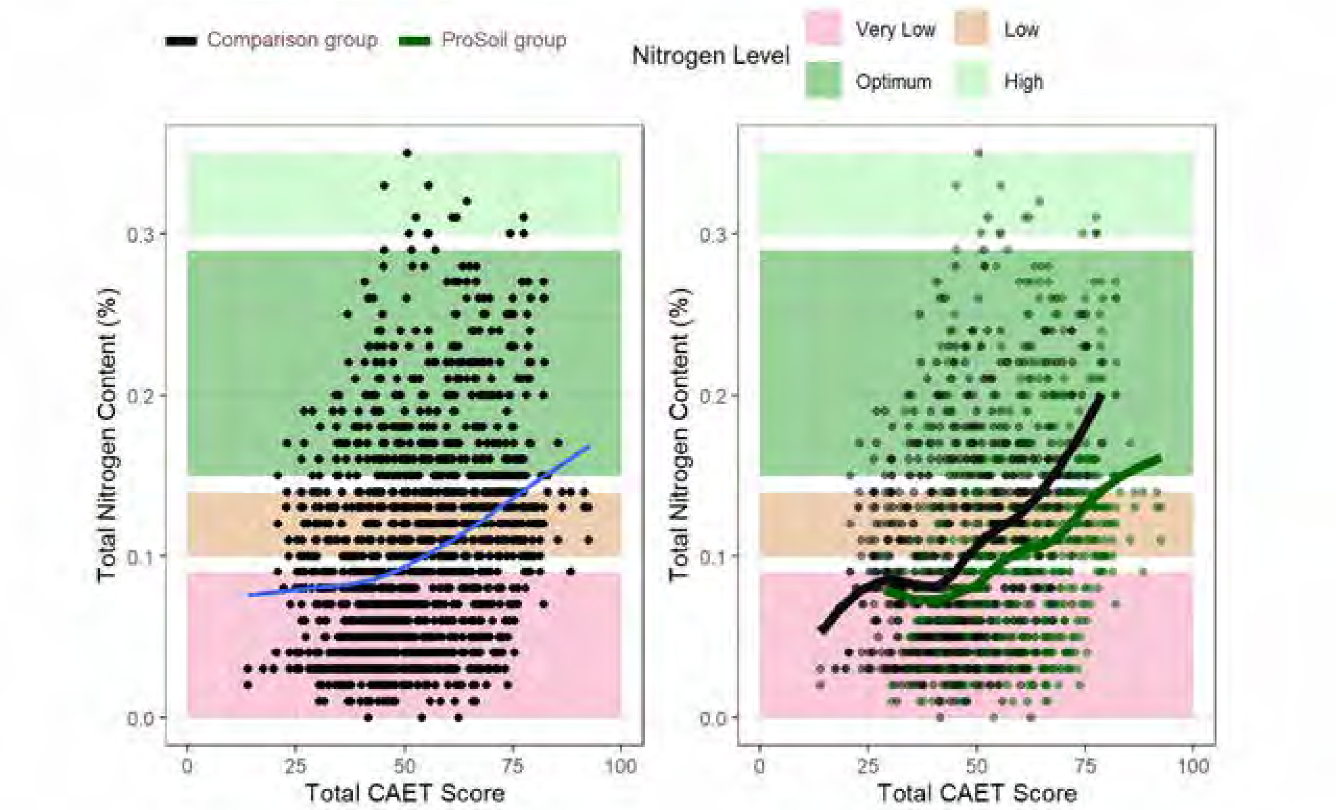


Figure 12. Correlation of degree of agroecological integration (CAET scores) with total soil nitrogen content for the total dataset (left) and disaggregated by ProSoil and comparison groups (right). The categorization of very low, low, optimum and high is based on critical levels according to LDSF.

Most soils in the study locations are strongly or moderately acidic (Figure 13). In the overall dataset, there are no clear correlations between CAET scores and soil pH. There does, however, appear to be a tendency for farms in the comparison group in advanced stages of agroecological transition to have particularly acidic soils. This does not seem to be the case for the ProSoil group. A closer look at the differences between countries (Annex 8) shows that this trend is particularly evident in Ethiopia, where ProSoil has focused on liming to address the issue of strongly acidic soils. As soil acidity is often a critical constraint to productivity, it is important to find agroecological solutions that reduce acidity.

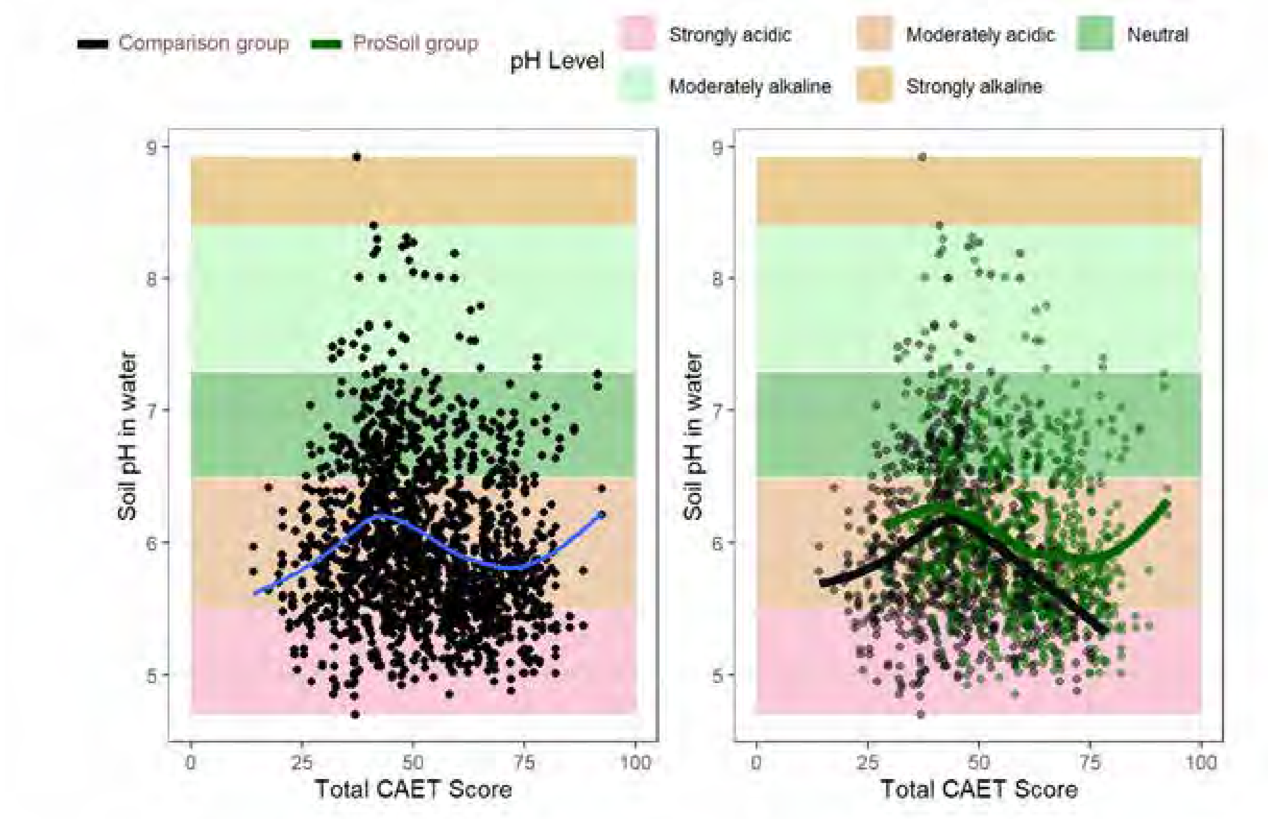


Figure 13. Correlation of degree of agroecological integration (CAET scores) with total soil pH for the total dataset (left) and disaggregated by ProSoil and comparison groups (right). The categorization of strongly acidic, moderately acidic, neutral, moderately alkaline and strongly alkaline is based on critical levels according to LDSF.

The dedicated focus on soil health and fertility management by ProSoil has led to small differences in measured soil health performance between the ProSoil and comparison groups, most notably soil organic carbon and soil pH. However, further investigation into the specific soil-management practices need to be conducted. As shown in Sections 3, 4.1 and 4.3, the support for farmers to transition to agroecology results in significantly better performance in other core criteria. Hence, it seems that through ProSoil interventions in the study sites, farmers are supported in adopting soil management practices that are more sustainable overall. Improvements in soil health take time, so there can be a considerable time lag between implementing agroecological soil-management practices and being able to measure significant differences in biological, chemical and physical soil-health attributes. Finally, it is important to note that the present study is not an evaluation of ProSoil, and the comparison group is not a control group. This implies that also in the comparison group, many farmers apply agroecological soil-health management practices. Some households may also have benefitted indirectly from ProSoil activities through spillover effects, and most have been engaged in other related projects as several past or active projects in all the study locations focused on soil fertility management.

4.3 Social performance, including health and nutrition

For this study, the TAPE sustainability dimensions 'social' and 'health and nutrition' are grouped together. The most significant results in the health dimension relate to food and nutrition security, showing a highly significant correlation between the degree of agroecological integration (CAET scores) and reduced food insecurity as well as increased dietary diversity. This suggests that in the study location, advancing agroecological transitions is an effective strategy for improving food and nutrition security. For women's and youth empowerment – the two core criteria of performance in the social dimension of TAPE – the results show only very limited correlations with CAET scores. The ProSoil group performs better than the comparison group on the Women's Empowerment in Agriculture Index and the Gender Parity Index, but the differences are minor for both indices (Annex 11). Regarding youth empowerment, it is noteworthy that youth from the ProSoil group are more likely to stay on the farm, rather than move elsewhere to seek employment and opportunities, if the household is on a lower level of agroecological transition (Annex 12).

4.3.1 Exposure to pesticides

An important component of agroecology's potential health benefits is its contribution to reducing producers' exposure to harmful pesticides. The TAPE results show that in the study locations, more agroecological farmers have a highly significant reduced risk of exposure to harmful pesticides (Annex 9) by applying more ecological and integrated pest-management practices and by having improved mitigation strategies for the spraying of pesticides. In the study locations, there appears to be limited correlations between the degree of agroecological integration (CAET scores) and the overall use of pesticides and their toxicity (Figure 14). The effect of ProSoil training and capacity development is particularly apparent in the higher scores for ecological and integrated pest management. On average, farmers of the ProSoil group also use less toxic pesticides than those used by farmers of the comparison group (Figure 14).

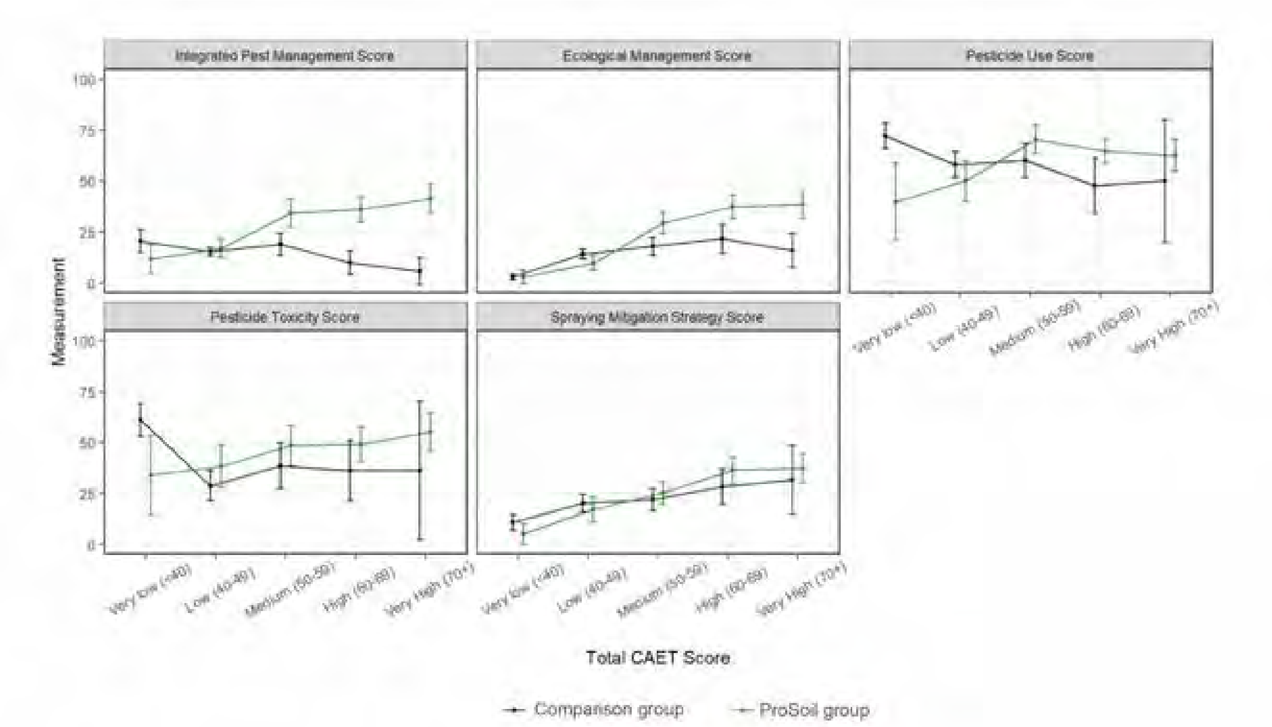


Figure 14. Overview of correlations between degree of agroecological integration (CAET score) and the individual TAPE indicators for exposure to pesticides. The overall CAET scores are split into five groups ranging from very low (<40) to very high (70+). For each individual indicator and the composite score, the means are plotted across these five CAET score groups. These means are plotted with 95% confidence intervals.

4.3.2 Dietary diversity and food security

Food and nutrition security is a crucial challenge in all the study locations, and the ProSoil programme aims to leverage improved soil management for the enhancement of food security. Figures 15 and 16 show that, in the ProSoil group, there is a close link between improved food and nutrition security and the degree of agroecological integration. While there is a highly significant positive correlation overall between CAET scores and improved dietary diversity and food security, this correlation is rather insignificant for the comparison group. On average, the households actively participating in ProSoil activities demonstrate a higher performance on food and nutrition security. However, this difference only becomes apparent for households at an advanced stage of agroecological transition (CAET score above 50). This effect is particularly apparent regarding dietary diversity, which is assessed through the number of food groups consumed. For the comparison group, the results are not correlated with the CAET scores. Yet for the ProSoil group, dietary diversity improves consistently with increasing CAET scores (Annex 10). Food security, on the other hand, improves consistently with increasing degrees of agroecological integration, irrespective of whether the households participated in ProSoil activities. Regarding food expenditures per capita, no significant correlation with CAET scores nor any marked differences between the ProSoil and comparison groups have been observed.

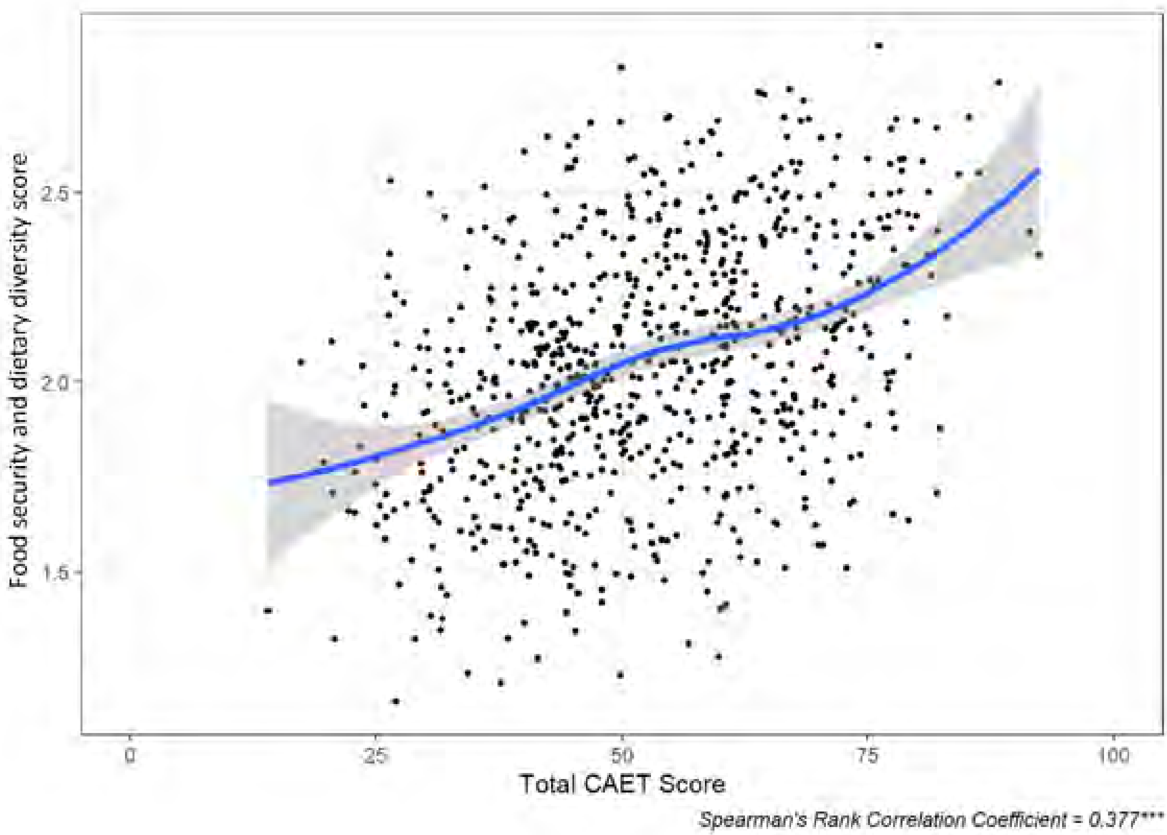
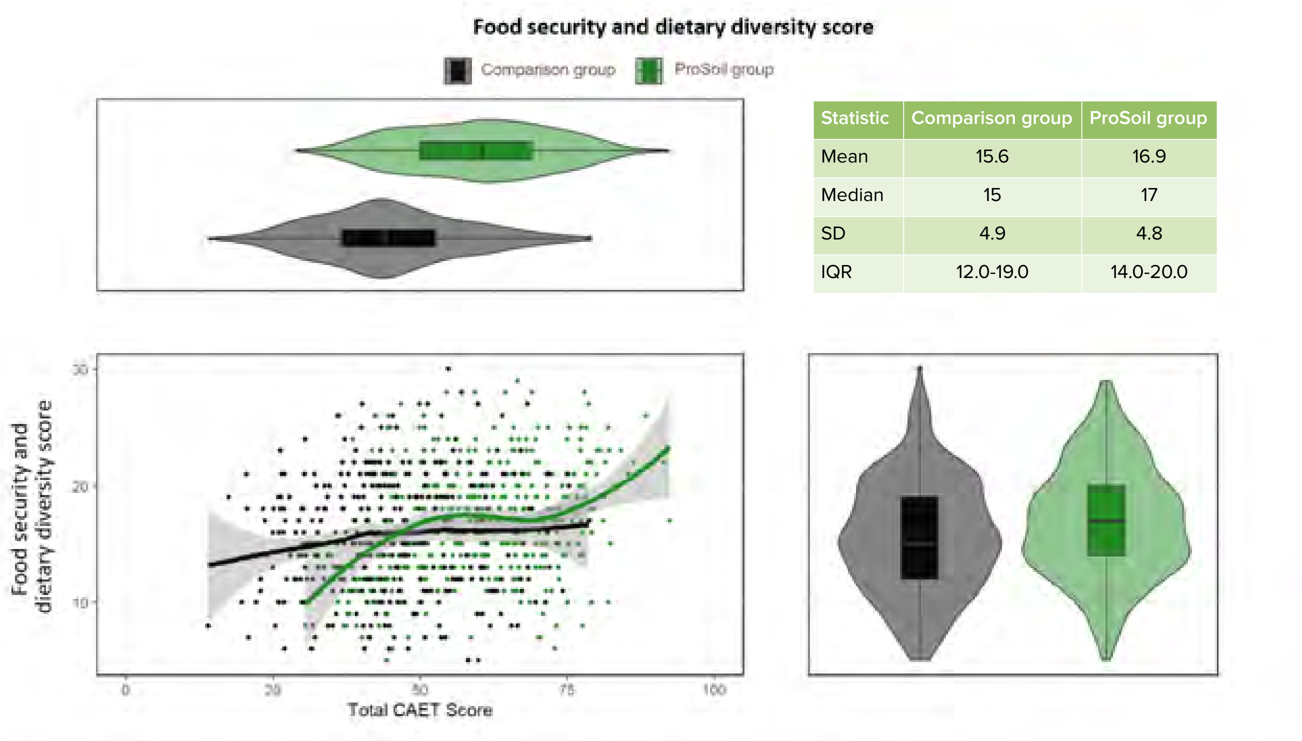


Figure 15. Correlation between degree of agroecological integration (CAET score) and composite dietary diversity and food security score, combining the three TAPE indicators for dietary diversity and food security: Number of food groups consumed, food insecurity experience scale, expenditures for purchase of food per capita. Scatterplot with a moving average line; a Spearman's rank correlation coefficient is also included.



Statistic	Comparison group	ProSoil group
Mean	15.6	16.9
Median	15	17
SD	4.9	4.8
IQR	12.0-19.0	14.0-20.0

Figure 16. Correlation between degree of agroecological integration (CAET score) and composite dietary diversity and food security score across the four countries disaggregated by ProSoil and comparison groups. Scores are disaggregated by ProSoil and comparison groups on a scatterplot along with combined box and violin plots and a table showing the mean, median, standard deviation and interquartile range of the composite scores.

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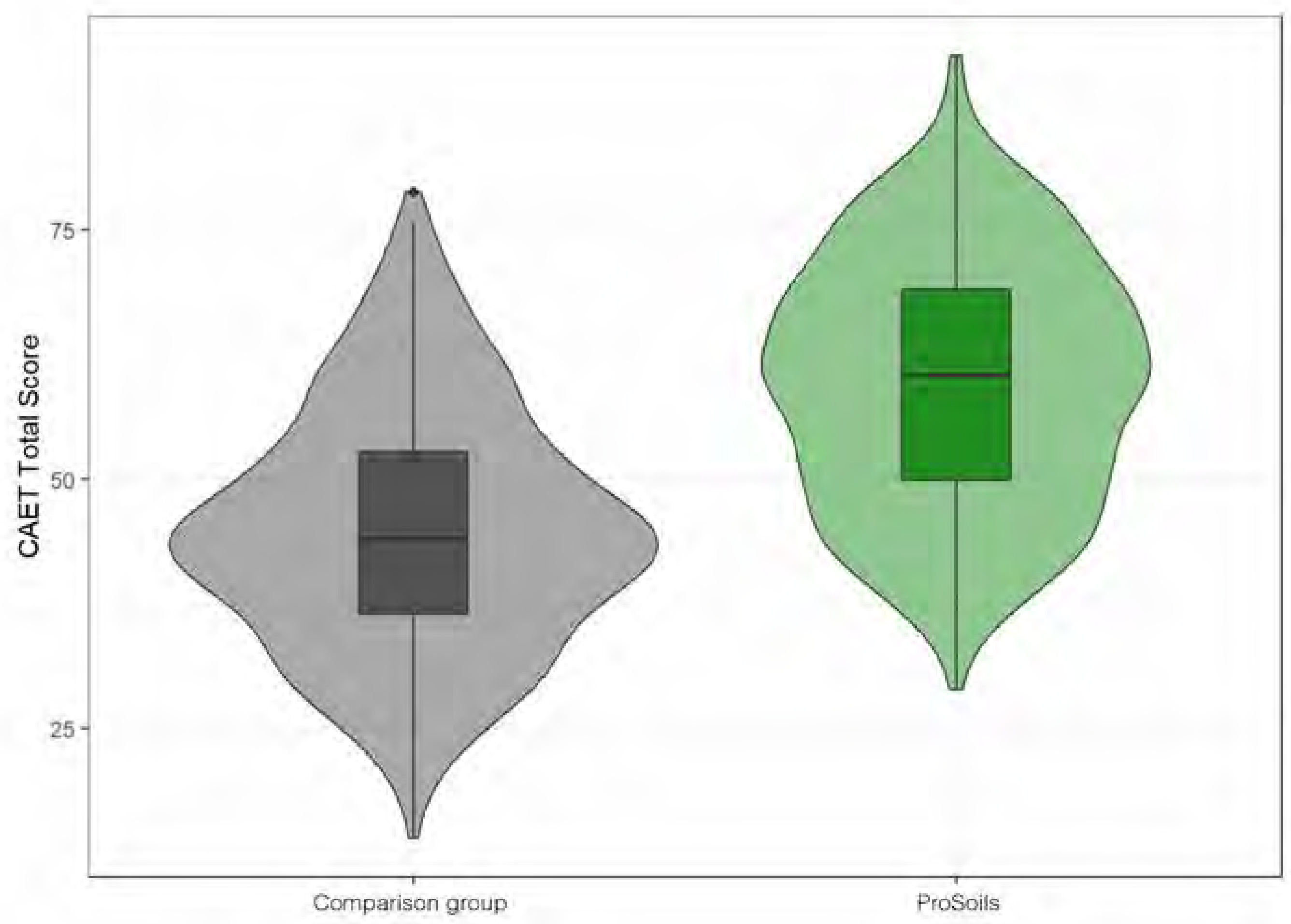
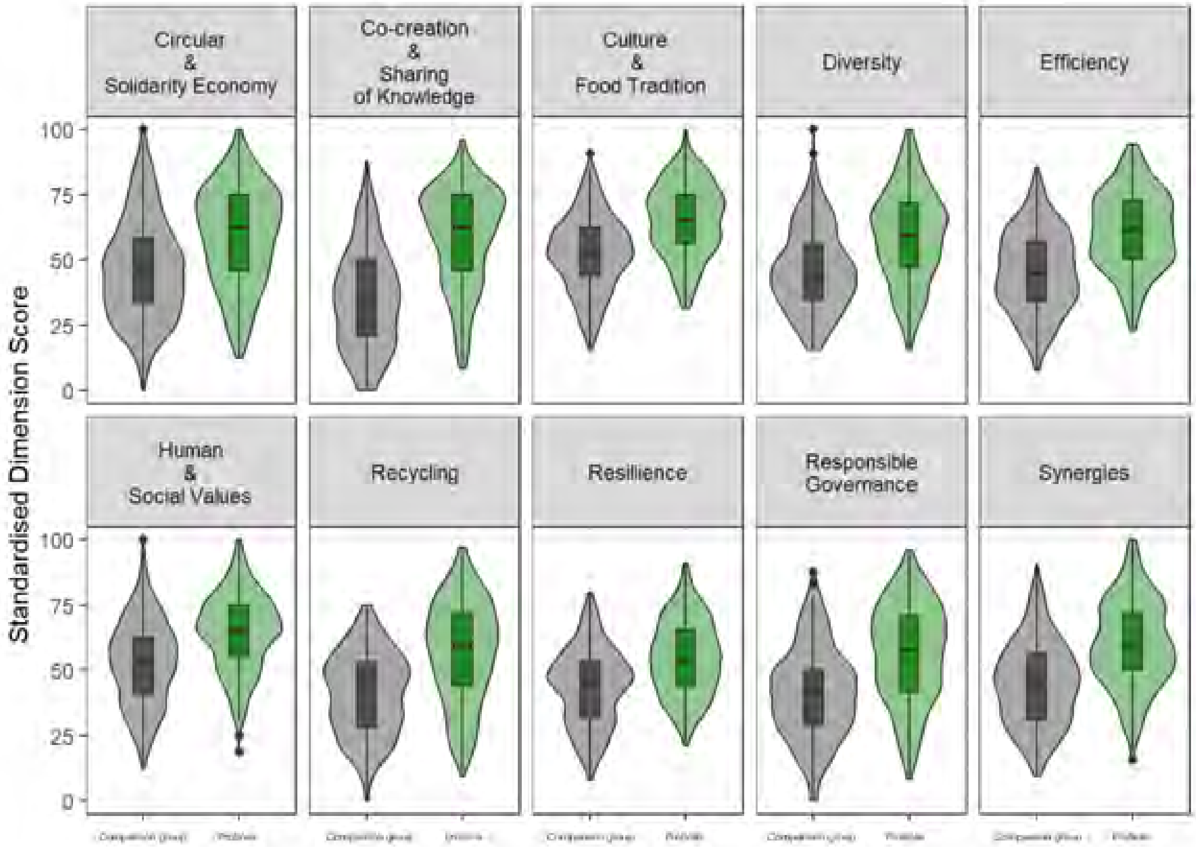
Annexes

Annex 1. CAET

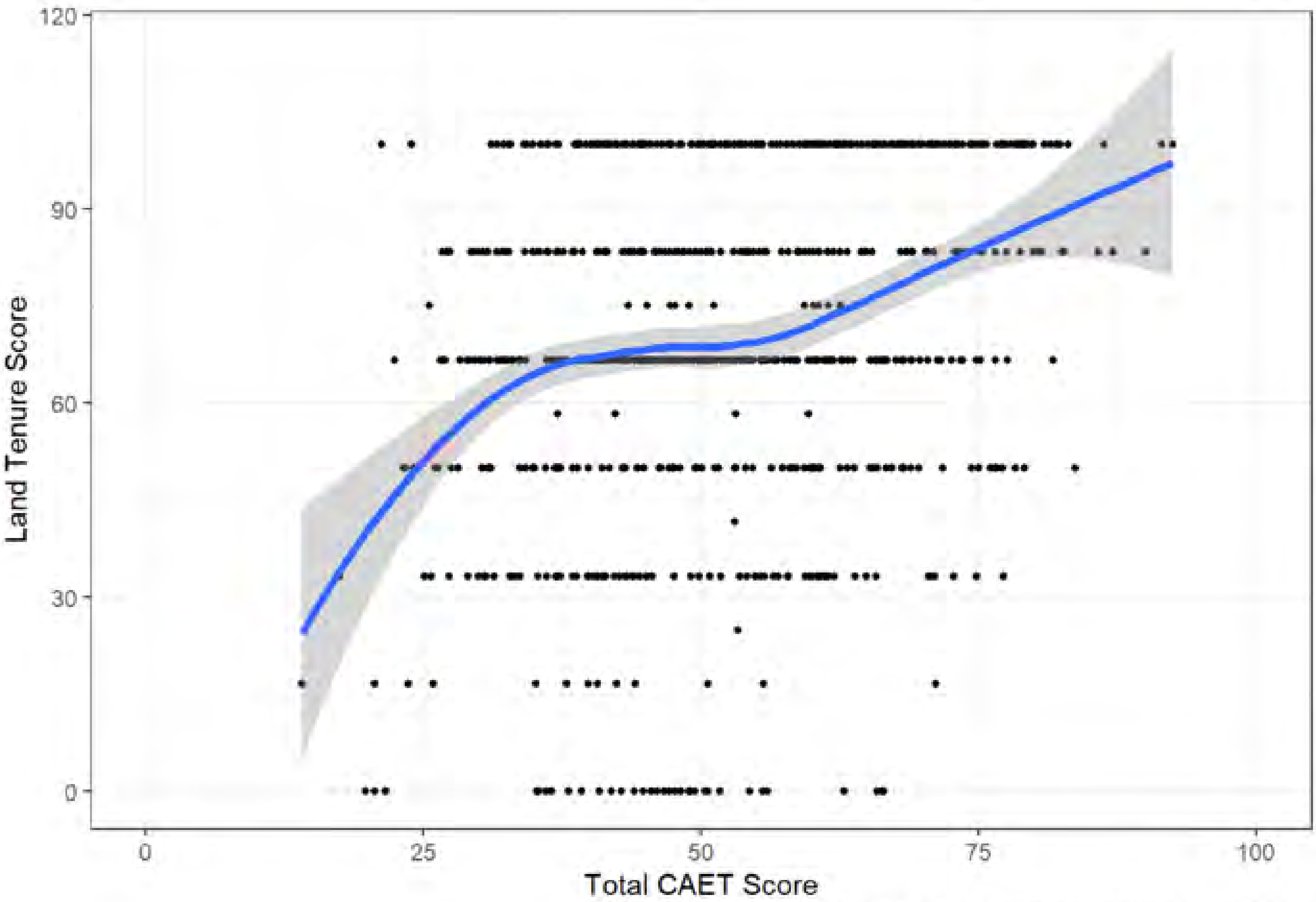




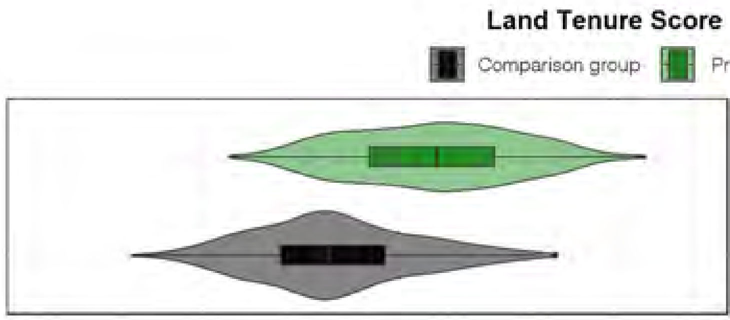
Dimension	Comparison Group	ProSoils	Difference	p.value
CAET Overall	44.9	59.6	-14.7	0.000
Diversity	46.2	59.2	-13.0	0.000
Synergies	44.8	59.9	-15.1	0.000
Recycling	41.0	56.9	-15.9	0.000
Efficiency	45.4	61.2	-15.8	0.000
Resillience	43.6	54.7	-11.1	0.000
Culture & Food Tradition	52.5	65.2	-12.7	0.000
Co-creation & Sharing of Knowledge	35.0	58.7	-23.7	0.000
Human & Social Values	52.8	64.7	-11.9	0.000
Circular & Solidarity Economy	46.5	59.0	-12.5	0.000
Responsible Governance	41.1	56.5	-15.4	0.000


Diversity
Responsible Governance
Circular & Solidarity Economy
Human & Social Values
Co-creation of Knowledge
Culture & Food Tradition
Resillience
Recycling
Efficiency
Synergies
100
75
50
Comparison group
ProSoils

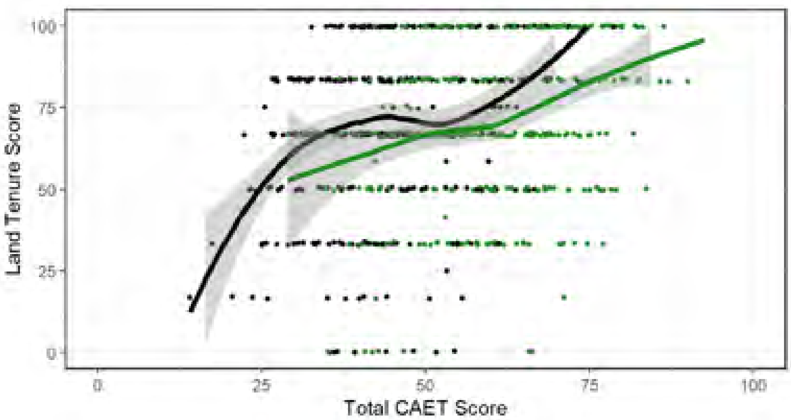
Annex 2. Land tenure

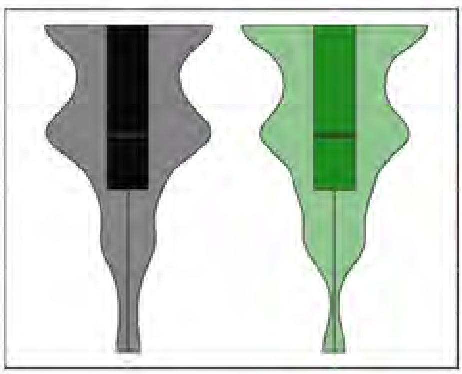


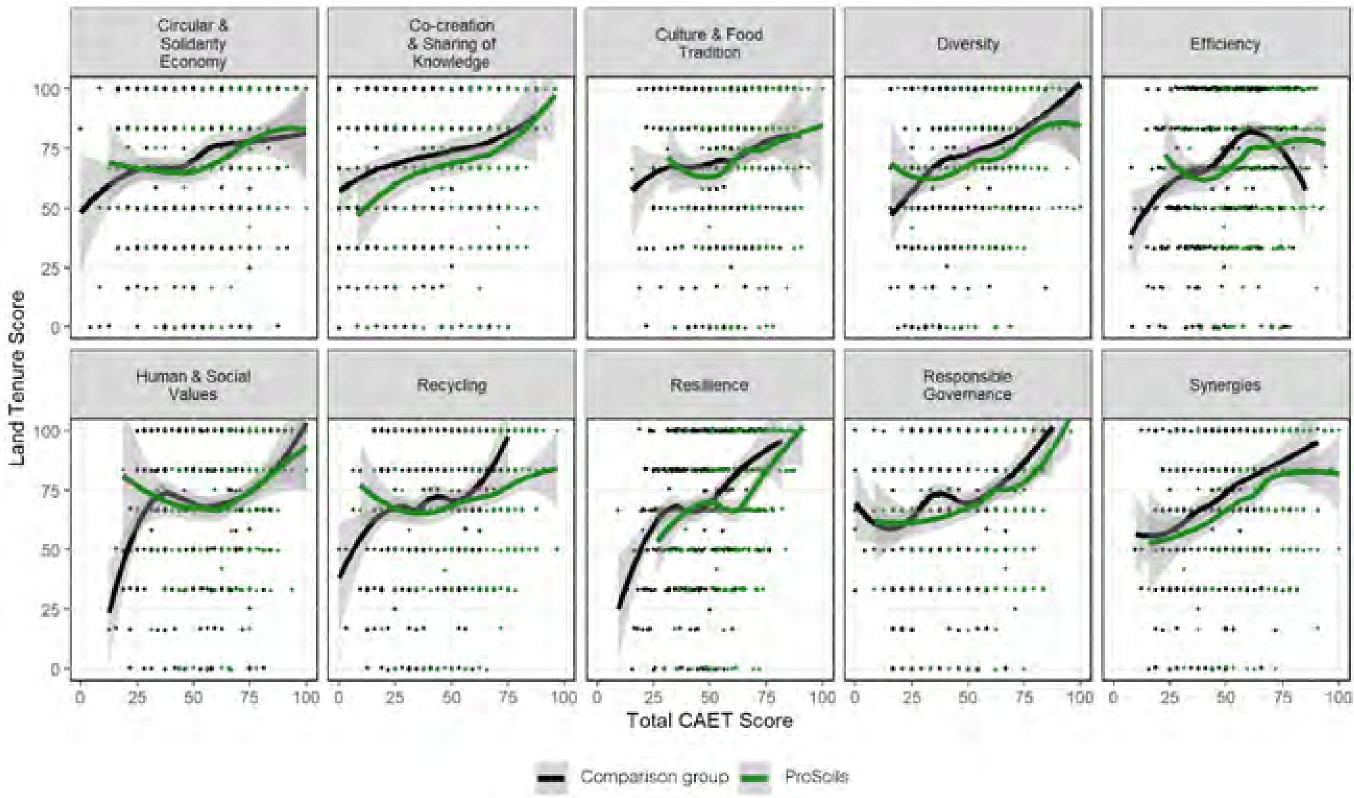
*Spearman's Rank Correlation Coefficient = 0.266****

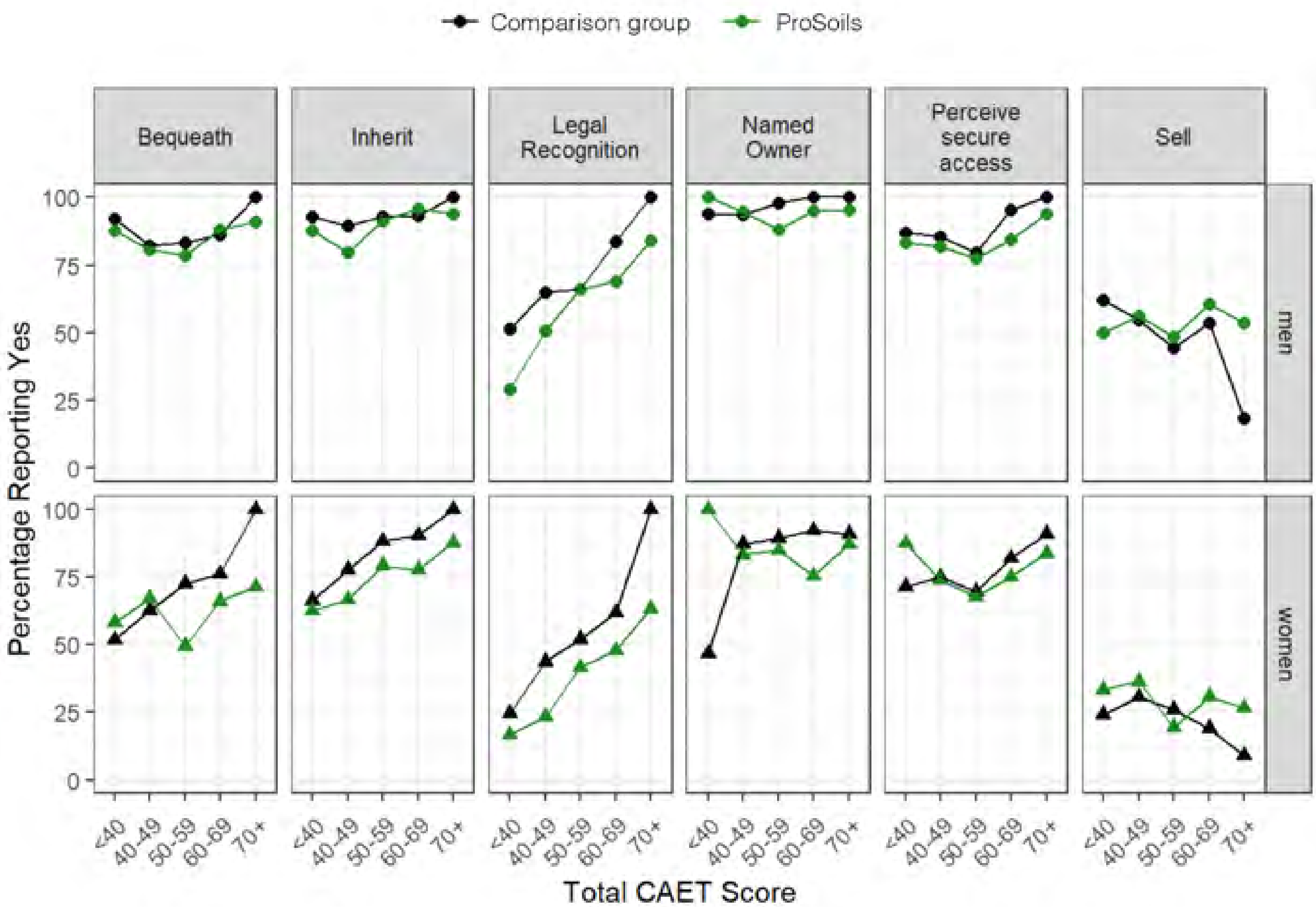


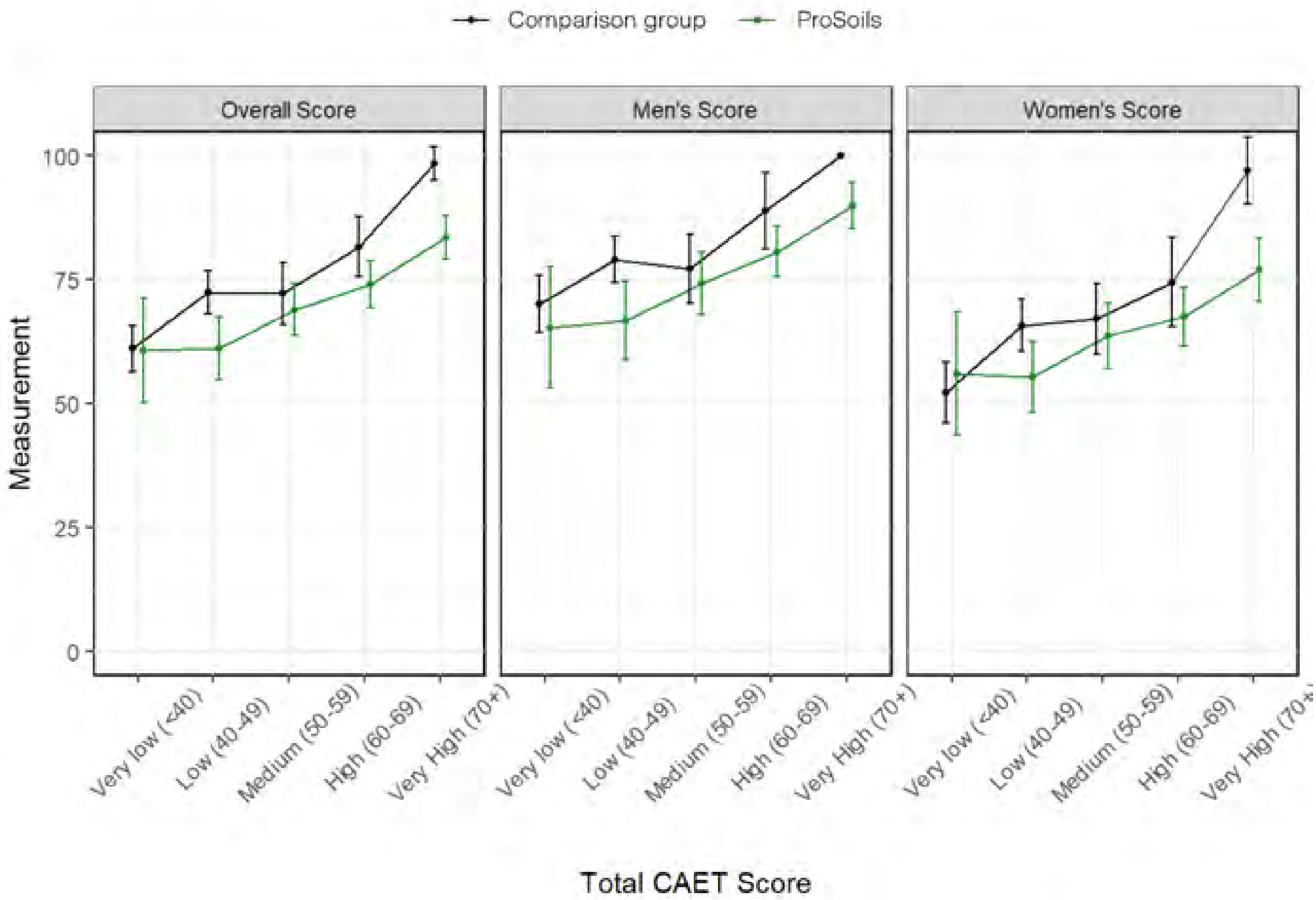
Statistic	Comparison group	ProSoils
Mean	70.3	71.8
Median	66.7	66.7
SD	27.3	26.8
IQR	50.0-100.0	50.0-100.0



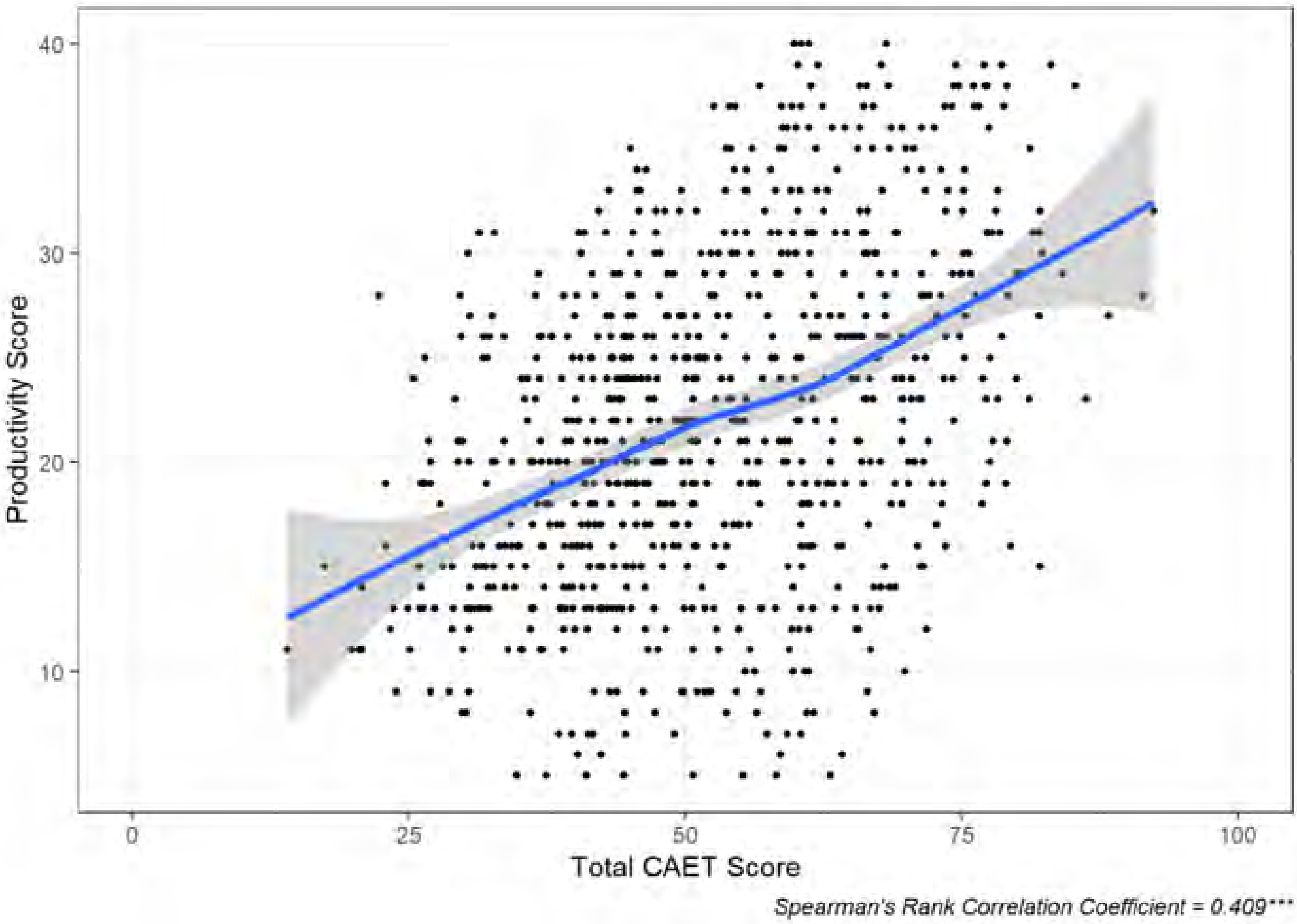


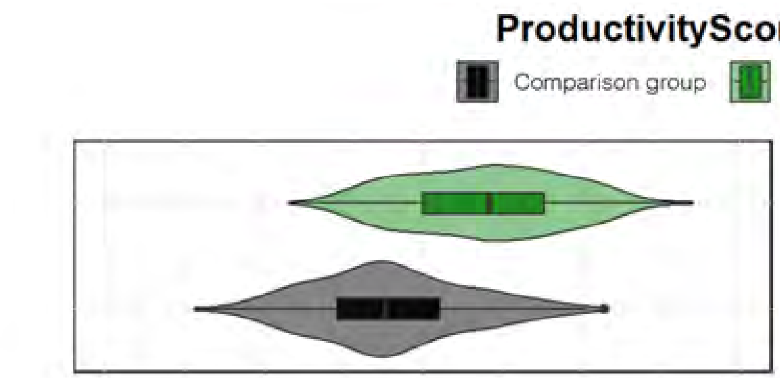

Circular & Solidarity Economy
Co-creation & Sharing of Knowledge
Culture & Food Tradition
Diversity
Efficiency
Human & Social Values
Recycling
Resilience
Responsible Governance
Synergies
Land Tenure Score
Total CAET Score
Comparison group
ProSoils


Comparison group
ProSoils
Bequeath
Inherit
Legal Recognition
Named Owner
Perceive secure access
Sell
men
women
Percentage Reporting Yes
<40
40-49
50-59
60-69
70+
Total CAET Score

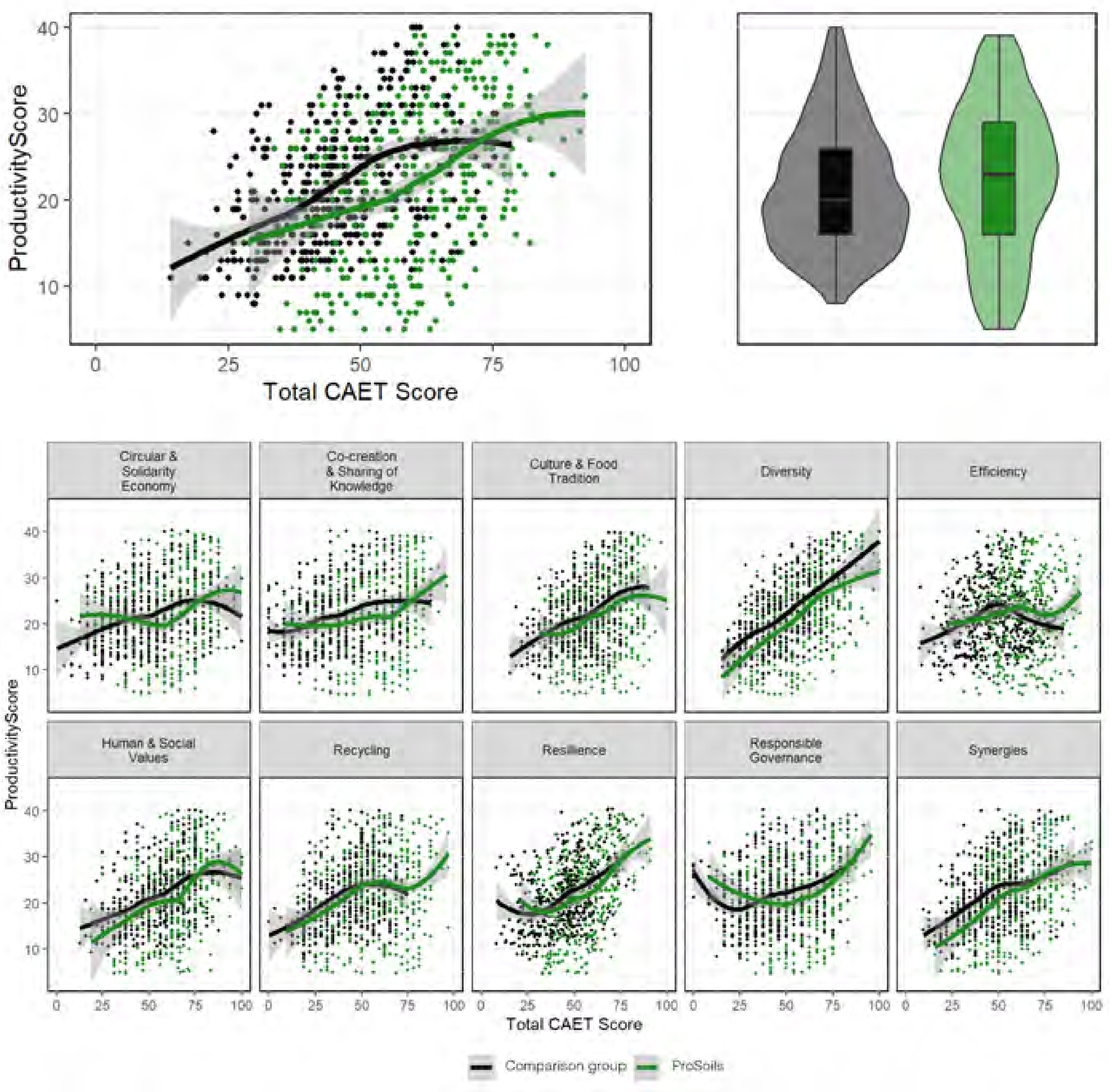

Comparison group
ProSoils
Overall Score
Men's Score
Women's Score
Measurement
100
75
50
25
0
Very low (<40)
Low (40-49)
Medium (50-59)
High (60-69)
Very High (70+)
Total CAET Score

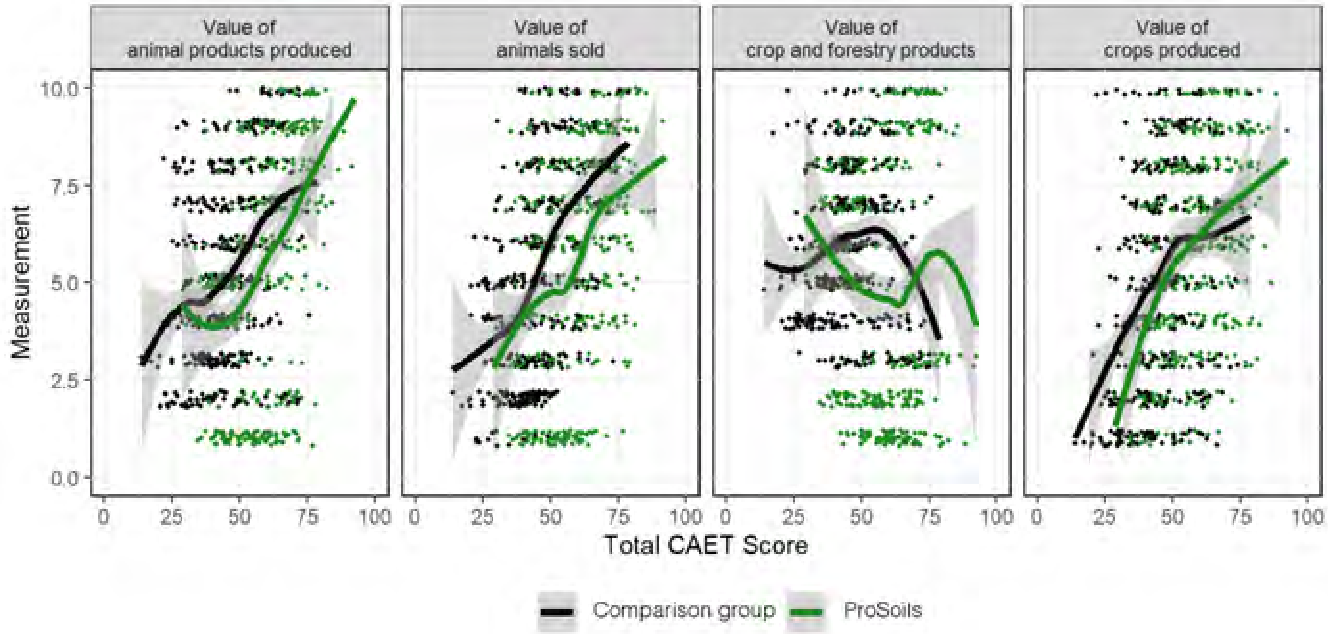
Annex 3. Productivity

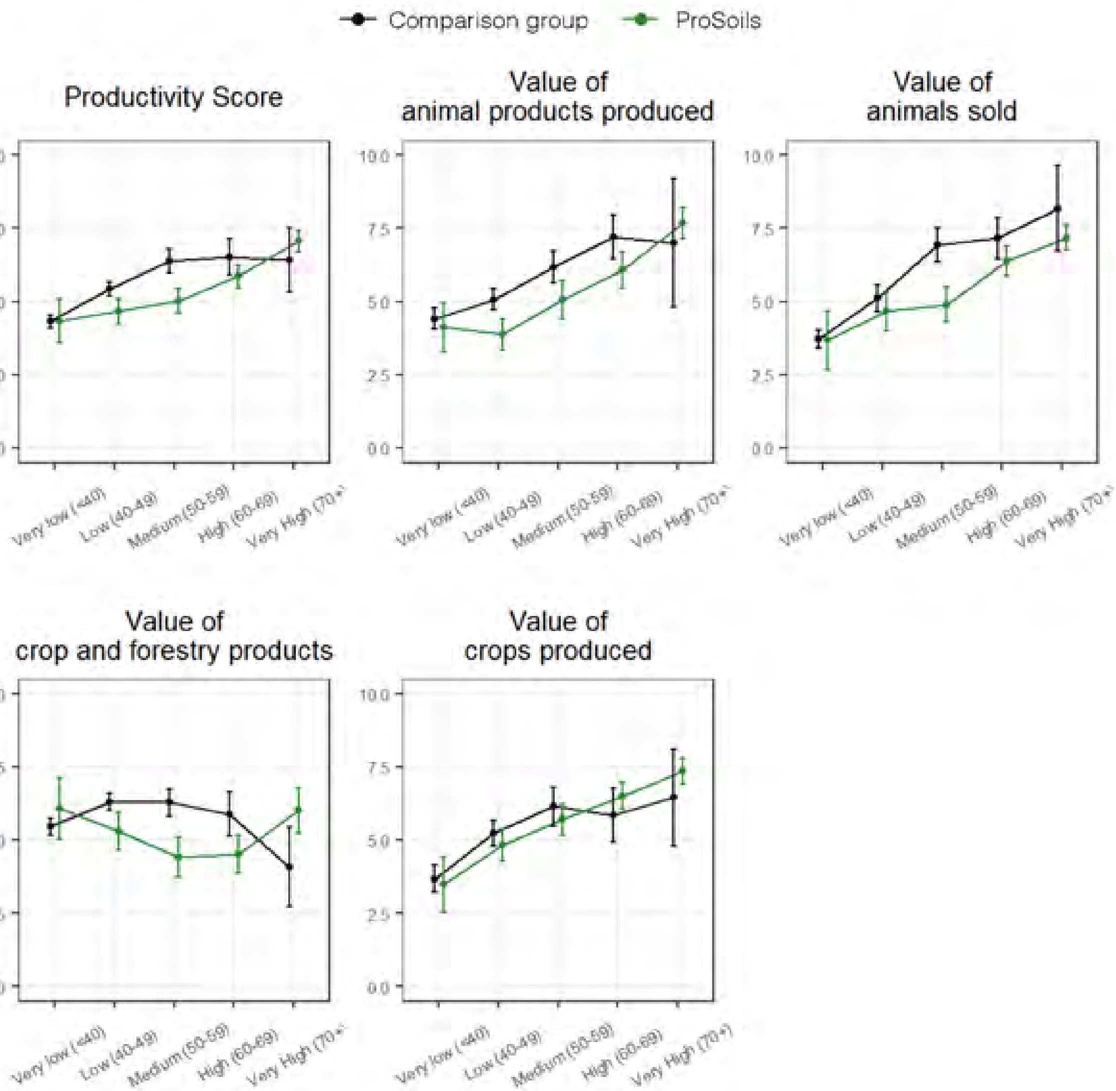




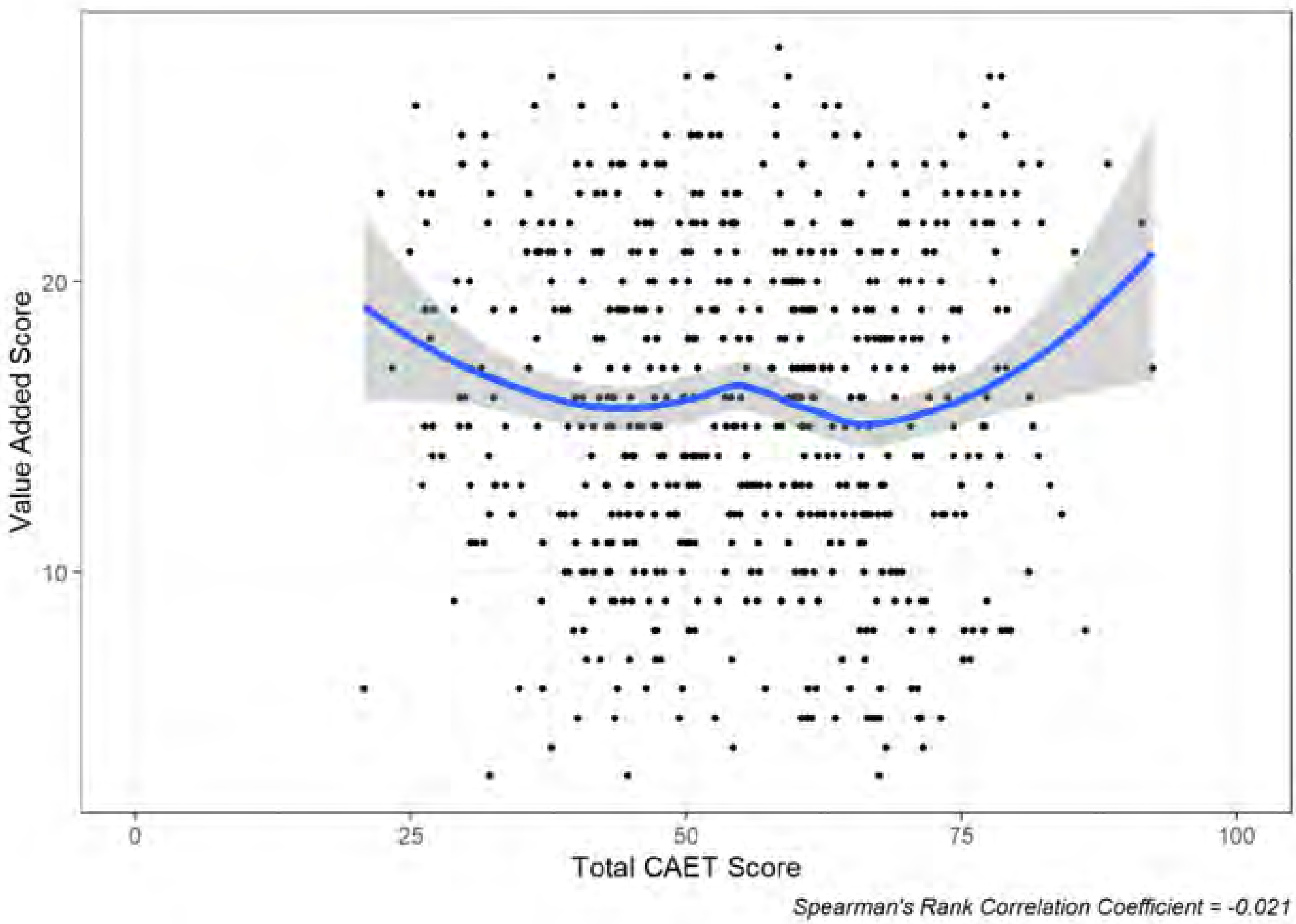
Statistic	Comparison group	ProSoi
Mean	21.5	22.5
Median	20	23
SD	7.1	8.7
IQR	16.0-26.0	16.0-29

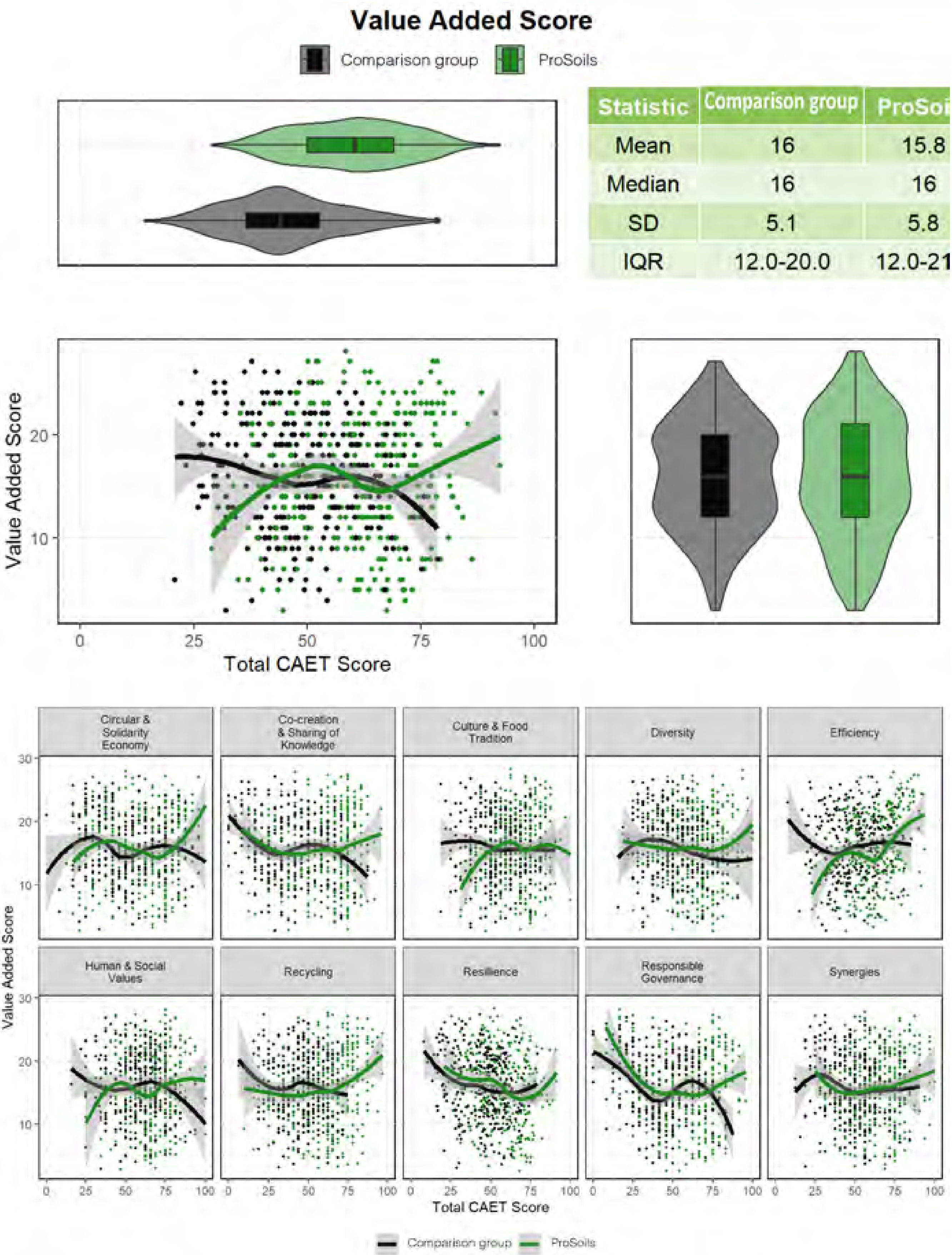



Value of
animal products produced
Value of
animals sold
Value of
crop and forestry products
Value of
crops produced
Measurement
10.0
7.5
5.0
2.5
0.0
0
25
50
75
100
Total CAET Score
Comparison group
ProSoils

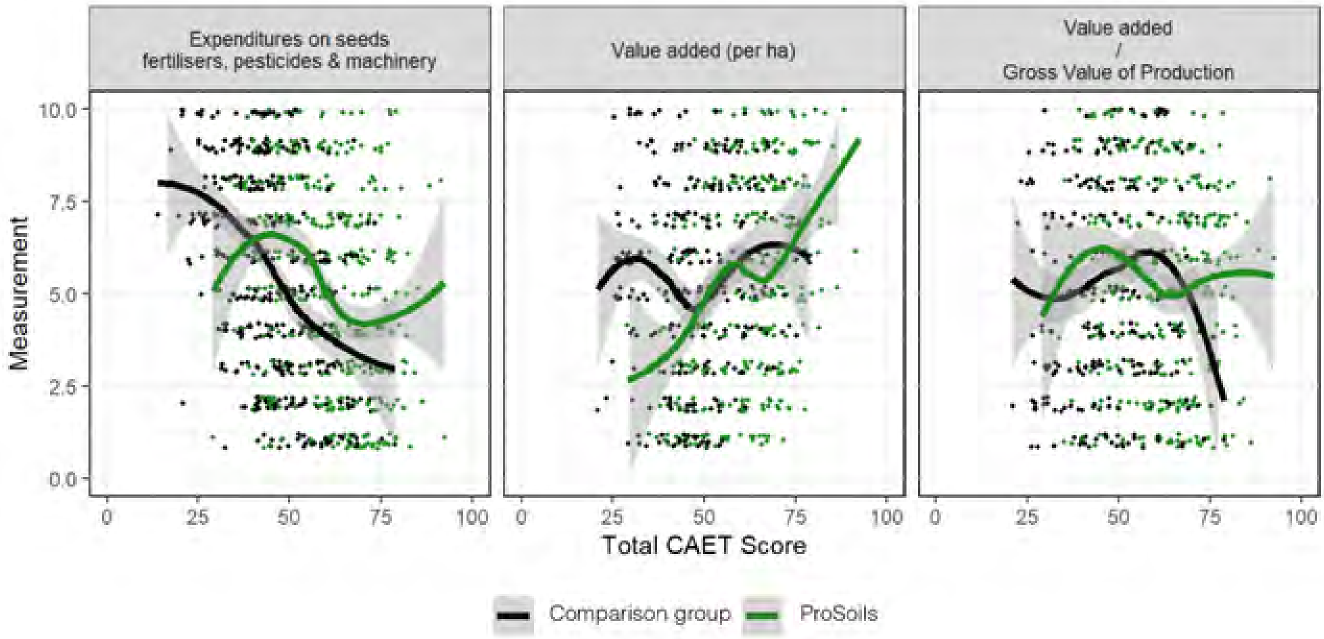

Comparison group
ProSoils
Productivity Score
Value of
animal products produced
Value of
animals sold
Value of
crop and forestry products
Value of
crops produced
40
30
20
10
0
10.0
7.5
5.0
2.5
0.0
Very low (<40)
Low (40-49)
Medium (50-59)
High (60-69)
Very High (70+)

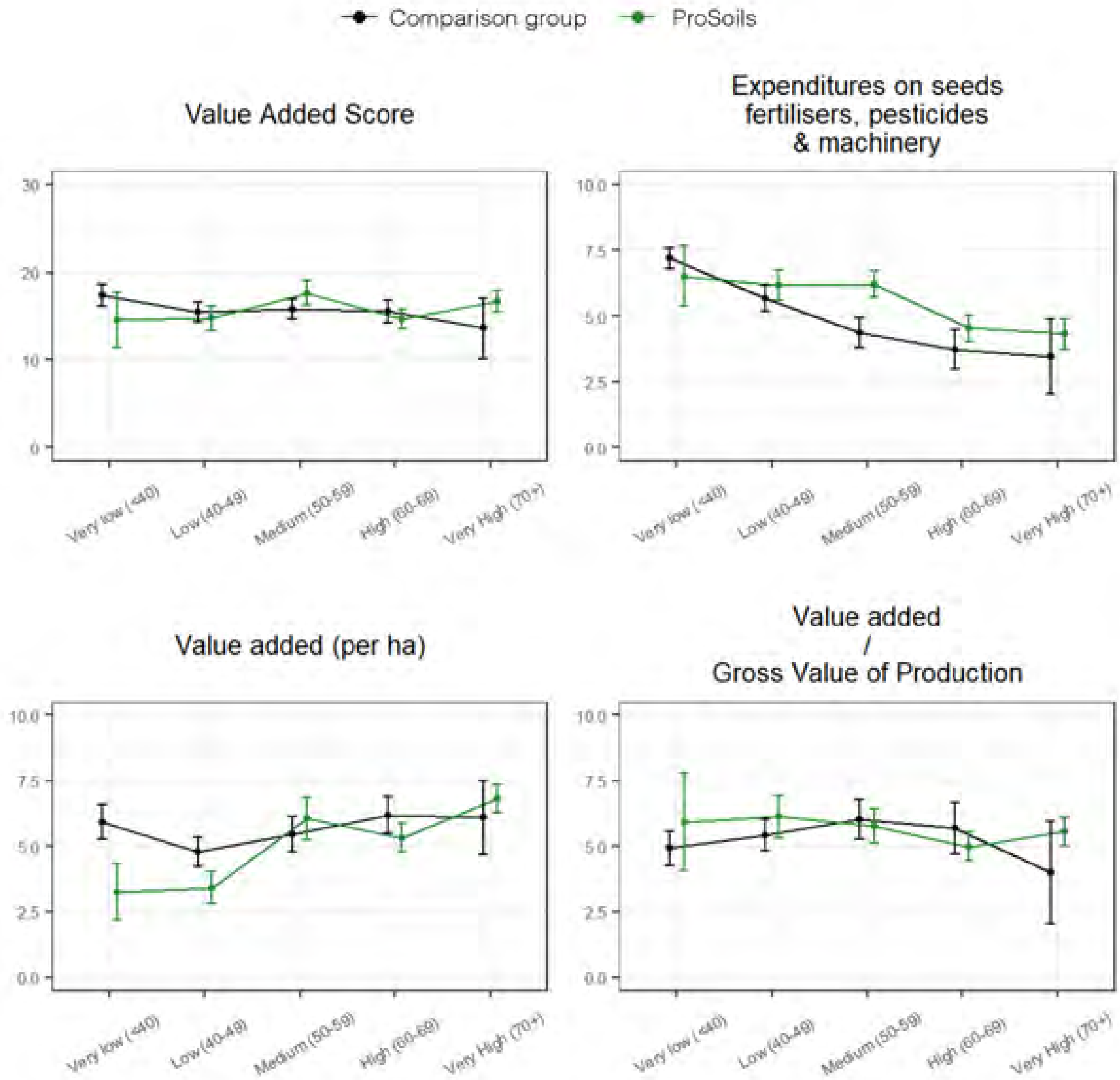
Annex 4. Value added



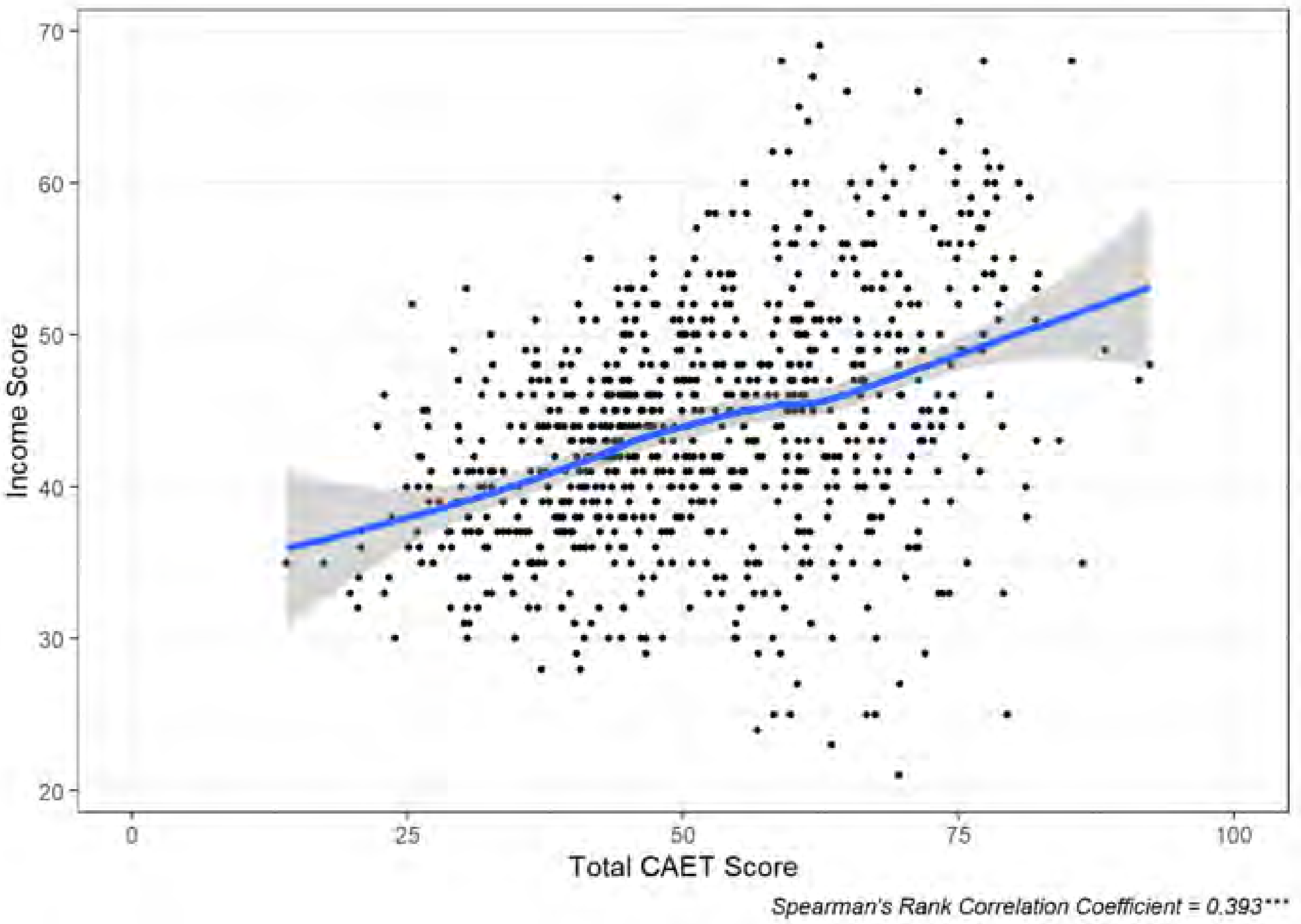


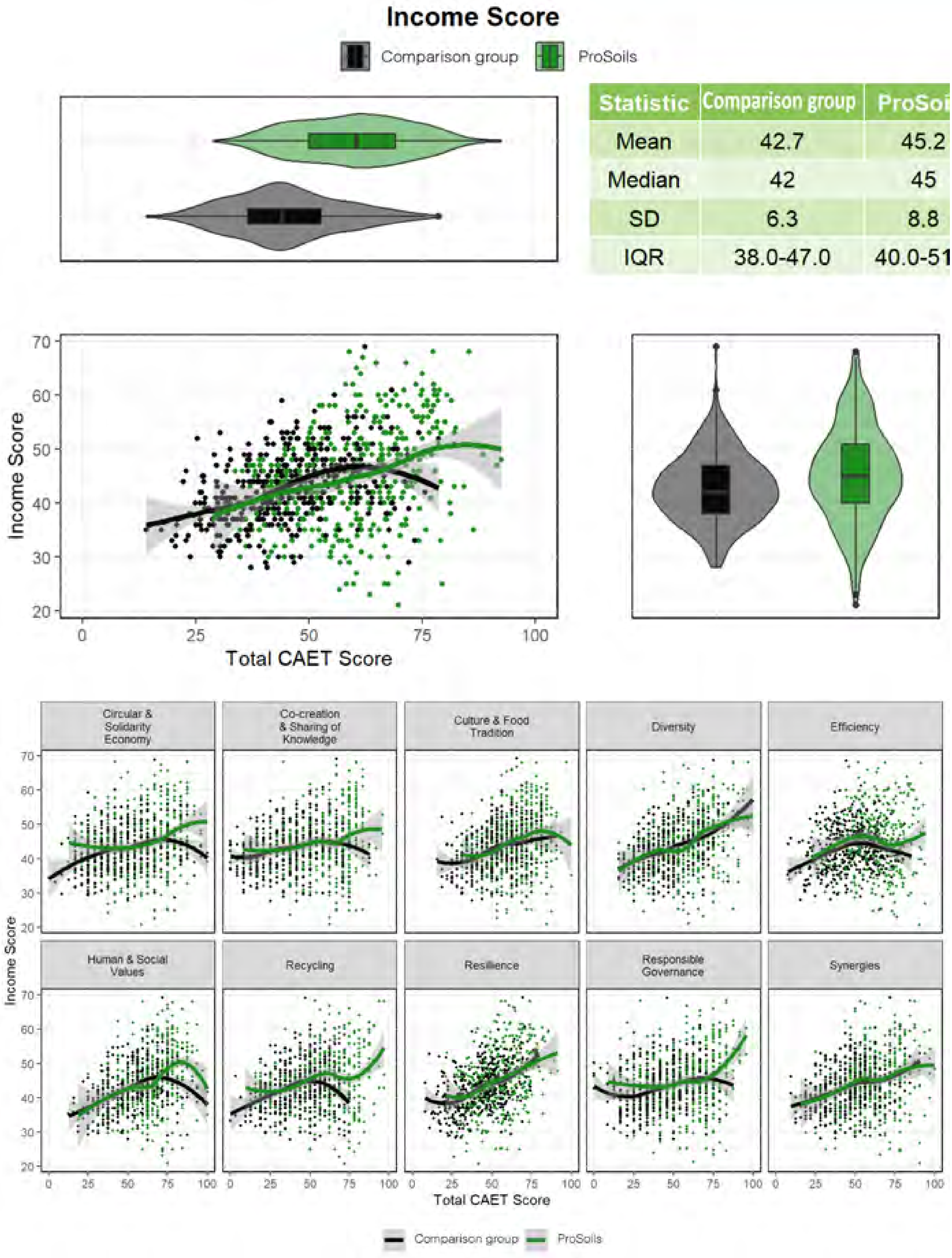
Statistic	Comparison group	ProSoi
Mean	16	15.8
Median	16	16
SD	5.1	5.8
IQR	12.0-20.0	12.0-21


Expenditures on seeds
fertilisers, pesticides & machinery
Value added (per ha)
Value added
/
Gross Value of Production
Measurement
10.0
7.5
5.0
2.5
0.0
0
25
50
75
100
Total CAET Score
Comparison group
ProSoils

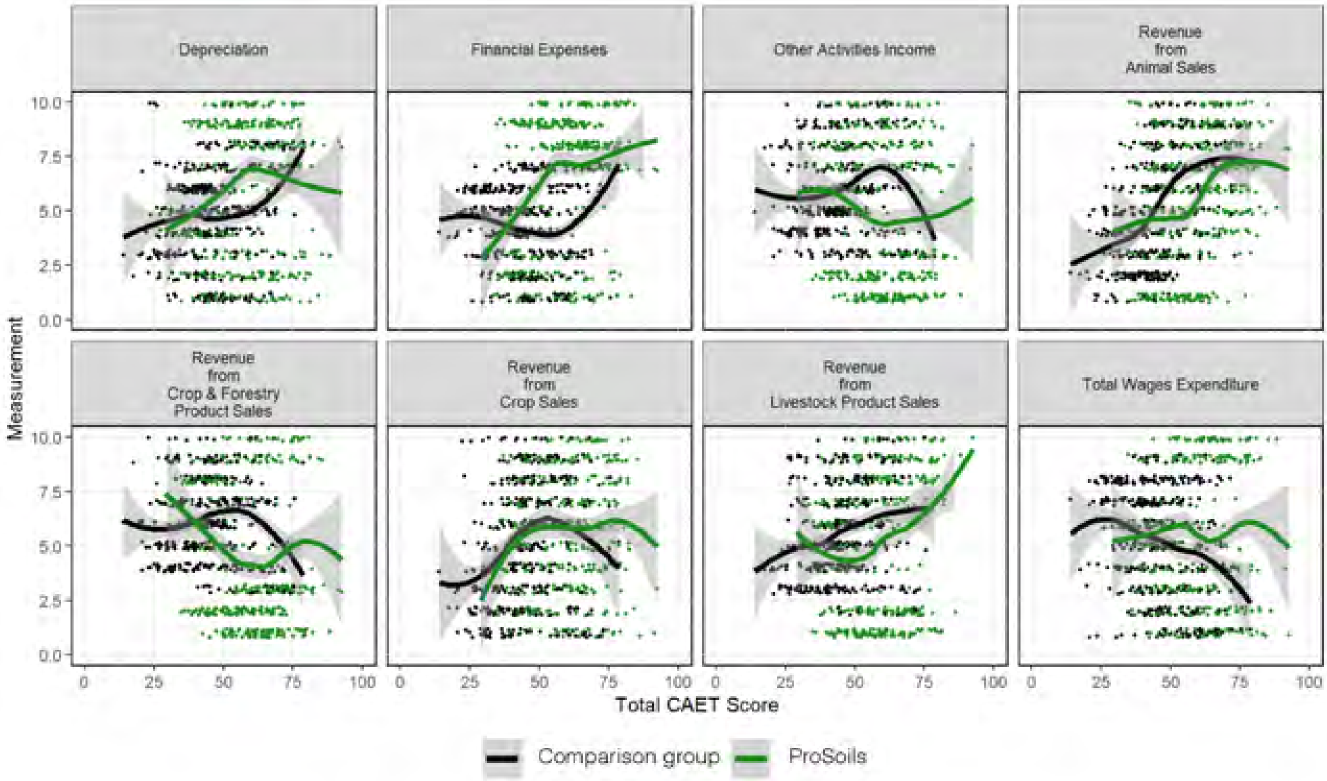

Comparison group
ProSoils
Value Added Score
Expenditures on seeds
fertilisers, pesticides
& machinery
Value added (per ha)
Value added
/
Gross Value of Production
Very low (<40)
Low (40-49)
Medium (50-59)
High (60-69)
Very High (70+)

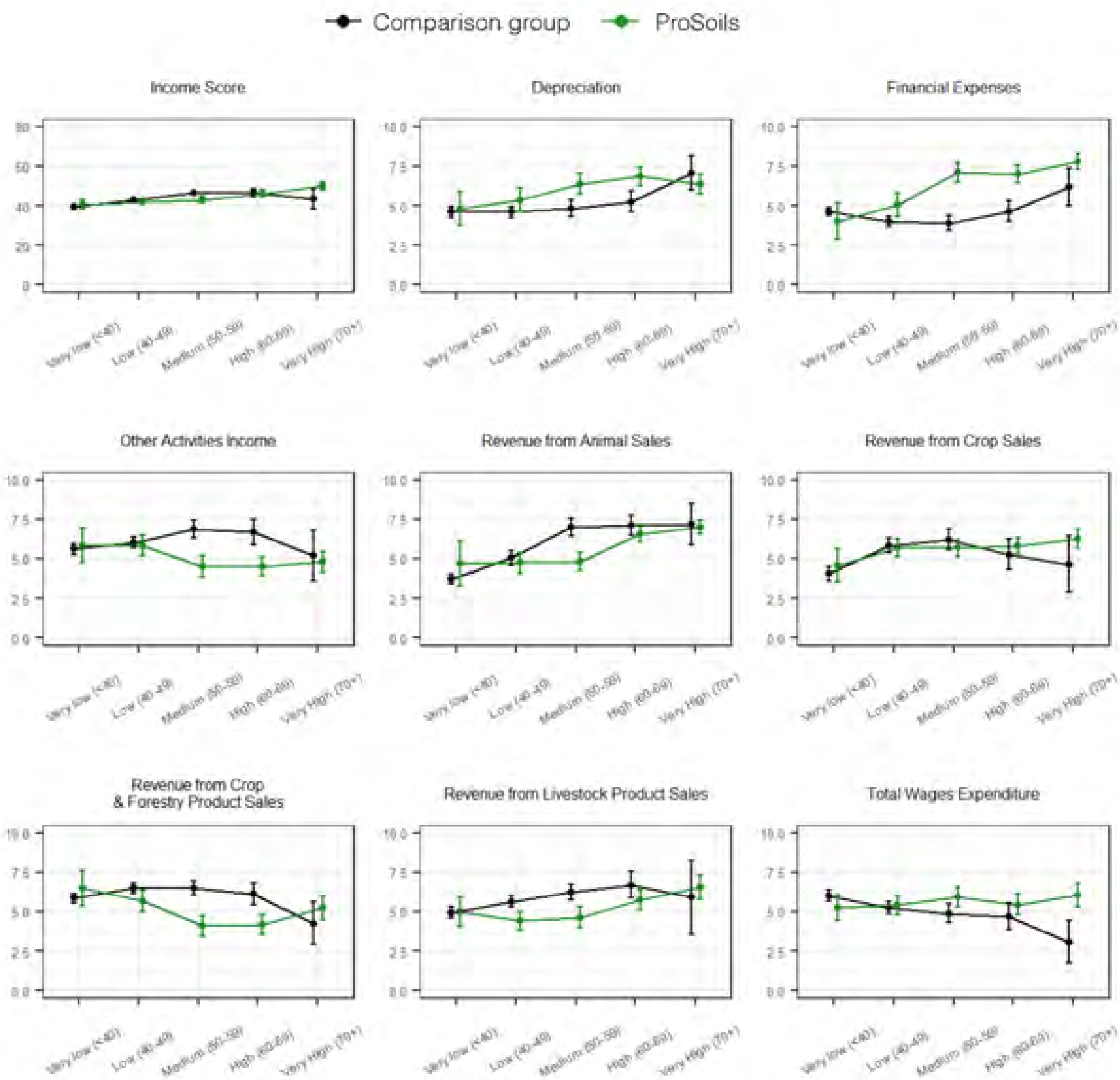
Annex 5. Income



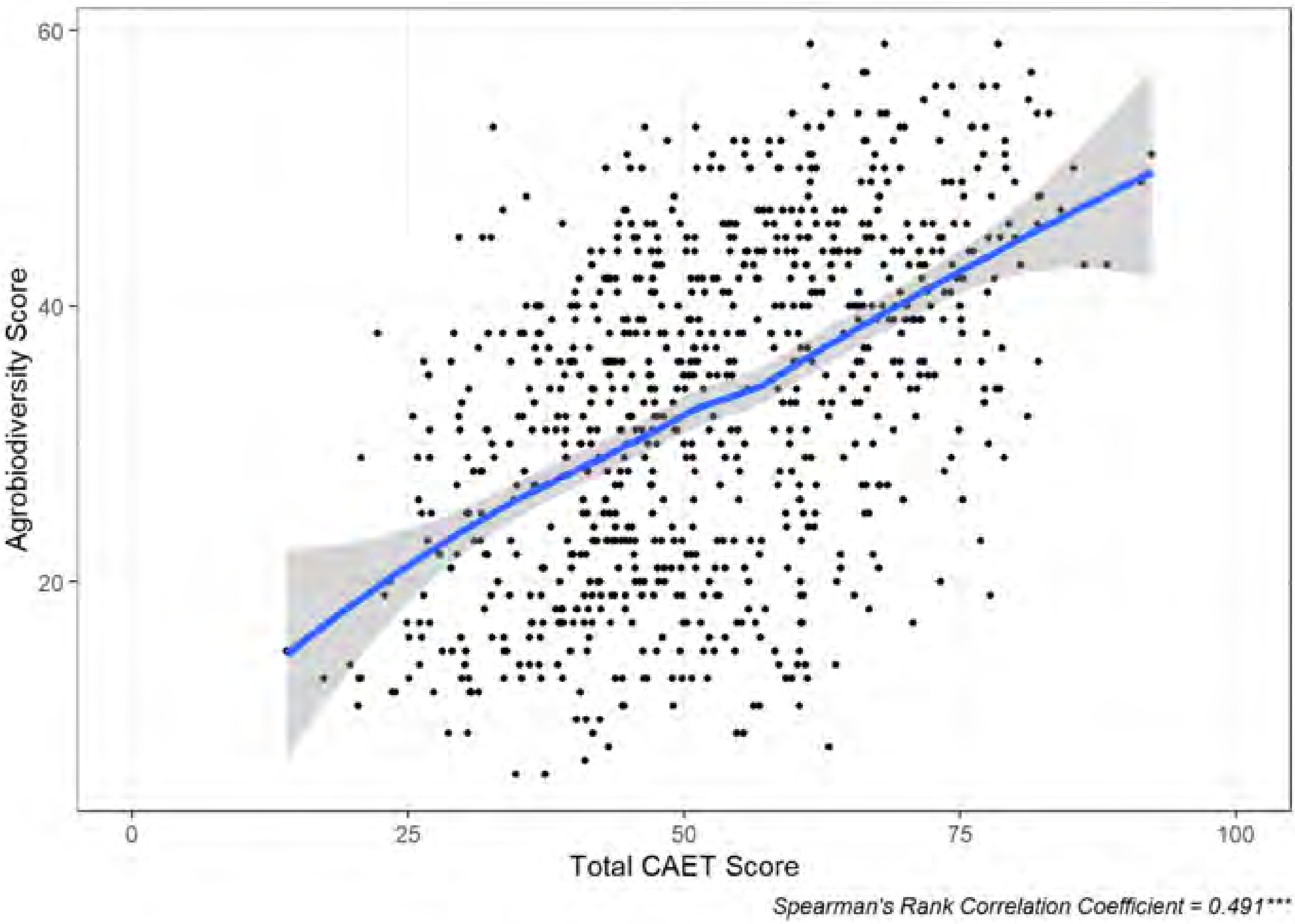


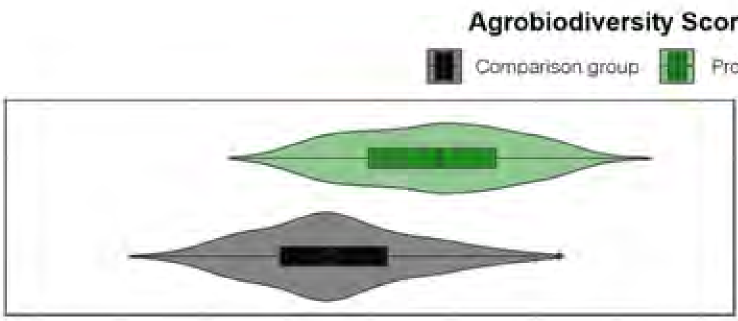
Statistic	Comparison group	ProSoi
Mean	42.7	45.2
Median	42	45
SD	6.3	8.8
IQR	38.0-47.0	40.0-51


Depreciation
Financial Expenses
Other Activities Income
Revenue from Animal Sales
Revenue from Crop & Forestry Product Sales
Revenue from Crop Sales
Revenue from Livestock Product Sales
Total Wages Expenditure
Measurement
Total CAET Score
Comparison group
ProSoils

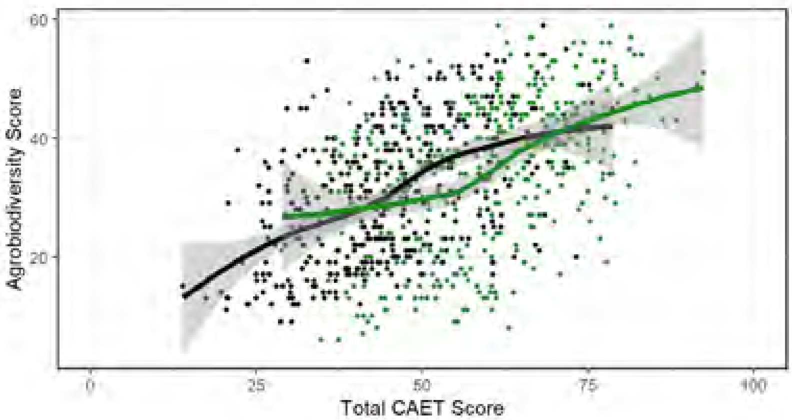

Comparison group
ProSoils
Income Score
Depreciation
Financial Expenses
Other Activities Income
Revenue from Animal Sales
Revenue from Crop Sales
Revenue from Crop & Forestry Product Sales
Revenue from Livestock Product Sales
Total Wages Expenditure
Very low (<40)
Low (40-49)
Medium (50-59)
High (60-69)
Very High (70+)

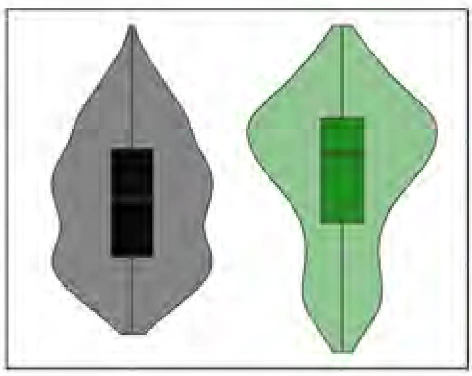
Annex 6. Agrobiodiversity

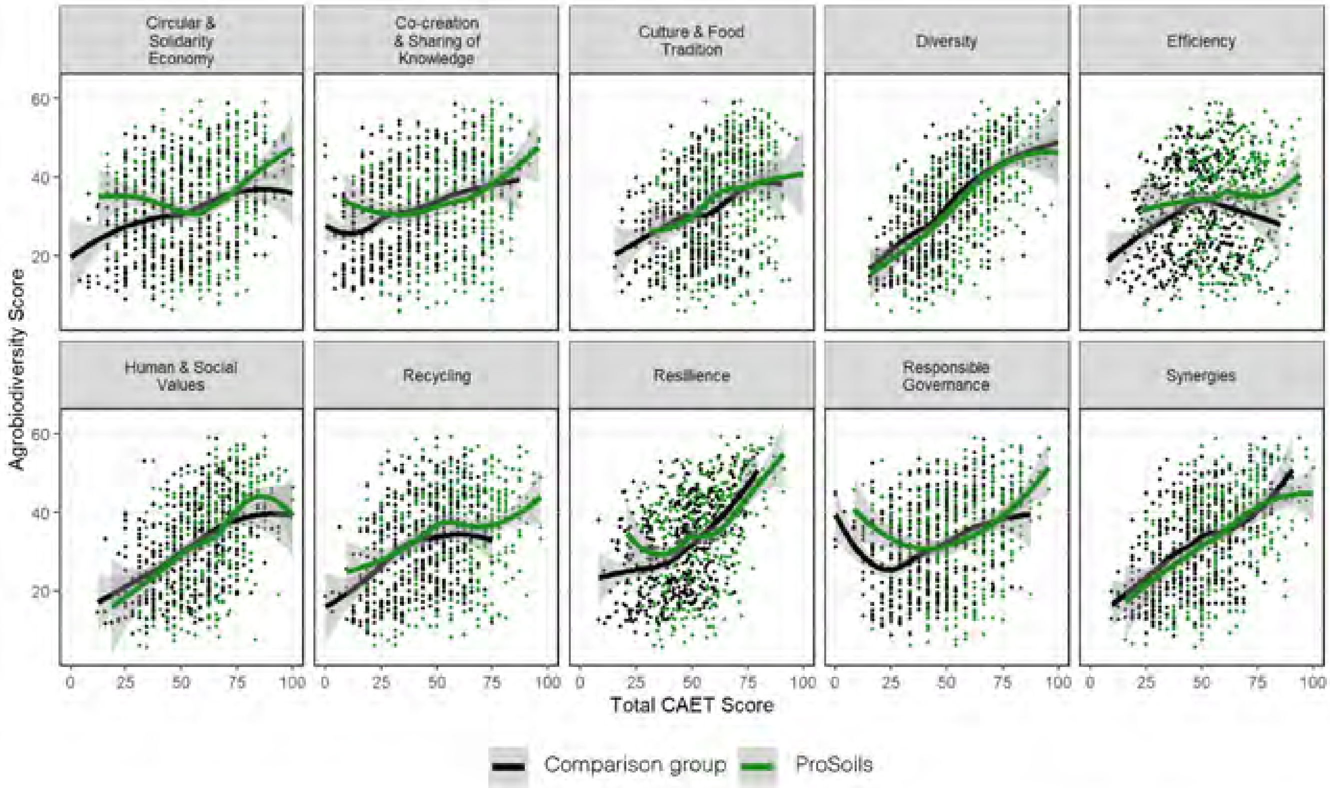


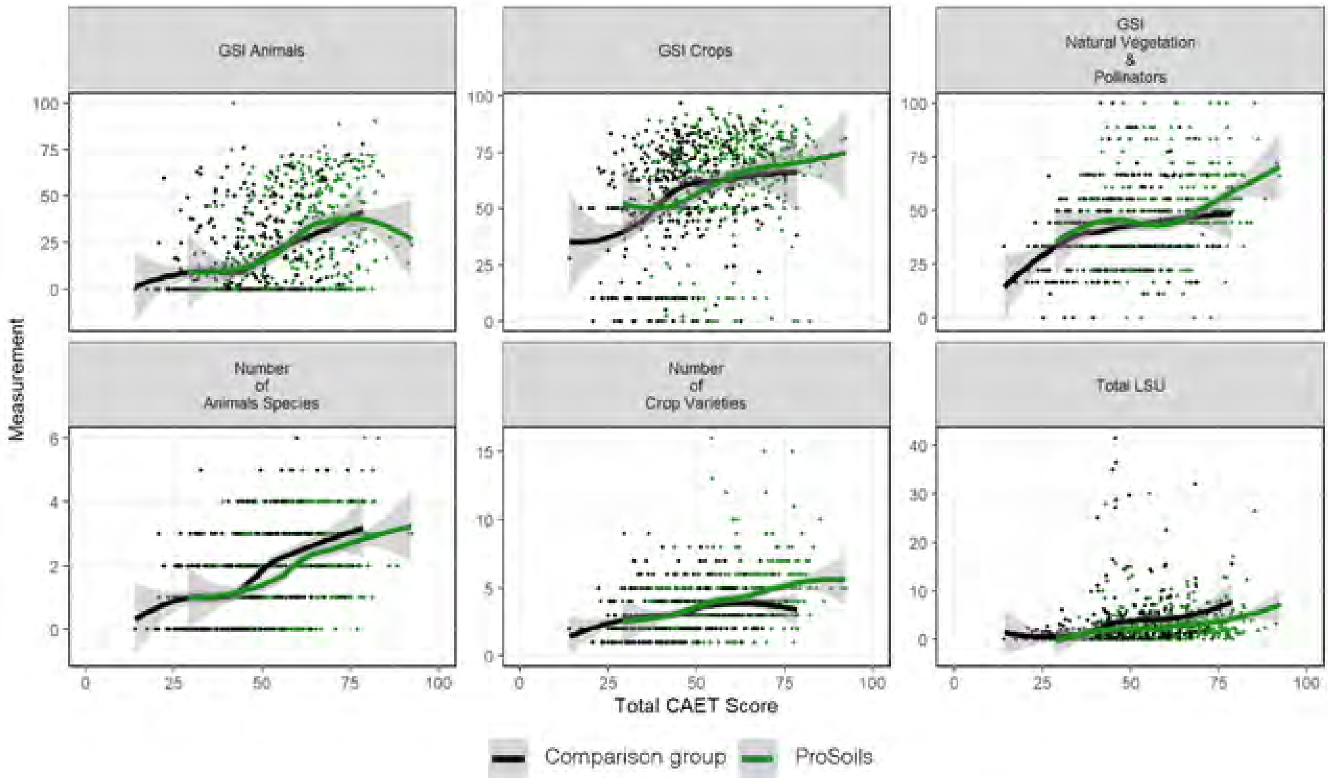


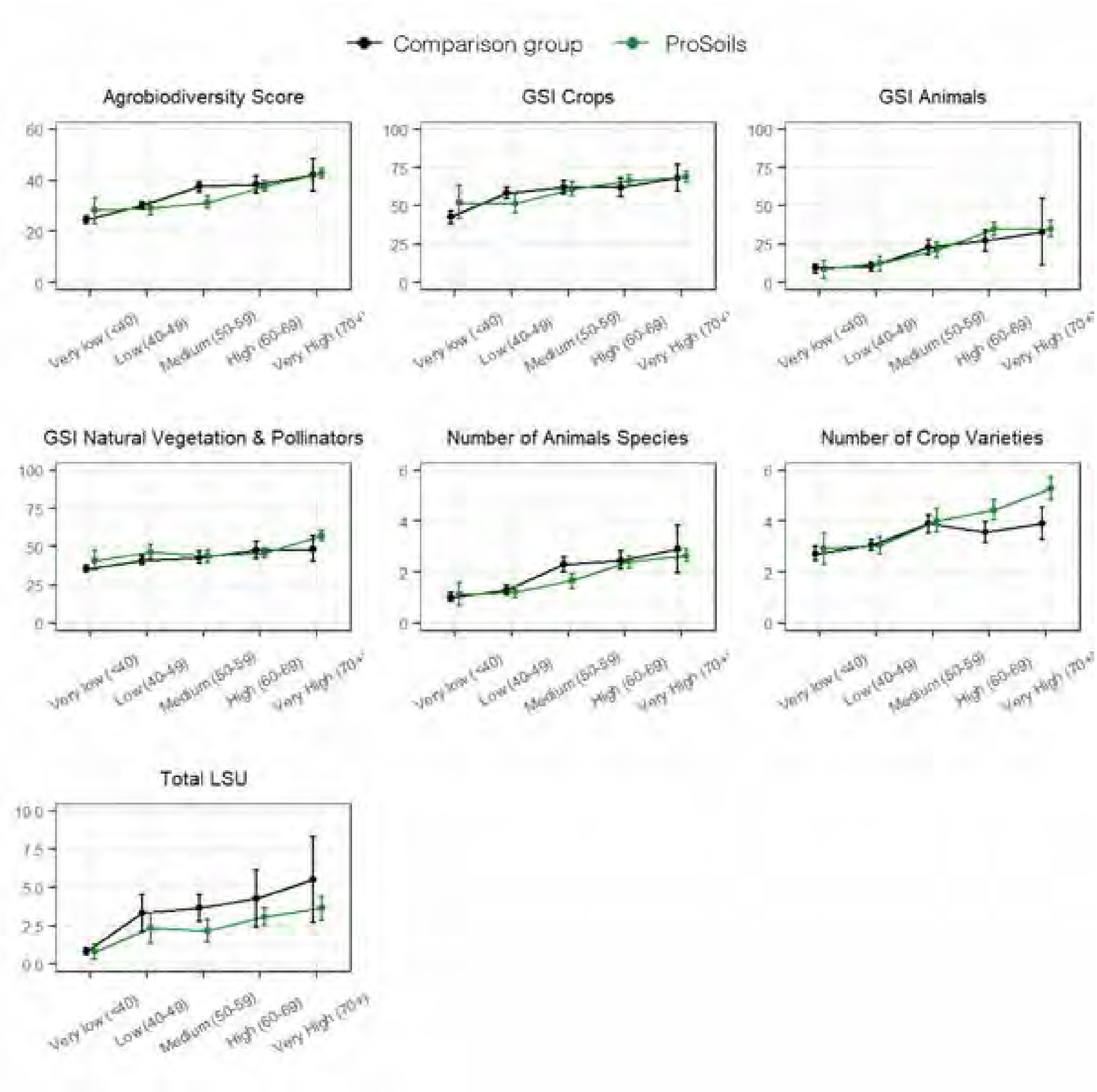
Statistic	Comparison group	ProSoils
Mean	30.7	35.1
Median	31	38
SD	11.1	12.5
IQR	21.5-39.0	27.0-44.0





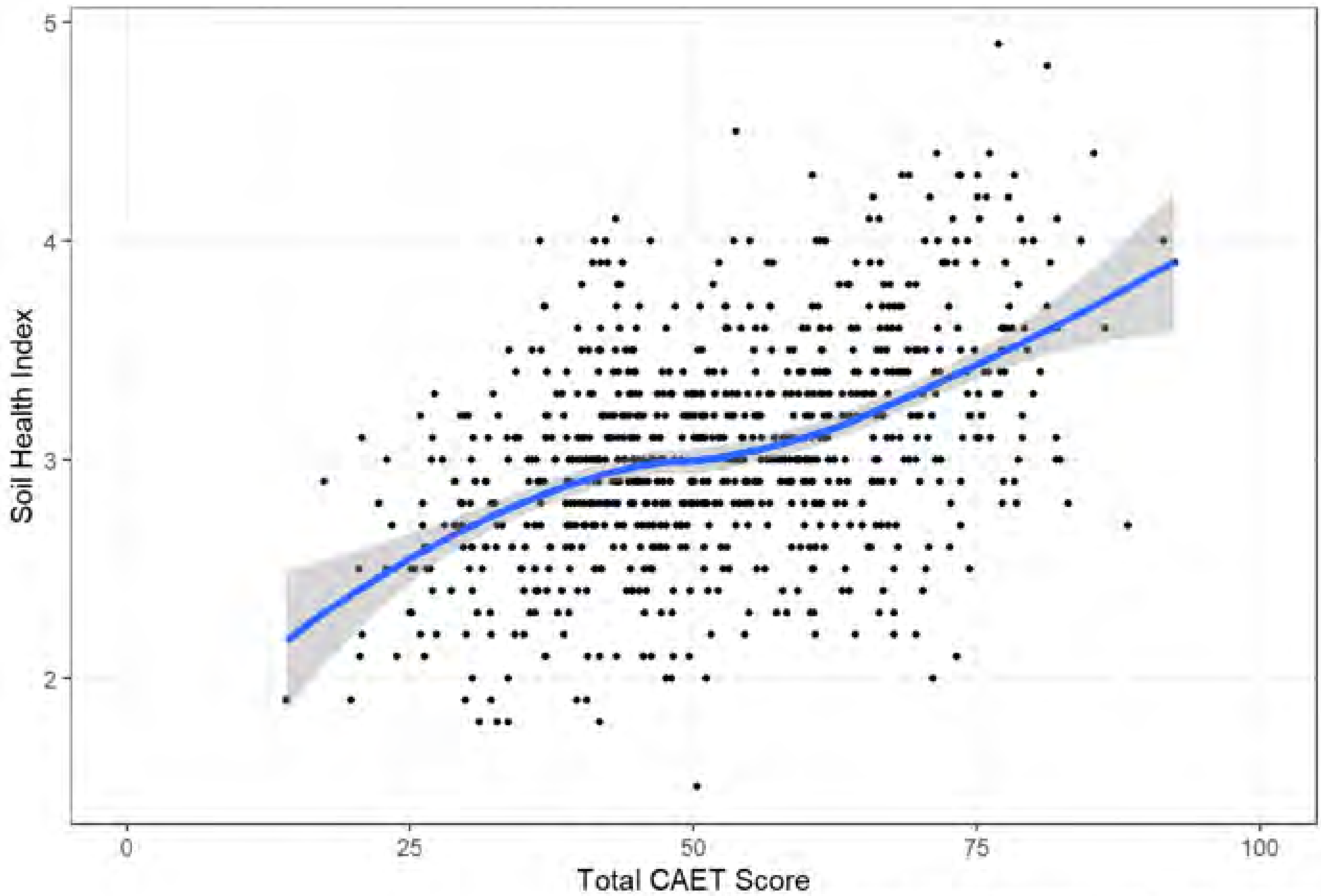

Circular & Solidarity Economy
Co-creation & Sharing of Knowledge
Culture & Food Tradition
Diversity
Efficiency
Human & Social Values
Recycling
Resilience
Responsible Governance
Synergies
Agrobiodiversity Score
Total CAET Score
Comparison group
ProSoils


GSI Animals
GSI Crops
GSI Natural Vegetation & Pollinators
Number of Animals Species
Number of Crop Varieties
Total LSU
Measurement
Total CAET Score
Comparison group
ProSoils

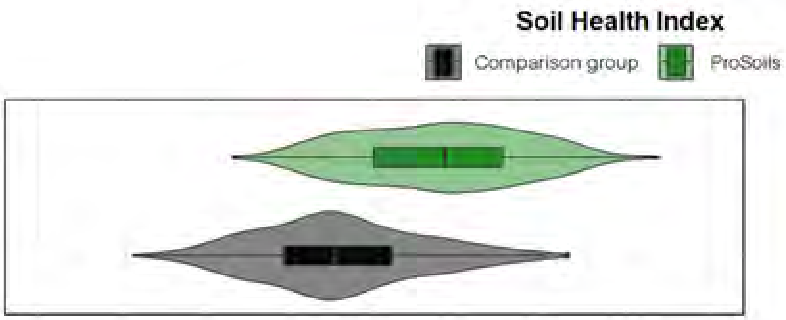


Comparison group
ProSoils
Agrobiodiversity Score
GSI Crops
GSI Animals
GSI Natural Vegetation & Pollinators
Number of Animals Species
Number of Crop Varieties
Total LSU
Very low (<40)
Low (40-49)
Medium (50-59)
High (60-69)
Very High (70+)

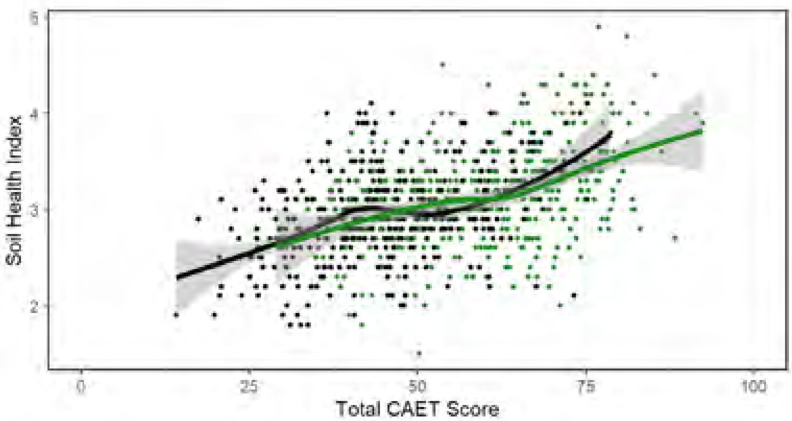
Annex 7. Soil health TAPE

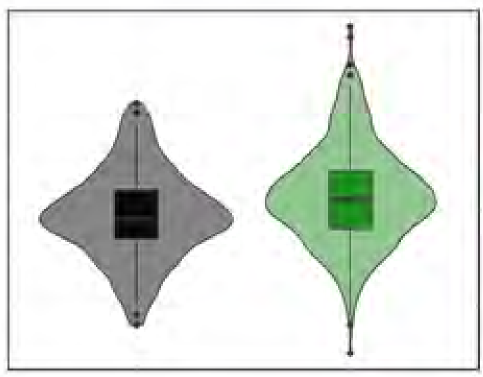


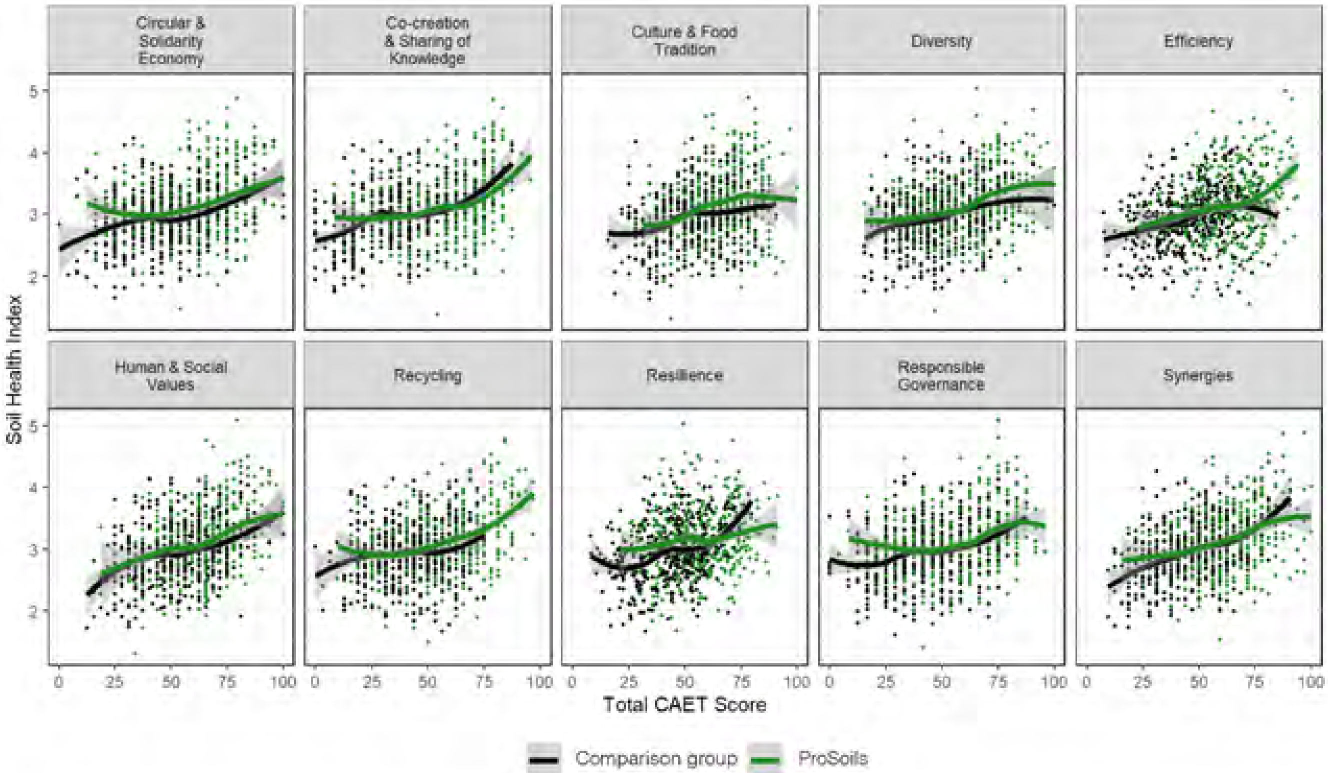
*Spearman's Rank Correlation Coefficient = 0.425****

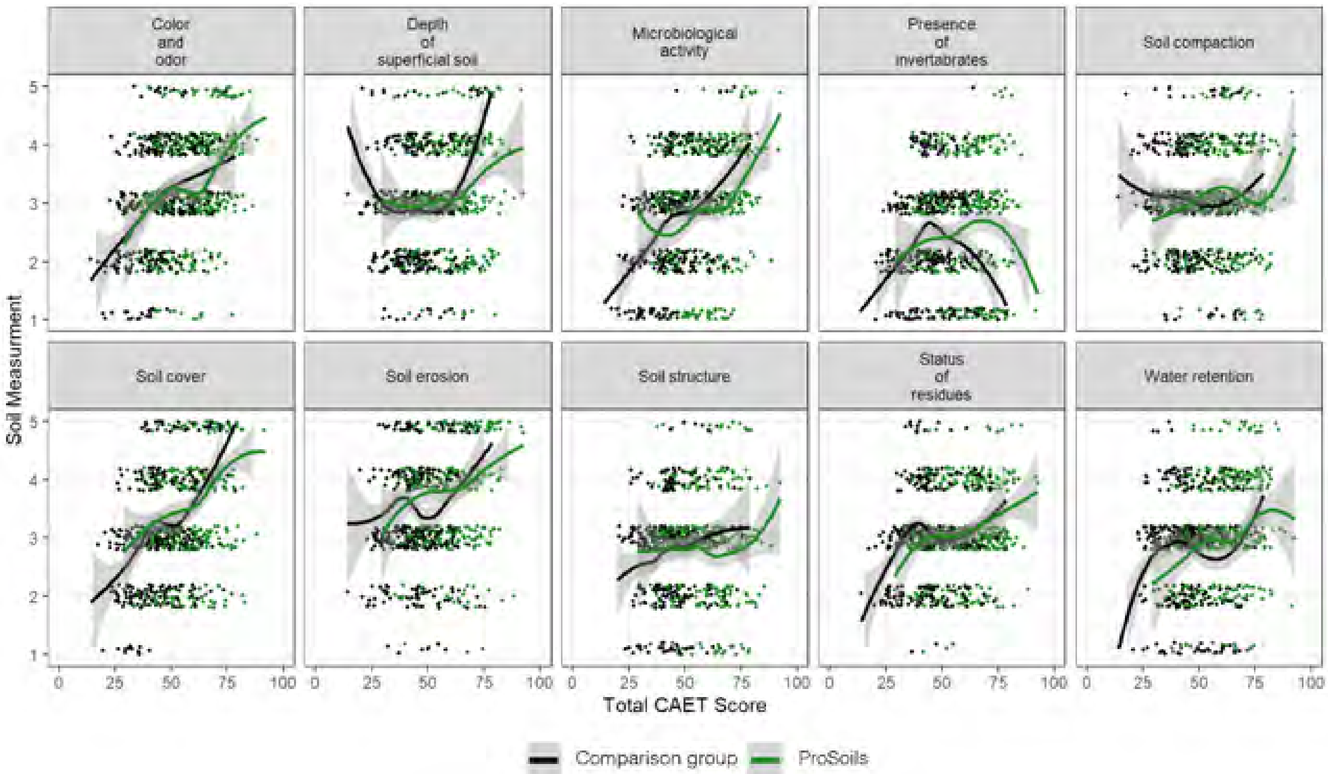


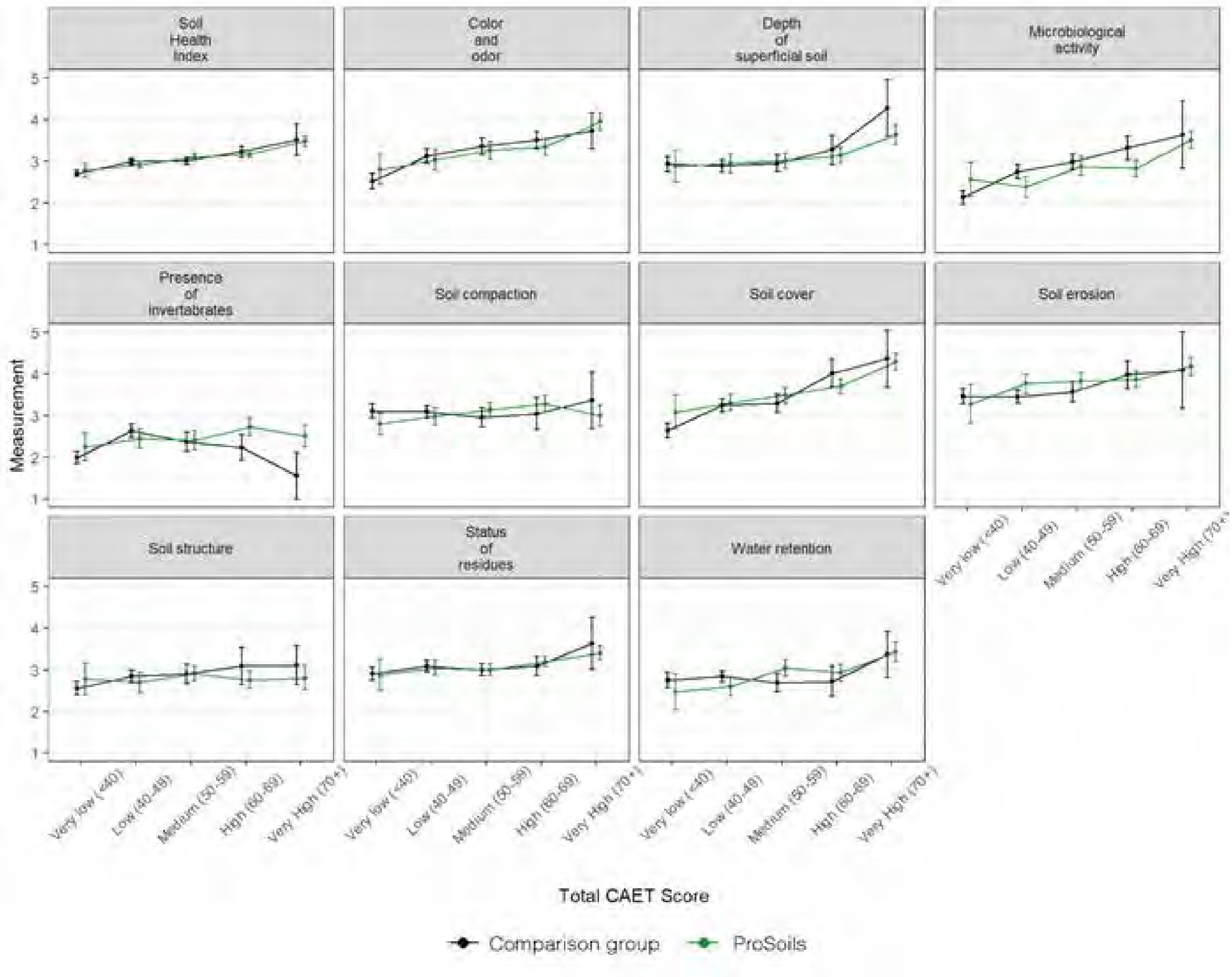
Statistic	Comparison group	ProSoils
Mean	2.9	3.1
Median	2.9	3.1
SD	0.5	0.5
IQR	2.7-3.2	2.8-3.4



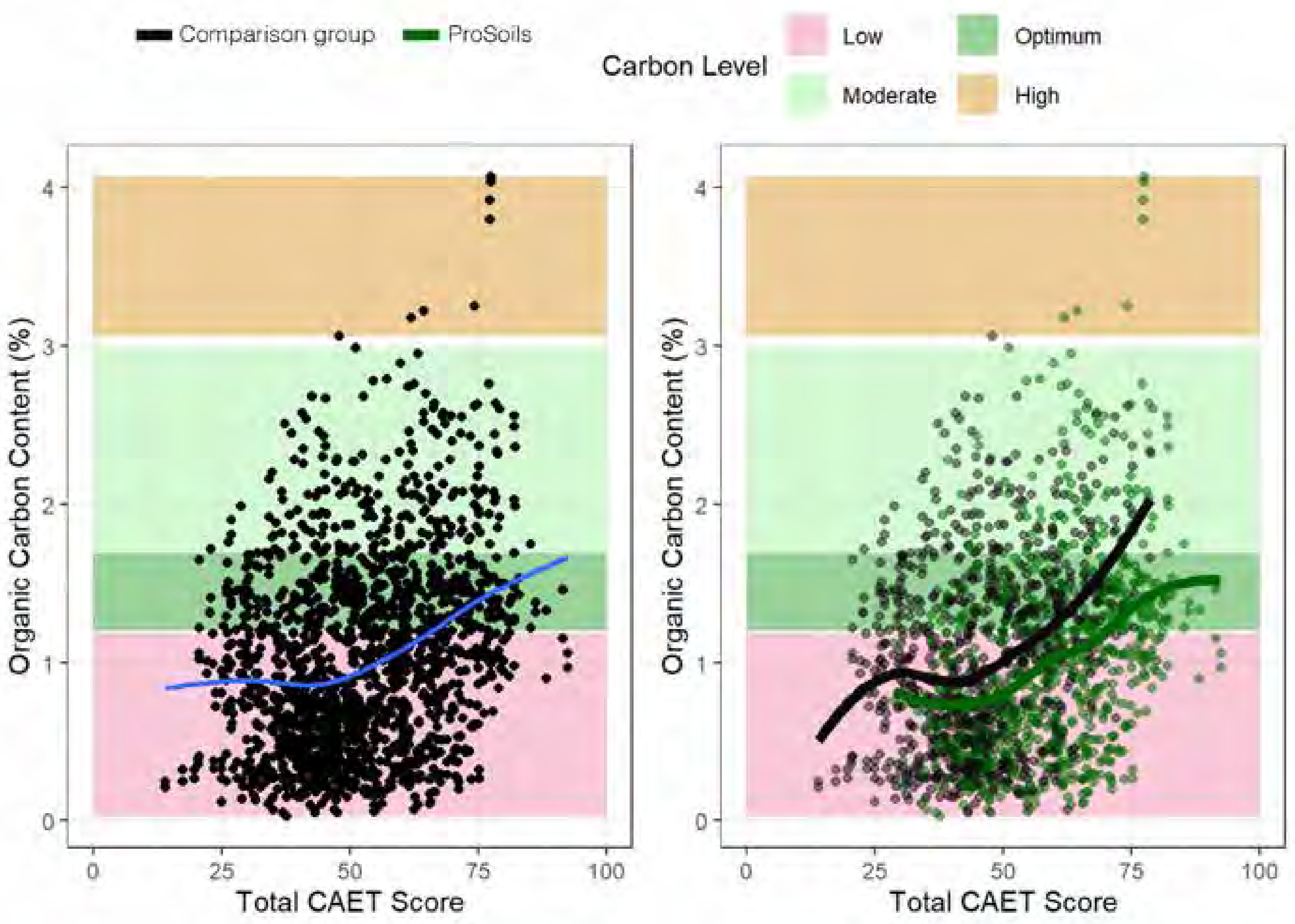


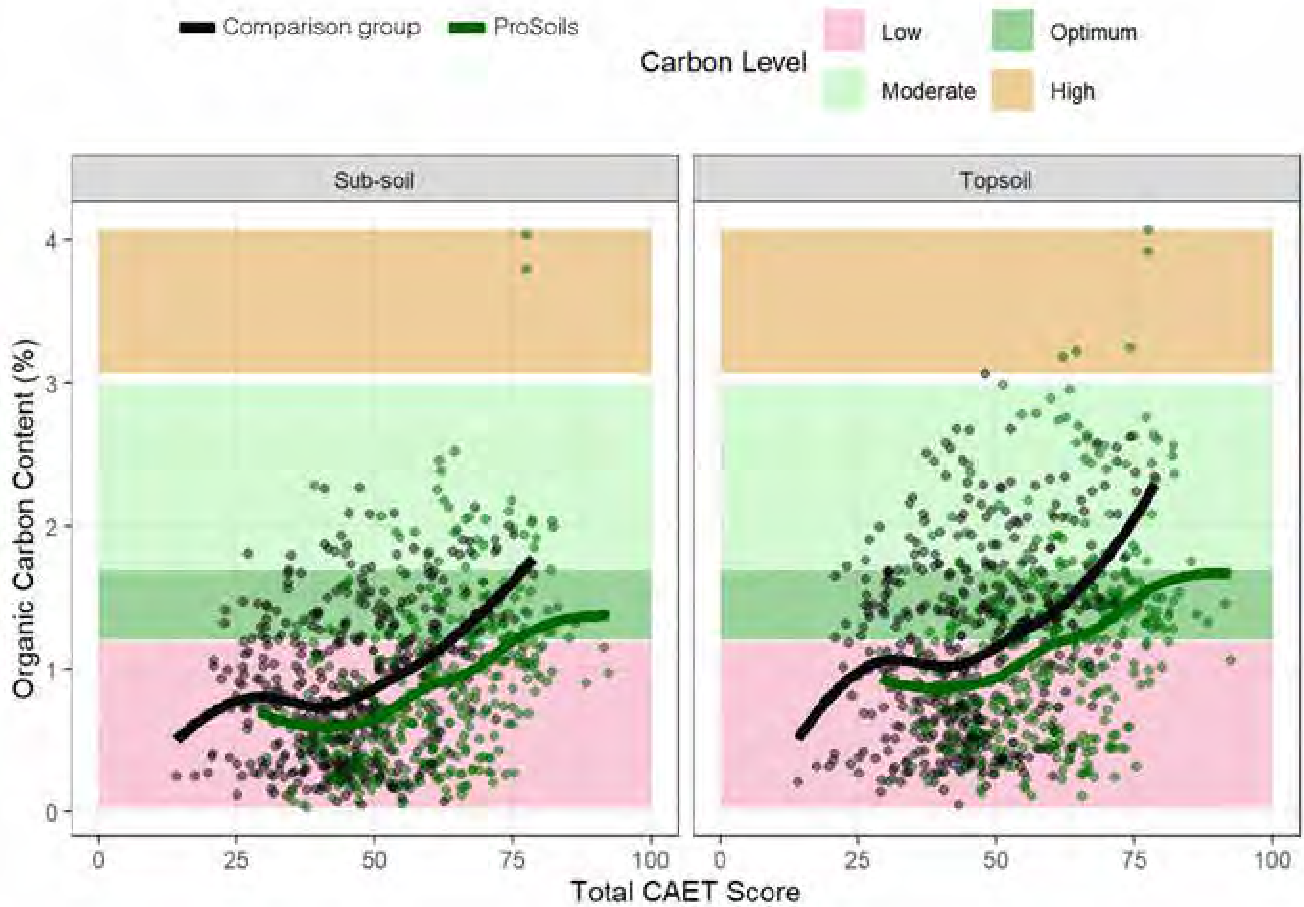

Circular & Solidarity Economy
Co-creation & Sharing of Knowledge
Culture & Food Tradition
Diversity
Efficiency
Human & Social Values
Recycling
Resilience
Responsible Governance
Synergies
Soil Health Index
1
2
3
4
5
0
25
50
75
100
Total CAET Score
Comparison group
ProSoils

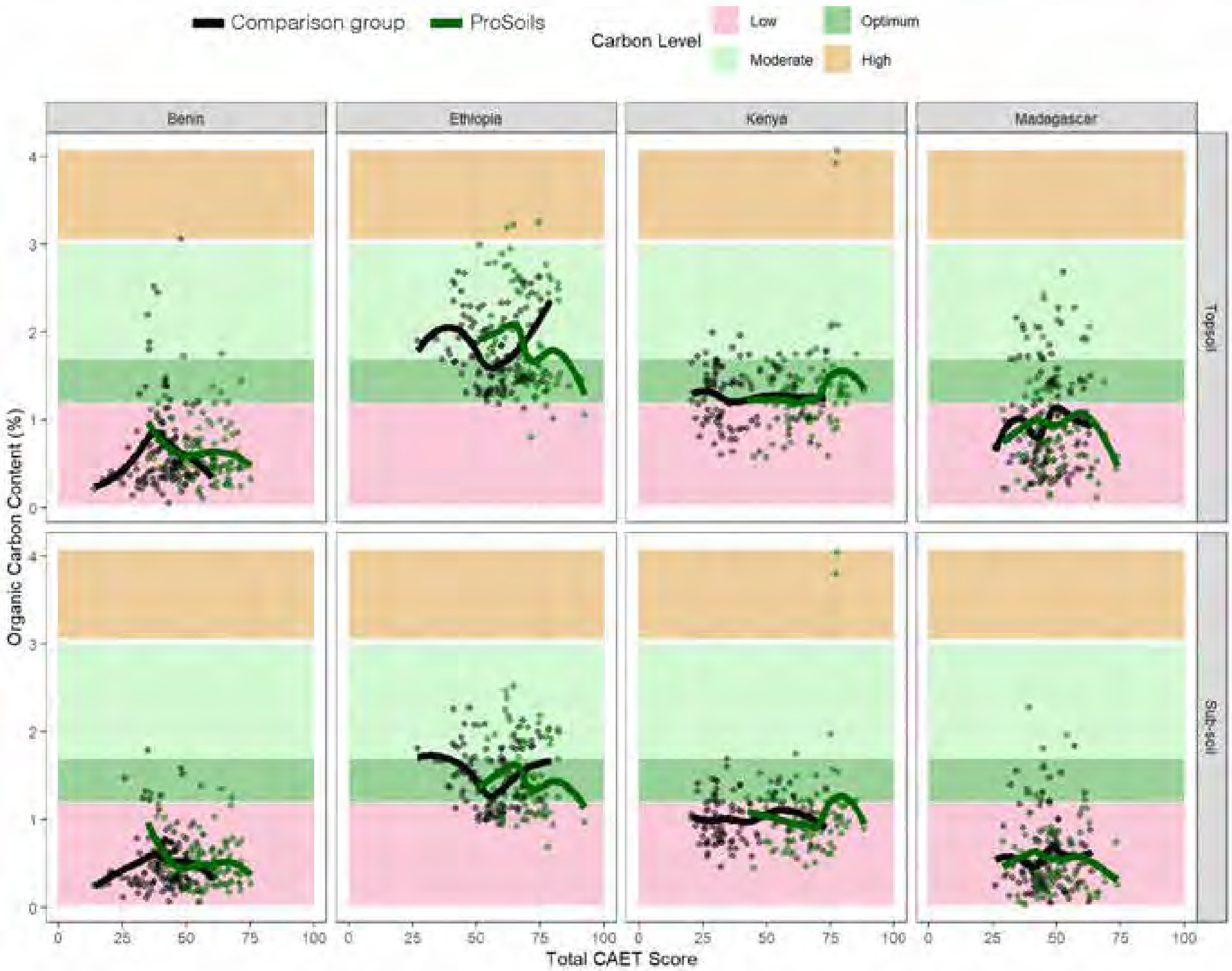

Color and odor
Depth of superficial soil
Microbiological activity
Presence of invertabrates
Soil compaction
Soil cover
Soil erosion
Soil structure
Status of residues
Water retention
Soil Measurment
1
2
3
4
5
0
25
50
75
100
Total CAET Score
Comparison group
ProSoils

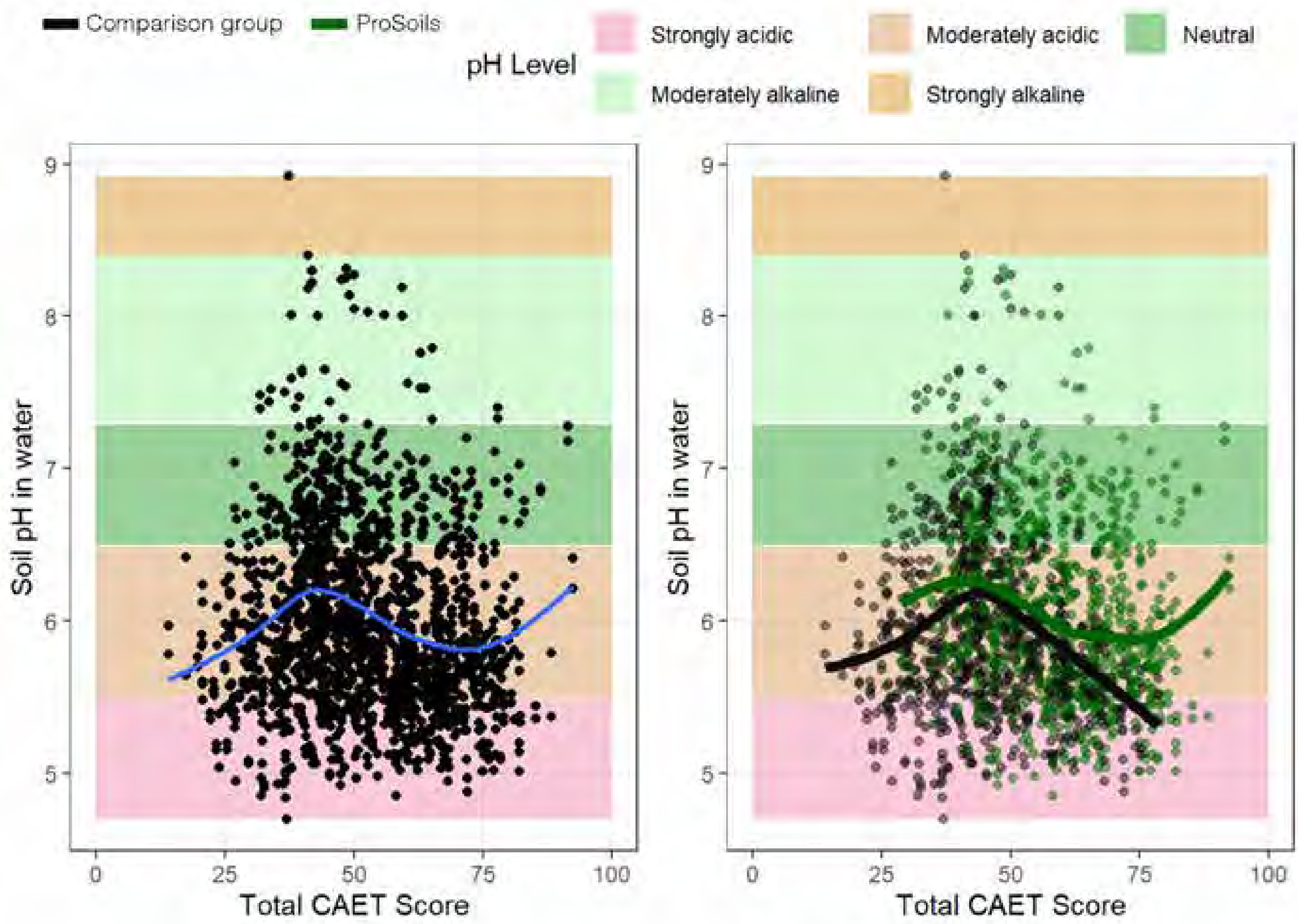

Soil Health Index
Color and odor
Depth of superficial soil
Microbiological activity
Presence of invertabrates
Soil compaction
Soil cover
Soil erosion
Soil structure
Status of residues
Water retention
Measurement
Very low (<40)
Low (40-49)
Medium (50-59)
High (60-69)
Very High (70+)
Total CAET Score
Comparison group
ProSoils

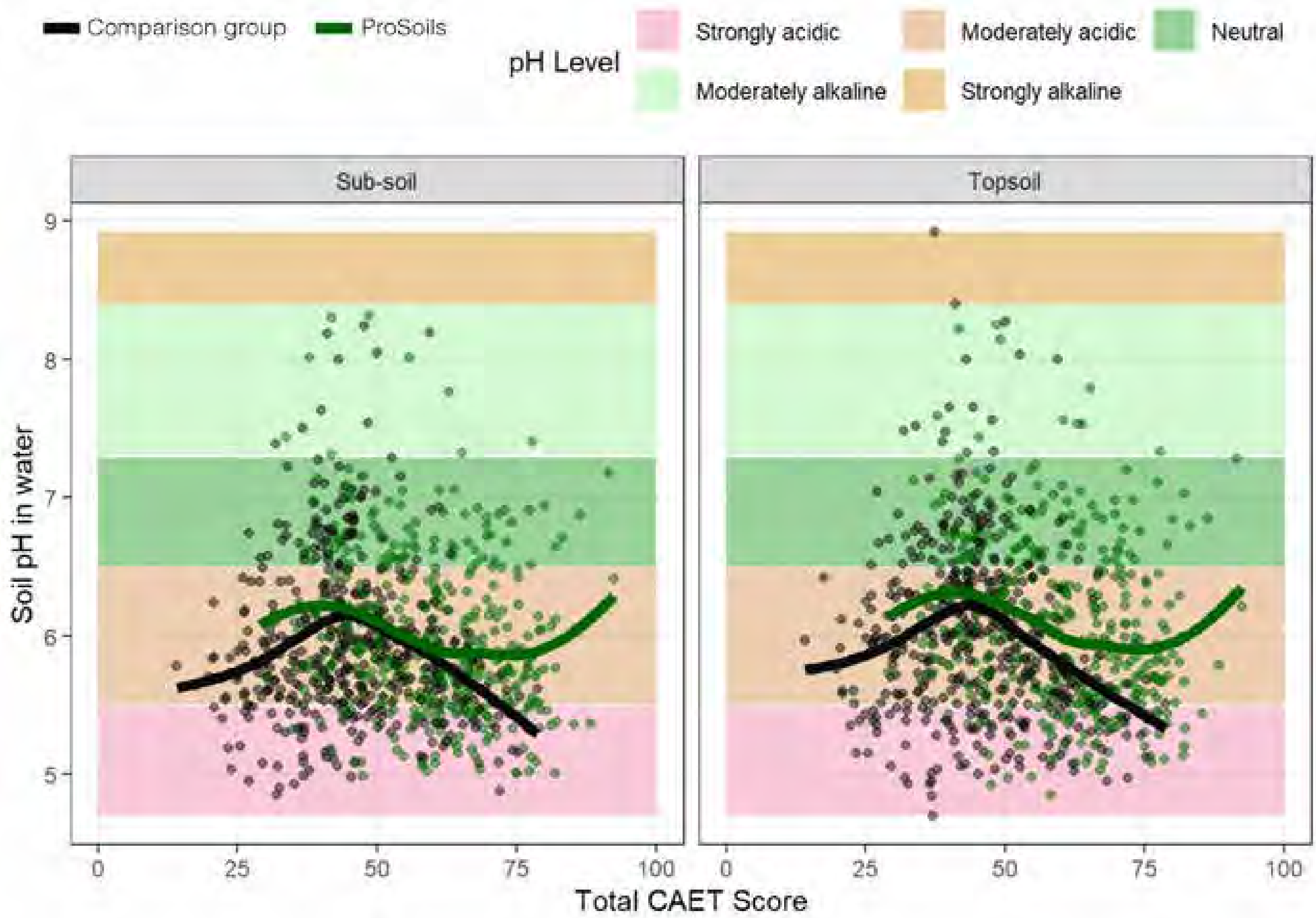
Annex 8. Soil health LDSF

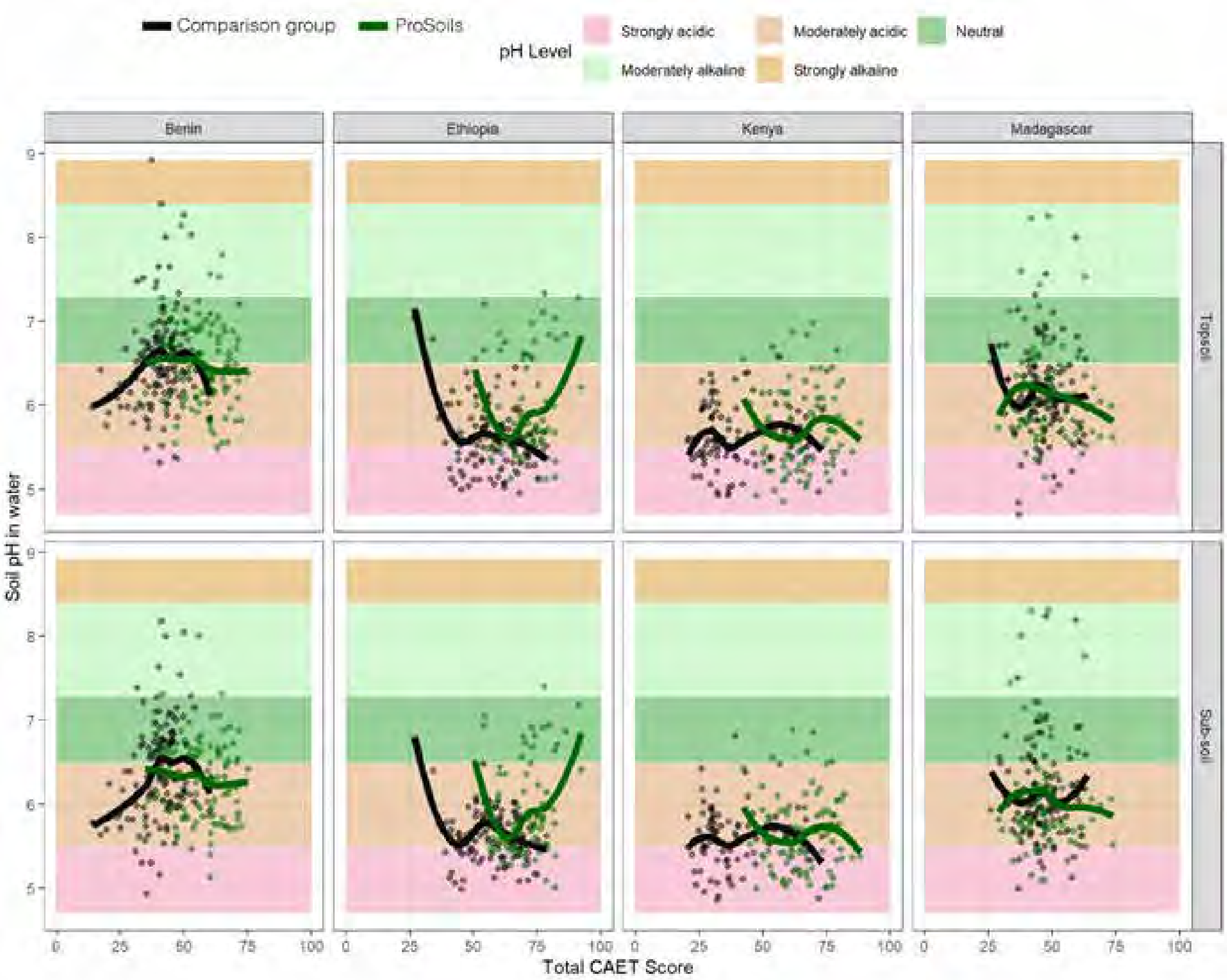


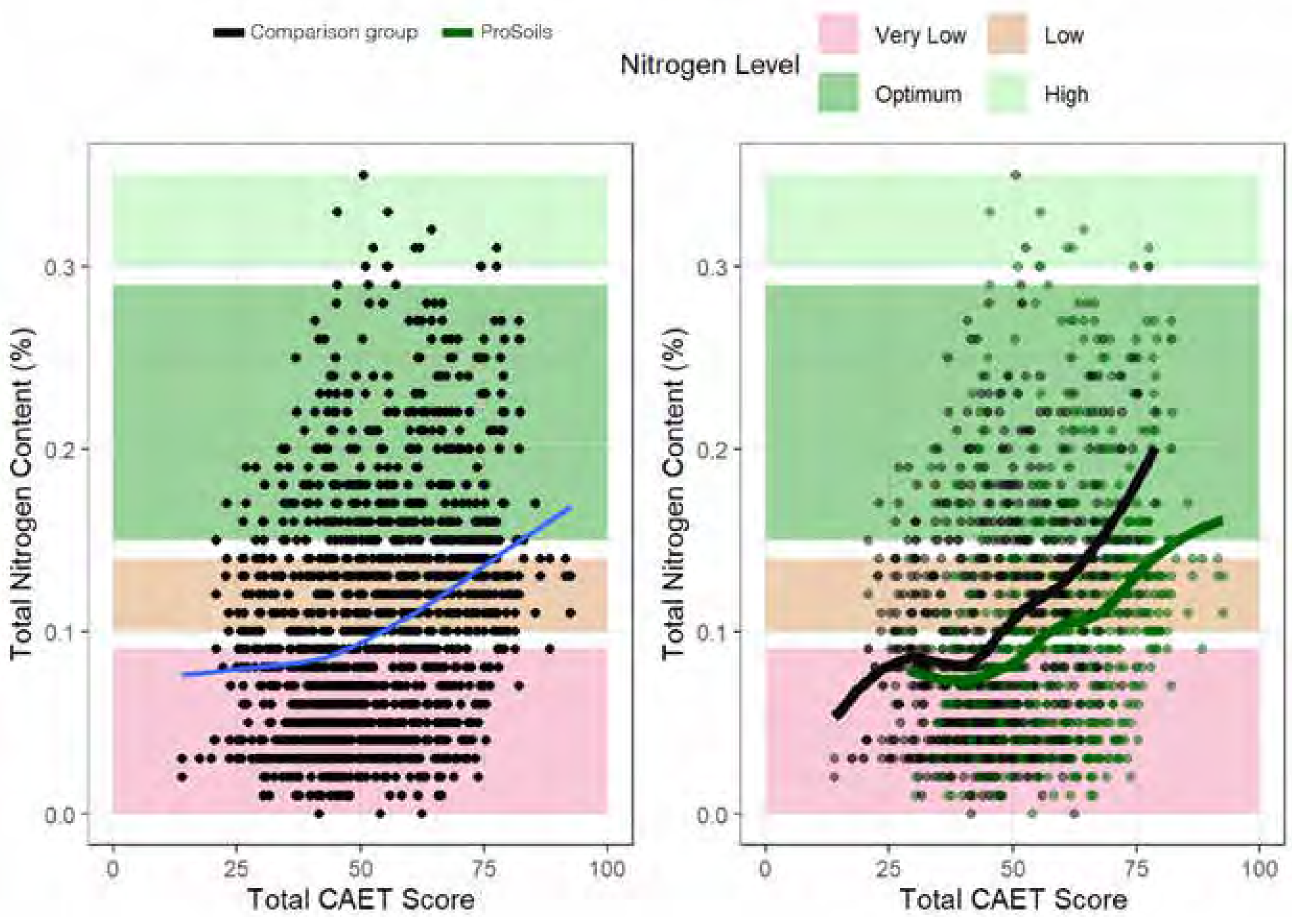

Comparison group
ProSoils
Carbon Level
Low
Optimum
Moderate
High
Sub-soil
Topsoil
Organic Carbon Content (%)
Total CAET Score

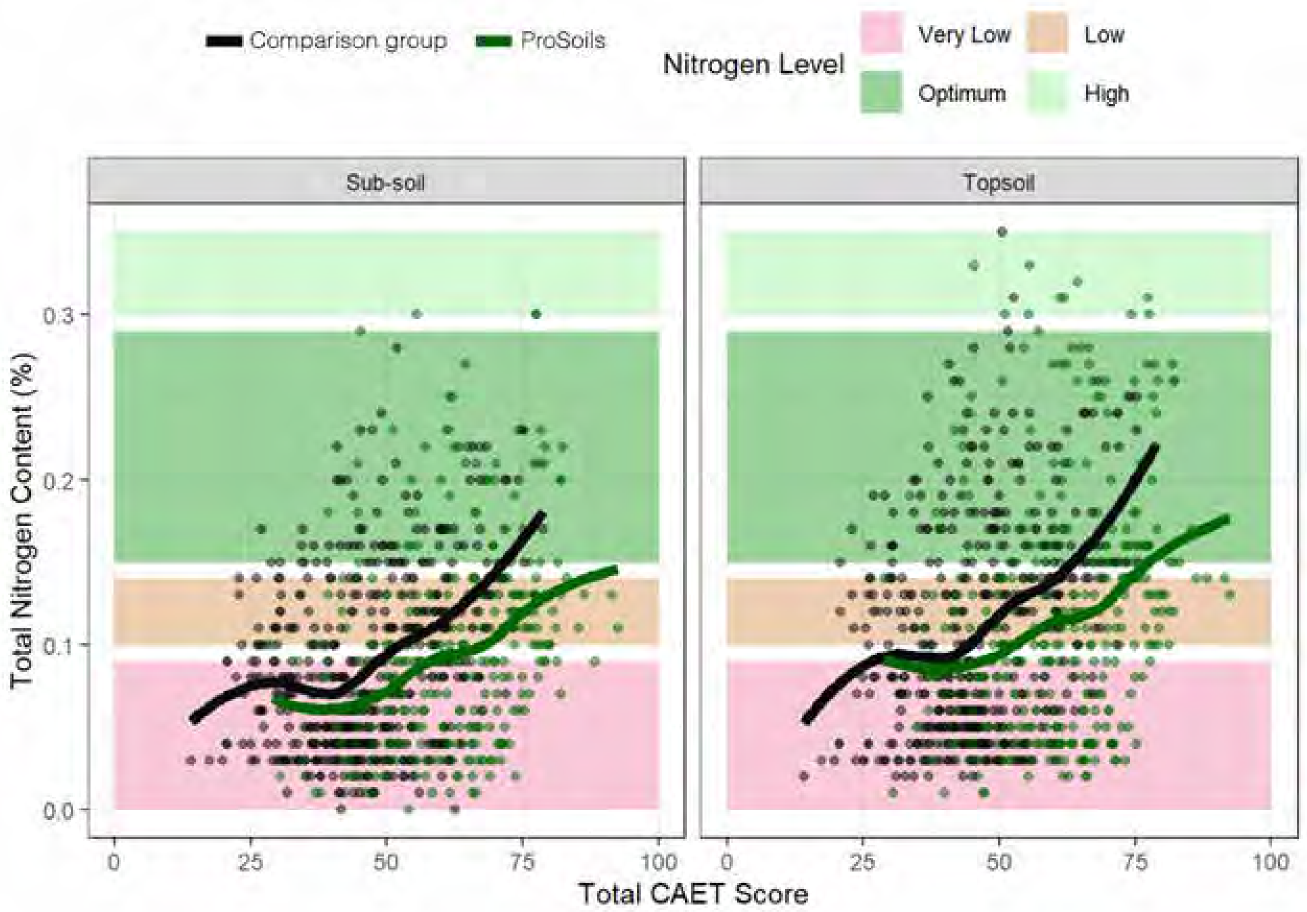

Comparison group
ProSoils
Carbon Level
Low
Optimum
Moderate
High
Benin
Ethiopia
Kenya
Madagascar
Topsoil
Sub-soil
Organic Carbon Content (%)
Total CAET Score

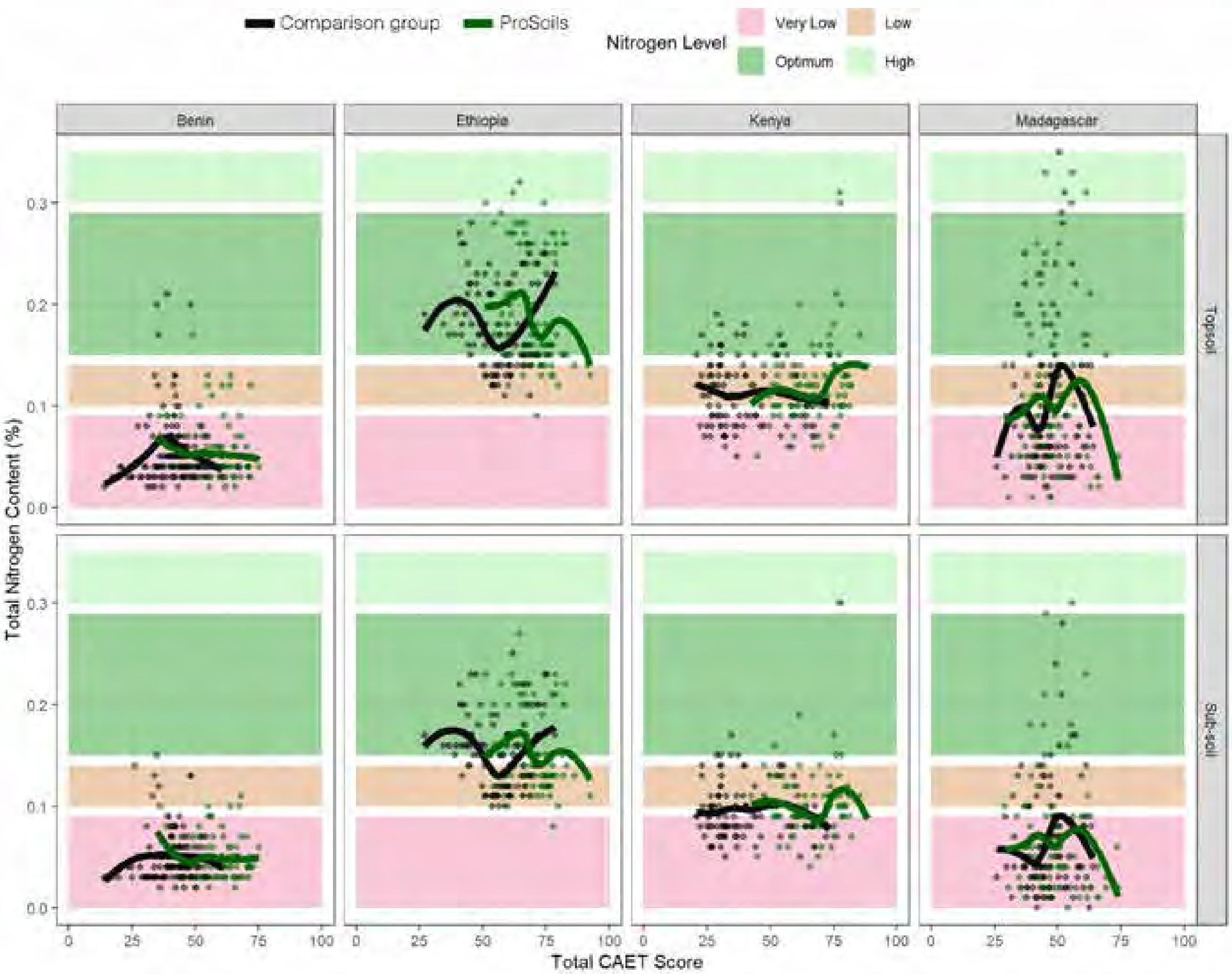

Comparison group
ProSoils
pH Level
Strongly acidic
Moderately acidic
Neutral
Moderately alkaline
Strongly alkaline
Soil pH in water
Total CAET Score

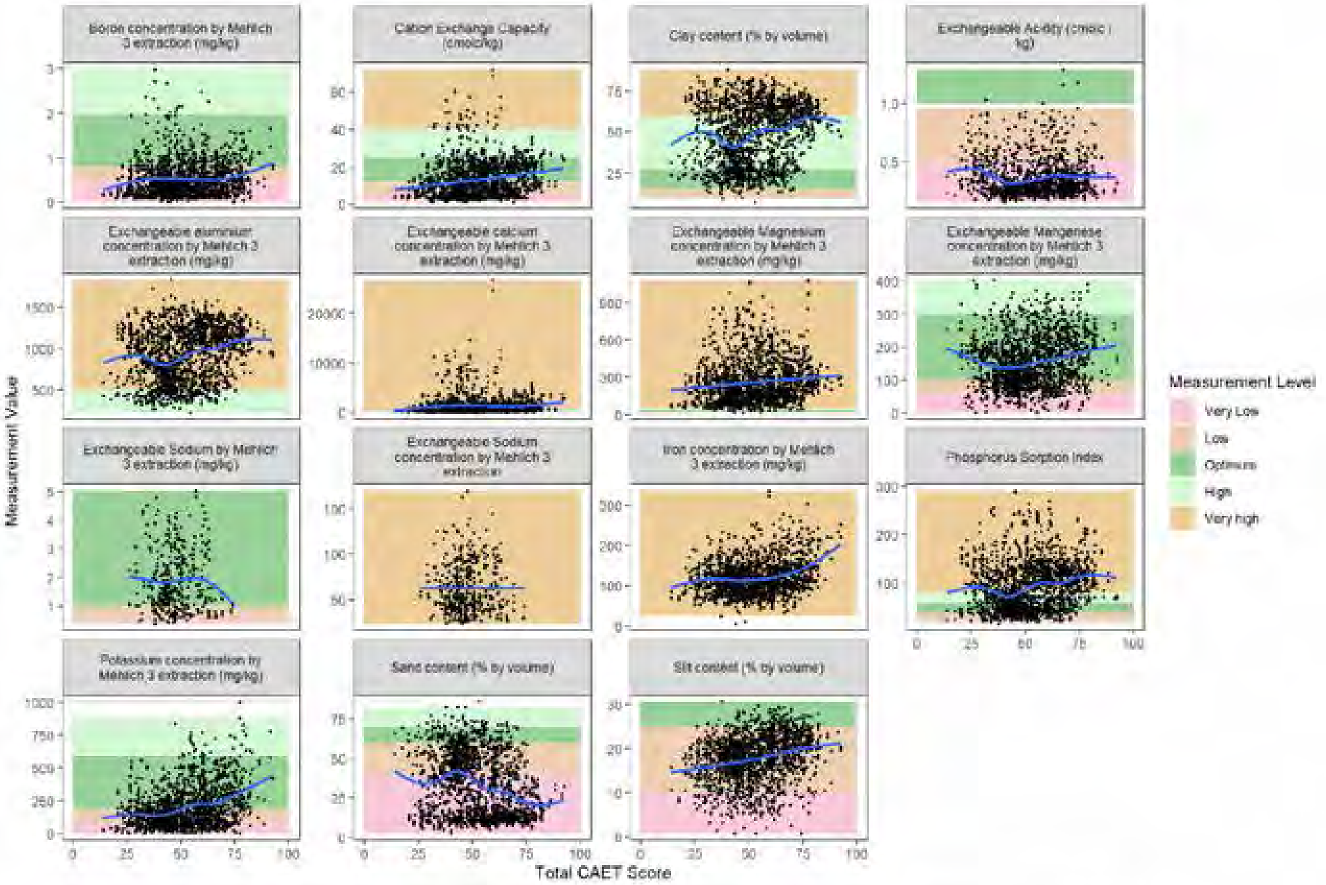

Comparison group
ProSoils
pH Level
Strongly acidic
Moderately acidic
Neutral
Moderately alkaline
Strongly alkaline
Sub-soil
Topsoil
Soil pH in water
Total CAET Score

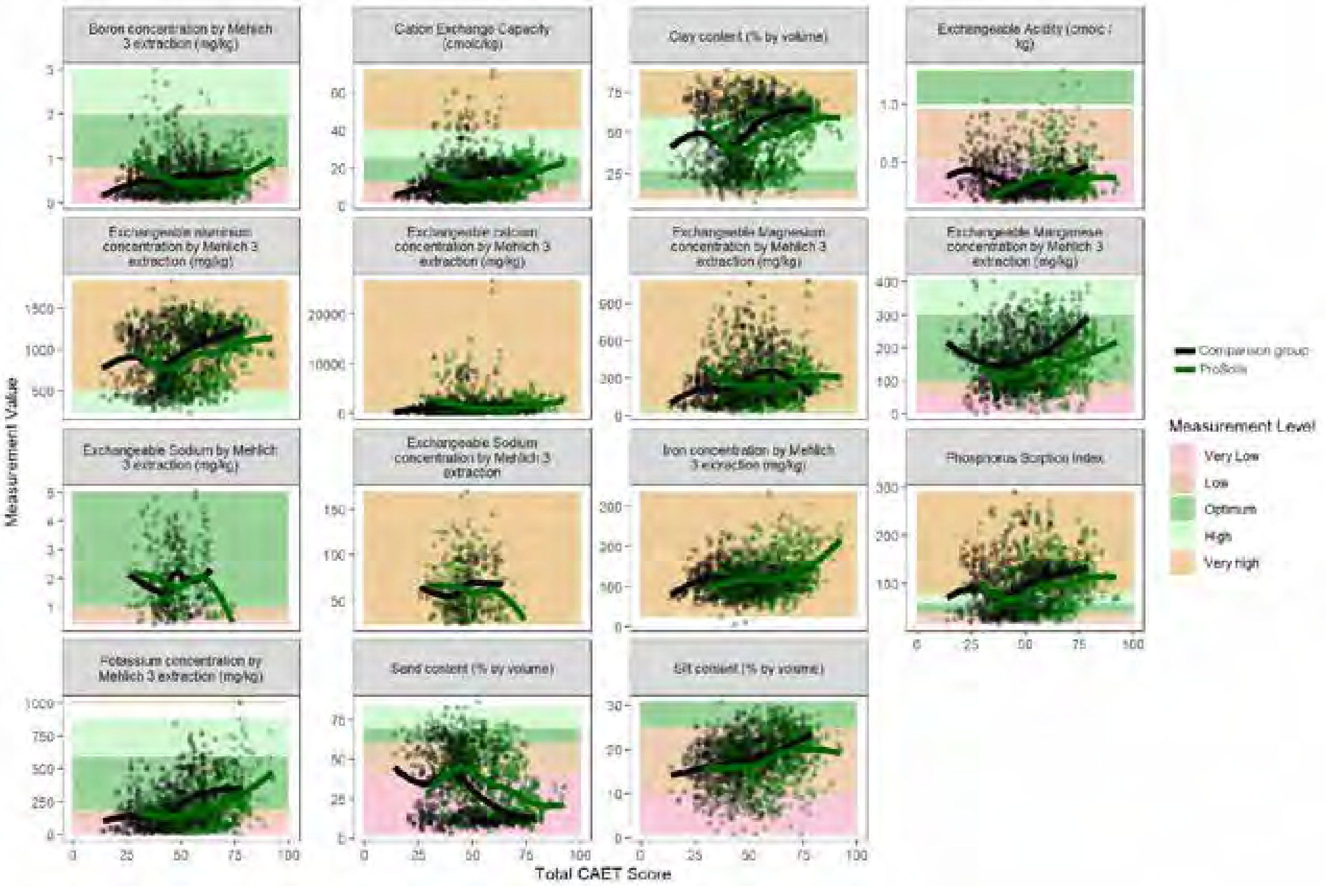

Comparison group
ProSoils
pH Level
Strongly acidic
Moderately acidic
Neutral
Moderately alkaline
Strongly alkaline
Benin
Ethiopia
Kenya
Madagascar
Topsoil
Sub-soil
Soil pH in water
Total CAET Score

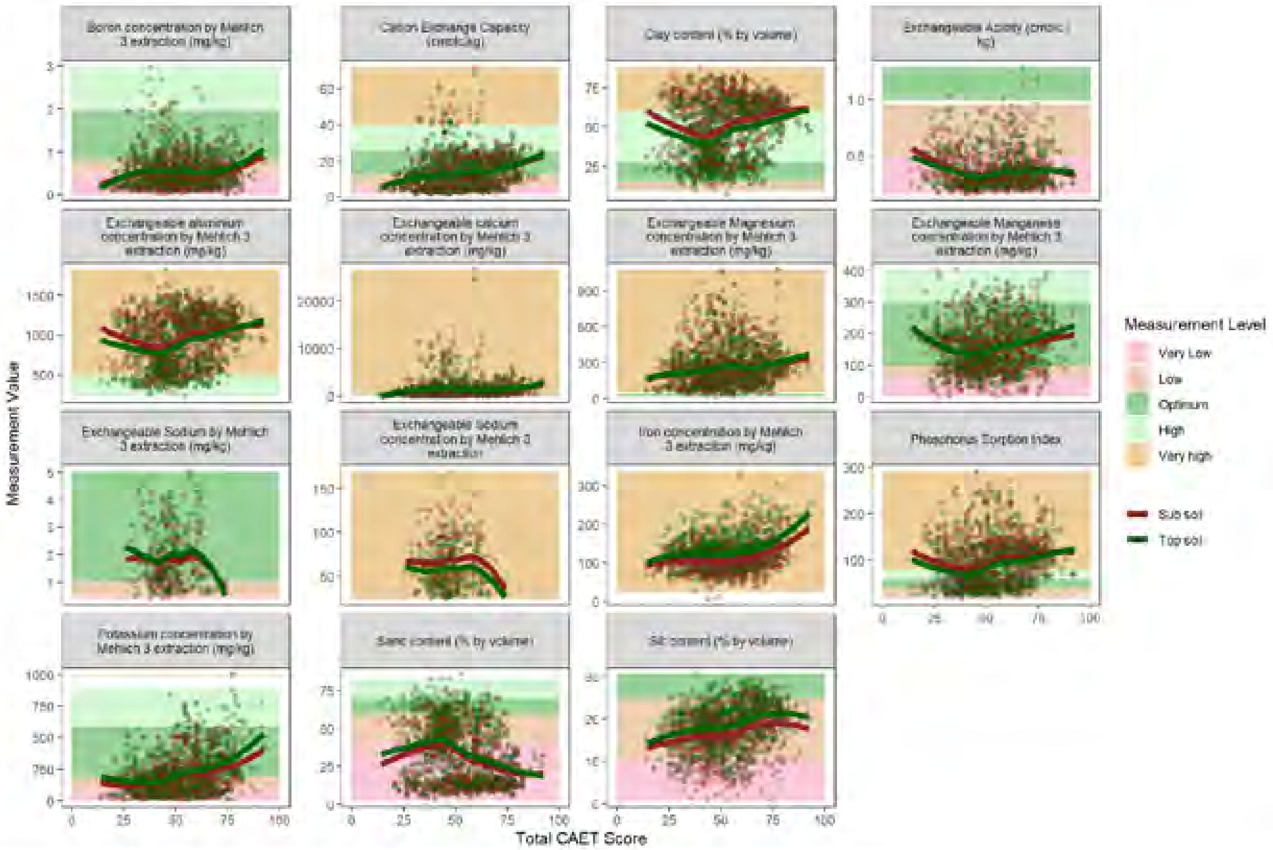

Comparison group
ProSoils
Nitrogen Level
Very Low
Low
Optimum
High
Total Nitrogen Content (%)
Total CAET Score


Comparison group
ProSoils
Nitrogen Level
Very Low
Low
Optimum
High
Sub-soil
Topsoil
Total Nitrogen Content (%)
0.0
0.1
0.2
0.3
0
25
50
75
100
Total CAET Score


Comparison group
ProSoils
Nitrogen Level
Very Low
Low
Optimum
High
Benin
Ethiopia
Kenya
Madagascar
Topsoil
Sub-soil
Total Nitrogen Content (%)
Total CAET Score


Boron concentration by Mehlich 3 extraction (mg/kg)
Cation Exchange Capacity (cmolc/kg)
Clay content (% by volume)
Exchangeable Acidity (cmolc / kg)
Exchangeable aluminium concentration by Mehlich 3 extraction (mg/kg)
Exchangeable calcium concentration by Mehlich 3 extraction (mg/kg)
Exchangeable Magnesium concentration by Mehlich 3 extraction (mg/kg)
Exchangeable Manganese concentration by Mehlich 3 extraction (mg/kg)
Exchangeable Sodium by Mehlich 3 extraction (mg/kg)
Exchangeable Sodium concentration by Mehlich 3 extraction
Iron concentration by Mehlich 3 extraction (mg/kg)
Phosphorus Sorption Index
Potassium concentration by Mehlich 3 extraction (mg/kg)
Sand content (% by volume)
Silt content (% by volume)
Measurement Value
Total CAET Score
Measurement Level
Very Low
Low
Optimum
High
Very high


Boron concentration by Mehlich 3 extraction (mg/kg)
Cation Exchange Capacity (cmolc/kg)
Clay content (% by volume)
Exchangeable Acidity (cmolc / kg)
Exchangeable aluminium concentration by Mehlich 3 extraction (mg/kg)
Exchangeable calcium concentration by Mehlich 3 extraction (mg/kg)
Exchangeable Magnesium concentration by Mehlich 3 extraction (mg/kg)
Exchangeable Manganese concentration by Mehlich 3 extraction (mg/kg)
Exchangeable Sodium by Mehlich 3 extraction (mg/kg)
Exchangeable Sodium concentration by Mehlich 3 extraction
Iron concentration by Mehlich 3 extraction (mg/kg)
Phosphorus Sorption Index
Potassium concentration by Mehlich 3 extraction (mg/kg)
Sand content (% by volume)
Silt content (% by volume)
Measurement Value
Total CAET Score
Comparison group
ProSoils
Measurement Level
Very Low
Low
Optimum
High
Very high



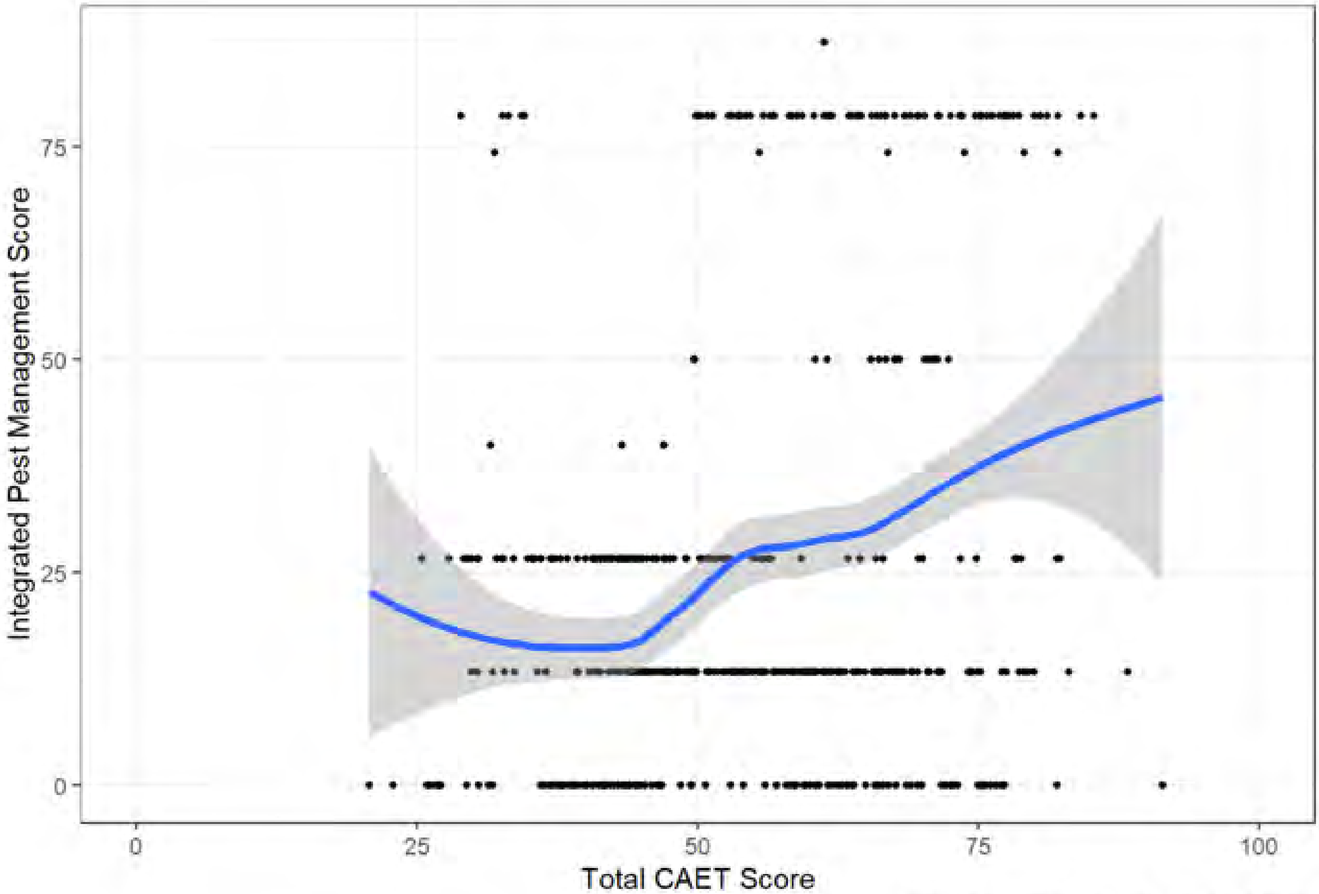
Spearman's Rank Correlations with Total CAET Score			
Measure	Overall	Comparison group	ProSoils
Cation Exchange Capacity (cmolc/kg)	0.265	0.324	0.298
Clay content (% by volume)	0.204	0.231	0.319
Exchangeable Acidity (cmolc / kg)	0.010	-0.167	0.164
Exchangeable aluminium concentration by Mehlich 3 extraction (mg/kg)	0.245	0.229	0.323
Boron concentration by Mehlich 3 extraction (mg/kg)	0.081	0.221	0.077
Exchangeable calcium concentration by Mehlich 3 extraction (mg/kg)	0.108	0.171	0.112
Exchangeable Sodium by Mehlich 3 extraction (mg/kg)	-0.015	0.096	-0.129
Iron concentration by Mehlich 3 extraction (mg/kg)	0.174	0.055	0.265
Potassium concentration by Mehlich 3 extraction (mg/kg)	0.307	0.414	0.327
Exchangeable Magnesium concentration by Mehlich 3 extraction (mg/kg)	0.173	0.229	0.189
Exchangeable Manganese concentration by Mehlich 3 extraction (mg/kg)	0.160	0.214	0.308
Exchangeable Sodium concentration by Mehlich 3 extraction	-0.005	0.149	-0.164
Soil pH in water (soil: water ratio of 1:2 weight to volume basis)	-0.141	-0.085	-0.239
Phosphorus Sorption Index	0.247	0.229	0.347

Spearman's Rank Correlations with Total CAET Score			
Measure	Overall	Comparison group	ProSoils
Sand content (% by volume)	-0.253	-0.283	-0.375
Silt content (% by volume)	0.286	0.290	0.306
Organic Carbon content	0.270	0.245	0.379
Total Nitrogen content	0.290	0.290	0.367

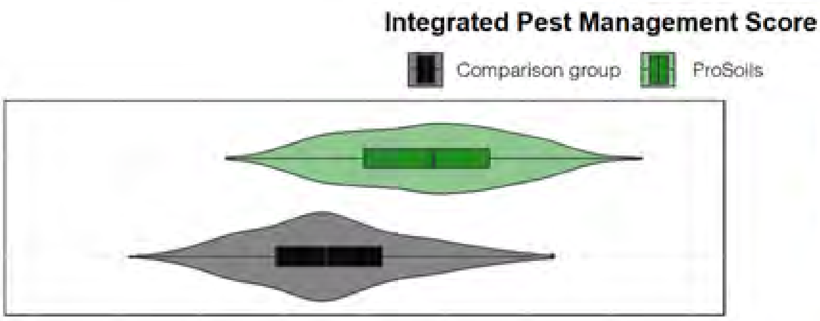
Spearman's Rank Correlations with Total CAET Score						
Measure	Overall Subsoil	Overall Topsoil	Comparison group Subsoil	Comparison group Topsoil	ProSoils Subsoil	ProSoils Topsoil
Cation Exchange Capacity (cmolc/kg)	0.273	0.257	0.333	0.315	0.306	0.289
Clay content (% by volume)	0.201	0.207	0.215	0.251	0.322	0.325
Exchangeable Acidity (cmolc / kg)	-0.026	0.048	-0.226	-0.116	0.123	0.212
Exchangeable aluminium concentration by Mehlich 3 extraction (mg/kg)	0.219	0.271	0.191	0.267	0.302	0.344
Boron concentration by Mehlich 3 extraction (mg/kg)	0.083	0.078	0.220	0.224	0.082	0.071
Exchangeable calcium concentration by Mehlich 3 extraction (mg/kg)	0.108	0.107	0.200	0.140	0.101	0.124
Exchangeable Sodium by Mehlich 3 extraction (mg/kg)	-0.018	-0.006	0.122	0.074	-0.164	-0.089
Iron concentration by Mehlich 3 extraction (mg/kg)	0.149	0.211	0.027	0.083	0.259	0.292
Potassium concentration by Mehlich 3 extraction (mg/kg)	0.294	0.321	0.456	0.374	0.281	0.373
Exchangeable Magnesium concentration by Mehlich 3 extraction (mg/kg)	0.175	0.170	0.228	0.230	0.178	0.198
Exchangeable Manganese concentration by Mehlich 3 extraction (mg/kg)	0.146	0.175	0.228	0.202	0.273	0.345
Exchangeable Sodium concentration by Mehlich 3 extraction	0.015	-0.028	0.163	0.133	-0.166	-0.180
Soil pH in water (soil: water ratio of 1:2 weight to volume basis)	-0.118	-0.160	-0.032	-0.131	-0.224	-0.252
Phosphorus Sorption Index	0.232	0.265	0.202	0.256	0.331	0.368
Sand content (% by volume)	-0.259	-0.250	-0.275	-0.292	-0.380	-0.372

Spearman's Rank Correlations with Total CAET Score						
Measure	Overall Subsoil	Overall Topsoil	Comparison group Subsoil	Comparison group Topsoil	ProSoils Subsoil	ProSoils Topsoil
Silt content (% by volume)	0.282	0.302	0.299	0.302	0.272	0.346
Organic Carbon content	0.292	0.261	0.253	0.246	0.426	0.358
Total Nitrogen content	0.308	0.279	0.289	0.300	0.412	0.335

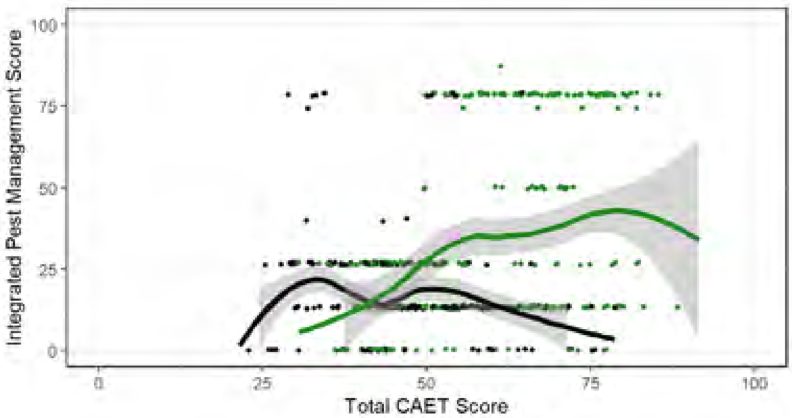
Annex 9. Exposure to pesticides

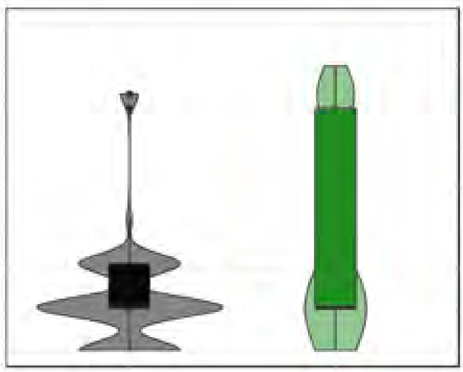


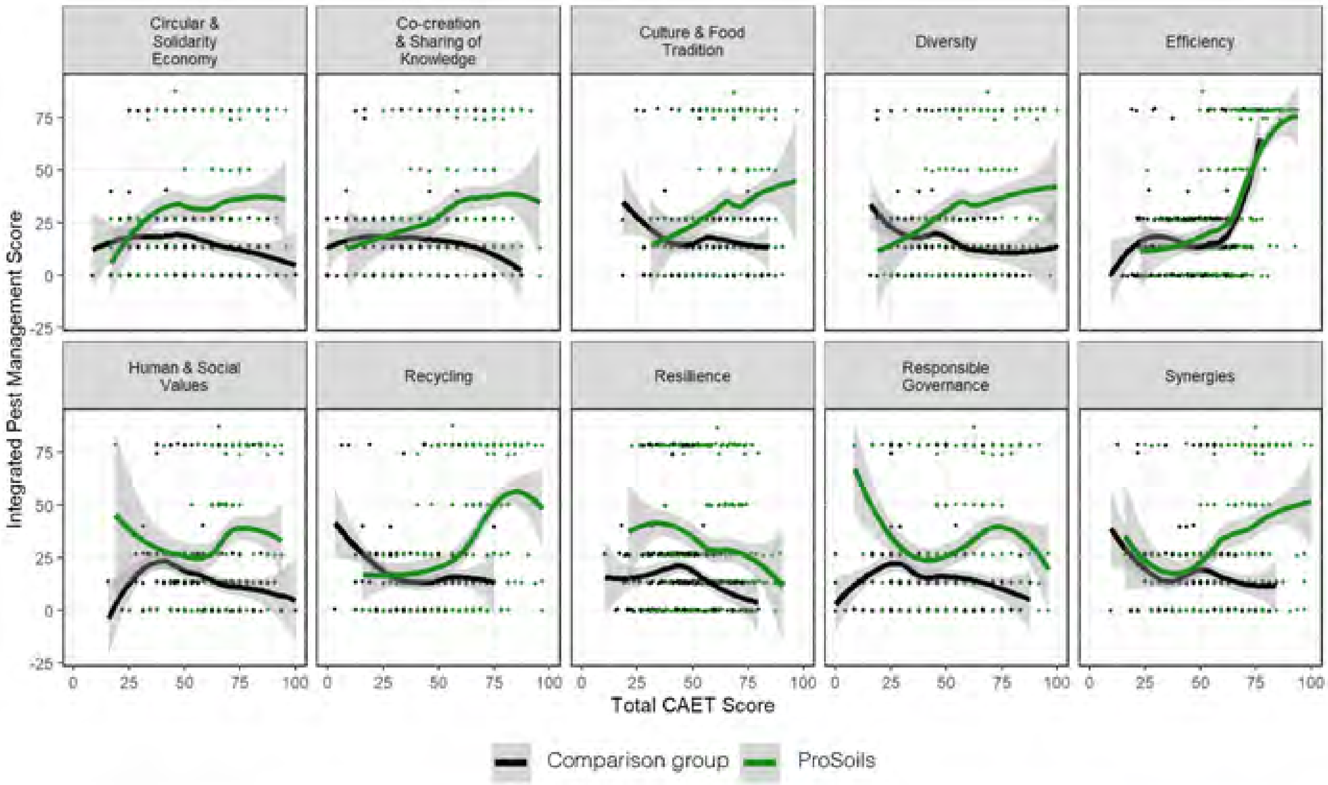
*Spearman's Rank Correlation Coefficient = 0.171****

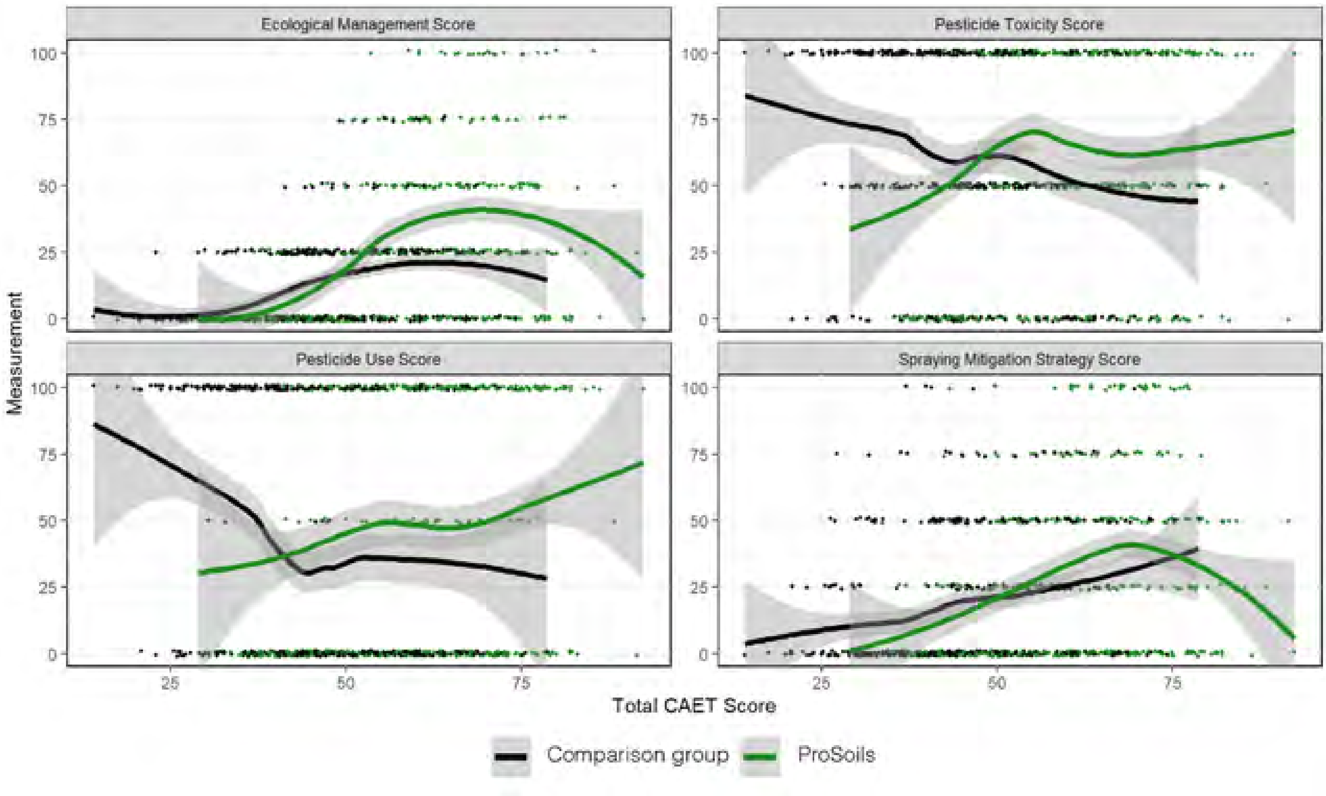


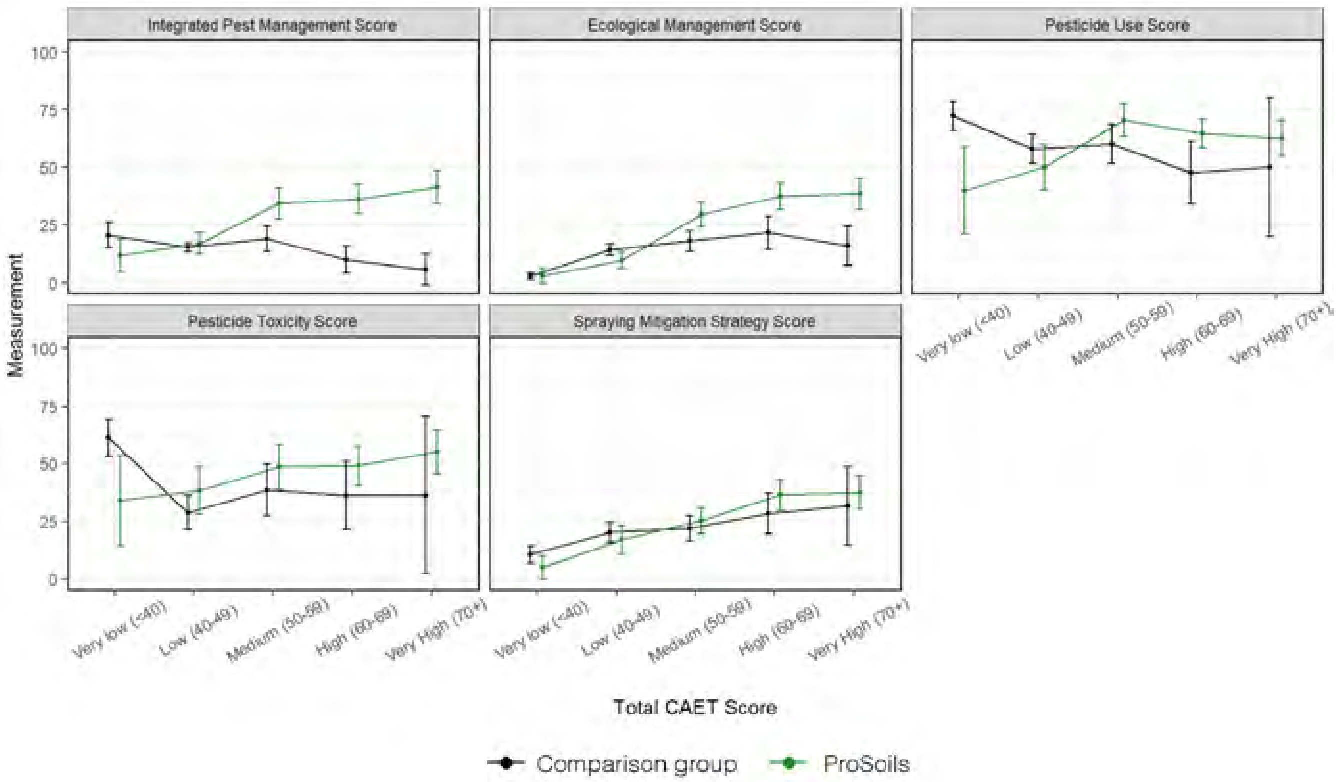
Statistic	Comparison group	ProSoils
Mean	16.5	32.4
Median	13.3	13.3
SD	16.5	30
IQR	13.3-26.7	13.3-74.3



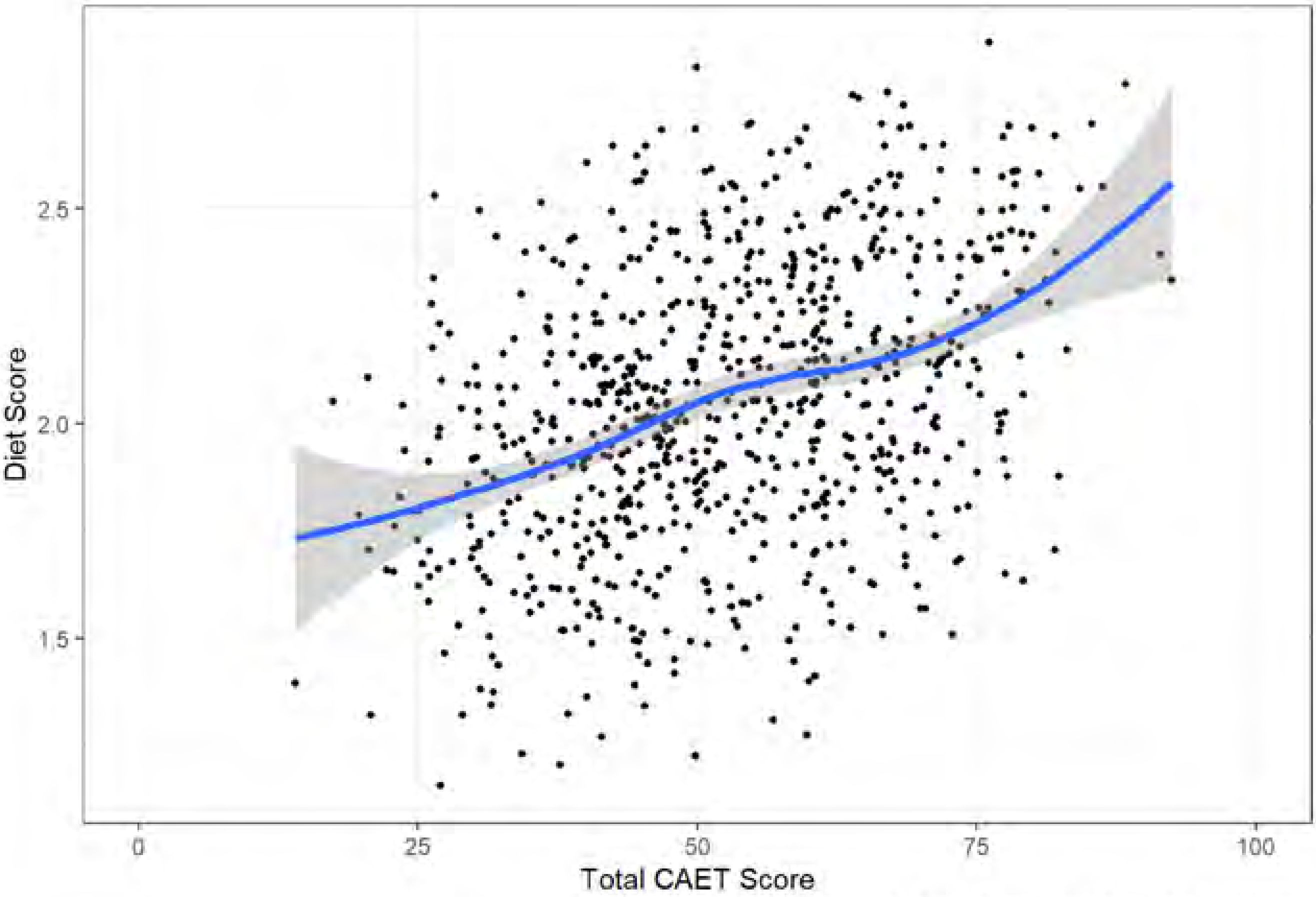



Circular & Solidarity Economy
Co-creation & Sharing of Knowledge
Culture & Food Tradition
Diversity
Efficiency
Human & Social Values
Recycling
Resilience
Responsible Governance
Synergies
Integrated Pest Management Score
Total CAET Score
Comparison group
ProSoils

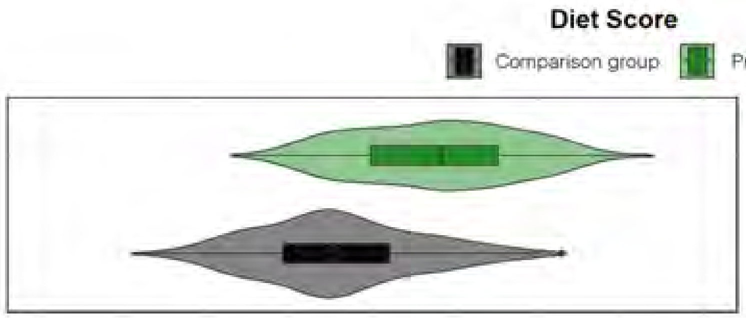

Ecological Management Score
Pesticide Toxicity Score
Pesticide Use Score
Spraying Mitigation Strategy Score
Measurement
Total CAET Score
Comparison group
ProSoils


Integrated Pest Management Score
Ecological Management Score
Pesticide Use Score
Pesticide Toxicity Score
Spraying Mitigation Strategy Score
Measurement
100
75
50
25
0
Very low (<40)
Low (40-49)
Medium (50-59)
High (60-69)
Very High (70+)
Total CAET Score
Comparison group
ProSoils

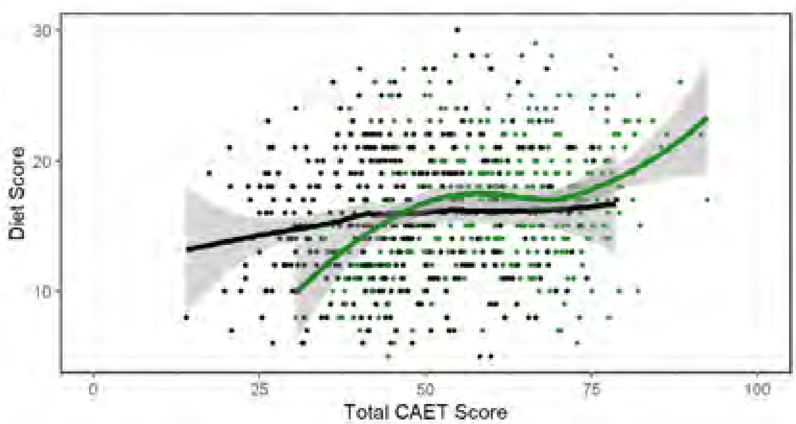
Annex 10. Dietary diversity food security

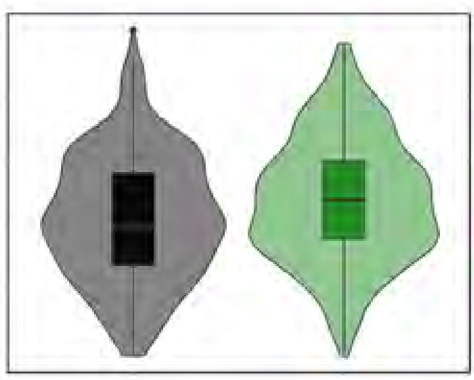


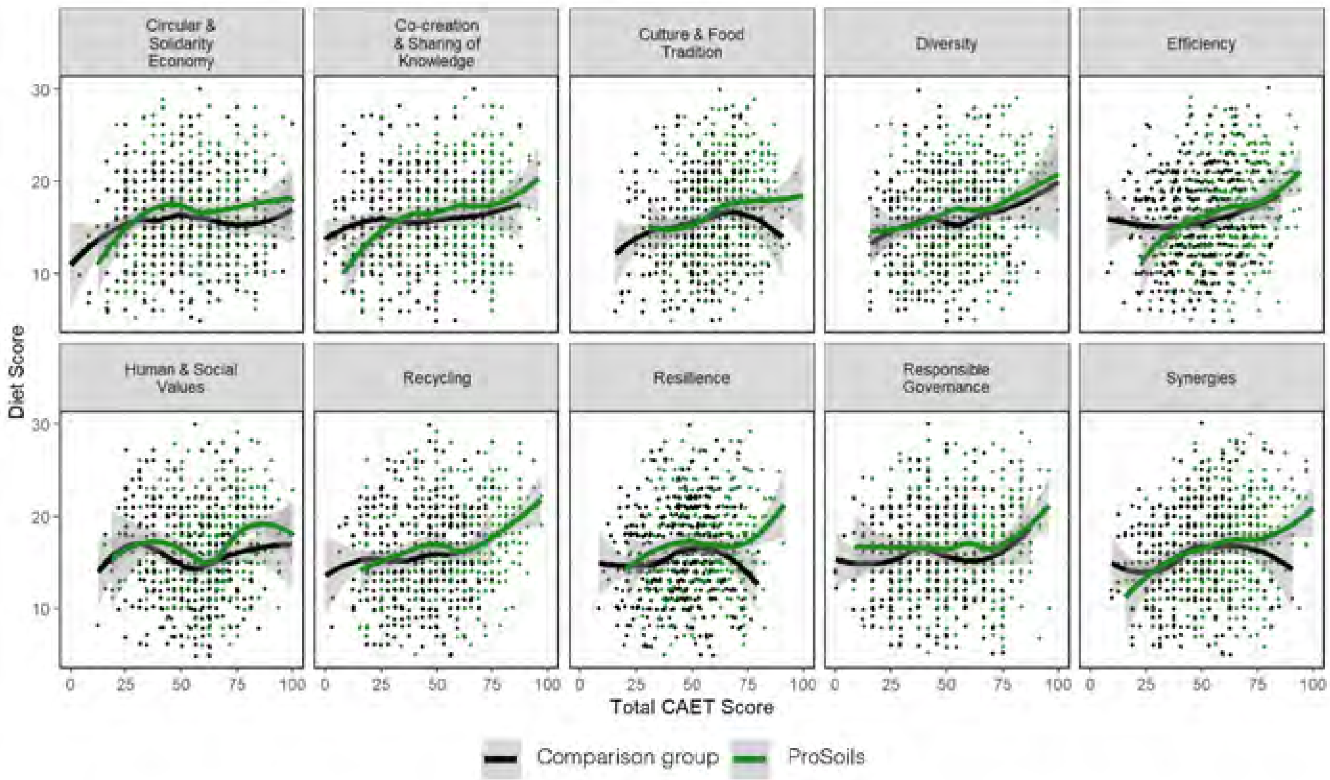
*Spearman's Rank Correlation Coefficient = 0.377****

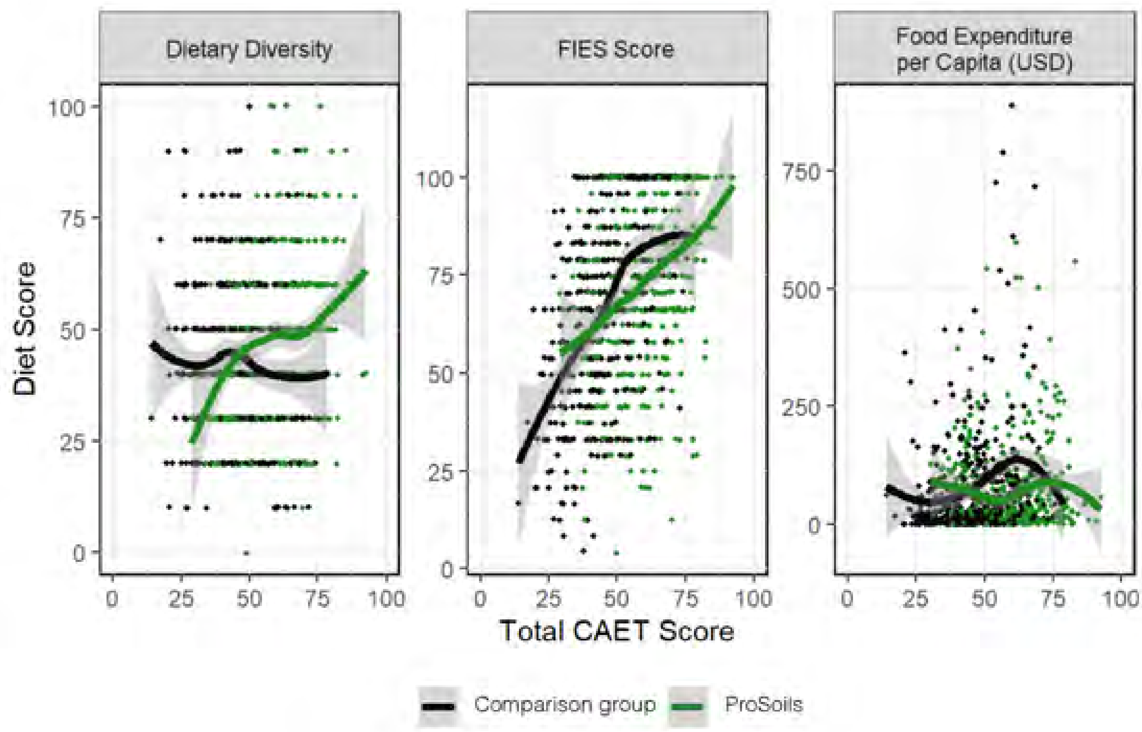


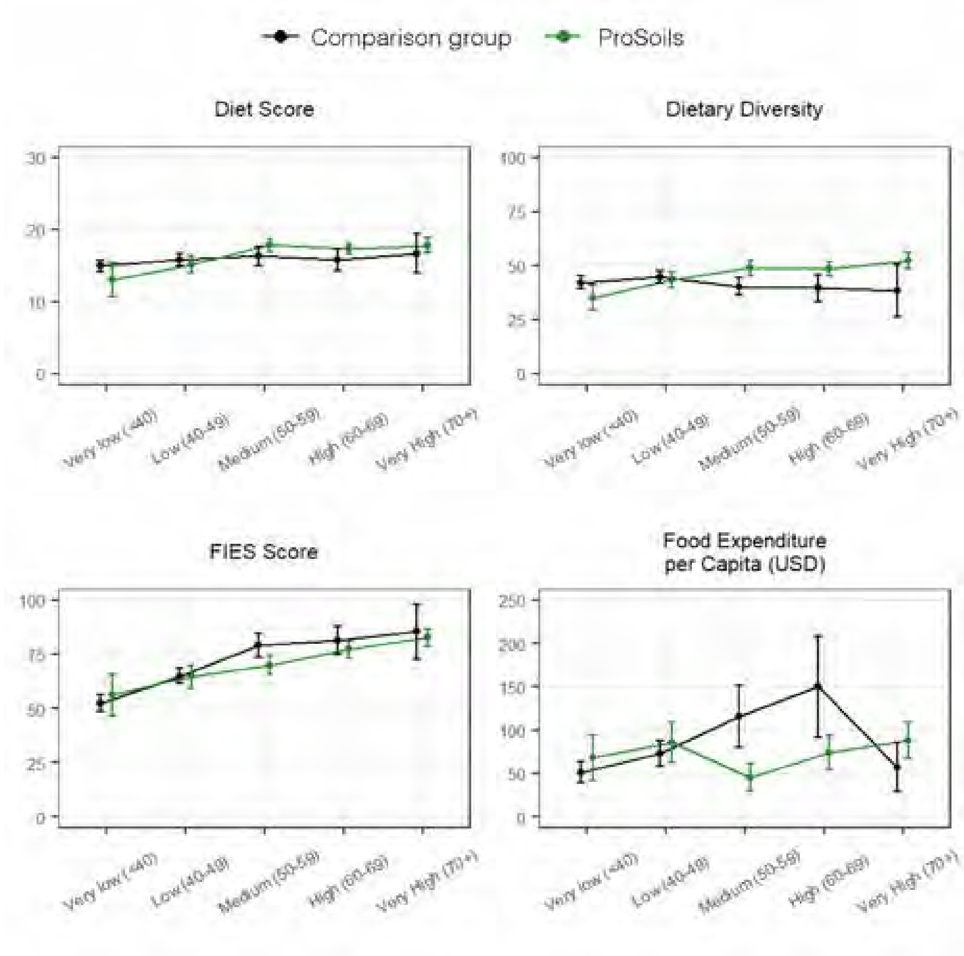
Statistic	Comparison group	ProSoils
Mean	15.6	16.9
Median	15	17
SD	4.9	4.8
IQR	12.0-19.0	14.0-20.0



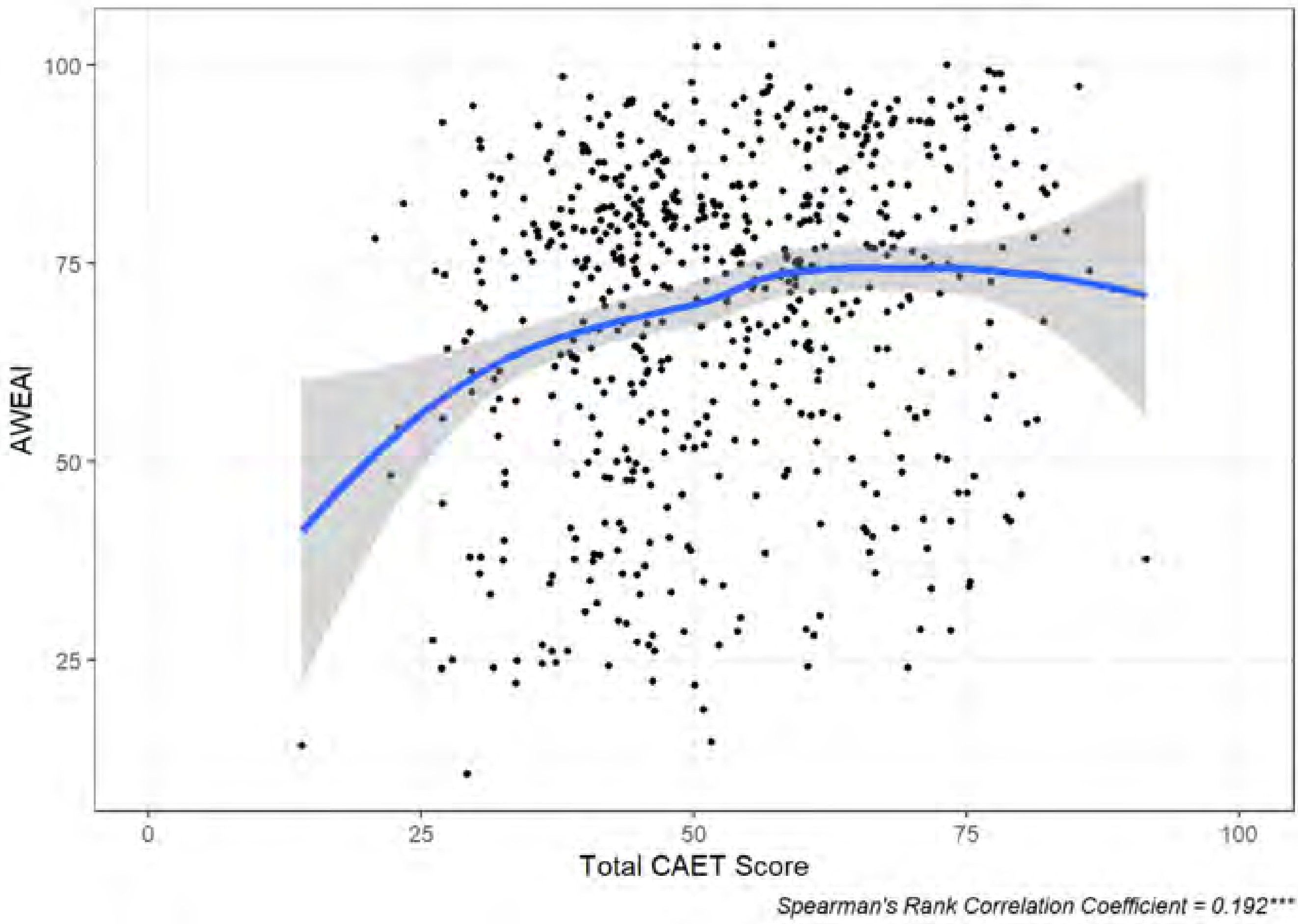


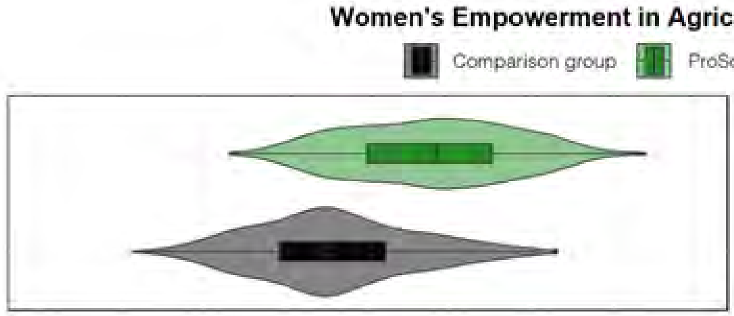

Circular & Solidarity Economy
Co-creation & Sharing of Knowledge
Culture & Food Tradition
Diversity
Efficiency
Human & Social Values
Recycling
Resilience
Responsible Governance
Synergies
Diet Score
30
20
10
0
25
50
75
100
Total CAET Score
Comparison group
ProSoils


Dietary Diversity
FIES Score
Food Expenditure per Capita (USD)
Diet Score
100
75
50
25
0
750
500
250
Total CAET Score
Comparison group
ProSoils

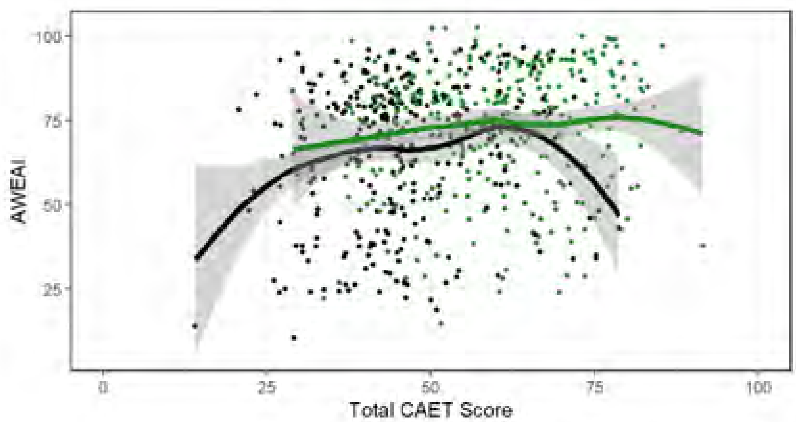

Comparison group
ProSoils
Diet Score
Dietary Diversity
FIES Score
Food Expenditure per Capita (USD)
Very low (<40)
Low (40-49)
Medium (50-59)
High (60-69)
Very High (70+)

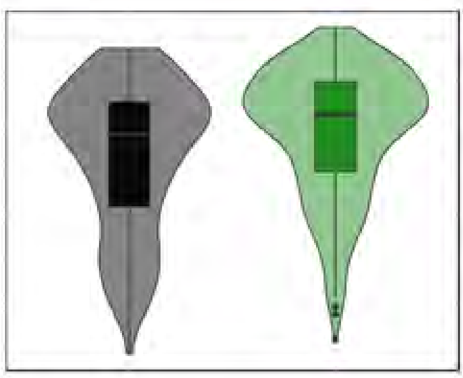
Annex 11. Womens empowerment

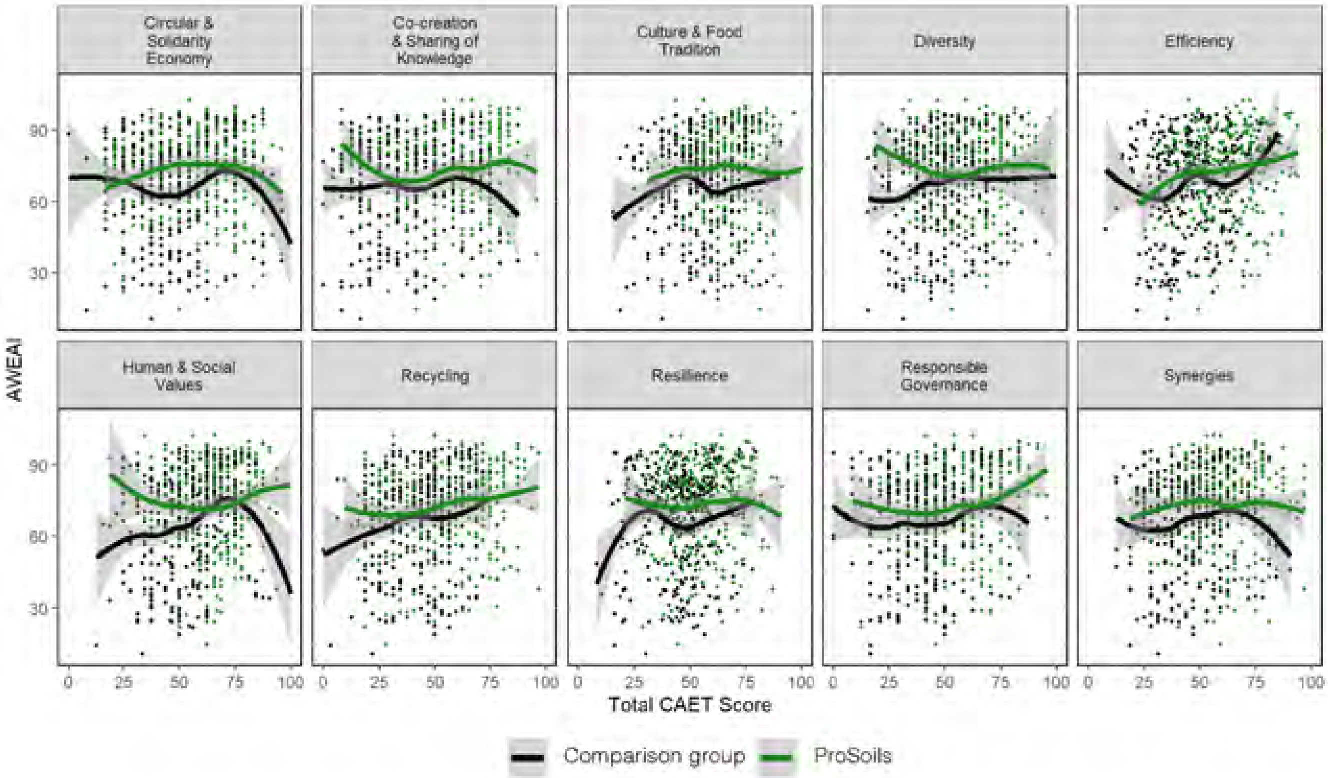


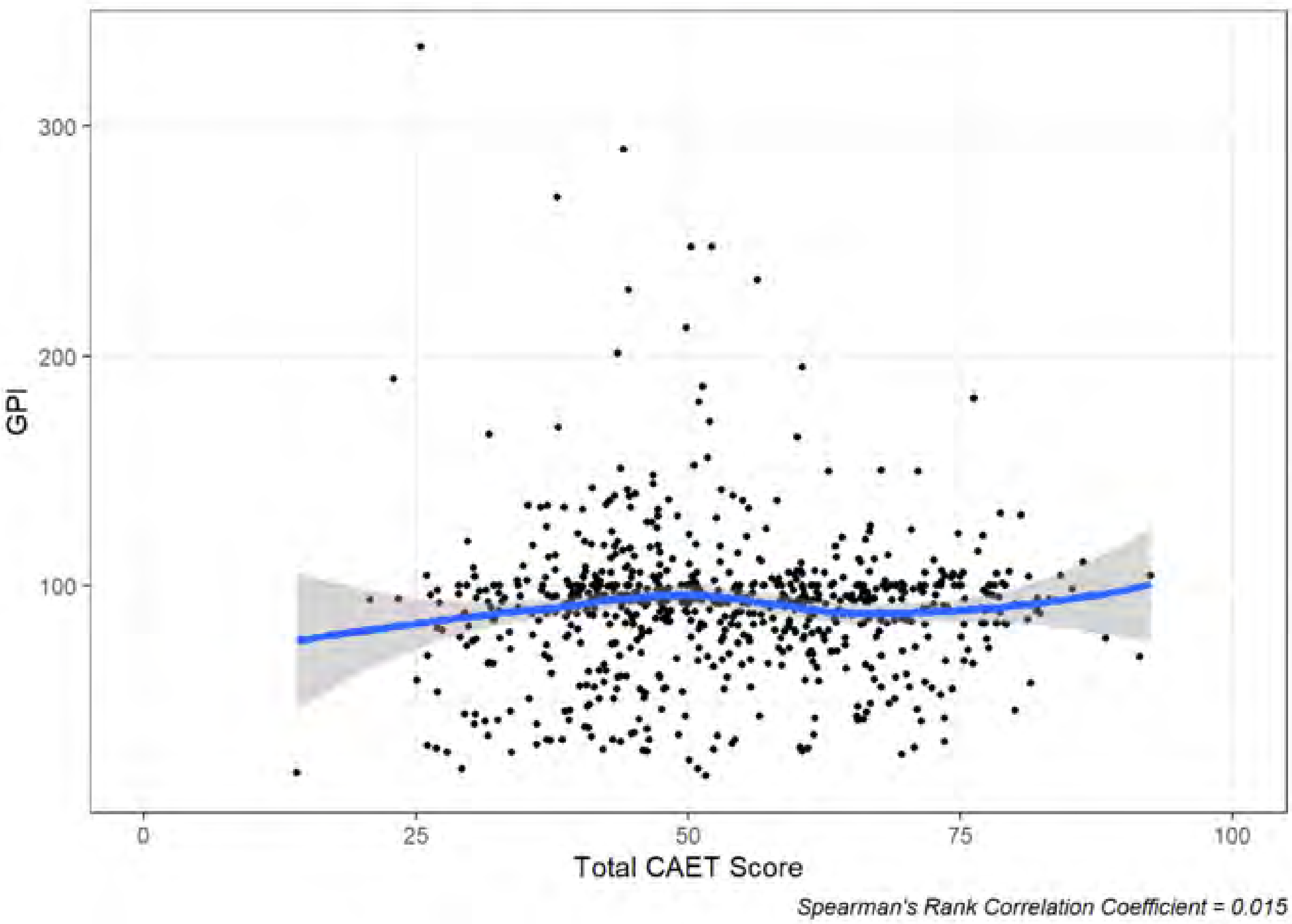


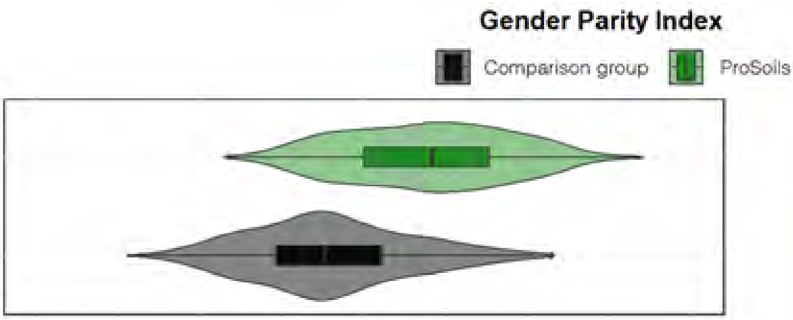
Statistic	Comparison group	ProSoils
Mean	66.4	73.6
Median	72.4	78.1
SD	20.7	18.1
IQR	52.1-81.7	62.0-87.2



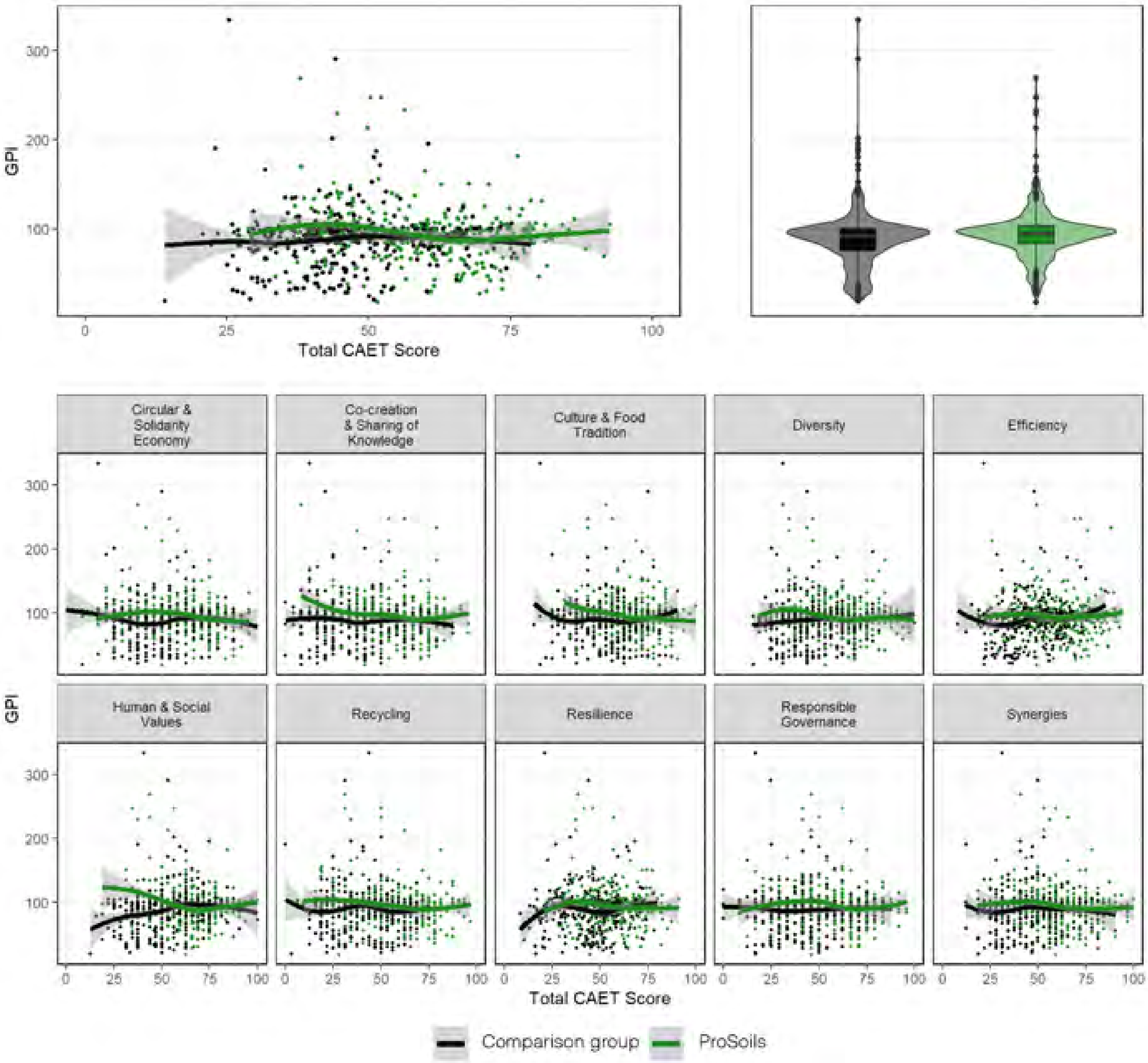


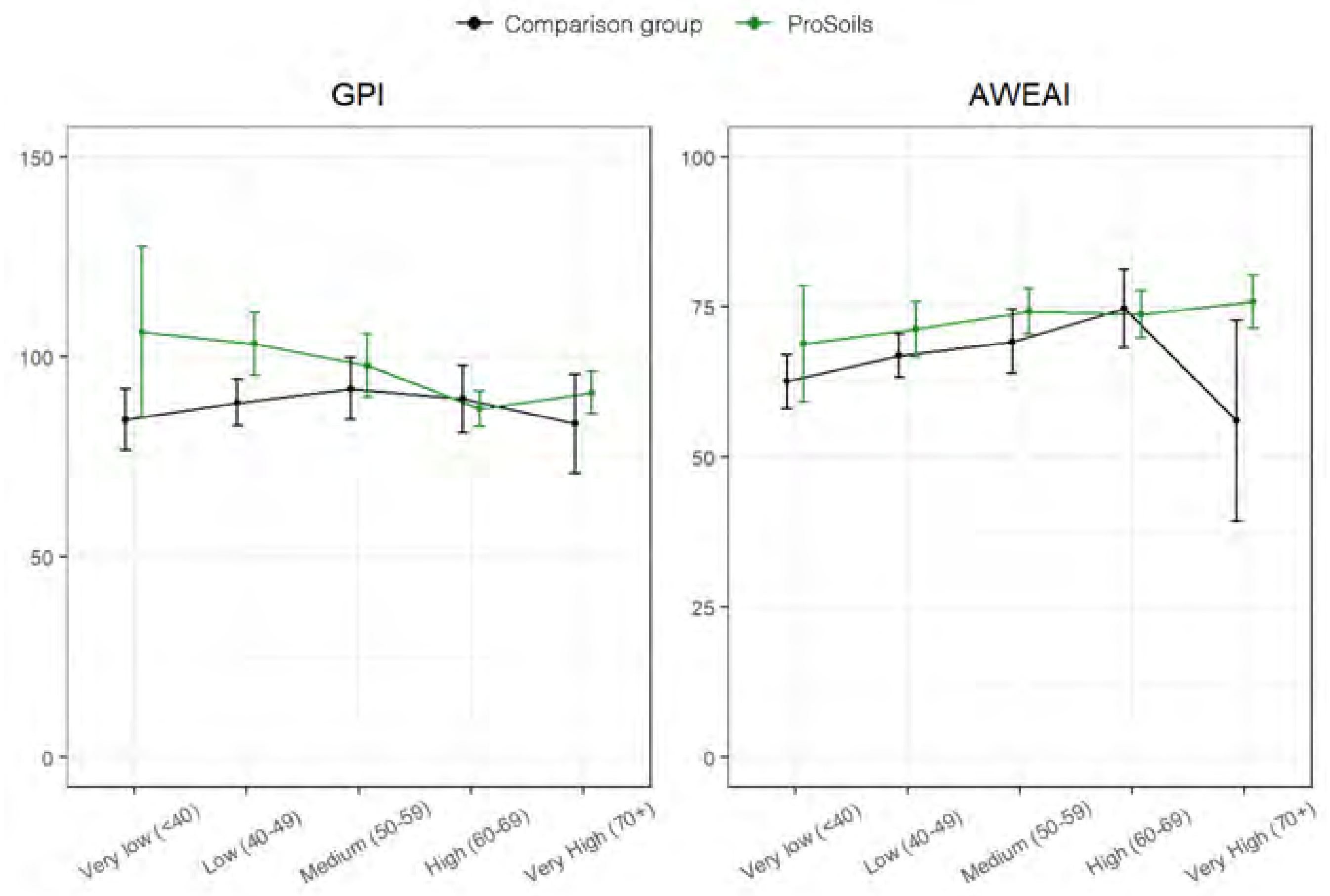

Circular & Solidarity Economy
Co-creation & Sharing of Knowledge
Culture & Food Tradition
Diversity
Efficiency
Human & Social Values
Recycling
Resilience
Responsible Governance
Synergies
AWEAI
Total CAET Score
Comparison group
ProSoils


GPI
Total CAET Score
Spearman's Rank Correlation Coefficient = 0.015

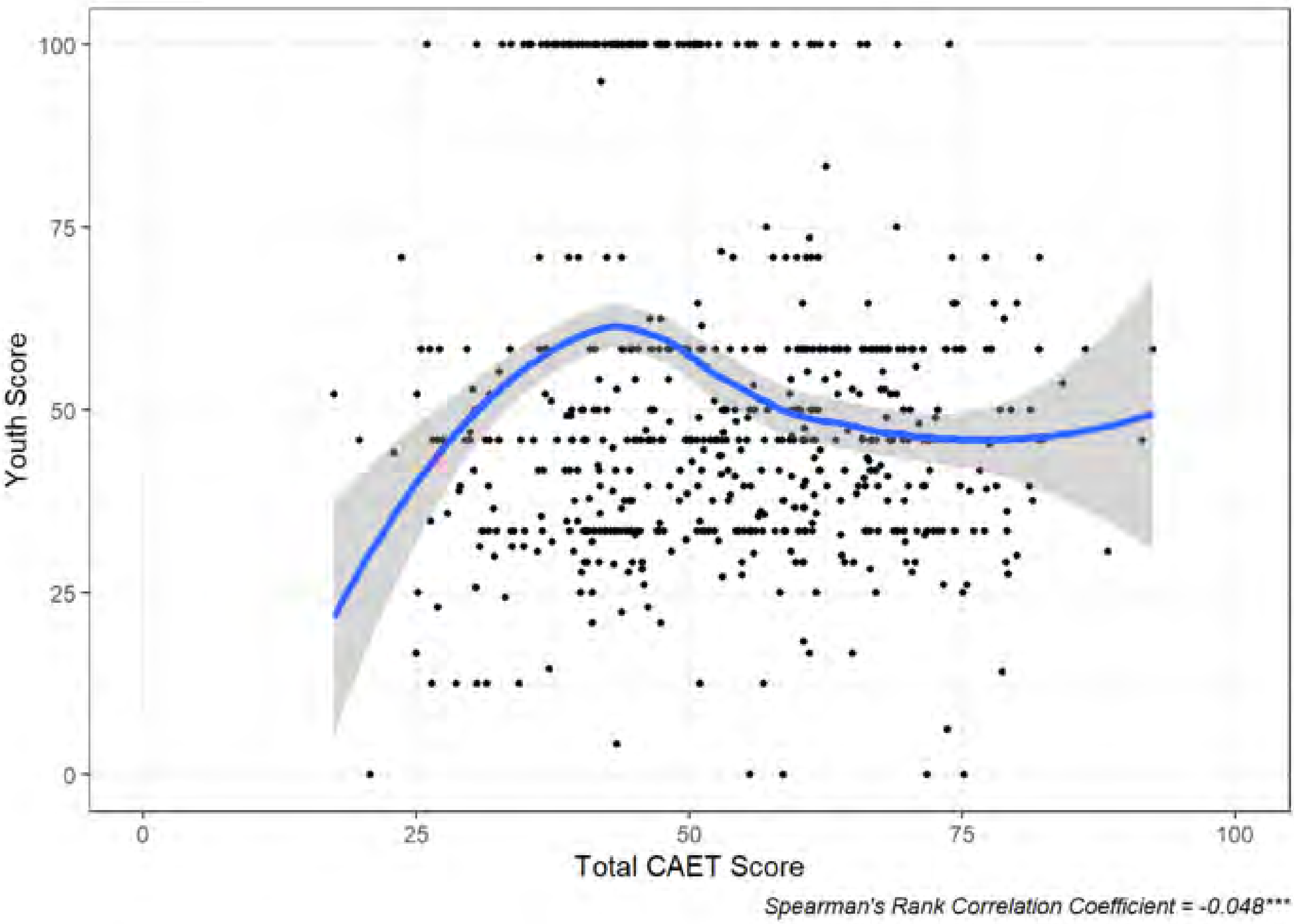


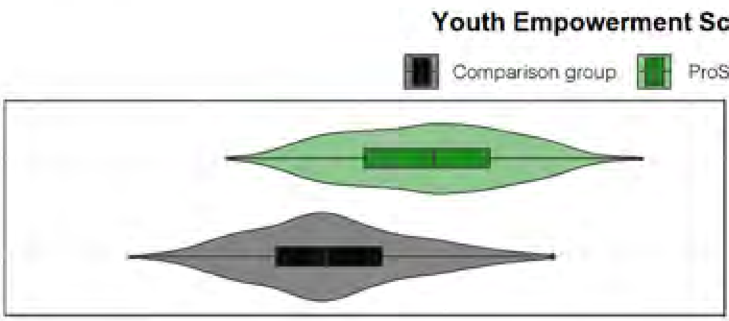
Statistic	Comparison group	ProSoils
Mean	87.9	94.6
Median	92.1	94.5
SD	33.6	30.6
IQR	74.6-100.0	83.2-102.9



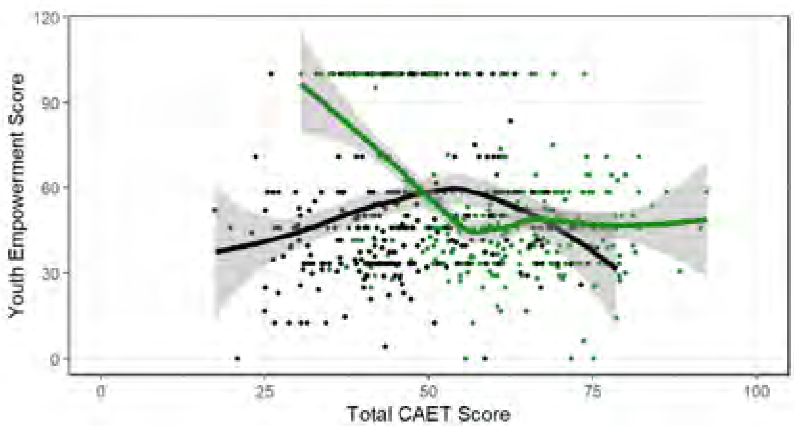

Comparison group
ProSoils
GPI
AWEAI
150
100
50
0
75
25
Very low (<40)
Low (40-49)
Medium (50-59)
High (60-69)
Very High (70+)

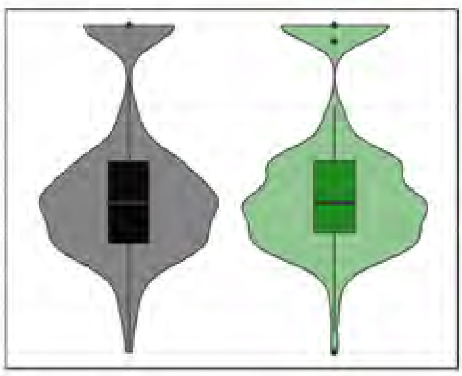
Annex 12. Youth empowerment

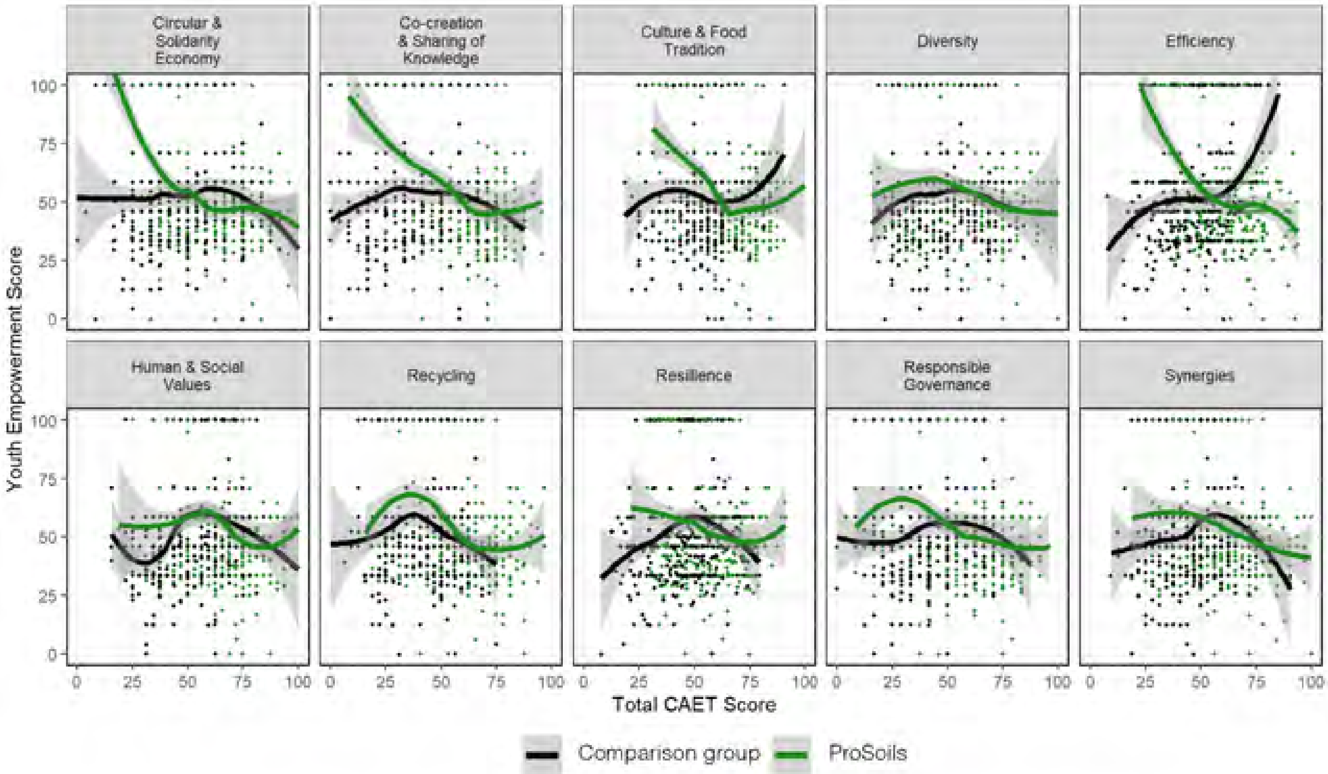




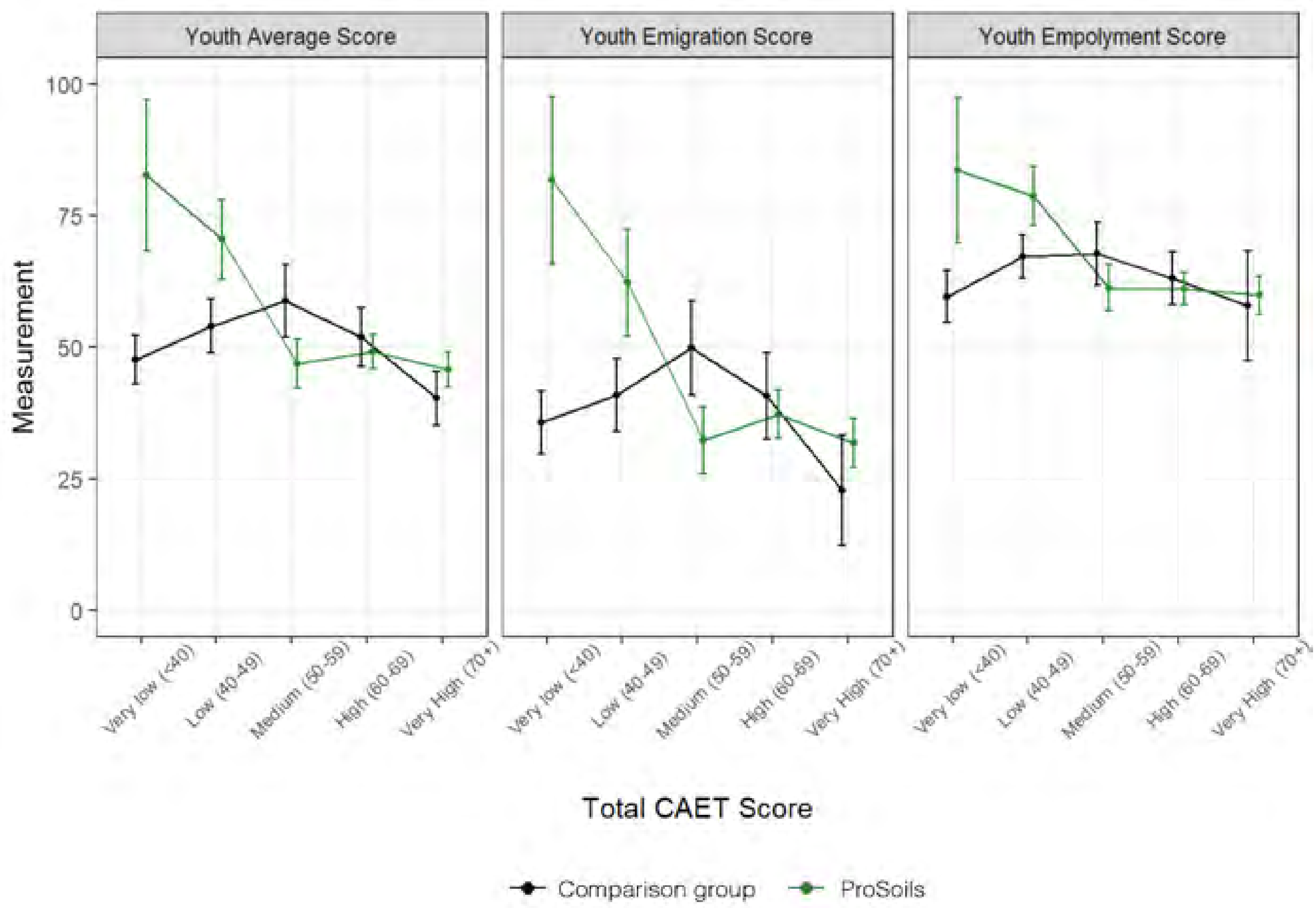
Statistic	Comparison group	ProSoils
Mean	52.2	53.3
Median	45.8	45.8
SD	24.3	23.7
IQR	33.3-58.3	36.7-58.3






Circular & Solidarity Economy
Co-creation & Sharing of Knowledge
Culture & Food Tradition
Diversity
Efficiency
Human & Social Values
Recycling
Resilience
Responsible Governance
Synergies
Youth Empowerment Score
Total CAET Score
Comparison group
ProSoils


Youth Emigration Score
Youth Empolyment Score
Youth Score
Total CAET Score
Comparison group
ProSoils



Youth Average Score
Youth Emigration Score
Youth Empolyment Score
Measurement
100
75
50
25
0
Very low (<40)
Low (40-49)
Medium (50-59)
High (60-69)
Very High (70+)
Total CAET Score
Comparison group
ProSoils

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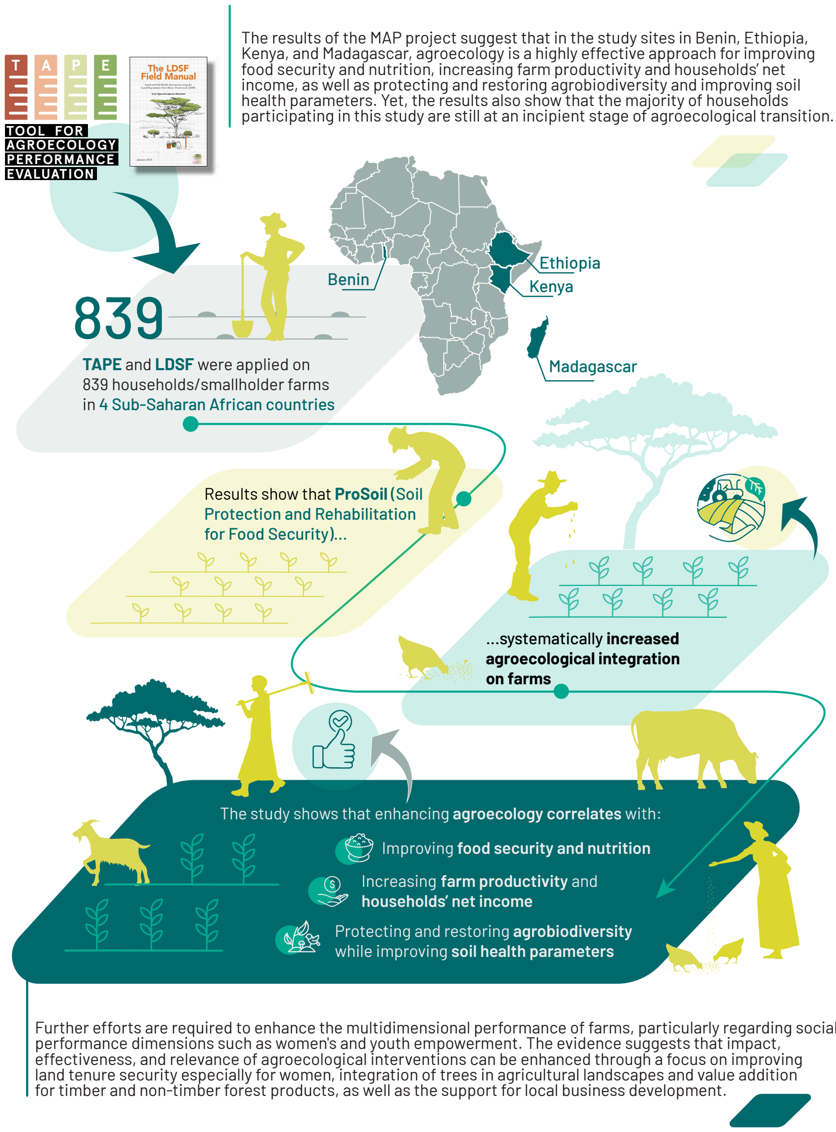
The Agroecology TPP Working Papers contain preliminary or advanced research results on agroecology issues that need to be published in a timely manner to inform and promote discussion. This content has been internally reviewed but has not undergone external peer review.



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.