



Using best-worst scaling to inform agroecological interventions in Western Kenya

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Abstract

Both the demand for food and the environmental impacts of food production are estimated to significantly increase by 2050. Agroecological interventions have proven effective in facilitating the transition from current food production systems to more sustainable ones. These interventions can not only ensure more equitable food and nutritional security but also address poverty and reduce environmental impacts. As such, agroecological interventions can generate both private and public ecosystem services. Farmers play a key role in how food is produced, as the practices they use are linked with their preferences and expertise, as well as the constraints they face. Understanding farmers' preferences for the adoption of different agroecological practices and their perceptions of the associated costs and benefits is critical to informing policies that can effectively support farmers in transitioning to more sustainable practices, including those that contribute to the generation of ecosystem services highly valued by broader society. To assess such preferences, we conducted a survey among farmers in Western Kenya which included a best-worst scaling experiment augmented by qualitative questions about the reasons for farmers' views about the importance of the benefits arising from agroecological practices. Results show that farmers have strong preferences for adopting agroecological practices that generate private goods and are directly related to increasing productivity and food security, including improving health of household members. These may also include practices that have some public good elements as well, such as increasing agrobiodiversity. However, practices that generate broader public good benefits, including improved forest quality/coverage, reduced off-farm environmental impacts, greater community-level resilience to shocks, and improved landscape and wildlife management, were less important to farmers. Such findings can be used to inform policies that support farmer adoption of agroecological interventions best suited to different farming communities, as well as indicating the need for additional types of market-based incentives, such as through Payments for Ecosystem Service mechanisms.

Keywords Adoption · Agroecological practices · Food security · PES · Public goods · Stated preference

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1 Introduction

Population growth, along with income growth – which impacts diets and food consumption patterns – are two of the most important drivers of future trends in food demand (van Dijk et al. 2021, Wezel et al., 2014). Total global food demand is expected to have increased by 30–62% between 2010 and 2050 (van Dijk et al. 2021). Commonly applied agricultural practices to meet such demand include the use of intensive farming practices and cropland expansion, resulting in long-term environmental impacts such as land degradation, loss of biodiversity and pollution (Tilman et al., 2011; Newbold et al., 2015; Ickowitz et al., 2022). The agricultural sector further generates more than a third of global anthropogenic greenhouse gas emissions and is therefore a major driver of climate change (Crippa et al., 2021). Without changes in food demand, diets, production methods and/or technological interventions, the environmental impacts of the food production system could increase by 50–90%, increasing the risk of ecosystem processes becoming destabilised (Springmann et al., 2018).

Transforming current food systems requires moving towards systems that are resilient, mitigate climate change and support food and nutrition security, while addressing social inequalities and poverty (Wezel et al., 2020; Kennedy et al., 2021; Singh et al., 2021). Various concepts have emerged which encompass the technological changes and mitigation measures required to address the currently unsustainable strategies for increasing food production. The most prominent and partly overlapping concepts for achieving such goals include sustainable intensification, organic farming, regenerative and conservation agriculture, ecological intensification and agroecology (see Ewert et al., 2023 for an overview).

Agroecology has received particular attention in recent years as an effective solution for addressing the challenges associated with our food systems through contributing to improving food and nutritional security, as well as farmer livelihoods (e.g. Wezel et al., 2014; Palomo-Campesino et al., 2018; Bezner Kerr et al., 2021; Deaconu et al., 2021; Gunaratne et al., 2021; Pandey et al., 2022; Ewert et al., 2023; Mouratiadou et al., 2024). The use of agroecological practices (AEPs) is particularly important and common in smallholder farming, which is estimated to occupy approximately 30% of all cultivated areas worldwide, while accounting for about half of all food consumption (Graeub et al., 2016; Samberg et al., 2016; Pandey et al., 2022; Ewert et al., 2023).

As defined by the United Nations Food and Agriculture Organization (FAO, 2018), agroecology is “an integrated approach that simultaneously applies ecological and social concepts and principles to the design and management of food and agricultural systems”. While key principles, elements and transitional levels have been identified (for example related to biodiversity and economic diversification), no definitive set of practices (such as intercropping or composting) that could be labelled as agroecological has been defined. Rather, practices may be classified along a spectrum related to, *inter alia*, their systemic nature, environmental-friendliness and equitability. The flexibility of approaches and not the fixed prescription of any particular method makes AEPs appropriate for use across a range of contexts (Berthet et al., 2016; HLPE, 2019; Ewert et al., 2023). This flexibility of AEPs can also foster capacity building through better incorporation of education, learning pathways and processes (Chantre & Cardona, 2014; Cristofari et al., 2018). AEPs can also lead to socio-economic benefits, such as fostering financial independence, market access and autonomy, knowledge exchange, social equity and partnerships (Dumont et al., 2016; Bezner Kerr et al., 2023). As such, AEPs result in the generation of both private and public

good ecosystem services. Yet, while AEPs can reduce the negative impacts of conventional farming, there are a range of constraints that reduce farmer potential for adoption. These are generally related to access to and quality of information and markets, limited financial capacity, perverse subsidies and limited linkages with extension agencies or local networks of farmers (Baumgart-Getz et al., 2012; Schader et al., 2021). This leads to a gap between the theoretical application of AEPs and their actual implementation (Dumont et al., 2016; Toffolini et al., 2019).

Farmers choose to adopt AEPs which are economically viable and from which they expect higher returns than from their current practices (Mohring & Finger, 2022), i.e. that provide private benefits by contributing to the overall income and well-being of the household (Misra, 2018). It is assumed that farmers thereby also choose practices that then provide environmental services that also benefit the public such as climate mitigation or improving public and environmental health through, for example, restricted use of antibiotics in animal husbandry and reduced synthetic pesticide use (Bezner Kerr et al., 2023). Farmers make constant trade-offs and also make decisions based on intrinsic benefits which are harder to expose (Bopp et al., 2019). However, if the private benefits of adopting AEPs do not exceed the benefits of conventional practices, farmers will be unlikely to adopt them. The challenge thus extends beyond merely supporting farmers to adopt AEPs that improve their capacity to capture private good benefits under institutional, technical and economic constraints (Baumgart-Getz et al., 2012), but also to motivate adoption of those practices that generate public goods.

Our study therefore aims to assess smallholder farmer preferences for AEP adoption in two counties in Western Kenya (Kisumu and Vihiga). A survey-based preference elicitation best-worst scaling (BWS) experiment was conducted with farmers in which they were asked to trade-off a range of private and public benefits arising from AEP adoption. This work seeks to make two contributions. Firstly, the results may be used to inform policies that can better support farmers to transition to more sustainable agriculture through the use of AEPs, including those that generate the ecosystem services that broader society might value. This is within a context of the challenges that Kenya faces in terms of a growing population, loss of agrobiodiversity, declining soil fertility, low agricultural productivity, poor agricultural diversification, emerging pests and diseases, as well as overuse of synthetic agrochemicals (Mburu et al., 2016).

Secondly, the study contributes to a growing body of literature regarding advanced methods for identifying preferences for the adoption of innovations and technologies, and for a better understanding of why choices are made. For this, a combined analysis of choice data and qualitative data was undertaken. Often, BWS results are presented on their own but here we verify the results by analysing open-ended follow-up questions which explore why farmers made the choices they did in the BWS experiment. This supports the interpretation needed to make sound policy recommendations.

2 Materials and methods

2.1 Research area

Kisumu and Vihiga counties in Western Kenya were selected for this study given previous interventions focusing on crop diversification, climate smart agriculture and other sustainable land management practices implemented by a number of different organisations (Gotor & Irungu, 2010; Kinyangi et al., 2015). In Kisumu County, Nyando, a sub-county with a population of 1.16 m and an average household size of 3.8 (KNBS, 2019) was selected for the purposes of this study. Nyando is characterised by a bimodal rainfall pattern and is subject to both drought and floods. Average annual rainfall ranges from 1,200 mm to 1,500 mm (MoALF, 2017). Agricultural activities include subsistence farming of food crops such as maize, sorghum, millet, sweet potatoes, cassava and beans, as well as cash crops such as tea, coffee and sugarcane. Dairy farming is also important.

Vihiga is a small and densely populated (population 590,000 people; 1043 inhabitants/km²) county. The average household size is 4.1 (KNBS, 2019). Agriculture accounts for over 34% of the county's gross product and for 80% of both direct and indirect employment (County Government of Vihiga, 2023). Situated on the eastern edge of the Nandi Escarpment, the county features hilly terrain with altitudes ranging from 1,300 to 2,000 m above sea level. The climate is characterised by a bimodal rainfall pattern and an average annual temperature of 23 °C. Average yearly precipitation is between 1,700 and 2,000 mm (County Government of Vihiga, 2023). The county has a humid tropical climate and two agroecological zones, namely upper midland and lower midland zones (Jaetzold et al., 2005). The majority of the people practice rainfed low-input subsistence agriculture on very small farms (average 0.4 ha). The main cash crop grown is tea in the upper midlands. Other food crops include bananas, beans, maize, sweet potatoes, cassava, groundnuts, sorghum and vegetables. Livestock, mainly cattle, poultry, sheep, goats, pigs and rabbits are kept throughout the county. Agroecological interventions have been undertaken by farmers including as part of projects promoting African leafy vegetables (Aura, 2013; Boedecker et al., 2019).

2.2 Data collection and sampling

Data were collected throughout November 2022 using a structured questionnaire in individual farmer interviews. In addition to the BWS experiment, the questionnaire included sections related to socio-economic and production system characteristics, such as farm size, tenure, location, labour availability, main crops and livestock produced, challenges affecting the farm, and farmer gender, age and education. After each of the BWS tasks, follow-up open-ended questions were included related to the reasons why a particular attribute was chosen as most or least important (see next section), with the aim of better understanding why farmers made their particular choices. A first version of the questionnaire and BWS experiment was tested in a pilot phase which consisted of two workshops (one in each county). Ten farmers participated in each of the workshops. We used the workshops not only to pilot the questionnaire but also to finalise the attributes to be used in the BWS experiment. An initial set of 20 attributes which can be associated with the private and public benefits of AEPs were identified based on a review of the literature, reports and in-depth key informant interviews. Four of these attributes were subsequently eliminated from the main survey and

final BWS experiment, as it was found that farmers considered these either to be unimportant or strongly linked to other attributes (see next section).

Fifty-eight farmers in Vihiga and 36 in Kisumu were interviewed using a purposive sampling method. Participants in both counties were selected from 296 pre-surveyed households based on their involvement in implementing AEPs. Local enumerators were hired and trained to conduct the interviews in the local languages (Swahili, Dholuo and Luhya). Given the substantial qualitative component and responses to the open-ended questions, each interview took about 1.5 h.

2.3 Best-worst scaling design

Best-worst scaling (BWS) is a survey-based method used to measure people's preferences or attitudes regarding a set of attributes. In a BWS experiment, participants are presented with a series of these attributes and asked to choose the best and worst attribute in each set (Louviere et al., 2015). The method was firstly introduced by Finn and Louviere (1992) and is based on the random utility framework (McFadden & Zarembka, 1974). BWS results allow quantification of the relative importance that respondents place on each of the attributes, thus providing a ranking.

The BWS method has several advantages over traditional rating scales or ranking methods, including increased sensitivity to differences in preferences, reduced respondent bias and improved statistical power (Marley & Louviere, 2005; Tamas & Popescu, 2018). This is partly because it is cognitively less challenging than full ranking exercises, particularly when many attributes need to be ranked (Flynn et al., 2007). Rating scales such as Likert have the problem that different respondents may associate different meanings to the categories used in the scales which makes comparing the results across different respondents challenging (Marley & Louviere, 2005). BWS can also eliminate bias in the responses and is therefore more objective than other types of rating and ranking methods (Tamas & Popescu, 2018).

The final 16 attributes (benefits of AEP adoption) for the BWS design are listed in Table 1. As listing all 16 attributes and asking respondents to choose the best and worst from those would be a cognitively challenging process, a restricted number of attributes was presented simultaneously. Using a balanced incomplete block design (BIBD), 16 BWS tasks were generated with six attributes each (Figure S1 in the Supplementary Materials). The BIBD is the most common design for the type of BWS experiment applied here and stipulates that every respondent sees each attribute the same number of times and that each attribute co-occurs with another attribute the same number of times (Louviere et al., 2015). Here, each attribute co-occurred with another one twice and each attribute appeared across all 16 tasks five times. We used the package *crossdes* in R to generate the design (Sailer, 2015). Each respondent was presented with all 16 tasks.

2.4 Data analysis

There are two broad approaches to the analysis of BWS data, a counting and a modelling approach (Louviere et al., 2015). Here, we only employed the counting approach as the results generated in this way address our objectives – i.e. to reveal the relative importance of an AEP attribute. Moreover, for BIBD, outcomes from the counting approach closely

Table 1 Description of the 16 potential benefits of adopting agroecological practices (AEPs) used as attributes in the best-worst scaling (BWS) experiment

Attribute	Expected benefit
<i>Private good benefits</i>	
Improved food and nutritional security of household members	Economic and social: Higher levels and quality of production lead to improved household access to sufficient, safe and nutritious food that meets dietary needs and food preferences for an active and healthy life.
Improved production reliability	Economic: Changes in practices can improve the reliability of production and income over a given time-horizon.
Potential to adapt AEP to a particular farm context	Economic and social: Potential to adapt the AEP to the particular context of the farm increases probability of successful adoption.
Low cost associated with AEP adoption	Economic: Cost-effective practices can reduce farming costs and therefore directly increase household income.
Improved access to complementary extension services / other sources of technical advice	Economic and social: Improved access to extension services/other sources of technical advice that accompany the introduction of an AEP could help increase the chances of <i>successful</i> adoption.
Improved health of household members	Economic and social: Improved food/nutritional security and reduced agrochemical use leads to better health of farmers and their family members.
Additional income associated with AEP adoption	Economic: Changes in practices can directly affect farming productivity through more output and therefore income.
No increase in overall labour requirement	Economic and social: Where labour availability is constrained and/or a significant input cost, the adoption of productivity-enhancing AEPs that require no permanent increase in labour requirements can contribute to improved livelihoods.
<i>Private good benefits with public good elements</i>	
Increased crop and/or livestock diversity	Economic and environmental: Farm production diversification can lead to increased production reliability and a reduction in downside risk for farmers. Public benefits are associated with the option, bequest and existence values linked with the conservation of genetic resource diversity.
Reduced need for chemical inputs (fertiliser and/or pesticide/herbicide)	Economic, social and environmental: Reduced need for synthetic agrochemical use reduces input costs and exposes farmer households to less harmful chemicals.
Improved farm soil quality	Economic and environmental: Improved farm soil quality can lead to higher and more reliable levels of production.
Reduced need for agricultural water use	Economic and environmental: Where water availability is constrained and/or a significant input cost, the adoption of productivity-enhancing AEPs that lead to a reduction in water use can contribute to improved livelihoods, as well as having potential benefits at the landscape level.

align with those from the modelling approach (Marley & Louviere, 2005). First of all, we calculated Best (B) and Worst (W) scores for each attribute by counting the number of times respondents chose an attribute as most important and as least important, respectively. The BW scores were then calculated by subtracting the Worst score from the Best score. This was done firstly on an aggregated scale, i.e. adding up all scores of all respondents, before also being carried out on an individual level, looking at each individual and their 16 choices. A positive BW score indicates that an attribute was chosen more often as being of highest rather than lowest importance, and vice versa. The aggregated BW scores were then divided by the frequency with which the attributes appeared, providing the aggregated mean BW scores. As each attribute was included in five different tasks, the mean BW score for each attribute could range from -5 (attribute chosen as least important four times) to $+5$ (chosen as most important four times).

To facilitate interpretation of the importance of attributes, standardised BW scores are often presented (Loose & Lockshin, 2013). For this purpose, we calculated the ratio score by taking the square root of the aggregated Best score divided by the aggregated Worst score ($\sqrt{B/W}$). The resulting coefficient indicates the choice probability relative to the most important attribute (Marley & Louviere, 2005). This coefficient was then scaled by a factor equal to the maximum square root of (B/W) so that the most important attribute was indexed at 1. This provides a standardised ratio scale which can be interpreted as the percentage relative importance of each attribute to the highest ranked attribute. We used the `support.BWS` package in R to analyse and visualise the BWS data (Aizaki, 2023), following the analytical steps provided in Aizaki and Fogarty (2023).

In addition to the aggregated scores, we also calculated individual/ disaggregated scores to explore preference heterogeneity for specific sub-groups of the sample, such as for women and men (Finn & Louviere, 1992). We then conducted statistical analyses on the individual mean scores involving non-parametric Kruskal-Wallis (KW) tests to link respondents' responses to their demographics and to identify factors influencing their choices and preferences. We used non-parametric tests to check for differences between preferences and farmer characteristics such as gender, village (location) and farm tenure. To test for a correlation between age and preference we applied Spearman correlation tests (Spearman, 1904). This test is a non-parametric test used to measure the strength and direction of the relationship between two variables when at least one variable is ordinal or when the relationship is not linear. It does not assume normality of the data or homogeneity of variance.

Results of a BWS often lead to attributes that have neither high nor low scores once aggregated over all respondents and are consequently regarded as neutral. Individual farmers, nevertheless, may have strong preferences in favour of them or against them. Following-up individual decisions through open-ended questions allowed us to further differentiate between attributes that were mostly neutral, and attributes for which a high polarity existed. The data from the open-ended follow-up questions about why farmers made their choices were transcribed and the reasons were categorised into the most commonly stated reasons.

3 Results

3.1 Sample description

Responses of four farmers were not included as they did not fully complete the BWS experiment. Slightly more women than men farmers were interviewed (Table 2). Most farmers (80%) had a modest income of no more than 15,000 KSh (\approx USD 123) per month after tax. Just over half the sample (54%) had attended or completed primary school as their highest level of education, while the remainder had completed secondary (35%) and higher education (11%). The majority of farmers (74%) owned the land they were cultivating and 71% were full-time farmers, as compared to part-time farmers who also had income from non-farming activities. The majority hired wage labour at certain times of the year (86%) and 69% found it difficult to find labourers. More than 80% stated they were very worried about the effects of climate change.

3.2 Preferred attributes of agroecological practices

Table 3 presents the proportion of the counts where an attribute was chosen as most important (B) and the counts where chosen as least important (W). Figure 1 depicts the relative importance, based on the standardised scale ratios, across all respondents. The highest ranked attribute was ‘Improved health of household members’, followed by ‘Improved production reliability’ which was considered approximately 5% less important. ‘Improved food and nutrition of household members’ was ranked 10% lower. The least important attribute was ‘No increase in labour requirement’ which was considered 82% less important than the most highly ranked attribute (Fig. 1).

The mean scores across all respondents and across the number of times an attribute was present in the tasks, i.e. the standardised mean BW scores, were similar (although not identical as a result of the normalisation process) to the scale ratios. The attributes with a positive value were selected more often as most important rather than least important by respondents; while the attributes with negative values were selected more often as least important rather than most important (Table 3, column ‘Std. mean BW’). ‘Improved food and nutritional security of household members’ was perceived as being the most important, with ‘Improved health of household members’ in second place (unlike its top ranking as per the relative score ratios), followed by ‘Improved farm soil quality’ and ‘Improved production

Table 2 Sample description

Characteristics	Percent
Female	63
Average age in years (SD; median)	45.8 (14.2; 44.5)
Education	
primary school	54
secondary school	35
higher education	11
Have own plot	74
Full-time farmer	71
Location	
Vihiga	38
Kisumu	62

Table 3 Results of the best-worst scaling (BWS) experiment

Attribute	aggregated					individual	
	B	W	BW	Ratio scale	Std. ratio scale	Mean BWS	Std. mean BW
Improved health of household members	187	39	148	2.19	1.00	1.57	0.26
Improved production reliability	116	26	90	2.11	0.96	0.96	0.16
Improved food and nutritional security of household members	214	55	159	1.97	0.90	1.69	0.28
Improved farm soil quality	147	52	95	1.68	0.77	1.01	0.17
Additional income associated with the adoption	133	58	75	1.51	0.69	0.80	0.13
Increased crop and/or livestock diversity	142	68	74	1.45	0.66	0.79	0.13
Improved access to extension services	149	106	43	1.19	0.54	0.46	0.08
Improved potential to adapt practice to farm context	64	76	-12	0.92	0.42	-0.13	-0.02
Improved local community land management for beauty and wildlife	50	97	-47	0.72	0.33	-0.50	-0.08
Reduced off-farm environmental impacts	29	77	-48	0.61	0.28	-0.51	-0.09
Improved local community ability to withstand shocks	52	119	-67	0.66	0.30	-0.71	-0.12
Improved forest quality and/or coverage	64	149	-85	0.66	0.30	-0.90	-0.15
Minimal costs associated with the adoption of technology	36	122	-86	0.54	0.25	-0.91	-0.15
Reduced need for chemical inputs	70	166	-96	0.65	0.30	-1.02	-0.17
Reduced need for agricultural water use	25	129	-104	0.44	0.20	-1.11	-0.18
No increase in overall labour requirement	25	164	-139	0.39	0.18	-1.48	-0.25

B: Best; W: Worst; Std: standardised

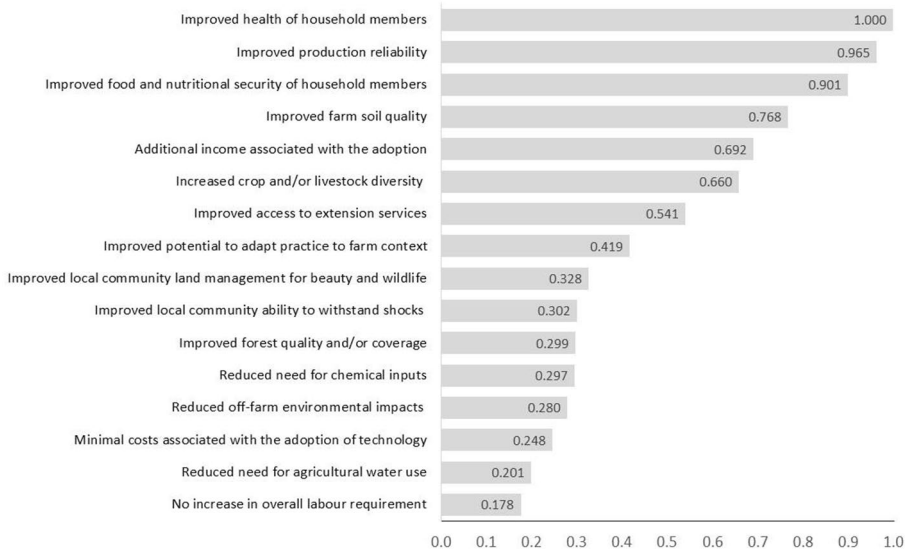


Fig. 1 Standardised attribute scores across all respondents in relation to the attribute with the highest score (100%)

reliability'. Additional income generated from the adoption of an AEP and increased agrobiodiversity were the fifth and the sixth most important attributes. 'No increase in overall labour requirement' was, again, the least important attribute considered when adopting an AEP and the initial adoption cost of the new practice was also considered to be unimportant.

The impact of four covariates were tested on farmers' preferences: gender, age (continuous variable), county location (Kisumu or Vihiga) and farm tenure (farmer ownership, as opposed to tenancy). Gender explained only very few variations in preference. Men were more likely to assign a high score to complementary extension services access that could support successful adoption of AEPs (KW=3.21, df=1, p -value=0.0731). Education had only a small effect as well. Better educated farmers regarded the food security aspect as more important than those with low education levels (KW=8.22, df=2, p -value=0.0164), whereas 'Improved local community ability to withstand shocks' was more important for farmers with low education levels (primary school; KW=6.012, df=2, p -value=0.0493).

Farmer owners assigned higher preference to increased agrobiodiversity (KW=3.26, df=1, p -value=0.0711) and 'Improved local community ability to withstand shocks' (KW=6.38, df=1, p -value=0.0116) but less towards complementary extension services access (KW=7.83, df=1, p -value=0.0051) and reliability (KW=3.90, df=1, p -value=0.0482).

Farmers in Kisumu placed higher importance than those in Vihiga on the attributes associated with the reduced need for chemical inputs (KW=5.84, df=1, p -value=0.0157), low costs associated with AEP adoption (KW=10.77, df=1, p -value=0.00103), reduced off-farm environmental impacts (KW=4.63, df=1, p -value=0.0313), improved forest quality and/or coverage (KW=7.39, df=1, p -value=0.0066), reduced need for agricultural water use (KW=13.9, df=1, p -value=0.0002) and 'No increase in overall labour requirement' (KW=13.14, df=1, p -value=0.0003). However, farmers in neither of these counties assigned positive scores to these attributes. Respondents in Kisumu were furthermore less likely to prefer practices that were associated with access to extension services to improve probability of adoption success than those in Vihiga (KW=3.17, df=1, p -value=0.0751).

The most significant difference between the two counties was regarding production. Compared to farmers in Kisumu, those in Vihiga placed higher importance on the food security aspect (median 3 to 1) (KW=26.86, df=1, p -value<0.0001), additional income (KW=10.77, df=1, p -value=0.0010) and improved production reliability (KW=22.70, df=1, p -value<0.0001), as well as on improved health of household members (KW=26.22, df=1, p -value<0.00001). To a lesser extent, farmers in Vihiga also placed higher importance on improved soil quality (KW=6.06, df=1, p -value=0.0139) than farmers in Kisumu.

Type of farm engagement (full-time farmer, as opposed to part-time farmer with off-farm employment) also moderately explained preference heterogeneity. For full-time farmers, improved forest quality/coverage was more important (KW=5.91, df=1, p -value=0.0151) and improved production reliability less important (KW=4.9084, df=1, p -value=0.0267) than for part-time farmers who often have off-farm sources of income. There was a weak negative correlation between the potential to adapt the practice to the particular farm context and age ($r = -0.18$; $S = 163,756$, p -value=0.0773), as well as between 'Improved health of household members' and age ($r = -0.2$; $S = 166352$, p -value=0.0511) and a positive correlation between no increased labour requirement and age ($r = 0.21$; $S = 108966$, p -value=0.0395).

3.3 Explaining preferences

The aggregated and individual BWS scores provide an indication of whether or not the majority of farmers found an attribute most or least important. However, these scores provide less information about attributes not chosen as best or worst, or if the best and worst scores cancel each other out and the reasons for choosing an attribute as best or worst were not articulated or captured. The strength of preference for certain attributes is clearer for some than for others. For example, in 47% of all choices involving ‘Improved food and nutritional security of household members’, respondents chose it as most important, while ‘Improved health of household members’ was most important in 43% of all choices (Fig. 2; Figure S2 in the Supplementary Materials). By comparison, in only 12% of all choices showing ‘Reduced need for agricultural water use’ and ‘No increase in overall labour requirement’ did respondents choose the two as most important, while a majority of respondents (>50%) considered them as neutral, i.e. selected them as neither most or least important, or considered them as least important (>30%; Fig. 2). By contrast, for the attributes ‘Reduced need for chemical inputs’ and ‘Complementary extension services access’, a relatively low percentage of respondents indicated these two as neutral (37% and 33% respectively). Instead, respondents were divided in their preferences. This divergence is also evident in the reasons provided by respondents when explaining their choices. Table 4 lists the most common reasons provided in response to the open-ended questions for choosing each attribute as most and least important.

Farmers’ responses to those questions revealed a number of relationships between the different attributes. There was, for example, a link between health and food security, with farmers identifying food security as important for health and health as important for family labour for food production. They argued that “good health will be achieved when the family has enough food” and that “only healthy family members can work”. Similarly, farmers

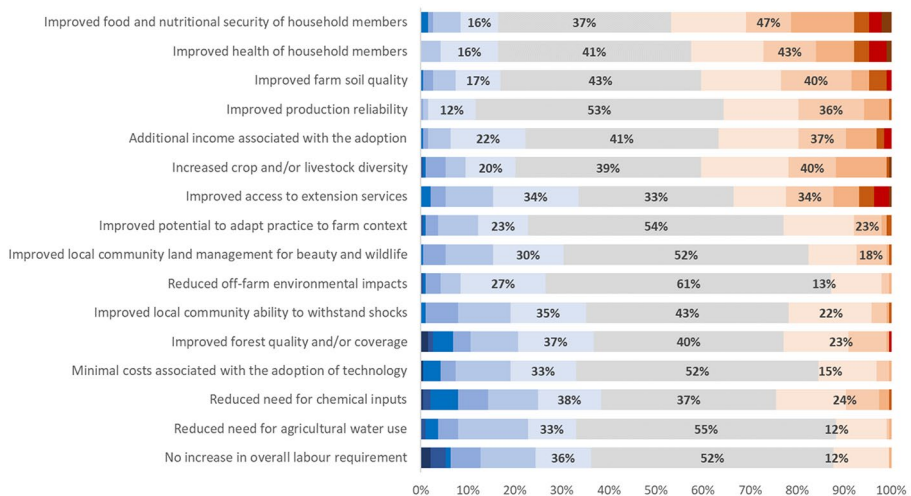


Fig. 2 Proportion of farmers choosing potential benefits of the adoption of agroecological practices as most (blue, mean Best-Worst scores from 1 to 6), least important (red, mean Best-Worst scores from -6 to -1) or as neither most nor least important (grey, Best-Worst score of 0)

Table 4 Reasons for choosing attributes related to potential benefits of the adoption of agroecological practices as most and least important in the best-worst scaling (BWS) tasks

Attributes	Most important	Least important
Improved health of household members	<ul style="list-style-type: none"> • Healthy family members offer cheap / free labour • Only healthy family members can work • Healthy food is good for body immunity 	<ul style="list-style-type: none"> • Health will not be controlled by the farm approach alone because we feed on other products which are not from the farm • Good health will be achieved when the family has enough food • Having income contributes to good health, so one needs income first • Will come after several years and not over a short time
Improved production reliability	<ul style="list-style-type: none"> • Provides consistency in income and thus sustains families • Longer time of productivity and fertility 	<ul style="list-style-type: none"> • Have enough food to sustain family
Improved food and nutritional security of household members	<ul style="list-style-type: none"> • Means income • Sustains family; everybody needs to eat • Stops malnutrition of children and balanced diet for all • Leads to health family members which are needed to increase production and sustain families and communities 	
Improved farm soil quality	<ul style="list-style-type: none"> • Leads to production reliability for both crops and livestock 	
Additional income associated with the adoption	<ul style="list-style-type: none"> • When having income, one can engage in every activity they need • With income all AEP can be applied • Additional income will improve the social lifestyle of the family and better-quality life • Needed to expand production 	<ul style="list-style-type: none"> • Is secondary, will be achieved after a long time and not immediately • Additional income is the second thing, but nutrition and healthy foods is the basic
Increased crop and/or livestock diversity	<ul style="list-style-type: none"> • Allows different tastes of food for family • Higher yield 	<ul style="list-style-type: none"> • Demands more water usage • Only applicable when soil quality is good • Little space to carry out
Improved access to extension services	<ul style="list-style-type: none"> • Learn how to grow maize and beans • Build capacity for good farming practices • Leads to exchange of knowledge and information • Provides training on AEP skills • Gain knowledge on improving the environment which attracts tourists 	<ul style="list-style-type: none"> • Too costly; reduce profit • No need for more training in agriculture • Information/extension services have been there already, but they have not been a solution
Improved <i>local community</i> land management for conservation of water sources, wildlife, beauty and agrotourism	<ul style="list-style-type: none"> • Improves attractiveness and can provide a new income stream from agrotourism 	<ul style="list-style-type: none"> • Do not offer skills on good environmental farming approaches • Agrotourism will not address food security issue in village • Wildlife or agrotourism will not do well because places are inaccessible • Wildlife requires large farms but here in our village, we have small plots • Population growth is the problem which needs to be solved first • No wildlife in area

Table 4 (continued)

Attributes	Most important	Least important
Improved local community ability to withstand shocks	<ul style="list-style-type: none"> • Floods/drought bring huge economic losses to farmers • Pest and community management may bring social development to the community through agrotourism 	<ul style="list-style-type: none"> • Pests and diseases are the result of a lack of nutrients in soil, so this needs to be addressed first • A community resilient to climatic shocks needs the energy, resources and time which only comes from healthy feeding • Floods and drought not problem in area • Do not have forest nearby • Not using forest resources
Improved forest quality and/or coverage	<ul style="list-style-type: none"> • Forest coverage and quality will attract more rainfall and higher production • Forest cover will help attract tourists and has cooling effect for humans 	<ul style="list-style-type: none"> • Not using any chemicals but only animal manure • Reduction in chemical use might lead to low production • Only does organic farming • Animal manure often not available when needed
Reduced need for chemical inputs	<ul style="list-style-type: none"> • Forest cover and quality will improve the climatic condition • Clean water and human health • Ensures healthy food • Causes acidity of the soil • Chemicals are expensive 	<ul style="list-style-type: none"> • Caring for the environment is responsibility of community • Everybody should do this for our world • This does not address food security directly • Will be solved when the forest is healthy • This can be achieved when the soil quality is good
Reduced off-farm environmental impacts		
Minimal costs associated with the adoption of technology	<ul style="list-style-type: none"> • This ensures more profit margin; less inputs farm ensures more profits • Costs matter in every agricultural practice • Low costs important, so more money for buying e.g. seeds, tools 	<ul style="list-style-type: none"> • Cost will not be an issue since we will have cheap labour from the family • Will still be low if there is enough rain • Can be low if you source everything from farm
Reduced need for agricultural water use	<ul style="list-style-type: none"> • Higher production since even the dry areas receive enough rainfall 	<ul style="list-style-type: none"> • Water can be conserved and used at low cost • Only use rainwater • Use of mulching, so no need for much water
No increase in overall labour requirement	<ul style="list-style-type: none"> • Less labour will cut on the cost of production 	<ul style="list-style-type: none"> • Labour not a problem

chose improved food security as most important as it helps combat malnutrition in children and provides a balanced diet for all household members. At the same time, it was also important for income generation (Table 4).

Farmers often chose improved soil quality as most important because they considered it to be linked to maintaining high levels of production reliability, with the overarching reason being, once more, income generation. The attribute additional income from adopting AEPs itself was chosen as most important because income was perceived as necessary to be able to meet potential upfront costs of AEP adoption and to upscale production. Additional income was also considered important for a better lifestyle and higher quality of life. 'Increased crop and/or livestock diversity' was chosen as most important because of its link to higher yields and also to provide the family with a diverse diet and different flavours. 'Improved access to extension services' was chosen as important to build capacity through training, develop networks for knowledge exchange and to learn how to grow specific crops.

For those attributes of relatively low importance, it nonetheless remains interesting to note the reasons given by those farmers who did state that they were the most important for them. Some farmers wanted to learn how to improve the environment and landscapes to make it more attractive for tourism which could provide a new income stream. The potential of agrotourism was also mentioned as reason why 'Improved local community land management for conservation of water sources, wildlife, beauty and agrotourism' and 'Improved local community ability to withstand shocks' were chosen as the most important attributes by some farmers. The attribute 'Improved forest quality and/or coverage' was also linked to attracting more tourists, besides also providing climate regulation services, and therefore chosen as most important by some farmers. Those farmers that identified 'Reduced need for chemical inputs' as most important stated this was related to economic, health and environmental considerations.

Many attributes were rarely chosen as most important (Fig. 2) and for one attribute, off-farm environmental impacts, only reasons for choosing it as least important were provided (Table 4). Reasons for choosing an attribute as least important were often motivated by the lack of private use potential or irrelevance to the individual farming and household situation. Many farmers, for example, stated that they did not have any forest land nearby which they had access to and/or did not use forest resources, so they chose 'Improved forest quality' as least important. The same applied to improved community-level resilience towards shocks, as many respondents did not consider that they have problems with floods or droughts and hence did not consider the need to adopt AEPs to increase capabilities to withstand these shocks (Table 4).

Reasons for choosing an attribute as least important were also largely motivated by the intertwined benefits for human health and farm productivity. Those relatively few farmers (Fig. 2) who chose 'Improved health of household members' as least important, argued that this was not related to farming practices because they did not consume their own farm products but consumed food brought in from elsewhere. Another reason was that family health is linked to having enough food, no matter what the farming practise is and, similarly, that sufficient income to be healthy is required, no matter how that income is obtained.

The only reasons given why 'Improved food and nutritional security of household members' was chosen as least important was that the household already had enough food. The reason why additional income associated with the adoption of AEPs was chosen as least important was that this was considered to follow automatically in the long-term when farm-

ing is done well. Farmers in this context considered that increased income was a secondary consideration for them and that rather family health and good food are the key to a thriving farm.

Farmers provided more insights and reasons for those attributes chosen relatively often as least important, i.e. those ranked as of being low importance and also the mid-ranking attributes. The reasons for choosing 'Improved access to extension services' included cost considerations for the service, no need for such advice (as was available through other contacts) or limited confidence that the service would provide specific sought-after skills or new knowledge (Table 4). The attribute 'Increased crop and/or livestock diversity' was selected as least important as it was considered that that would require more space, water and good soil to cultivate a larger diversity of crops. 'Reduced need for chemical inputs' was chosen as least important because farmers were already not using these as an input, as opposed to organic manure, or needed to use synthetic chemical inputs because of a lack of manure. An additional consideration was a fear of declining productivity resulting from lower use of such chemical inputs.

The reasons given behind choosing 'Reduced off-farm environmental impacts' as least important were among the most diverse, such as considering that environmental stewardship was a role of the entire community rather than individual farmers. Farmers also related this attribute to other issues that they considered more important, such as soil and forest health which they already did. A few farmers also did not consider that environmental issues are directly related to food productivity and security, and so did not consider this attribute to be so important when deciding to adopt an AEP.

4 Discussion

This study presents results of an innovative application of a stated preference method, a BWS experiment, with qualitative follow-up questions. Overall, the results indicate that respondents considered a range of farm household private good benefits to be the most important when making decisions about whether to adopt a new AEP. Family health, improved household food/nutritional security, improved soil quality, production reliability, additional income generation and increased crop/livestock diversity were identified as the most important benefits of adopting AEPs (Fig. 2). Reasons for farmers choices and the implications of the low importance assigned to the adoption of AEPs with principally public good benefits are discussed below.

4.1 Private good benefits

4.1.1 Family health and productivity

Farmers valued family health as the most important potential benefit arising from adopting AEPs. This was not surprising and relates closely with the principles of agroecology that such practices should support not only environmental health but also long-term human health through better work conditions and higher quality of work (Bezner Kerr et al., 2023). Previous studies have provided evidence that the application of AEPs can lead to improvements in human health (e.g. O'Rourke et al., 2017; Deaconu et al., 2021). Family members

provide low-cost labour and only healthy family members can work, as farmers noted in the follow-up questions designed to better understand responses to the BWS experiment. As such, healthy family members are also essential for farm productivity and food security, with the high preference for benefits related to food and nutritional security also being as expected. These two benefits, ‘Improved health of household members’ and ‘Improved food and nutritional security of household members’ are intricately linked, with some farmers arguing that the latter should come first because family health follows from that.

Reasons for identifying the benefits which are directly associated with high yield and income (ranked second and third important) were that food security was related to producing enough food, which in turn was considered key to income generation, as well as maintaining family health and nutrition (Table 4). Food security and sovereignty considerations have been found to significantly impact the decisions to adopt AEPs in other countries (e.g. Misra, 2018). Farmers in Vihiga assigned higher rankings to the farm productivity and food security related benefits than their counterparts in Kisumu (Figure S3) showing their greater need for these benefits for their livelihoods. Consequently, it would be expected that any AEPs that are more directly focussed on generating these benefits are more likely to be adopted by farmers in Vihiga.

4.1.2 Access to extension services

While the high rankings of the AEPs associated with private good benefits are relatively straightforward to understand, it is with those that are ranked in the middle and with overall negative BW scores (Table 3) where the results are particularly interesting and differences between farmers most apparent. The availability of complementary extension services to support successful adoption, for example, was positively ranked overall, although there were equal numbers of farmers who considered this attribute to be least important (Fig. 2). Many farmers remarked that reasons for this benefit to be considered important was the provision of training needed to adopt new practices and enhanced networking. This aligns with the principles of agroecology and findings that AEPs that include farmer networks have been proven to have positive impacts on food security (Berthet et al., 2016; Bezner Kerr et al., 2021). Knowledge transfer and exchange, including co-creation of knowledge, as part of adopting AEPs also includes knowledge provision about the interaction between environmental factors, productivity and human and environmental health (Oteros-Rozas et al., 2019; Wezel et al., 2020; Bezner Kerr et al., 2021).

However, in rural areas farmers might not necessarily gain adequate information from extension officers due to structural constraints and technological bias, making it less likely for them to adopt environmentally-friendlier practices (Amoak et al., 2022). Farmers in Vihiga perceived the benefits of potential extension service as less important than those in Kisumu. Existing farmer support associations (such as community seed banks) resulting from the ‘African leafy vegetables’ project in Vihiga meant that farmers in Vihiga thought that they already had adequate access and ultimately considered other AEP attributes to be relatively more important. Such findings could be used to target specific farmers for particular training sessions, and also to improve extension services to make them more appropriate and appealing to more farmers.

Landowners placed higher importance on extension service availability (Figure S4 in the Supplementary Materials), production reliability and additional income generation. Those

leasing land tended to assign lower rankings to soil quality and agrobiodiversity compared to landowners. Such findings may be explained by lower feelings of responsibility for what happens to the land in the long term for non-land owners, particularly when lease agreements are short-term and informal (Friis & Nielsen, 2016; Hammond Wagner et al., 2016). Similarly, full-time farmers with no off-farm income valued this attribute more highly than those who do farming part-time, potentially because of their higher dependence on the land for their livelihoods.

4.1.3 Cost minimisation and additional income

We found that respondents were divided in their preferences towards minimising the costs of AEP adoption. Respondents in Vihiga considered such costs to already be low, for example for composting or crop rotation and by sourcing inputs on-farm, including cheap family labour. By contrast, respondents in Kisumu attributed higher importance to the adoption costs since they were generally more income-driven than those in Vihiga. AEPs are generally considered to use resources more efficiently and thus reduce costs (Wezel et al., 2020). As such the results are unsurprising. However, if low costs of adopting a new, more labour intensive practice hinges on cheap labour provided by family members, this could be challenging in the future. If opportunity costs for labour were higher, for example, leading to family members being attracted away from farm work to other employment opportunities or to pursue educational studies, the costs might become a more important issue for the farming business.

Any additional costs of AEP adoption could also be met with the additional income generated through the adoption of a new AEP. This benefit was considered more than twice as important as minimising adoption costs (Fig. 1). Such additional income was considered to be needed to compensate for any upfront AEP adoption costs and to increase production, echoing results of similar studies (Antwi-Agyei & Nyantakyi-Frimpong, 2021; Dagne et al., 2023).

4.1.4 Labour requirement

Equally intriguing and also linked to cost minimisation was the result that the 'No increased overall labour requirement' attribute was ranked as the least important benefit of adopting AEPs. This lack of importance was more pronounced in Vihiga and among farm owners. Although specific reasons for considering this attribute unimportant were not provided, we hypothesise that the ready availability of labour from younger family members, particularly in Vihiga, could be a contributing factor. Farmers in Vihiga emphasised that, in their context, the limiting factor is the availability of farmland rather than labour. However, this result was nonetheless surprising as the lack of labour has been found to be a limiting factor to upscaling productivity in similar contexts involving AEP adoption (e.g. Hennessy & Rehman, 2007; Morais et al., 2018; Antwi-Agyei & Nyantakyi-Frimpong, 2021; Ewert et al., 2023). Labour shortages in rural areas can be caused by the changing aspirations of young people, with their better education fostering rural outmigration to pursue other career paths (Morais et al., 2018; Geza et al., 2021; Jansuwan & Zander, 2022). Furthermore, where new labour-intensive technologies are to be adopted, labour shortages and the decreasing interest of

younger people who could be the drivers behind such innovation (Assan et al., 2020; Dagne et al., 2023) can compromise the degree of successful adoption.

4.2 Private benefits with potential public good dimensions

4.2.1 Soil quality and agrobiodiversity

The potential for improved farm soil quality was perceived as important for the dependability of crop and livestock-related food production (see Table 4) and environmental health. Better soil quality can be achieved by reduced use of toxic synthetic inputs as part of AEP adoption (Bezner Kerr et al., 2023, among others), and can therefore also counter environmental degradation and ground water quality decline which can be considered a public good benefit (Table 1).

Another benefit that was ranked important by farmers for stable and high productivity but also with a view to facilitating dietary diversity, was the potential for increased use of crop and/or livestock diversity. Maintaining high levels of agrobiodiversity also strengthens resilience as a risk-diversification strategy and to cope with (unexpected) climatic, economic, and social shocks and disruptions (Di Falco & Chavas, 2009; Maligalig et al., 2021; Pandey et al., 2022). As such, increased use of diversity is often seen as an important aim of AEP adoption (Wezel et al., 2020; Bezner Kerr et al., 2021; Ewert et al., 2023; Drucker et al., 2024; Kliem, 2024). While farmers considered these private benefits as important, the conservation of agrobiodiversity in the fields of the rural poor also constitutes a global public good (Drucker & Ramirez, 2020; Drucker et al., 2024) in the form of indirect use (e.g. resilience at the landscape scale), option, bequest and existence values (Table 1).

4.2.2 Chemical inputs and water use

The two benefits related to reducing inputs, ‘Reduced need for chemical inputs such as fertiliser and/or pesticide/herbicide’ and ‘Reduced need for agricultural water use’ are also considered core elements of agroecology (Wezel et al., 2020; Bezner Kerr et al., 2021). They provide both, private and public good benefits (Table 1). However, neither type of benefit was regarded as very important when adopting AEPs in the context of our study (Fig. 1; Table 3) In particular, farmers in Vihiga did not attribute high levels of importance to these two benefits, mainly because they stated they already use very little chemical inputs. They also stated that they depend on rainwater for which they said they usually had plenty and can conserve water at low cost (see Table 4). As farmers do not expect significant additional private benefits from these attributes, adopting AEPs based on their potential for reducing chemical inputs and using less water is likely to be considered a poor incentive for adoption. This despite the fact that both types of benefit can greatly contribute to environmental health and indirectly to farm productivity.

4.3 Pure public good benefits

Respondents considered those attributes with purer public benefits, even community-level ones, to be relatively unimportant. These include improved forest quality and/or

coverage, reduced off-farm environmental impacts (pollution of groundwater, rivers and/or streams; reduced carbon emissions), improved local community land management for aesthetics and wildlife, and improved community-level resilience (Table 1). All these potential benefits were of lower importance in Vihiga than in Kisumu (Figure S3). This may be because farmers in Vihiga County consider themselves to be less exposed to climate change risks and environmental degradation than Kisumu County.

4.3.1 Local community ability to withstand shocks

With an overall negative score (Table 3), farmers did not consider this benefit, which is assumed to provide public benefits at the community level, as important when adopting AEPs. Respondents instead considered that their communities were not vulnerable to floods and droughts, that on-farm soil management was a more effective means of controlling pests/diseases and that a healthy well-fed population (i.e. higher priority attributes) is essential for achieving such community-level resilience.

4.3.2 Off-farm environmental impacts

This is a pure public good benefit which is generated when many farmers apply sustainable practices such as AEPs across a given agroecological landscape (Table 1). Potential long-term benefits may include climate change mitigation through emission reductions. (Bezner Kerr et al., 2023). The overall scores were negative (Table 3) which means it does not play an important role in farmers' decisions to apply AEPs. The main reason for this is that off-farm environmental impacts were largely considered to be the responsibility of the community and to not address food security directly. This corroborates the overall findings of our study, i.e. that if the benefits of AEPs do not directly contribute to productivity or family health, then farmers may well not take them into consideration when making adoption decisions. This does not, however, necessarily imply that small-scale farmers do not contribute to climate change mitigation. Climate change adaptation and mitigation strategies often go hand in hand, with farmers constantly adapting to changing conditions if it secures productivity and food security, often through the application of traditional knowledge (Nyong et al., 2007; Ogunyiola et al., 2022).

4.3.3 Land management for aesthetics and wildlife and forest quality

Overall, the benefits 'Improved forest quality and/or coverage' and 'Improved local community land management for conservation of water sources, wildlife, beauty and agrotourism' had negative scores, signifying that farmers most often chose this benefit as least rather than as most important. Many farmers who considered improved forest quality/coverage as unimportant stated that they did not have any such resources nearby and consequently did not use any. Those who rated this benefit as important did so because they considered it has a positive impact on climate and rainfall and can help to attract tourism (Table 4). The prospect of attracting more tourists and increasing agrotourism in the area was also mentioned as a reason for ranking land management as important. However, the majority of farmers remarked that agrotourism would not address food security, that their farms were too small and that their location is hard to

access. They also said that they already struggle with population growth and that more people would strain the food and housing systems. Such considerations accord with the finding that while agrotourism might provide a new income stream, it is not necessarily sustainable, unless it is clearly integrated into sustainable traditional agroecosystems (Addinsall et al., 2017).

4.4 Policy implications

Our results overwhelmingly showed that farmers preferred benefits from adopting AEPs that generate private goods related to food/nutritional security and family household member health, rather than benefits that principally generate public good ecosystem services. Public benefits related to reducing environmental degradation and deploying higher levels of agrobiodiversity were only preferred because farmers directly linked them to productivity and family health. If farmers do not expect the private benefits from AEPs to be higher than public good benefits, the chances of farmers adopting those are much reduced. This indicates the need for additional types of financial support to facilitate the adoption of such public good AEPs, such as through the implementation of Payments for Ecosystem Service (PES) incentive mechanisms (Batáry et al., 2015; Vainio et al., 2021).

Such incentive mechanisms could also be complemented by awareness-raising amongst community members about the potential longer-term livelihood and sustainability benefits of public good AEP adoption. This could be facilitated by additional extension advice of relevance to those specific AEPs, given that farmers did appreciate extension services as a benefit overall. In addition to training, this service could support efficient networking, increased farmer-to-farmer exchanges and social recognition rewards; as well as information dissemination regarding potential incentive schemes to assist farmers to cover any extra costs associated with the AEPs (see Mouratiadou et al., 2024).

Although most farmers already showed a high awareness of environmental degradation and the effect on productivity, services that go beyond those that directly benefit food production and family health (i.e. the public good services, as discussed previously) were of lower importance. Extension officers also have an important role to play, in particular since extension service access was mainly regarded as a positive aspect of adopting AEPs. While labour availability was not seen as a major constraint to AEP adoption, understanding farming households' choices in the context of the changing nature of opportunity costs vis-à-vis off-farm employment over time could well be important.

Although the additional costs associated with AEP adoption were not considered important, farmers still argued that they needed additional income to meet potential upfront costs. Where such additional income might not necessarily materialise, an alternative approach would involve supporting farmers with payments in the early years of the transition if there is evidence of income forgone associated with lower productivity and yields and/or the need for upfront investments (Mouratiadou et al., 2024).

For future research, to determine the magnitude of farmer incentives needed to motivate the provision of public good benefits and whether the willingness to pay for such services is sufficient to secure them at scale, the associated BWS attributes may be the

focus of more in-depth studies. This can be done through multi-attribute preference elicitation methods applied to both farmers and the general public. The results could inform the design and implementation of community-level PES schemes, building on existing institutions of collective action, to effectively deliver public good ecosystem services at scale.

5 Conclusions

To assess farmer preferences for adopting agroecological practices (AEPs) with different attributes, a best-worst scaling (BWS) experiment was conducted with 94 farmers in two counties in Western Kenya. Results show that improved health of household members and household food/nutritional security were perceived as the most important attributes or benefits of AEPs, together with others that generate private benefits related to improved soil quality and production reliability, additional income and increased crop and/or livestock diversity. Conversely, benefits for the broader public, such as improved forest quality, community resilience, reduced off-farm environmental impacts, less need for synthetic chemicals, and better landscape and wildlife management, were less important to farmers. These findings highlight the need for support mechanisms like Payments for Ecosystem Services (PES) to encourage the provision of public goods and to identify which ecosystem services the public values most. This study also aimed to advance BWS experiment methodology. Best-Worst (BW) scores indicate the relative preference strength for each attribute. A neutral score, where an attribute is neither chosen as the best nor the worst by many participants, can complicate interpretation as it shows no strong preference response. This ambiguity can reduce the reliability and validity of the findings. To address this, this study included detailed discussions with respondents after each choice to differentiate between truly neutral attributes and those with high polarity (most or least important). Although time-consuming, gathering detailed reasons for respondents' choices is recommended for better clarity and insight when performing BWS surveys.

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Data availability The data for this study will be made available on request.

Declarations

Conflicts of interests The authors have no competing interests to declare that are relevant to the content of this article.

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