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Farmers' perceived values in intercropping: An application of the means end chain framework in Swedish agriculture

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ABSTRACT

Values have been recognized as the principles that guide individuals' actions and behaviour. Insight into important values that drive farmers' behaviour in intercropping adoption, a sustainable farming practice, can contribute to promoting the adoption. This paper investigates the role that values take in shaping farmers' decision to intercrop in Sweden. Specifically, drawing upon the means end chain (MEC) approach and laddering interviews, the paper explores how intercropping farmers, in their own words, describe the attributes of intercropping, consequences of those attributes, and the values achieved from those consequences. The paper found that yield improvement, good fodder and healthy soil were the most prominent perceived attributes. Cost reduction and profitability were perceived by farmers as the two most important consequences of intercropping. Results highlight that though both pecuniary and non-pecuniary values jointly shaped the decision to intercrop, the former is the stronger motivator for adopting decision. The existence of multifaceted values suggests that intercropping farmers have strived for not only viable farm businesses but also environmental protection, social responsibility, and the happiness in their faming occupation.

1. Introduction

Intensified monoculture has been the dominant approach to crop production in Europe for the last several decades. Given its reliance on the intensive use of fossil energy, synthetic pesticides and fertilizers, this farming system increases yield at the cost of soil fertility and the environment, contributing to greenhouse gas emissions and biodiversity loss in rural areas (Voisin et al., 2014; Wezel et al., 2018). Moreover, most of the crops in monoculture systems are vulnerable to environmental irregularities and climate change because of their ecological homogeneity, posing a threat to food security (Salaheen and Biswas, 2019) under seasons of extreme weather events such as the drought in Northern Europe in 2018.

Intercropping, the cultivation of two or more crop species simultaneously on the same field at a certain time (Wang et al., 2014) can be a potential solution to obtaining a more sustainable farming system. From a resource efficiency perspective, intercropping can be more efficient than sole cropping since the joint production of two or more crops often reduces input consumption per unit of output (Ho et al., 2017). In many cases, intercropping improves and secures yield (Raseduzzaman and Jensen, 2017) and thus presents a possible means to strengthen farms' economic viability. However, it is worth noting that the improvement in yield of intercropping is strongly context dependent (Weih et al., 2021). The potential advantages of intercropping might go beyond the farm's cropping systems. For instance, in mixed crop-livestock farms, grass and legume grown in conjunction increases yield and nutritive value of forage, which supports animal production (Rusdy, 2021). From an environmental perspective, intercropping is an example of low input farming practice, whichrequires less chemical pesticides and fertilizers (Maitra et al., 2021). This results in less environmental impact, improved biodiversity, and subsequently better management of pests and diseases (Jensen et al., 2020). Particularly, growing legumes with other species in a mixture increases soil nitrogen content (Jensen et al., 2020) and is thus a strategy to reduce farms' dependence on chemical fertilizers. All of these contribute to improving rural livelihood and the sustainability of farming communities.

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However, despite the highlighted potentials, intercropping adoption in European agriculture is still low (Bonke and Musshoff, 2020). This is a result of its management complexity (Kiær et al., 2022), the absence of a functioning market for intercropping outputs used for human food, inadequate technologies for sorting mixed seeds, and the lack of policy support (Jensen et al., 2020). Recently, the Common Agricultural Policy (CAP) 2023–2027 has recognized intercropping as a potential agricultural practice that can be supported by eco-schemes measures (European Comission, 2021). Nevertheless, eco-scheme faces a high uncertainty as a voluntary incentive since it depends on farmers' voluntary participation (Piñeiro et al., 2020). The incentive offered, farmers' personal characteristics (e.g., farmers' environmental preferences and belief), and farms' conditions, among others, influence such voluntary participations (Piñeiro et al., 2020). Review studies on farmers' adoption of agricultural technologies consistently confirm that behavioural factors (e.g., farmers' goals in farming, knowledge, perception) are increasingly important in driving adoption decision (Chavas and Nauges, 2020; Dessart et al., 2019).

To enhance intercropping adoption, a comprehensive understanding of the adoption decision from the farmers' perspective is required. In this respect, insight into the values that farmers' aim to achieve via intercropping is particularly promising. Personal values have been recognized by psychologists as moral compasses that guide people's actions and behaviours (Bardi and Schwartz, 2003; Rohan, 2000). Particularly, farmer studies show that personal values are important drivers of farmers' decision to adopt new and improved farming practices (Hansson and Kokko, 2018; Leduc et al., 2023; Ngigi et al., 2018). However, there is a limited understanding of how farmers' personal values guide their decision in intercropping adoption. Though previous research has identified a number of potential economic and environmental benefits of intercropping (Maitra et al., 2021). Information on how farmers, who implement intercropping, view the attributes and consequences of intercropping implementation is lacking. Subsequently, the relationship between personal values, perceived consequences, and attributes of intercropping remains underexplored. Ultimately, we lack convincing evidence from intercropping adopters to be used to communicate with non-adopters. We also lack empirical evidence on farmers' motivations in intercropping adoption from their own perspective to inform agricultural policies for intercropping.

Against this background, this paper investigates the role values play in shaping farmers' decision to intercrop in a European setting, with Sweden as a case study. More specifically, drawing upon the means end chain (MEC) approach (Gutman, 1982; Reynolds and Gutman, 2001), this paper explores in-depth how intercropping farmers describe the attributes and consequences of intercropping in their own words and the values they aim to achieve through those consequences. The paper thus investigates the cognitive links between those perceived attributes, consequences, and farmers' personal values.

This study contributes to the existing literature on farmers' behaviour in intercropping uptake. It is the first study that employs MEC approach to map farmers' perception of meaningful attributes of intercropping practices, corresponding consequences, and important personal values. MEC approach has been applied to understand farmers' reasoning behind the choice of improved agricultural technologies (Okello et al., 2019), organic farming (Leduc et al., 2023), and soil health promoters (Foolen-Torgerson et al., 2023). There are not many applications of MEC in previous farmer studies and none of them has employed MEC for intercropping. Since each farming practice has its own characteristics, the results of the current study are unique with identified linkages among attributes, consequences, and values being relevant to the uptake of intercropping practices, as compared to MEC studies above.

By providing an in-depth understanding of farmers' motivations in intercropping adoption, the study can inform communication strategies to promote intercropping. Limited knowledge of intercropping, including knowledge about its benefits, represents a key barrier to the adoption (Ha et al., 2023). The insight into the attributes and consequences of intercropping experienced by adopters can be convincing evidence to encourage non-adopters who have similar farming conditions like respondents in this study. An understanding of the underlying values of intercropping adoption can assist the design of policy measures for intercropping. For instance, if pecuniary values are deemed important in driving adoption, economic incentives are needed to motivate the uptake. Insights into underlying values of intercropping can also be used to improve farm advisory support.

2. Conceptual framework

2.1. Means-end chain (MEC) approach

The MEC model and its related laddering method (Gutman, 1982; Reynolds and Gutman, 2001) were originally developed to study the relationship between consumers' values and consumption behaviour. Specifically, MEC explains how a selected product or service (means) facilitates the achievement of the desired end stage (values), such as happiness and security. According to MEC, a product/action is chosen when it has "attributes" that can offer desired "consequences", resulting in important "values" being fulfilled. MEC is usually measured by the laddering method (Grunert et al., 1995). This method involves a probing process, starting with eliciting important attributes, then corresponding consequences, and finally values linked to these consequences. In this way, MEC and laddering technique construct a hierarchical framework that connects attributes to consequences and values. Though departing from consumer research (Gutman, 1982; Reynolds and Gutman, 2001), the application of MEC has been extended to studies on farmers' adoption of agricultural technologies, especially sustainable farming practices (Barnes et al., 2022; Hansson and Lagerkvist, 2015; Leduc et al., 2023; Okello et al., 2019).

The use of MEC framework is relevant to understand farmers' decision making in intercropping adoption. Studies show that adoption of sustainable farming practices depends on landholders' perception that whether the practice enhances the attainment of their personal goals (Pannell et al., 2006) and offers them benefits (positive consequences) (Streletskaya et al., 2020). Perceived attributes of a farming practice also influences farmers' adoption (Ridier et al., 2021; Wang et al., 2021). Since values, perceived attributes, and perceived benefits or consequences have been proven to influence farmers' adoption decision, these three constructs should be incorporated in single studies to better explain adoption decisions. The MEC is a useful approach to bring the three constructs together and the final aim is to systematically understand their relationships.

Applying MEC on this study, farmers are assumed to intercrop if the perceived attributes of intercropping (e.g., good pest management) results in desired consequences (e.g., reduced pesticide use) that leads to the fulfilment of important values that they wish to achieve (e.g., business success). Here attribute refers to the characteristics of intercropping itself. Each attribute might offer one or several perceived consequences experienced by farmers. Consequences can be negative or positive. Perceived positive consequences (benefits) are expected to motivate intercropping adoption. Among various possible consequences, farmers would place greater importance on consequences that lead to important values. Moreover, a perceived consequence such as "reduced pesticide use" might subsequently link to different values like "environmental protection" and "feel good about myself'. This way, perceived intercropping attributes are the starting points, perceived consequences are the middle points, and perceived values are the end points of the MEC' hierarchical framework.

2.2. Farmers' personal values and the adoption of sustainable farming practices

According to psychological literature, personal values are defined as

important principles that guide people's life (Bardi and Schwartz, 2003; Schwartz, 1994). Values drive motivations, prompting individuals to act in a way that expresses their values and achieve their underlying goals (Bardi and Schwartz, 2003). Values determine the attractiveness of choices and actions by shaping the perception of the choice and its outcomes (Sagiv and Roccas, 2021). When a choice is perceived positively and in line with what people find important, it is more likely to be chosen. Since values are relatively stable over time and across situations, they can predict a variety of behaviours (Sagiv and Schwartz, 2022). A behaviour can be associated with one or more values (Bardi and Schwartz, 2003). For instance, intercropping can lead to both "economic success" and "feel good about myself". However, only dominant values, those more important, greatly influence farmers' decision (Gasson, 1973).

There is a growing interest in farmers' personal values and the way they view their farming in agricultural literature. Howley (2015) categorized farmers' perceptions of the benefits from farming into two groups: pecuniary and non-pecuniary (Howley, 2015). The happiness of being a farmer, the emotional connection with others, and the importance "being the boss" on their own land are some examples of non-pecuniary benefits perceived by farmers. On the other side, examples of perceived pecuniary benefits include "good living" and substantial financial rewards from farming (Howley, 2015). There is ample empirical evidence that suggest that the uptake of sustainable farming practices is strongly driven by perceived pecuniary benefits such as profitability (Dessart et al., 2019) and pecuniary values like "maintaining the business" and "earning a living" (Leduc et al., 2023). However, pecuniary benefits, though undoubtedly important, are insufficient in explaining farmers' adoption of sustainable practices (Dessart et al., 2019). Various non-pecuniary values are also found to be crucial elements of farmers' decision-making (Hansson and Lagerkvist, 2015; Howley, 2015). It has been shown that farmers' positive feeling and sense of righteousness facilitates actions to improve animal welfare (Hansson and Lagerkvist, 2015). The joy of being a farmer was found to strongly influence strategic choices such as the intention to stay in farming, business diversification, and the participation in off-farm employment (Howley, 2015). Recent literature on "good farming" has shown that farmers have a strong sense of farmer identity that extends beyond the productivism paradigm of farming, where increasing productivity and/or profitability is the main focus (Leitschuh et al., 2022). Farmers were found to place equal importance on the place-meanings of family legacy, stewarding a viable future, and caring for the land as they did on profitability and efficiency (Leitschuh et al., 2022). A proportion of farmers bear considerable social and environmental responsibility, for instance, choosing to sacrifice profit to engage in environmental practices or to help others (Streletskaya et al., 2020). A study reported that perceived responsibility for future generations and sustainability increased the likelihood of adopting biodiversity measures (Brown et al., 2021).

Regarding value typology, influential work by Schwartz (1994) identified 10 types of personal values among human. These values include power (e.g., social power), achievement (e.g., successful), hedonism (e.g., enjoying life), stimulation (e.g., daring life), self-direction (e.g., freedom), universalism (e.g., social justice), benevolence (e.g., helpful), tradition (e.g., humble), conformity (e.g., politeness), and security (e.g., feel safe). Turning to the agriculture-focused literature, early research by Gasson (1973) examined values that motivate the decision to pursue farming as an occupation and categorized farmers' values into instrumental, social, expressive, and intrinsic. Maybery et al. (2005) identified three important value categories including lifestyle, economic, and land conservation as potential influences of farmers' implementation of land conservation practices. Though there are different approaches toward value typology, a common point among these approaches is that values have multi-faceted dimensions of economic and non-economic orientations. In this study, we mainly used the personal value set identified by Schwartz (1994) to categorize the values conceptualized by the interviewed intercropping farmers. Schwartz (1994)'s typology provides an array of personal values that also holds true to farmers and reflect multiple dimensions of their values. A number of farmer studies in Europe have applied this typology and confirmed its validity (Graskemper et al., 2022; Hansson and Sok, 2021). Moreover, identified values based on Schwartz (1994)'s work will be grouped into pecuniary and non-pecuniary to allow a high level abstraction.

3. Method and material

3.1. Interview process

We collected data via laddering interviews (Reynolds and Gutman, 2001) to elicit MECs that respondents then used to explain their intercropping adoption. We applied the "soft" laddering technique (Grunert and Grunert, 1995), which is explorative in nature, to allow respondents to freely describe the constructs in their own words via the utilization of individual semi-structured interviews. An alternative of "soft" laddering is hard laddering technique, which is based on structured questionnaires (e.g., computerised questionnaires) with a pre-determined list of constructs (Russell et al., 2004). Compared to hard laddering, "soft" laddering technique is more explorative, therefore allowing more diverse responses from respondents (Russell et al., 2004) and providing richer context information, which could aid researchers in understanding the meaning of responses (Grunert and Grunert, 1995). More importantly, via soft laddering, we wanted to listen to farmers in their own words to discuss the attributes of intercropping, its consequences, the values they aimed to achieve, and finally to outline their perspective on intercropping.

Using soft laddering technique, respondents were firstly asked to state the top five important attributes of intercropping. Next, to "climb" up the ladder, for every attribute mentioned, a series of questions 'Why is it important to you?' was used to elicit benefits (positive consequences) and values. The probing process ended when respondents were unable to provide further reasons of importance. The final purpose of this process was to construct sets of linkages or ladders among attributes (A), consequences (C), and values (V) (see Table 1). Textual recording was made during interviews to keep track of responses and for the purpose of clarification and modification if necessary.

One-to-one interviews were conducted online during March to May 2022 by the research team. We chose to collect data online to include intercropping farmers from different geographical regions while ensuring the cost efficiency of data collection process. There is no official

Table 1
Example of laddering interview.

Interview questions	Responses
Why is it important to you?	Feel good about myself (V)
	↑
	Develop farm business (V)
	↑
	Profitability (C)
	↑
	Reduce pesticide cost (C)
	↑
Which attributes of intercropping are important to you?	Good pest management (A)
↑	
Start	

register or information available to identify which farmers are intercropping. Instead, we compiled a set of possible participants from our own professional networks and from those of farm advisors that we contacted. Additionally, we recruited respondents by a snow-ball approach, asking them to suggest additional farmers for later interviews. An invitation letter to participate in the study was sent to the identified farmers' email, stating that the participation being voluntary and that farmers' identity being kept confidential. Among 60 invited farmers, 33 participated in interviews. This sample size is higher than the minimum sample size requirement of 20 for laddering studies, as suggested by Reynolds and Olson (2001). On average, each interview took 30–40 min and consisted of two parts. The first part concerning farmers' demographic characteristics and agricultural production. The second part captures intercropping attributes, perceived consequences, and farmers' personal values using the laddering technique mentioned previously (Reynolds and Gutman, 2001).

3.2. Respondents and their farms

Since our purpose was to map farmers' perceived values in intercropping, we only recruited intercropping adopters. Table 2 presents respondents' and their farms' characteristics. The average age of respondents was 52 and 88 % of respondents are male. These figures reflects the aging farming population and the male-dominance in farming communities in Sweden, as shown in recent statistics by the Swedish Board of Agriculture (Swedish Board of Agriculture, 2022). Intercropping groups varied among interviewed farmers. Cereal-legume was the most common intercropping pattern. Within cereal-legume intercropping, peas were often mixed with either oat or barley. Catch crops in the legume family such as alfalfa and clover were often grown with ley or cereals for feed production and to improve soil fertility. Ley crops were also mixed with nitrogen fixing legumes and cereals for the same purpose. Noticeably, about 70 % of interviewed farmers had mixed farms (animal-crop integrated) and 58 % were engaged in organic production.

3.3. Data analysis

The interviews were conducted in Swedish, which were then transcribed and translated into English. Following the suggestion by Reynolds and Gutman (2001), an inductive qualitative content analysis was carried out to identify all ladders across respondents and develop a set of summary codes that contained all attributes, benefits, and values mentioned by farmers. All of these elements were further converted into master codes where similar responses were assigned to a common code (denominator) to allow aggregation of responses across individual respondents. For example, if a farmer said "*Intercropping with legumes creates natural nitrogen*" and other farmer said "*In intercropping, nitrogen is transferred from one crop to other crops",* both responses were coded as *"nitrogen fixing*". The second and the third authors worked independently on the first master code. When there were discrepancies, the team used the original interview transcripts to discuss the most suitable code. Since the first set of master codes contained a high number of constructs (600 in total), a broader way of coding (see Kilwinger and van Dam (2021)) was employed by the first author to reduce the number of constructs to a manageable proportion.

Next, these master codes were used to develop an implication matrix and a hierarchal value map (HVM) with the aid of the software "LadderUX" (Vanden Abeele et al., 2012). The implication matrix illustrates how each construct is related to other constructs and the number of times they connect to other constructs directly and indirectly. Based on the implication matrix, HVM provides a visualization of linkages among constructs. By eliminating unnecessary and incidental links, this hierarchical value map becomes readable and understandable, allowing attention to be directed to the dominant means-end chains (Kilwinger and van Dam, 2021).

To achieve an interpretable HVM while retaining the most important data, a cut off level of 3 was chosen to discard less important linkages. MEC elements with less than three linkages to other MEC elements were omitted in HVM. As a result, 47.19 % of elicited linkages were retained. Reynolds and Gutman (2001) suggested a cut-off value from 3 to 5 for a sample size from 50 to 60 and that cut off value should retain two-thirds of linkages. Given the large number of linkages elicited (2986 linkages), we chose to retain a smaller proportion of linkages than the recommended level to reduce the complexity of HVM. As suggested by a MEC study of Hansson and Lagerkvist (2015), we inspected interpretability and data richness across HVMs with varying cut-off values before finally deciding on the cut off level. A cut-off level of either 5 or 4 retained an even smaller number of linkages and led to the removal of some meaningful ones. For instance, using a cut-off level of 4, the linkages from "healthy animals" to "animal welfare" and from "others' livelihood" to "be a good farmer" were removed (see Fig. 2, Appendix). Using LadderUX, frequencies of linkages across and within respondents were counted (Vanden Abeele et al., 2012). A dominant construct is the one that appears frequently across multiple individual ladders. In this study, after the HVM was constructed by LadderUX, we calculated the number of respondents citing each retained linkage. If a linkage was mentioned two or more times by a respondent, it was counted only once. The purpose is to reveal universal patterns of relationships among cognitive constructs across respondents.

Table 2
Descriptive statistic of variables.

Famers'- and farms' characteristics	Mean (standard deviation) or %
Age	51.7 (9.4)
% of male farmers	88
Arable land holding (ha)	311.0 (380.7)
Intercropping area (ha)	72.7 (160.2)
Intercropping type	
- Cereal-legume	79
- Catch crop-cereal	18
- Cereal-legume-ley	15
- Legume-ley	18
- Mix of ley	9
- Others	9
Farm type (%)	
- Crop and service	12
- Crop farm	18
- Mixed farm	70
% organic farms	58
Number of employees per farm	3.6 (2.1)
Intercropping experience (year)	7.9 (5.8)
Farming experience (year)	12.4 (6.2)

4. Results

Fig. 1 presents a modified HVM, in which the most important links were included and links associated with the attributes and benefits of common meaning were merged and/or adjusted. A total of 2986 links and 308 ladders were elicited by the 33 interviews. An average ladder contained four to five elements while an average respondent had around nine ladders. Given the cut-off level of 3, 20 % direct links and 27 % indirect links were retained in the HVM. In the HVM, yellow, green, and blue boxes indicate intercropping attributes, consequences, and farmers' values associated with the consequences, respectively. The boldness of a link represents the strength of the association between its two elements, measured by the number of times the association was mentioned in the interviews.

4.1. Perceived intercropping's attributes

The HVM highlights ten intercropping's attributes (yellow boxes). "Improved/secured crop yield" was the most salient attribute, appearing in 96 ladders and 20 interviews in total. Moreover, higher and more secured crop yield was the most frequently cited by respondents. It is

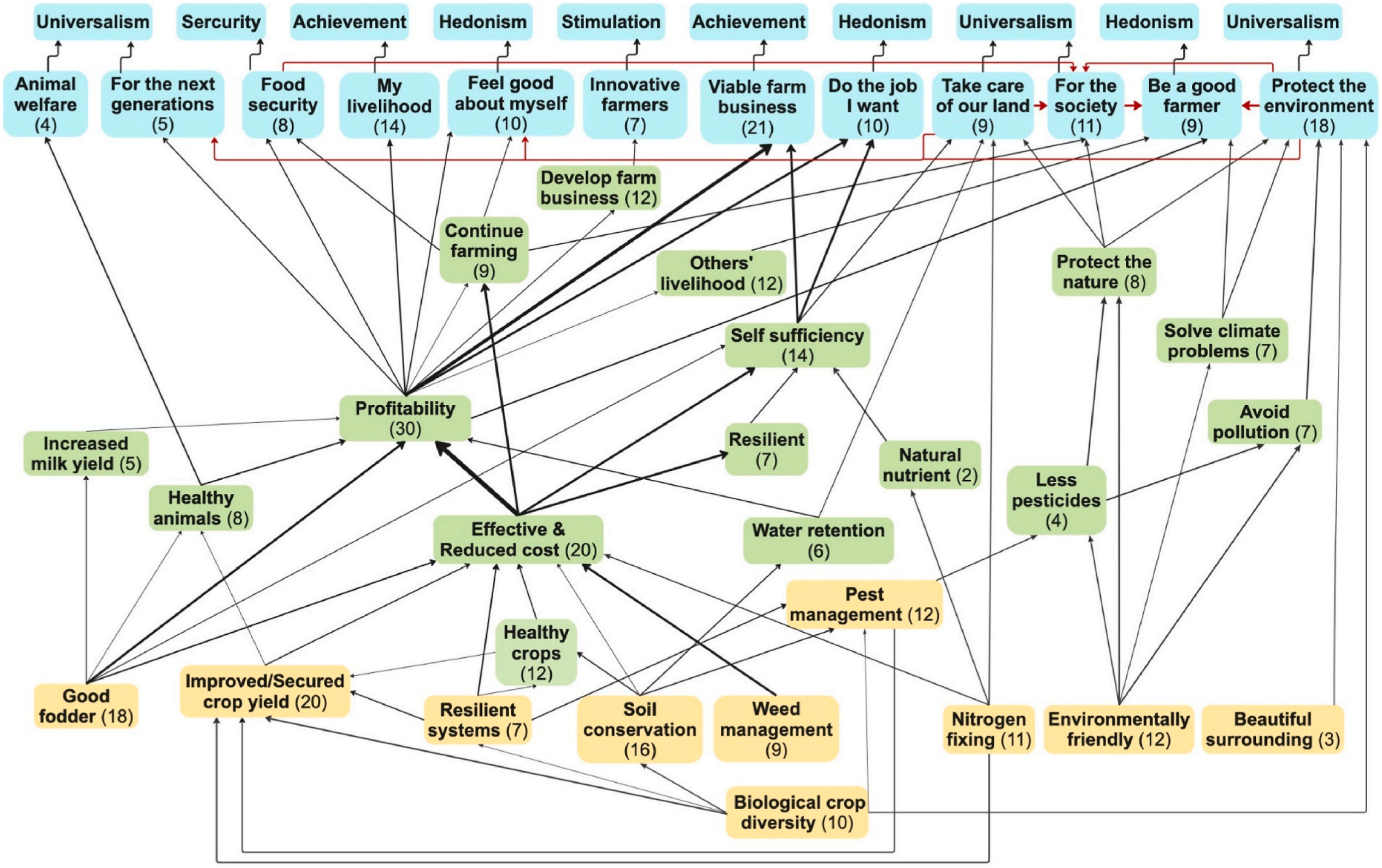

Fig. 1. Hierarchical value map (HVM) for intercropping adoption. **Note:** cut-off = 3, Consequences, attributes, and values are presented in yellow, green, and blue boxes, respectively. The thickness of lines presents strength of associations. Numbers shown in boxes denote the number of interviewed farmers mentioning the concerning consequences, attributes, and values. (For interpretation of the references to colour in this figure legend, the reader is referred to the Web version of this article.)

followed by "good fodder", which was presented in 18 interviews and 53 ladders and "soil conservation", which appeared in 16 interviews and 61 ladders. Since most respondents intercrop ley with legumes, there was a common perception that intercropping fodder had good and balanced nutritional content. Respondents also believed that intercropping with legumes resulted in better soil moisture, soil fertility, and increased presence of micro-organisms in the soil, leading to "soil conservation". The attribute "resilient systems" refers to the ability to adapt with climate change and spread production risks. For example, some respondents highlighted that wheat-pea and barley-pea intercropping prevent plant lodging, enable threshing, and reduce harvest loss. Moreover, some emphasized that if they lost the harvest of one crop in intercropping systems, the harvest from other crops was still protected.

"Weed management" and "pest management" advantages were also recognized, as one respondent said: "*Intercropping is good for minimizing the risk of disease and more diversity which means that we do not have the same diseases*". "Nitrogen fixing" refers to the ability to capture nitrogen when intercrop with legume. This attribute was often cited by respondents, especially organic farmers. "Environmentally friendly" was viewed by farmers though different angles such as carbon restoration, low input farming, supporting biodiversity and nature, and producing food without destroying the natural environment. "Beautiful surrounding" means "a clean and tidy farmyard", which was considered a result of having sufficient and good fodder from intercropping to raise animals indoors (e.g., pigs) instead outdoor raring, which is not aesthetically pleasing. Nevertheless, it could also be interpreted as "a beautiful living environment" or "beautiful to see all birds and insects due to intercropping", as mentioned by respondents.

Noticeably, some of the attributes above are related to each other. In the respondents' view, intercropping was associated with better biodiversity and crop diversity, resulting in the improvement of yield, pest management, soil quality, and the resilience of crop systems. For example, respondents related "biodiversity/crop diversity" with "soil conservation" and "improved/secured crop yield". One respondent indicated that "*diversification increases the utilization of the soil … With different crops in a unit area, more microorganisms are active and keep lives in the soil going. … So the mixed crops can get access to as much nutrition as possible … So the plant nutrition will favour the crops and give a high yield*". The link between "biodiversity/crop diversity" and "pest management" was cited by some respondents. For instance, one said "*Intercropping benefits pollinators and other insects. Beetles, for example, eat bad seeds and harmful insects*". Respondents believed that a higher yield assumed by intercropping compared to sole cropping was due to the advantages of intercropping in pest management and nitrogen improvement.

4.2. The relationship between perceived attributes, perceived consequences, Fig. 2 and farmers' values

Most of the attributes were perceived to offer a shared consequence, namely "effective & reduced cost" (Fig. 1). A common perception among the respondents is that given a better yield (in both quality and quantity), improved soil and weed management, resilience, improved biodiversity, and the ability to capture natural nitrogen, intercropping systems could reduce costs and thus become more effective and profitable. Noticeably, the connection between "effective & reduced cost" and "weed management" was strong. According to one respondent, *"Intercropping against weeds. Weed takes yield and creates higher costs in a field. I can save diesel and other costs if there is less weed."* Respondents explained

that better soil, because of intercropping, leads to healthy crops and better yield while requiring less chemical input. All these factors increase production efficiency. Another perception was that good soil eases soil preparation, requiring less energy and increasing profit. Respondents also indicated that pesticide and fertilizer costs were reduced thanks to improved weed and pest management and nitrogen fixing abilities of intercropping systems. Respondents with mixed farms reported increased profit via increased milk yield and healthy animals, which were both considered the result of good fodder from intercropping. Lastly, it was perceived that producing fodder for sale also achieves high economic return due to high fodder quality and yield from intercropping, as mentioned by some respondents.

It is worth noting that among all the links presented in HVM, the link between "effective & reduced cost" and "profitability" is the strongest. The former was cited in 30 interviews and 84 ladders. The latter was mentioned in 20 interviews and 130 ladders out of 308 ladders. As shown in HVM, they are two main constructs connected to many others. The importance of "effective & reduced cost" and "profitability" is clear evidence for farmers' high interest in the economic benefits of intercropping. In addition, farmers perceived that profitability, as an economic outcome of intercropping, was the means to achieve several personal goals and values. The result shows that "profitability" connects to 9 types of values in direct and indirect ways.

Our MEC interviews revealed 13 values (Fig. 1) including "animal welfare", "improved food security", "for the next generation", "my livelihood", "feel good about myself", "innovative farmers", "viable farm business", "do the job I want", "take care of our land", "for the society", "be a good farmer", and "protect the environment". "Improved food security" refers to either farm households or of the society on a whole. "For the next generation" means the benefits farmers could offer to future generations while "for the society" means the current contributions made by farmers for the society. Among the values above, "viable farm business", which appeared in 21 interviews and 70 ladders, was the most salient value. "Protect the environment" and "my livelihood" were the second and third most salient farmers' personal values, respectively. The former was mentioned by 18 respondents and shown in 38 ladders. The latter was indicated by 14 respondents and included 33 ladders.

The consequence "profitability" connects to all values, except "animal welfare" and "protect the environment". Regarding the connection between "profitability", "improved food security", "for the society", and "continue farming", a respondent emphasized that profitability was the foundation of farm's existence and the factor allowing them to continue farming, produce enough food for the society, and contribute to creating societal welfare. Profit was also perceived as the means for farmers to obtain good livelihood, wellbeing, and viable farm business. It also made respondents feel good about themselves and support them in doing the job they want. It was indicated by respondents that profitability enabled them to further develop the farm business, and thus providing an opportunity to learn new things and inspire others. In other words, allowing them to become innovative farmers. This reflects the relationship between the three constructs: "profitability", "develop farm business", and "innovative farmers".

"Profitability" also leads to "be a good farmer", which is a desirable value of 9 respondents. Respondents indicated that, a good farmer is defined as one with a successful farming business, highlighting the importance of profit. "Profitability" also connects to the consequence "other livelihood", which further leads to the value "be a good farmer". Particularly, "others' livelihood", was mentioned by 12 participants. Some respondents cited that with profitable production, they could bring benefits to others, such as livelihood to their employers, suppliers, and anyone dependent on the farm business. This way, the notion of good farmers also encompasses moral responsibility, as highlighted by a farmer "*I want to be a good farmer and a good member of society. Want to run my production at the best way possible. Proud to be a farmer*".

"Self-sufficient" appears as another important benefit offered by intercropping. It was the result of having "good fodder", "effective and reduce costs", a "resilient" farm, and the "nitrogen fixing" feature of intercropping systems. Respondents believed that fodder produced by their own farms from intercropping with legume was an effective way to address market problems (e.g., the limited supply of soybean in animal feed) and reduce dependency on feed suppliers. For some respondents, growing fodder for their own farms helped farmers have better control over the quality of fodders and enhance the traceability of animal feed in their animal production. Respondents believed that the nutrient self-sufficiency gained from intercropping has helped them remain strong in energy crises where the price of fertilizer rise rapidly. Intercropping with legumes helped them reduce the purchase of fertilizer. Particularly in organic farms, natural nitrogen from legume-based intercropping systems was seen as a vital fertilizer source. Making production factors (fodder, fertilizers) available at farms also reduced transportation and thus saved energy costs. In general, respondents viewed that thanks to intercropping, they could produce cheaper and high-quality outputs, be more resilient to a changing market and climate, and became self-sufficient.

"Self-sufficient" was further seen as a means for farmers to achieve two values: "viable farm business" and "do the job I want". The connection between "self-sufficient" and "do the job I want" was strong. A farmer highlighted that the reward of being self-sufficient was the sense of autonomy and the pleasure from conducting farming the way he likes. Inversely, the consequences of not being self-sufficient was that farmers were unable to pursue the sustainable farming as they desire: "*If you're not independent and self-sufficient, you will have to adopt a particular system that you don't like, for example, the use of chemical fertilizers and pesticides in conventional crop production*".

Other important perceived consequences of intercropping are "less pesticides", "protect the nature", "solve climate problem", and "avoid polluting". All of these benefits were derived from the attribute "environmentally friendly". Each benefit above further connects to one or more values following: "take care of our land", "for the society", "be a good farmer", and "protect the environment". Respondents were aware that keeping the land covered by a rich layer of vegetation from intercropping resulted in carbon sequestration, a solution to reduce the impact of climate change. Some respondents expressed a strong motivation to be a part of the climate solution rather than the problem. Many respondents said they were motivated to intercrop due to the perception that intercropping, as a low input farming practice, requires less pesticides and chemical fertilizers and thus reduces environmental pollution. Intercropping with catch crops was believed to prevent nitrate leaching from soil, also resulting in reduced pollution. Less chemical inputs were perceived to contribute to protecting nature. This way, farmers could satisfy their desire of protecting the environment, contribute to the society, and take care of the soil and arable land.

The relationship above was mentioned by a respondent: *"Intercropping creates an ecosystem that works. It is the most natural way of working. The privilege of maintaining land requires respectful treatment. (I feel) a responsibility for coming generations. The land is inherited (by them), therefore we must manage it well"*. The quote is also evidence for the connection between the two values "take care of our land" and "for the society". "Take care of our land" also links to two other values including "for the next generation" and "feel good about myself". For example, a farmer stated that "*the arable land needs to be managed and utilized. Thus, the soil remains in a good condition so we can use the land in the future as well. This is what I like to do and feel good about*". Similarly, "protect the environment" also leads to the values "for the next generation" and "feel good about myself". Respondents reported that intercropping, as a low input system, reduced soil and water pollution while enhancing soil health. All of these factors were perceived to benefit future generations, which is a value that respondents want to achieve. It was believed that doing so made farmers feel good and proud of themselves, as indicated by a respondent: "*Environment protection means, for example, not having to plough or cultivate the fields as often. To continue farming, I need to take*

consideration to the environment and try to do what's best for it. Being a farmer is the best thing I know". To summary, there exists multiple interlinks among different types of values.

5. Discussion

We used a MEC approach (Gutman, 1982) and laddering interviews (Reynolds and Gutman (2001) to investigate intercropping farmers' perception about the attributes of intercropping, associated consequences and values, which are desirable end-states that farmers strived to achieve. Data were collected via in-depth interviews with 33 Swedish farmers, who have adopted intercropping. For the first time, this study revealed intercropping attributes and consequences experienced by intercropping adopters. Another novelty of the study lies in the mechanism in which values drive farmers' decision to intercrop. Specifically, we uncovered how the perceived attributes and corresponding consequences of these attributes mediate the relationship between the values farmers aim to achieve from intercropping and their adoption decision.

We elicited a range of intercropping attributes perceived by interviewed farmers. These include better crop yield, soil conservation, better fodder, improved weed and pest management, enhanced biodiversity, resilience, nitrogen fixing ability, environmentally friendly, and beautiful surrounding. Some of them like soil conservation, environmental friendly, and enhanced biodiversity were also realized for organic farming, from farmers' perspective (Leduc et al., 2023). Nevertheless, the attribute "nitrogen fixing" was not reported by farmers in the above study, suggesting that it is unique for intercropping systems, as shown by our result. An intercropping study (Himanen et al., 2016) also found similar potentials of intercropping perceived by Finish participants. Diverging from Himanen et al. (2016), we discovered the attribute "better fodder" as one of the most important attributes. This attribute, together with its perceived consequences (healthy animals, increased milk yield, reduced costs, profitability, self-sufficiency), reflects the specific context in our study, in which, most of the studied farms are mixed farms, where intercropping outputs are often used for animal feed in a farm. This mirrors a study in Sweden, in which farmers with livestock production were more likely to be at the higher stages in intercropping adoption process (Ha et al., 2024). Our study highlights that identified perceived attributes and consequences of intercropping are context dependent. Thus, not only behavioural, but also situational factors shape farmers' decision to intercrop.

These perceived attributes were associated with perceived consequences. Among them, higher profit, effective and reduced costs, and self-efficiency were the most dominant. These four consequences of intercropping are also recognized by stakeholders in a study from Finland, a country with similar intercropping types and climate condition as Sweden (Himanen et al., 2016). Similarly, less inputs, fewer costs, and profit are among dominant perceived consequences of organic farming (Leduc et al., 2023), suggesting the efficient use of resources when adopting sustainable farming practices. Our result above implies the importance of perceived economic incentives in intercropping adoption. Nevertheless, we found that farmers valued not only economic but also environmental benefits of intercropping. This is evident through the three perceived consequences including "protect the nature", "solve climate problems", and "avoid pollution" being cited by approximately 60 % of respondents (22 farmers).

The attributes and consequences of intercropping found in this study are unique to intercropping adopters with specific farming situations and experience. Most of respondents in this study were experienced adopters (8 years on average) and had a high interest in intercropping with legumes and organic farming. In MEC elicitation, knowledge of the product (intercropping practice as our case) and range of convenience (e.g., pesticides being outside the range of convenience of organic farmers) determine the presence or absence of a construct (Kilwinger and van Dam, 2021). Given their experience, our respondents are expected to have a good knowledge of intercropping. In addition, since most of them are organic farmers, they intercropped extensively with legumes to produce natural nitrogen and abstain from using pesticides. Thus, they were evidently aware of the economic and environmental benefits from the practice. It can be noted that our findings, based only on the perspective of only adopters, differ from another survey in Sweden by Ha et al. (2024), which includes both adopters and non-adopters. While intercropping adopters in the current study were aware of the multiple economic and environmental benefits of intercropping, respondents in the study by Ha et al. (2024) did not show a clear favourable attitude to these benefits, especially economic. By using the MEC approach and focusing on intercropping adopters, we were able to capture the benefits of intercropping that farmers have experienced. This way, our findings are specific for intercropping adopters and differ from other related studies that aggregate results from both adopters and non-adopters in their analysis.

Interestingly, we found that profit was the means to an end rather than an end itself. It enables the attainment of a broad range of both pecuniary and non-pecuniary values that go beyond pure profitability. Specifically, profit from intercropping was believed to lead to viable farm business and better livelihood, a salient pecuniary value. Profitability was also connected to personal values with social and hedonic connotations including "for the next generations", "improved food security", "feel good about myself', and "be a good farmer". Broadly speaking, respondents believed that financial gains from intercropping provides the means for them to address societal problems and fulfil their desire of being a good and responsible farmer. This result echoes a MEC study by Leduc et al. (2023), which found that for Swedish organic farmers, profit acted as an instrument to achieve societal security and the feeling of satisfaction. The finding of current study implies that farmers are driven by social and environmental values for which profit is a means. This emphasises that we need to study farmers as utility maximiser rather than profit maximisers. Here, utility means the overall satisfaction derived from both non-monetary and monetary outcomes.

Through identified values, an image of intercropping adopters who are not purely profit-oriented was revealed. The co-existence of both pecuniary and non-pecuniary values suggests that intercropping farmers care about not only financial gains but also social and environmental problems. In our study, 27 out of 33 respondents referred to both economic and non-economic orientations when conceptualising their values. Among non-economic oriented values, "protecting the environment" was cited by 18 respondents. This result is in line with Streletskaya et al. (2020), who indicated that social and environmental considerations drive farmers' decision to participate in pro-environmental programs. Our finding is also consistent with Leduc et al. (2023), which shows that organic farmers perceive the attainment of economic, social, and environmental values from the adoption of organic farming. According to the review by Sagiv and Schwartz (2022), a consistent finding across cultures is that universalism values, which refers to an understanding, appreciation, tolerance, and protection for the welfare of all people and of nature, are positively related to pro-environmental behaviours. In line with previous research on pro-environmental behaviours, this study highlights that the adoption of intercropping is driven by not only pecuniary but also non-pecuniary values that farmers pursue.

Among a set of identified values, "viable farm business" appears as the most salient. Though both pecuniary and non-pecuniary values shaped farmers' decision to adopt intercropping, like in the case for pecuniary benefits, pecuniary values appear to be more influential than non-pecuniary values. The finding is also in line with an array of empirical evidence worldwide, which confirms that economic incentives are one of the main motives to adopt sustainable farming practices among many rural landholders (Dessart et al., 2019). Existing literature also shows that economic benefits of intercropping are context dependent and certain intercropping systems like oat-pea intercropping used for feed can be a viable practice (Manevska-Tasevska et al., 2024).

This study also found that self-sufficiency was perceived to enhance

farmers' autonomy and allow famers to continue farming the way they like, as evidenced by the connection between "self-sufficient", a perceived consequence of intercropping, and the personal value "do the job I want". Both "self-sufficient" and "do the job I want" relate to the concept "food sovereignty", which is defined by Campesina (2007) as "*the right of peoples to healthy and culturally appropriate food produced through ecologically sound and sustainable methods, and their right to define their own food and agriculture systems*". Our finding implies that intercropping was believed to enhance farms' self-sufficiency, thereby contributing to food sovereignty among rural landholders by strengthening their control over resources, the right to farm the way they wish, and agency - the capacity to make their own decision.

The results of this study confirm the argument made by Gasson (1973) in her influential paper about the existence of value systems held by farmers and the interconnectedness among different values within the value system. We found that for most of the interviewed farmers, intercropping adoption led to the achievement of several values and some serve as a means to attain others. For instance, intercropping helped farmers take care of the soil, which was viewed as the means for contributing to the society and the next generation, and for feeling good about themselves. Moreover, in farmers' views, intercropping adoption enabled them to protect the environment, which in turn allowed them to continue farming and made them feel good. Based on the influential work of Rokeach (1973), the values "take care of our soil" and "protect the environment" can be classified as instrumental values while "for the society", "for the next generation", and "feel good about myself" are terminal values. Terminal values are desirable end-states while instrumental values refer to desirable modes of behaviour that provide a means to achieve the end-states. These findings highlight that sustainable farming practices like intercropping can result in the attainment of different values that farmers pursued.

Based on the personal value typology of Schwartz (1994, 2012), the end-stages highlighted in this study can be interpreted in light of personal values that are categorized into five emerged value groups. These groups include "hedonism", "universalism", "achievement", "security", and "stimulation". Accordingly, "feel good about myself", "be a good responsible farmer", and "do the job I want" belongs to "hedonism" group, which refers to the positive feelings for oneself. "Animal welfare", "for the next generation", "take care our land", and "protect the environment" can be grouped into "universalism", which implies the appreciation and protection for the welfare of all people and the nature. "My livelihood" and "viable farm business" can be labelled as "achievement", which means personal success. "Improved food security" and "innovative farmer" belongs to the "security" and "stimulation" groups, respectively. Stimulation means the excitement, novelty, and challenges in life. The findings above suggest that intercropping farmers have strived for not only their own success but also societal welfare. Focusing in on farmers' statements regarding values in the "hedonism" group, we revealed that many farmers felt proud about themselves and had a strong desire to build a good self-image.

This study presents some limitations. First, since it only includes intercropping adopters, it does not provide information on the reasons for non-intercropping behaviour and the personal values of non-adopters while this information is important to inform interventions targeting non-adopters. Second, given the setup of MEC, the study could only reveal the benefits of intercropping and therefore being unable to capture perceived barriers to the adoption. Third, though MEC application can provide in-depth insight into farmers' motivations in intercropping adoption in a specific situation, the question whether changes in situational circumstance can lead to changes in farmers' motivations remains unanswered.

Via the application of MEC, we could gain in-depth understanding of perceived attributes in intercropping, the consequences of attributes and values farmers aim to achieve by intercropping. While this brings useful insights to farmers' reasoning behind using intercropping, other behavioural factors, which are outside the scope of this study, are also relevant for understanding intercropping adoption. Future MEC research is needed to understand farmers' choices of intercropping beyond reasons highlighted by the MECs such as risk aversion, farmers' innovativeness, and social interactions between farmers to further the understanding about intercropping adoption. For example, employing MEC, Foolen-Torgerson et al. (2023) examined the influence of social interactions on farmers' choice of soil health promoters. It would be interesting to test the same idea in MEC studies on intercropping adoption decision. Moreover, since this study revealed the value systems of intercropping adopters only, it would be interesting to explore value segmentation across adoption stages of intercropping in future studies.

6. Conclusions and policy implications

This study employed MEC approach to explore personal values driving farmers' decision to intercrop in Sweden. Since MEC is typically used for consumer research, we have adapted it for the context of the study. By using MEC, this study was able to provide unique insight into the linkages among perceived attributes and consequences of intercropping, and farmer personal values to map farmers' cognitive models of cause and effect in intercropping adoption. In this way, the study advances the existing literature on farmers' behaviour in intercropping adoption and MEC applications in farmer studies that are currently limited.

Through the study, intercropping adopters have been portrayed as knowledgeable farmers who could recognise a range of attributes and benefits offered by intercropping. In the farmers' view, intercropping was profitable and could improve farms' self-sufficiency, which is particularly important given the context of the current energy crisis. Intercropping was also perceived as a solution to climate change and environmental degradation. Such perceived consequences allowed for the attainment of multiple values pursued by farmers. These include farmer' livelihood, a viable farm business, an innovative farmer, improved animal welfare, improved food security, contributing to the next generation and society, feel good about oneself, do the job the farmer wants, be a good farmer, taking care of our land, and protecting the environment. Though pecuniary values (viable farm business, farmer' livelihood) appear as the strong drivers of intercropping adoption, the co-existence of different pecuniary and non-pecuniary values suggests that intercropping farmers have strived for not only business success but also environmental protection, social responsibility, and the happiness in farming occupation. The result also implies that both pecuniary and non-pecuniary values jointly shape the decision to intercrop.

Given the important role of both economic incentives and pecuniary values, intercropping adoption can be stimulated by making intercropping practices more economically viable. For that purpose, financial supports such as Agricultural Environmental Scheme (AES) are required to compensate farmers for income losses resulting from intercropping or reward them for providing environmental goods (Manevska-Tasevska et al., 2024). Moreover, when intercropping systems entails higher production costs compared to mono-cropping, market-based instruments that focus on innovative solutions should be implemented to enhance market conditions for less competitive intercropped products, e.g. via developing and expanding markets for new products and improving supply chain coordination (Brannan et al., 2023; Manevska-Tasevska et al., 2024).

Given their experience, social and environmental considerations, intercropping farmers can be role models for those who have not yet intercropped and play a role in accelerating the transition towards intercropping. Policies that facilitate knowledge sharing is needed. Communication initiatives on intercropping should target intercropping adopters as key communicators, who can build relatability as co-farmers and share their views and experiences with others. Personal values are relatively permanent (Sagiv and Schwartz, 2022), and thus are unlikely to change in the short term. For non-adopters of intercropping, what can

be changed is their awareness for intercropping attributes and positive consequences or benefits. Limited knowledge of the benefits of intercropping prevents the adoption (Ha et al., 2023). Thus, communication programs should focus on forming perceived attributes and benefits of intercropping that express the important values of non-adopters. Though little is known about whether adopters and non-adopters differ in value systems, evidence from a related study by Leduc et al. (2023) shows that both organic and non-organic adopters express pecuniary values and non-pecuniary values. Thus, it is expected that adopters and non-adopters of intercropping might share several important values. Nevertheless, messages delivered to non-adopters should be neutral, considering benefits, technical challenges, and contextual factors associated with intercropping. Additionally, scientific evidence of viable and sustainable intercropping systems like oat-pea intercropping used for feed (Manevska-Tasevska et al., 2024) should be disseminated to farmers. Non-adopters of intercropping, who are operating mixed farms or livestock farms like our respondents, should be the focus of communication efforts.

This study suggests that intercropping adoption could contribute to not only economic and environmental sustainability but also social stability of rural areas. Accounting for farmers' perspective, we highlight that intercropping can empower rural landholders by strengthening their agency and self-sufficiency. We stress that intercropping adoption can improve the relationship between farmers, their land, and their communities since it fulfils their desire to continue farming, contributes to the society, in addition to feeling good about themselves. All of these are crucial to the development of rural areas.

CRediT authorship contribution statement

Thanh Mai Ha: Writing – review & editing, Writing – original draft, Visualization, Validation, Software, Methodology, Formal analysis, Conceptualization. **Frida Svensson:** Writing – review & editing, Methodology, Data curation, Conceptualization. **Julia Thelin:** Writing – review & editing, Methodology, Formal analysis, Data curation. **Gordana Manevska-Tasevska:** Writing – review & editing, Writing – original draft, Investigation, Funding acquisition, Conceptualization. **Martin Weih:** Writing – review & editing, Writing – original draft, Funding acquisition, Conceptualization. **Helena Hansson:** Writing – review & editing, Writing – original draft, Validation, Supervision, Methodology, Investigation, Funding acquisition, Conceptualization.

Declaration of interest

This study has no conflict of interest. All authors have agreed with the content of this manuscript and the selected journal.

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Appendix A. Supplementary data

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Data availability

Data will be made available on request.

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