agromix

Report on the acceptance, institutional barriers and conditions to adoption of successful and improved value chain network (VCN) approaches

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[1] **R**=Document, report; **DEM**=Demonstrator, pilot, prototype; **DEC**=website, patent fillings, videos, etc.; **OTHER**=other

[2] **PU**=Public, **CO**=Confidential, only for members of the consortium (including the Commission Services), **CI**=Classified

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1 Executive summary

Background

The transition to Mixed Farming (MF) and Agroforestry (AF) marks a pivotal shift from traditional agricultural practices towards more integrated, sustainable, and diversified farming systems. However, this transition is complex and poses several challenges. It involves integrating various components like annuals, perennials, green manure, animals, and diverse tree species, making it complex. MF combines crop and livestock components, adding to the complexity, while AF requires the cultivation of diverse tree species alongside crops, demanding careful management and knowledge of forestry and agriculture practices.

One key challenge is the absence of ready-made solutions for MF and AF, forcing farmers to rely on knowledge acquisition and experimentation. Additionally, these systems take a longer time to yield benefits compared to traditional agriculture, as they involve multiple components with varying maturation periods. Complex decision-making is another obstacle, as farmers must navigate numerous options and often modify their systems over time, introducing uncertainty. Achieving self-sustainability and self-diffusion in MF and AF takes more time compared to earlier agricultural innovations. Social and economic factors significantly influence adoption decisions, with farmers considering increased productivity, risk reduction, and economic viability. Therefore, a socio-economic analysis of adoption literature is crucial. This contributes to a better understanding of acceptance, institutional barriers, and conditions to adoption. Which then can lead to successful and improved VCN approaches for agroforestry and mixed farming adoption.

Objectives and Significance

The primary objective of this report is to analyse the institutional barriers and conditions that influence the adoption of MF and AF practices, particularly focusing on the role of value chain network approaches in facilitating adoption. By synthesising the findings from the literature review, survey data, and econometric analyses, the report aims to provide actionable insights for developing targeted interventions and policies to enhance the adoption rates of these sustainable practices. The integration of theoretical insights with empirical findings offers a robust framework for understanding the complex dynamics of MF and AF adoption and the multifaceted nature of the decision-making processes involved.

Socio-economic analysis of adoption literature

In sociology, innovation refers to a new idea, practice, or object that people recognise as new. The term 'adoption' describes the act of people starting to use or follow this innovation. 'Diffusion' means the innovation spreads widely across a community or society. To ground the analysis in a solid theoretical foundation, a comprehensive literature review was conducted for MF and AF, involving 401 papers spanning from 1980 to 2023, identified through specific keywords on Scopus and Google Scholar. After several exclusion rounds, 20 relevant papers, published between 2008 and 2023 and focusing specifically on adoption choices through surveys and econometric methodologies, were selected. This literature review serves as a critical theoretical framework for the subsequent analysis, providing insights into the drivers, barriers, and conditions influencing the adoption of MF and AF practices.

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Research on adoption in agriculture has focused on two levels: individual farm-level adoption decisions and macro-level diffusion patterns. Farm-level adoption examines factors influencing a household's decision to adopt innovations, while diffusion studies investigate how innovations spread across larger populations or regions. A combination of social, economic, and cultural factors influences the adoption and diffusion of agricultural innovations. Sociologists focus on social aspects, such as characteristics of adopters, perceptions of innovations, and communication channels, while economists emphasise profitability, investment risks, and economic forces driving adoption. Various frameworks and models, such as the expected utility framework, are used to model technology adoption under uncertainty. These models consider factors like risk aversion, wealth, and experience in adoption decisions. Alternative approaches include hierarchical decision tree models and behavioural economics models.

In the context of MF adoption studies, research initially focused on low-input and sustainable agriculture, assessing risks and impacts. However, interest in MF practices surged in the early 2000s, with researchers examining benefits and external factors influencing adoption.

AF adoption studies followed a similar trajectory, with descriptive research in the 1990s evolving into more comprehensive studies in the 2000s. Both MF and agroforestry adoption research have evolved over the years, incorporating multidisciplinary approaches, advanced statistical techniques, and a deeper understanding of the complex decision-making processes involved in the adoption of sustainable agricultural practices.

The study of adoption in MF and AF practices has evolved into two distinct lines of inquiry: Ex-Ante Studies and Ex-Post Studies. Ex-Ante Studies assess the potential adoption of MF/AF systems by evaluating feasibility, profitability, and acceptability, providing insights for decision-makers. Ex-Post Studies focus on explaining past adoption behaviour and the influence of factors like farmer characteristics, farm attributes, and socioeconomic variables on adoption decisions.

Survey and Econometric modelling

An experimental approach was adopted for the research, combining a large survey with econometric modelling to delve into farmers' decision-making processes and the external factors influencing adoption rates. Over 400 farm households in various climatic regions were surveyed to understand their intentions towards MF and AF adoption under different policy and market scenarios. This methodological choice, underpinned by the theoretical insights from the literature review, allows for a nuanced analysis of the factors driving or hindering the adoption of sustainable farming practices.

Results

The analysis of sales channels for agroforestry and conventional farming systems, shows a nuanced differentiation in where and how products are sold. Agroforestry farms tend to sell a larger share of their products through cooperatives, especially livestock products, and demonstrate a stronger engagement with collective sales channels. This is contrasted with conventional farms, which have a higher tendency towards individual sales, such as to processors for arable products. Mixed farms show a similar pattern to agroforestry, with a significant portion of their economic value coming from cooperative sales and a higher engagement with collective sales channels, indicating an integrated approach to farming activities.

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Farmers' opinions about the current supply chain reveal that agroforestry farmers perceive more stability in prices and are less concerned about the restrictiveness of production standards and the reliance on external inputs. This contrasts with conventional and mixed-farm systems, where such concerns are more prevalent. The opinions suggest that agroforestry practices may offer a more resilient and autonomous approach to farming, reducing vulnerability to external market and environmental factors.

Motivational factors for adopting sustainable farming practices highlight the significance of improving resilience against climatic and market changes for agroforestry farmers. Policy incentives, such as payments from agricultural support schemes, are more influential for those considering mixed farming. The findings suggest that policy support is crucial for encouraging the adoption of these practices, with a particular emphasis on reducing dependence on external inputs and navigating regulatory changes.

The behaviour of farmers regarding the adoption of AF and MF practices is dissected into categories based on their current and potential future adoption. Active adopters are characterised by a commitment driven by environmental concerns and personal values, while passive adopters are motivated by profitability. Conditional non-adopters are open to adoption if it becomes more profitable, whereas resistant non-adopters are unlikely to change due to various barriers, including scepticism towards new systems and resistance to change.

Econometric analyses further elucidate the factors influencing farmers' decisions to adopt MF and AF practices compared to conventional farming methods. Two separate multinomial logit regression models were used to analyse the adoption of MF and AF under future scenarios, considering a range of explanatory variables that include farm characteristics, farmer demographics, and external factors.

Mixed Farming (MF) Adoption

- **Agricultural Education and Technical Advice:** Like AF, agricultural education and access to technical advice are positively associated with the adoption of MF practices. Educated farmers and those with advisory support are more likely to explore and adopt mixed farming systems.
- **Land Availability:** The availability of land continues to be a positive factor for MF adoption, indicating that spatial resources provide an opportunity for implementing mixed farming systems.
- **Agro-Climatic and Environmental Scheme Participation:** Participation in agro-climatic and environmental schemes is positively linked to the adoption of MF, suggesting that policy incentives and support for environmentally friendly practices can encourage farmers to adopt mixed farming.
- **Diversification:** The tendency towards diversification is a strong predictor of MF adoption, reflecting a broader strategy of risk management and sustainability.
- **Livestock Activity:** Unlike AF, livestock activity shows a positive association with passive adoption of MF, indicating that livestock farmers might consider mixed farming as an alternative under certain conditions but are not actively pursuing it.

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Agroforestry (AF) Adoption

- **Land Management:** There is a positive correlation between the availability of land and the likelihood of adopting AF practices. This suggests that farmers with more land are more inclined to integrate agroforestry into their farming practices, possibly due to the flexibility larger landholdings offer for diversification and experimentation with sustainable practices.
- **Organic Farming:** Farmers already engaged in organic farming are more likely to be active adopters of AF. This indicates a synergy between organic farming principles and agroforestry practices, both of which emphasise environmental sustainability and ecological balance.
- **Diversification:** The model shows that farms engaged in diversified activities, beyond traditional crop cultivation and livestock rearing, are more likely to adopt AF. This might reflect a broader approach to farming that values innovation and sustainability, making such farmers more receptive to agroforestry.
- **Technical Advice:** Access to technical advice is a significant factor in adopting AF, particularly for active and conditional non-adopters. This underscores the importance of knowledge transfer and advisory services in promoting sustainable farming practices.
- **Agricultural Education:** Farmers with a background in agricultural education are more inclined towards adopting AF, highlighting the role of formal education in shaping perceptions and openness to sustainable practices.
- **Country-Specific Factors:** The model indicates significant country-specific differences in AF adoption, suggesting that regional policies, market conditions, and cultural factors play a critical role in influencing farmers' decisions.

Conclusion

The comparative analysis of sales channels reveals a nuanced preference for cooperative and collective sales among AF and MF practitioners compared to conventional farmers, who lean more towards individual sales channels. The analysis likely reiterates farmers' more favourable views on supply chain stability and flexibility in AF and MF systems, highlighting the perceived benefits in terms of price stability, reduced dependency on external inputs, and less restrictive production standards. These perceptions underscore the alignment of AF and MF practices with resilience and sustainability goals.

The econometric analysis findings emphasise the significant role of land availability, agricultural education, technical advice, and diversification in promoting the adoption of sustainable farming practices. The analysis probably underscores the synergy between organic farming and AF adoption, and the importance of policy support and environmental schemes in encouraging MF practices.

The results highlight the need for targeted policy interventions, education, and advisory services to support farmers in transitioning towards these practices. Concluding remarks could also stress the importance of considering regional differences and farmers' specific contexts in designing support mechanisms and incentives.

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2 Expected impact

The adoption topic in agriculture, particularly in the context of sustainable practices like Mixed Farming (MF) and Agroforestry (AF), can have a profound and far-reaching impact. One of the primary impacts of quantitative adoption analysis is on individual farmers. By examining the factors that influence the adoption of MF and AF, this analysis empowers farmers with critical information.

Farmers can make more informed decisions about whether to embrace these sustainable practices on their farms. For example, if the analysis reveals that access to credit is a significant driver of adoption, farmers can explore financial options and better plan their investments. Quantitative analysis provides policymakers with insights into the specific barriers and drivers of adoption. Armed with this knowledge, they can design and implement targeted interventions to promote sustainable agriculture. Whether it's providing credit access to resource-constrained farmers or offering training programs on agroforestry techniques, these interventions can be more precisely tailored to address the identified needs. Resource allocation is a critical aspect of agricultural development. Limited resources, including funding, expertise, and manpower, must be directed where they can have the most significant impact. Quantitative analysis allows for evidence-based resource allocation. Policymakers can prioritise initiatives and investments that are more likely to lead to increased adoption, ensuring that resources are used efficiently.

Many countries and regions have set sustainability goals related to agriculture. Quantitative analysis serves as a tool for monitoring progress toward these goals. By tracking adoption rates and identifying trends over time, policymakers can assess whether the adoption of MF and AF practices is aligning with broader sustainability objectives. Agricultural policies play a pivotal role in shaping farming practices. Quantitative analysis can inform the development and refinement of these policies. It allows policymakers to understand which policy measures are most effective in driving adoption and which may need adjustments or enhancements. Quantitative analyses often include cost-benefit assessments.

This aspect is crucial for both farmers and policymakers. For farmers, understanding the economic benefits of adopting sustainable practices can influence their decisions. Policymakers can use these assessments to justify investments in sustainable agriculture by demonstrating the potential for improved livelihoods and economic gains for farming communities. Sustainable agricultural practices like AF can have positive environmental impacts, such as increased carbon sequestration and improved soil quality. Quantitative analyses can quantify these environmental benefits, which is essential for advocating for practices that mitigate the environmental impact of agriculture. The findings of quantitative analyses are valuable knowledge assets.

They are disseminated through various channels, including workshops, training programs, and publications. Extension services and agricultural advisors can use these insights to educate farmers and build their capacity in adopting sustainable practices. When quantitative analyses identify factors that positively influence adoption, successful interventions can be scaled up or replicated in other regions or communities. This scaling-up process can accelerate the adoption of sustainable agricultural practices on a broader scale. Sustainable agricultural practices like MF and AF can enhance the resilience of farming systems to climate change. Quantitative analysis can assess the role of these practices in climate adaptation and highlight their importance in building resilient farming communities.

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In conclusion, quantitative analysis studying adoption in agriculture has multifaceted impacts. It **empowers** farmers with knowledge to make informed choices, **informs** policymakers on effective strategies for sustainable agriculture, and contributes to achieving broader sustainability goals. By identifying barriers, drivers, and economic benefits, this analysis plays a pivotal role in transforming agricultural systems towards greater sustainability and resilience, benefiting both farming communities and the environment. It represents a vital step toward a more sustainable and prosperous future for agriculture.

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3 Context and objectives

WP5 with the study of the socio-economics and the value chain assessment is a central component of the AGROMIX research project. WP5's primary objective of executing a comprehensive socio-economic analysis pertaining to mixed farming (MF) and agroforestry (AF) systems across various levels, encompassing individual farm units, broader landscapes, and complex value chains. The overarching goal is to facilitate and accelerate the shift towards agricultural methods that exhibit greater sustainability and resilience in the face of environmental challenges within the European agricultural sector.

The workpackage is composed by 5 tasks (Figure 1). **Task 5.1** focuses on assessing the financial and socio-economic performance of selected MF/AF systems to comprehend their economic implications. **Task 5.2** seeks to identify pivotal characteristics that drive the success of Value-Chain Networks (VCNs) within MF/AF systems, yielding insights for potential replication. **Task 5.3** investigates farmers' attitudes, preferences, and the factors influencing the adoption of VCN approaches in agriculture, with a specific emphasis on addressing challenges in implementation. **Task 5.4** conducts integrated economic and life cycle assessments of policy instruments crafted to bolster MF/AF systems and VCNs, critically evaluating their sustainability and impact. Lastly, **Task 5.5** endeavours to formulate practical guidelines to facilitate the establishment and maintenance of successful MF/AF VCNs, offering policy recommendations to promote sustainable agricultural practices.

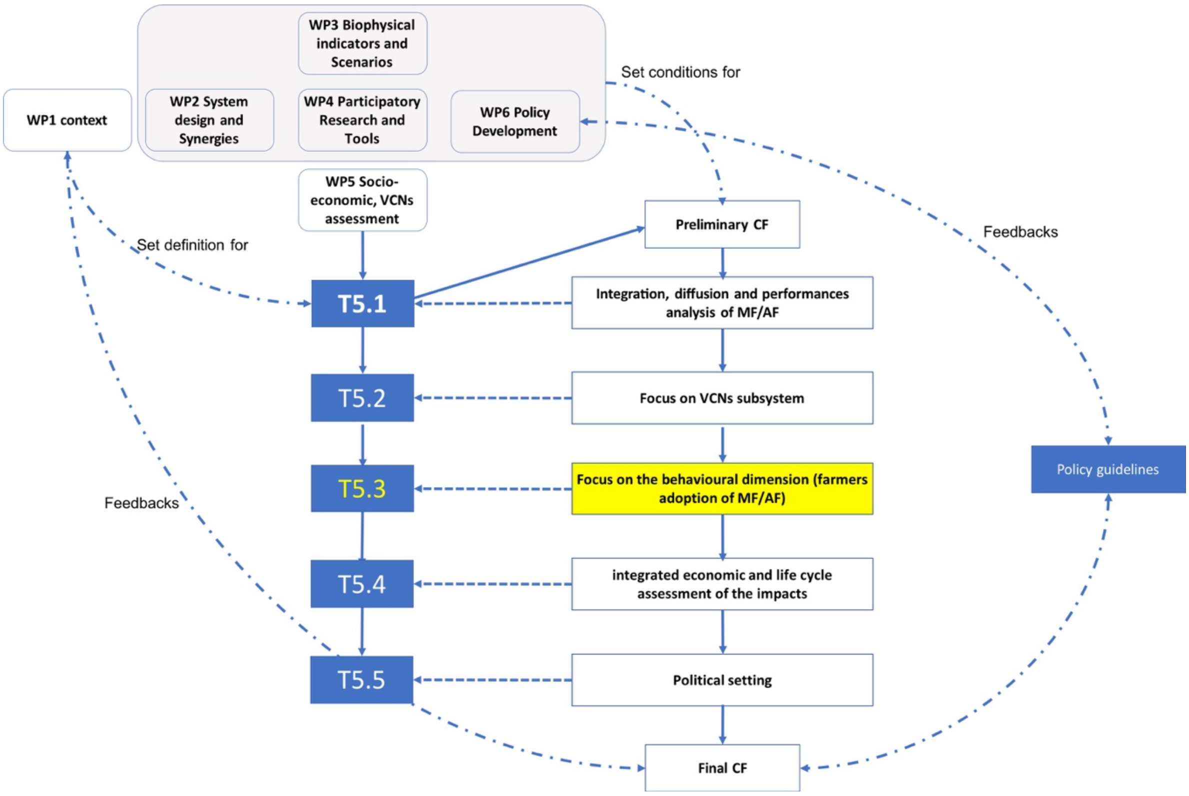

Figure 1. WP5 Tasks flow and relation with other WPs

Report D5.3 explores how the agricultural community adopts MF/AF systems, examining farmers' attitudes, preferences, and the factors that influence their decision to adopt new VCN approaches. It assesses acceptance levels, identifies obstacles to VCN adoption, and pinpoints conditions needed for successful VCN implementation.

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To accomplish these objectives, Task 5.3 strategically leverages insights and data gleaned from Task 5.1, which examined the financial and socio-economic performance of MF/AF systems, and Task 5.2, which identified key characteristics contributing to the success of VCNs within these systems.

The core activities of Task 5.3 involved employing a standardised survey methodology, targeting representative producers across selected European countries such as Italy, Germany, Netherlands, UK, Serbia, and Greece. The survey was designed to probe farmers' responses under varying market conditions and evolving policy dynamics. Behavioural econometrics methods were applied to meticulously analyse and interpret farmers' behaviour and decision-making processes concerning VCN adoption. The expected outcomes encompassed the multifaceted understanding of farmers' decision-making and behaviour in relation to Value-Chain Networks (VCNs).

The research activities were designed to provide comprehensive insights into farmers' attitudes towards innovative VCN business models and governance structures, including both short supply chains and more extensive VCN configurations. Moreover, the task aimed to identify and articulate the various barriers, obstacles, and challenges that farmers might have encountered when considering VCN integration into their agricultural practices. Simultaneously, it endeavoured to pinpoint the enabling factors and conditions necessary to encourage and facilitate the adoption of VCNs within agricultural operations. Additionally, the task delved into the complex interplay between market conditions and policy frameworks, elucidating their influence on farmers' decisions regarding VCN adoption.

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3.1 Explanation and justification of delays

Unforeseen delays and challenges *had a significant impact on the completion of Task 5.3.*
These challenges initially stemmed from disruptions caused by the COVID-19 pandemic, which affected the completion of previous tasks. These prior tasks were crucial as their outcomes played a pivotal role in shaping the survey design, data collection strategies, and the overall approach of Task 5.3. Consequently, the pandemic-induced interruptions in the earlier phases had a cascading effect on the timelines and progress of Task 5.3, as well as on subsequent WPs and tasks within the AGROMIX project.
Furthermore, even after the pandemic, difficulties arose in coordinating the survey design, and the data collection efforts among project partners, further complicating the task's progress. Despite these hurdles, dedicated efforts were made to overcome these challenges and ultimately resume and finalise the necessary data collection activities, all while steadfastly upholding the project's objectives. In Italy, we are completing the data collection, and we have reached 80%. In Serbia, the expected quota has been reached, and in Greece, it has been completed. In England, support has also been requested from the coordinator to help the UK partner implement a hybrid collection strategy (utilising multiple sources to maximise efforts). In Germany, an agency has been found to gather the missing data and minimise the delay.

This is the final document that encompasses an executive summary, an impact statement, a chapter on the adoption of MF/AF, and an extensive literature review with analysis. It also includes a comprehensive methodological section, along with a presentation of survey results in detailed matrices. The annex features the finalised questionnaire, carefully crafted with input from various project partners and complete coding for the variables under investigation. This document represents the culmination of our analysis, with no sections pending updates.

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4 Adoption of sustainable agricultural practices

4.1 The adoption challenge - acceptance, institutional barriers and conditions

Analysing the adoption of MF/AF is crucial for understanding the shift from traditional to sustainable farming. This review highlights key factors like complexity, effort, and benefits, which are central to farmers' decisions. It addresses the challenges in adopting these methods, including the need for tailored solutions, decision-making complexities, sustainability, and economic impacts. The analysis has identified the following six major challenges:

1. **Complexity:** Adopting MF/AF methods is significantly more complex than conventional farming due to the need to balance a variety of elements like annuals, perennials, green manure, fodder, animals, and other components. In MF, the integration of crop and livestock demands careful coordination of growth cycles, nutritional needs, and harvest timings, along with animal care. AF introduces complexity with the cultivation of diverse tree species alongside crops, requiring attention to species interactions, spatial planning, and canopy management. Additionally, practices like contour hedgerows and alley cropping in AF demand a thorough understanding of both forestry and agriculture to create a cohesive system (Rafiq et al. 2000).

2. **Lack of Pre-Packaged Solutions**: In MF and AF, unlike traditional farming which has standardised practices and inputs, there are no one-size-fits-all solutions. Farmers must therefore rely on gaining knowledge, experimenting, and tailoring approaches to successfully implement these diverse farming approaches (Barrett et al. 2002).

3. **Longer Timeframe for Benefits:** MF and AF involve longer periods before benefits are seen, compared to traditional farming where annual crops yield quicker returns. In MF and AF, integrating diverse components and waiting for certain crops or trees to mature can take years. This extended timeline, often three to six years, can affect adoption rates as farmers must invest in long-term experimentation and adaptation to successfully manage these systems (Franzel and Scherr 2002).

4. **Complex Decision-Making:** The multifaceted nature of both AF and MF complicates the analysis of adoption patterns. Farmers engaging in either AF or MF are presented with a plethora of options to choose from and often find themselves modifying their chosen systems over time. This complexity adds an element of uncertainty to the adoption process (Vosti et al., 1998).

5. **Sustainability and Diffusion:** Both AF and MF projects typically demand more time to achieve self-sustainability and self-diffusion compared to earlier Green Revolution innovations in agriculture (Amacher et al., 1993).

6. **Socio-Economic Considerations:** Research suggests that the decision to adopt MF/AF is significantly influenced by social and economic factors. This includes expected contributions to increased productivity, risk reduction, and enhanced economic viability compared to alternative practices (Arnold and Dewees, 1995; Sain and Barreto, 1996; Salam et al., 2000; Scherr, 2000). Therefore,

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conducting a social and economic-based analysis of the adoption literature is indispensable to assess the feasibility and potential benefits of both AF and MF systems.

4.2 Definitions of adoption, diffusion, and innovation

In sociology, innovation is conceptualised as an entity— be it an idea, practice, or tangible object— that is perceived as novel by an individual. This definition emphasises the subjective nature of individual perception. Adoption, in this context, refers to the process an individual undergoes from first encountering an innovation to ultimately integrating and using it in practice. This process goes through several stages, from becoming aware of the innovation to fully accepting and using it (Rogers and Shoemaker, 1971; Rogers, 1983; Evans, 1988).. However, this type of definition does not allow for a precise assessment of adoption on different scales, such as at the farm level (Feder et al., 1985). To define adoption at the farm-level, we need to look at how the innovation process is managed. From an economic perspective, innovation is seen as a technological aspect of production that introduces uncertainties, both perceived and objective, about its effects on production. Farmers address these uncertainties over time by gaining experience, adjusting the innovation, and improving their skill in its use. As a result, adoption, according to Feder et al. (1985), is defined at the farm level in economic terms as the degree to which a new technology is used in a long-term equilibrium. This depends on the farmer having complete information about the innovation and its potential benefits.
Conversely, diffusion pertains to the dissemination of innovations, particularly those adjudicated as "successful," through their integration with or displacement of extant, suboptimal alternatives (Sarkar, 1998). The diffusion paradigm encapsulates both spatial and temporal dimensions, thereby measuring the extent and duration through which the innovation is adopted and operationalised.
According with these definitions the early adopters are frequently identified as innovators, and the diffusion process encompasses the dissemination of the innovation to other segments of the population (Feder and Umali, 1993). To recap:

- **Adoption** signifies the cognitive acceptance and comprehensive utilisation of a perceived novel idea or practice.
- **Innovation** constitutes the introduction of fresh concepts, practices, or objects into a specific context, often accompanied by inherent uncertainties.
- **Diffusion** pertains to the widespread proliferation of successful innovations as they supplant or amalgamate with existing alternatives, considering both spatial and temporal dimensions.

These fundamental concepts are integral to comprehending the dynamics of technological evolution, particularly in the realm of agriculture and farming practices.

4.3 Methodology

To summarise the existing knowledge on adopting MF and AF, we carried out a literature review. Our method is systematic and clear, aiming to reduce bias by clearly stating our assumptions, following Tranfield et al. (2003)'s guidelines. Our goal is to outline the main challenges and proposed solutions for adopting MF and AF, highlighting key factors and variables for the subsequent econometric phase of our analysis. The bibliographic analysis commenced with the identification of the most pertinent scientific articles indexed in

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Scopus and Google Scholar, **published in English between 1980 and 2023**. Following the guidance provided by Atkinson and Cipriani (2018), we executed a search query employing specific keywords and their combinations on both Scopus and Google Scholar with the following three steps:

1. We consider MF as the practice of deliberately integrating crop and livestock production to benefit from the resulting ecological and economic interactions (Püttsepp et al., 2021). Therefore, given the multifaceted nature of mixed farming, our chosen keywords included "mixed farm" (or "mixed farming" or "crop and livestock" or "integrated farm" or "integrated farming") AND "adoption". Then we consider AF as the practice of deliberately integrating woody vegetation (trees or shrubs) with crop and/or animal systems to benefit from the resulting ecological and economic interactions (Burgess et al., 2015; AGFORWARD project). Therefore, the chosen keywords included "agroforestry" (OR "agroforestry systems" OR "tree-crop integration" OR "tree-livestock integration" OR "silvopastoral systems" OR "silvoarable systems") AND "adoption". We then meticulously selected papers based on their relevance to the adoption topic in agriculture, thoroughly examining titles, abstracts, and keywords. Initially, we identified 401 works, which were subsequently narrowed down to 149, considering only those papers that effectively addressed the issue of the adoption of innovative practices.
2. A secondary screening was then conducted to differentiate between papers employing a qualitative research approach and those reflecting a quantitative analysis, resulting in a final selection of 108 papers.
3. Finally, a further refinement was applied to limit the sample to papers that specifically assessed the adoption choice through surveys and econometric methodologies, excluding those that primarily focused on evaluating the influence on farm livelihoods, as well as the assessment of changes, performance, efficiency, and the impact on the sustainability of farming systems. In the end, our final sample comprises 20 papers published between 2008 and 2023.

4.4 Results

The section is structured to initially present overarching theories of adoption, subsequently narrowing down to the specifics of mixed farming and agroforestry. It emphasises the progression of research methodologies and the integration of multidisciplinary approaches in understanding adoption dynamics. The goal is to shed light on the complex interplay between social, economic, and cultural factors in the adoption and diffusion of agricultural innovations. Following this, we examine empirical studies on MF and AF adoption, highlighting ex-ante and ex-post approaches. This serves to explore the determinants of adoption choices and the challenges encountered in examining adoption patterns and impacts. This section provides the theoretical framework for the development of the survey and the selection of variables of interest for the subsequent econometric analysis.

a. General agricultural studies

Adoption studies traditionally examine individual (farm-level) and macro-level perspectives, focusing on household decisions and broader diffusion patterns, respectively (Feder and Umali, 1993). Studies focused on farm-level adoption are dedicated to understanding the factors that influence these decisions, whether analysed statically or dynamically, incorporating elements of learning and experience. Conversely diffusion

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studies investigate how adoption spreads across larger populations or regions, highlighting trends within the diffusion process concerning spatial and temporal dimensions.

In synthesis, the expected utility framework, proposed by Just and Zilberman (1983), dominates the modelling of technology adoption, emphasising the maximization of expected profit while considering risk and constraints. Extensions of this framework, such as portfolio and safety-first models (Feder et al., 1985; Bigman, 1996), and learning-based approaches (Foster and Rosenzweig, 1995), enrich the analysis by incorporating factors like risk aversion and experiential learning. The hierarchical decision tree model offers an alternative by simplifying decision-making into sequential steps (Gladwin, 1976). Overall, these models and frameworks provide deep insights into the multifaceted process of agricultural technology adoption, addressing the complexities and uncertainties inherent in such decisions.

According with our review the research on adoption and diffusion of agricultural innovation spans multiple disciplines, with sociologists exploring social influences, and economists analysing economic drivers of adoption. Viewed from a multidisciplinary perspective, adoption is recognised as a multi-dimensional process influenced by factors such as perceived profitability, establishment costs, compatibility with value systems, and the ability to communicate knowledge among adopters and potential adopters. Looking at the general agriculture application in the literature, the expected utility framework is a prevalent approach for modelling technology adoption under conditions of uncertainty. Initially proposed by Just and Zilberman in 1983, this framework addresses the need for a theoretical foundation to explain the stochastic relationship between production under new and old technologies. The central premise of the expected utility model is that adoption decisions are based on maximising expected utility or profit, considering various constraints like land availability, credit, labour, and more. This entails farmers choosing from a range of alternatives, including traditional practices, to optimise their profit or utility. The correlation of outputs between different technologies plays a crucial role in determining adoption rates, especially when risk aversion decreases with increased wealth (Marra et al., 2003). Numerous adoption models have extended the expected utility framework. Portfolio models, for instance, consider land allocation decisions as choices to maximise the expected utility of income, factoring in risk aversion levels, stochastic interactions between variables, and socioeconomic factors like wealth, age, and education (Feder and Umali, 1993). According to Feder et al. (1985), safety-first models depart from the traditional utility function, assuming that utility is zero below a certain ''disaster'' level and one above it. These models focus on minimising the risk of failing to achieve specific minimum targets or safety margins (Bigman, 1996). Learning by doing and farmer experimentation models, pioneered by Foster and Rosenzweig (1995), highlight the role of imperfect knowledge as a barrier to adoption. Experience initially enhances decision-making regarding new technologies, but its impact diminishes over time. Moreover, the experience and experimentation of neighbours can influence a farmer's adoption decisions. Farmers with experienced neighbours tend to be more profitable, creating incentives for others to rely on their 'neighbours' learning rather than engaging in experimentation themselves.

Recognising the limitations of traditional adoption literature, which often leads to inaccuracies due to the reliance on a single model for empirical analysis, some researchers have sought to refine the approach. Feder and Umali (1993) highlight how choosing just one model can introduce biases and errors. In response, Abadi Ghadim and Pannell (1999) proposed a more nuanced model that views adoption as a layered process, where farmers gather information and learn through practice, considering their different attitudes towards risk.

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Additionally, Gladwin (1976) introduced a hierarchical decision tree model as an alternative to the expected utility theory. This model simplifies decision-making by evaluating options one at a time, discarding those with unfavourable attributes early on. This sequential process ensures that only the most viable options, which meet all set criteria without triggering any disqualifying conditions, are considered for final selection. This approach contrasts with the expected utility theory, which tends to assess all possible options in parallel, potentially complicating the decision-making process.

b. Mixed Farm adoption studies

Studies on the adoption of mixed farming practices have shown a growing interest since the early 2000s (Figure 2). While the term "mixed farming" itself doesn't appear frequently (the words "mix" or "mixed" occur approximately 58 times in the initial sample), in most cases, there is a rotation of terms that include "Crop, livestock, and forestry," "Crop and livestock production," "integrated crop-livestock systems," "crop-livestock production system," "cropping and manure management," "crop-livestock integration," "grain & graze," "integrated farming systems," "integrated management," "flexibility of farming systems," "trade-offs associated with integrating forages into crop-livestock systems," "conservation agriculture," and even extending to "adaptation strategies," "climate risk reduction practices," "safe and sustainable agricultural practices," "multiple climate-smart agricultural technologies," “climate-smart agriculture” and "agricultural diversification”. For the ease of the reader, we will simplify such complex scenarios referring in the analysis to “MF practices”.

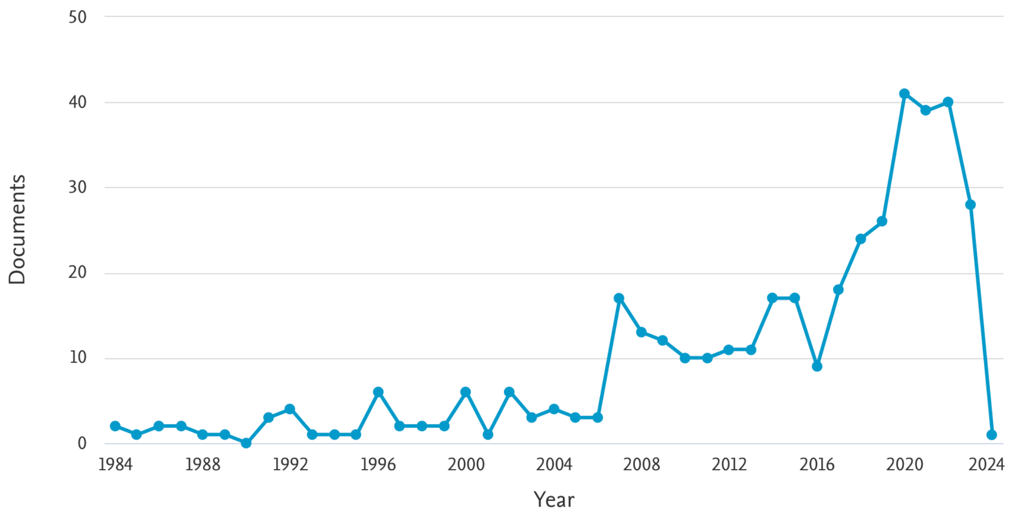

Figure 2. Documents by year (n. 401 documents)

In synthesis, early mixed farming (MF) adoption studies focused on integrated systems for sustainable agriculture, assessing risks, impacts, and farm management implications. From the 2000s, research expanded to include how external factors affect adoption, utilising advanced statistical and economic models. Studies like Jal and Herrero (2008) analysed factors influencing the adoption of specific technologies, while recent research has explored Climate-Smart Agriculture practices and their adoption driven by climate change concerns. Advanced models, such as the MIDAS, have simulated decision-making

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processes, and newer studies have adopted integrated approaches, analysing whole farming systems and the adoption of practice bundles to enhance sustainability, resilience, and productivity, employing methods like Principal Component Analysis and behavioural theories to understand complex decision-making dynamics in adoption.

Initial efforts in MF adoption studies focused on the concept of 'integrated systems' within the context of low-input and sustainable agriculture. In the 1990s, the first studies focused on assessing the risks and impacts of integrated approaches, the implications for farm management, and the performance of integrated systems in the context of agricultural intensification processes and various environmental challenges or in the management of key resources such as water with cost-benefit assessments, case studies and discussions with farmers. However, from 2008, MF adoption research gained momentum with more comprehensive studies that explore how external factors influence the adoption of more integrated farming systems, including statistical analyses and farm economic models. This marked an expansion in the depth and breadth of adoption studies in MF.

These studies primarily considered the adoption decision in terms of the benefits or advantages that could be gained from implementing MF practices and specific production technologies. In the study by Jal and Herrero (2008), the decision to adopt specific dairy production technologies is influenced by the perceived benefits or advantages that these technologies can offer to mixed crop-livestock farmers in Santa Cruz, Bolivia (i.e. if the derived benefits from adopting that technology are higher than a certain threshold). Then the researchers use a logistic regression model to analyse the farmers' characteristics, farm-level variables, and institutional factors that influence the adoption of the different alternative technologies and conduct separate logistic regression analyses for different groups of farmers, possibly based on specific characteristics or farming systems. This allows them to identify factors that are particularly relevant to different subsets of the population.

With increasing concerns about climate change - between 2010 and 2015 - the adoption studies began to explore the adoption of Climate-Smart Agriculture (CSA) practices. The modelling approach expanded to incorporate CSA practices, such as conservation agriculture, agroforestry, and drought-resistant crop varieties. Researchers started using more advanced statistical techniques, including multivariate probit models and structural equation modelling, to capture the interdependencies among different practices and their determinants. In specific cases farmers' choice of adopting MF practices has also been analysed using bio-economic model for whole-farm management. Byrne et al. (2010) use the MIDAS (Model of Integrated Dryland Agricultural System) to simulate farmers' decision-making in diverse regions across southern Australia and assess how factors such as soil type, flock composition, commodity prices, and production levels affect the feasibility of adopting lucerne in mixed crop-livestock systems. This modelling approach provides valuable insights into the economic factors and constraints that impact the decision to adopt lucerne, aiding in the identification of key determinants influencing farmers' choices.

In the subsequent years adoption studies moved toward more integrated approaches, considering the adoption of combinations of practices within farming systems. Principal Component Analysis (PCA) and other data reduction techniques were applied to identify patterns of adoption among multiple practices.
Researchers began examining the adoption of whole farming systems or bundles of practices designed to enhance sustainability, resilience, and productivity. The adoption problem was increasingly modelled as a

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multivariate decision-making process, accounting for complex interactions among practices. In Mujeyi et al., (2020) the researchers used PCA to identify technology combinations (sets/combinations) adopted by farmers based on nine different CSA (Climate-Smart Agriculture) technologies. The PCA helped in grouping farmers into three technology combinations according to their adoption of these practices. Subsequently, they applied multinomial logistic regression to explain the adoption of these constructed technology bundles, considering various explanatory variables. This approach allowed them to analyse how different factors influenced the adoption of specific combinations of CSA practices.

Other approaches incorporate behavioural economics and psychology to better understand farmers' decision-making processes. Researchers delved into the role of subjective norms, attitudes, risk perceptions, and social networks in shaping adoption behaviours. The Theory of Planned Behaviour (TPB) and other behavioural theories were applied to model how farmers' intentions and attitudes influenced adoption. Hierarchical decision tree models have been applied to MF adoption. These models break down the decision-making process into sub-decisions, allowing for the identification of constraints and a detailed examination of the adoption process. In the study by Bosma et al. (2012), the modelling of adoption of integrated rice-fish farming systems is based on a three-layered hierarchical tree that considers motivational and social factors into the adoption model. These factors include farmers' reference frames (FRF), which represent their subjective motivations for adopting or not adopting integrated rice-fish farming. Then the approach combines a fuzzy logic, to model discrete social motivations within a dynamic context. It helps capture the complexity and subjectivity of farmers' decision-making processes. Fuzzy logic allows for the consideration of various motivations and reference frames in a simulation of adoption. The adoption model is structured as a three-layered hierarchical tree, where different factors and motivations are organised hierarchically. This tree represents the decision-making process, with various factors influencing each other and the ultimate decision to adopt or not.

c. Agroforestry adoption studies

In summary, AF adoption research, initially trailing general agricultural studies by two decades, began with descriptive efforts lacking in theory and empirical rigor. Momentum picked up in the 1990s with more detailed studies incorporating statistical analyses and cost-benefit assessments. Theoretical models developed during this period focused on agroforestry as an investment, considering factors like labour, capital, and income. Key studies by Amacher et al. (1993) and others applied household production theory, highlighting the role of market incentives, biophysical conditions, and resource endowments in adoption decisions. Recent approaches include dynamic models and decision tree analyses to address uncertainties and risks in adoption, emphasising the need for on-farm experimentation and a more nuanced understanding of the adoption process in agroforestry.

Agroforestry adoption research followed a similar historical trajectory of the studies in general agricultural adoption but lagged by about 20 years. Initial efforts in agroforestry adoption studies were descriptive and prescriptive, lacking formal theoretical development and rigorous empirical analysis. However, in the 1990s, agroforestry adoption research gained momentum with more comprehensive studies, including statistical analyses, cost-benefit assessments, surveys, and discussions with project staff and farmers. This marked an expansion in the depth and breadth of adoption studies in agroforestry.

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Theoretical models of agroforestry adoption, which emerged in the mid-1990s, predominantly employ a household production framework to explain agroforestry adoption as an investment decision guided by the maximisation of expected utility or profit. These models consider various constraints such as labour, capital, and income limitations. For instance, Amacher et al. (1993) were among the first to apply household production theory to agroforestry adoption, assuming decreasing absolute risk aversion and predicting that income from various sources, labour, capital, land endowments, land tenure, and tree product prices positively influence tree planting adoption. Conversely, prices of non-forest consumption goods reduce adoption, while the effect of the riskiness of household forest product production remains undetermined. Mercer and Pattanayak (2003) and Pattanayak et al. (2003) extend this framework, conducting a meta-analysis of multiple regression-based adoption studies. They highlight that agroforestry adoption hinges on market incentives, biophysical conditions, resource endowments, risk, uncertainty, and household preferences. Introducing a household-specific safety-first constraint to the expected utility model allows households to assess expected returns based on a probability distribution for minimum income, dependent on income potential. This approach, as demonstrated by Shively (1997), shows that adoption decisions are influenced by farm size, non-farm income, farm-specific attributes (like soil quality and slope), the probability of a consumption shortfall, and a comparison of net benefits. This constraint highlights the significance of the probability of falling below subsistence levels for low-income households. Shively (2001) utilises a dynamic expected utility model combined with an equation of motion for soil stocks to examine how consumption risks and investment costs impact the adoption of contour hedgerows for soil conservation. This model reveals that the valuation of soil conservation methods depends on investment costs, innovation risk, and the capacity to bear risk. It indicates that assuming risk-neutrality may lead to incorrect adoption predictions for low-income households when the risk of consumption shortfalls is high. Besley (1995) explores the impact of property rights on tree planting and conservation investments in Ghana through three perspectives: security, collateral-based, and gains-from-trade. These models reveal that increased land-tenure security bolsters investment incentives. Pannell (2003) employs a dynamic profit-function analysis to demonstrate how uncertainty inhibits adoption, especially for risk-averse farmers. Uncertainty can lead to incorrect predictions of expected benefits, prompting farmers to delay adoption in some cases. Pannell argues that uncertainty remains an underexplored impediment to the adoption of innovative land conservation practices, and on-farm experimentation is akin to adoption as production systems are continuously tested and modified based on evolving perceptions and expectations.

Hierarchical decision tree models have been applied to agroforestry and natural resource management (NRM) adoption. These models break down the decision-making process into sub-decisions, allowing for the identification of constraints and a detailed examination of the adoption process. Researchers like Swinkels, Franzel, and Gladwin have improved the rigor of decision tree analysis by subjecting hypotheses to statistical inference tests, combining scientific hypothesis-testing with participatory approaches to enhance adoption analysis.

d. Empirical adoption studies

The study of adoption in the context of MF and AF has evolved over the years, with a focus on understanding the factors that influence farmers' decisions to adopt these practices. On this stream of literature, economists have played a dominant role, as in the general-adoption research since the 1970s (Mercer and Miller, 1998). Within this research domain, two distinct lines of research have emerged.

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Ex-Ante Studies take a forward-looking approach, often grounded in a 'farming systems' framework. Researchers aim to evaluate the potential adoption of various MF/AF systems. They employ both researcher-led and participatory on-farm research methods to assess the feasibility, profitability, and acceptability of these innovations within the specific biophysical and socioeconomic context of farmers (Byerlee and Collinson 1980; Chambers et al. 1989; Scherr 1991a, 1991b). The primary goal is to define the 'boundary conditions' under which farmers are likely to embrace a particular MF/AF system or practice (Franzel and Scherr 2002). Researchers in this approach examine various factors, including biophysical and socioeconomic conditions, farm attributes, and resource availability. Simulation models, participatory research techniques, and farm-level assessments are commonly used to estimate the feasibility and potential impacts of adopting MF/AF systems. The objective is to provide insights into the circumstances in which MF/AF could prove profitable, feasible, and acceptable to farmers.

Ex-Post Studies, on the other hand, focus on explaining past adoption behaviour related to MF/AF. These investigations seek to understand the influence of factors such as farmer characteristics, farm attributes, project interventions, and demographic and socioeconomic variables on previous adoption decisions. These empirical studies often employ binary choice regression models, typically utilising cross-sectional household survey data. However, there have been criticisms that many of these studies lack strong links between empirical analyses and underlying theoretical frameworks. Additionally, they may not comprehensively examine the full spectrum of potential factors influencing adoption (Pattanayak et al. 2003). In the ex-post approach, researchers delve into the historical adoption and practices of mixed farming among farmers. Data collection involves studying both farmers who have adopted mixed farming and those who have not. Researchers then employ regression models and household survey data to uncover the drivers of mixed farming adoption. The primary focus is to elucidate why certain farmers have embraced mixed farming while others have not.

These two approaches offer distinct insights into MF/AF adoption. While ex-ante studies provide a forward-looking perspective, ex-post studies offer a retrospective analysis of historical adoption patterns.

Table 1 Types of studies

Ex-ante studies	***Ex-post studies***
• Current et al. (1995), who evaluated the profitability of agroforestry technologies in Central America and the Caribbean, finding most to be potentially profitable, though influenced by various constraints like capital and labour. • Franzel and Scherr (2002) highlighted agroforestry's potential in sub-Saharan Africa for income enhancement and environmental benefits, noting that wealth affects adoption rates but isn't a barrier for the poorest. • Vosti et al. (1998) explored the adoption of simple agroforestry systems in the Brazilian	• Pattanayak et al. (2003) reviewed 120 articles on smallholder adoption of agricultural and forestry technology, developing a framework of five key factors: preferences, resource endowments, market incentives, biophysical factors, and risk and uncertainty. This framework guided a meta-analysis of 32 studies on agroforestry and soil conservation, identifying the most influential factors on adoption. Contrary to expectations, household preferences and resource endowments were less significant, with uncertainty and risk, market incentives, and biophysical factors

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Amazon, identifying high initial investments and market uncertainties as major obstacles for smallholders, emphasising the need for a thorough understanding of all factors affecting the profitability and adoption of agroforestry practices.	playing more crucial roles in adoption decisions. • Additionally, a study by Simmons et al. (2002) highlighted the importance of institutional over household preference variables in tree planting decisions in Brazil and Panama.

The empirical literature under review highlights the complex factors influencing farmers' decisions. It focuses on elucidating how risk, uncertainty, and household preferences significantly impact adoption patterns. This analysis also considers traditional factors like age, gender, and education, as well as structural elements such as resource endowments. Additionally, it examines the effects of market incentives, institutional variables, and biophysical factors on the decision-making processes of farmers (Table 2).

Table 2. Main focus and insights from the empirical sources

Focus	***Description***	***References***
Risk and uncertainty	Most of contributions discusses the significant role of risk and uncertainty in the adoption of agricultural innovations, particularly agroforestry. They highlight the limited empirical research directly addressing these issues and points out the challenges in adequately measuring farmers' risk perceptions. Several studies identify key variables such as tenure, experience, and extension training as significant predictors of agroforestry adoption. They note the positive impact of secure land tenure and explore the effects of yield, price, and consumption risks on adoption patterns. Furthermore, the analysed literature discusses how risk aversion and access to credit can influence farmers' decisions to adopt soil conservation practices.	Feder, G., & Umali, D. L. (1993). Smale, M., & Heisey, P. W. (1993). Abadi Ghadim, A. K., & Pannell, D. J. (2003). Pannell, D. J. (2003). Marra, M., Pannell, D. J., & Abadi Ghadim, A. (2003). Pattanayak, S. K., Mercer, D. E., Sills, E., & Yang, J.-C. (2003). Shively, G. (1997, 1999a, 1999b, 2001).
Household preferences	Literature explores the varied adoption patterns among farm households, attributing the differences to a range of attitudes and preferences such as risk tolerance and conservation priorities. It notes the difficulty in directly measuring these preferences, leading researchers to rely on proxy variables like education, age, gender, and socio-cultural status. Gender is highlighted as a significant factor, with studies showing men are more likely to adopt agricultural innovations than women. While education and age are commonly considered, their impact on adoption is not always significant, possibly due to the homogeneity within farmer	Mercer, D. E., & Pattanayak, S. K. (2003). Pattanayak, S. K., Mercer, D. E., Sills, E., & Yang, J.-C. (2003). Barrett, C. B., Carter, M. R., & Timmer, C. P. (2002).

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	populations or the influence of other educated household members. The analysed sources also discuss how the selection of study samples might introduce bias, particularly when focusing exclusively on farmers.	
Gender role	The sources examine the impact of gender on the adoption of agroforestry practices, highlighting notable differences in adoption rates between male and female-headed households. Scherr's study in Kenya (1995) showed that male-headed households tend to plant more trees for commercial purposes, whereas female-headed households focus more on planting trees for fuelwood. Research by Gladwin et al. (2002a) in Eastern Zambia found that female-headed households were more likely to adopt improved fallows, a sustainable agricultural practice, with adoption rates nearly equal between female and male-headed households. Place et al. (2002) further explored the interplay between wealth and gender, noting that wealthier male-headed households were more prone to adopt intensive practices like increased fertiliser use, whereas the adoption of improved fallows remained consistent across gender and wealth groups, corroborating Gladwin's findings.	Scherr, S. J. (1995). Gladwin, C. H., Thomson, A. M., Peterson, J. S., & Anderson, A. S. (2002a). Place, F., Adato, M., Hebinck, P., & Otsuka, K. (2002).
Resource endowments	The literature discusses the influence of farmers' assets and resources, such as labour, land, livestock, savings, and access to credit, on their decision to adopt new agricultural technologies. Theoretical and empirical evidence suggests that households with higher economic well-being, possessing what is termed "risk capital," are more likely to be early adopters of innovative, albeit unproven, agricultural technologies. These resources enable them to undertake investments that come with higher risks. Studies show that resource endowments significantly impact adoption decisions, with income, assets, labour, and credit availability being key factors. Notably, apart from income, the presence of these resources generally correlates with a higher likelihood of adopting new agricultural technologies.	Hyde, K., Amacher, G. S., & Magrath, W. (2000). Patel, B., Rogers, E. M., & Juma, C. (1995). Scherr, S. J. (1995). Pattanayak, S. K., Mercer, D. E., Sills, E., & Yang, J.-C. (2003).
Market incentives	Several sources highlight the significant role of market incentives, such as agricultural and tree-product prices, in influencing land use decisions and the adoption of agroforestry practices. Despite their importance, studies integrating market incentives like input and output prices, market accessibility, and transportation	Godoy, R. (1992). Hyde, W. F., & Amacher, G. S. (2000). Shively, G. E. (1999b).

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	costs into agroforestry adoption research are limited, featured in only a third of such studies. However, where included, market incentives have been found to significantly impact adoption decisions positively in over half of the cases. Shively's study (1999b) specifically examines how price volatility and levels affect farmers' decisions to plant mango trees in the Philippines, demonstrating that price fluctuations, particularly in staple crops like rice, can significantly influence the planting of tree crops. This finding points to the need for more in-depth research on how short-term market price changes can affect agroforestry adoption decisions.	Pattanayak, S. K., Mercer, D. E., Sills, E., & Yang, J.-C. (2003).
Biophysical factors	Biophysical factors, which encompass elements like slope, soil quality, and irrigation, have unfortunately received limited attention in agroforestry adoption studies. A meta-analysis by Pattanayak et al. (2003) revealed that these biophysical factors were incorporated into just 27% of the agroforestry adoption studies reviewed. Nonetheless, their significance as adoption predictors is evident, as they proved statistically significant in 64% of cases when included in the analysis. Interestingly, the direction of significance for many biophysical factors exhibited inconsistency. Poorer soil quality often showed a positive correlation with adoption. However, it's worth noting that there is a point at which soil quality can deteriorate to such an extent that investments become impractical. In contrast, slope variables consistently displayed a positive impact on adoption, with steeper slopes generally providing incentives for farmers to embrace agroforestry practices (Pattanayak et al., 2003).	Pattanayak, S. K., Mercer, D. E., Sills, E., & Yang, J.-C. (2003).

Most agroforestry adoption studies have primarily relied on logit or probit models to analyse binary adoption decisions, where the outcome variable is either 1 (adoption) or 0 (non-adoption). The choice between these two models typically doesn't make a significant difference, as they yield similar results when there are few positive or negative responses. However, the theoretical justification for selecting one model over the other is often lacking. Examples of studies using the logit model include those by Alavalapati, Sunderlin, Thacher, Adesina, Salem, Otsuka, Owubah, Adesina and Chianu, and Mercer.

When studying both the probability and extent of adoption simultaneously, different modelling approaches are required. Researchers have occasionally used the tobit model, ordered multinomial logit, or two-stage Heckman models in such cases. Unfortunately, these approaches are relatively rare in the agroforestry adoption literature. The tobit model is suitable when the same independent variables influence both the

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probability and size of the dependent variable. The ordered tobit accounts for the truncation of the dependent variable at upper or lower limits. The ordered multinomial logit model is applicable when the dependent variable is categorical, hierarchical, and censored, and when the same variables influence both adoption and the extent of adoption. A two-stage Heckman model becomes necessary when different variables affect the decision to adopt and the extent of adoption.

Several agroforestry adoption studies have made the common error of treating categorical independent variables as continuous. This means assuming that the intercept shift is the same for each category of the independent variable. However, this assumption is often unlikely to be valid, and it's essential to correctly represent categorical variables using dummy variables. This misrepresentation can lead to incorrect model results and should be avoided in rigorous analysis (Greene, 1997).

Key Methodological Challenges and Open Problems:

Choice of Binary Model: The use of logit and probit models, while common, lacks strong theoretical justification. Future research should explore whether one model is consistently more appropriate than the other in specific contexts.

Simultaneous Decision Modelling: Studying both the probability and extent of adoption together is essential but remains underutilised in agroforestry studies. Researchers should consider these complex adoption patterns more frequently.

Limited Use of Advanced Models: Models like the tobit, ordered multinomial logit, and two-stage Heckman models are not extensively used in agroforestry adoption research. Greater adoption of these models could provide more accurate insights.

Handling Categorical Variables: Treating categorical independent variables as continuous can lead to incorrect results. Researchers should be cautious and use dummy variables correctly when dealing with categorical data.

Contextual Specificity: The choice of modelling approach should consider the specific context of each agroforestry system and its unique adoption factors, as one-size-fits-all models may not be suitable. Researchers should tailor their methodologies to the specific circumstances of each study.

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5 Survey Material and Methods

5.1 Use of stated intentions

A lot of literature has investigated adoption of innovative farming systems. While the previous section focused on drivers of this adoption, this one describes the different methodological approaches to estimate adoptions.
Economic literature has proposed two different approaches to investigate the adoption of new practices or farming system: a) the use of stated intentions; b) the programming approaches. Both methods have pros and cons as the former depends on the ability of decision-makers (i.e. farmers) to understand the questions, apply reflex on new conditions and apply adaptation strategies. This approach is largely adapted on the literature, especially when the decision concerns relevant key parameters managed by the decision maker. For example, several authors have applied it to simulating structural changes (Bartolini and Viaggi, 2013; Raggi et al., 2013; Peerlings et al., 2014), investment decisions or sustainable management strategies (Doran et al., 2022) or adaptation capacities (Peerlings et al., 2014).

The use of stated intention to describe the changes in farming systems allows for isolation of the effect of new market or policy conditions and then is often used when the research question focuses on designing new incentives and policy mechanisms (Wheeler, 2008; Bartolini and Viaggi, 2012). However, as with other *ex-ante* techniques, the use of stated intention may differ by observed empirical pieces of evidence has empathised that in the most, stated intentions reveal true ex-post behaviour(Gordon et al., 2022) or can disclose already planned strategies. In addition, Viira et al., (2014) describe that stated intention different by ex-post behaviour based on how questions are related with the farm life cycle context, observing a better prediction when behaviour concerns is regarded as positive rather than negative (i.e. farm continuation versus farm abandonment).

5.2 Data collection

In this report, we analyse the determinants of the farm typologies in front of the adoption of AF/MF and the policy effect on such changes. This analysis is conducted using the stated intentions collected through survey information and comparing the determinants between AF and MF.
Considering a not uniform level of farmers' information about agroforestry and mixed farms we developed the following definitions provided before beginning the survey.

What is Agroforestry?
"Agroforestry systems combine arboreal with annual crops and/or meadow plants and grazing on the same land surface. With the right organisation this multifunctional approach can increase the productivity of the system compared to a more conventional way of production, as it can produce many different products such as timber, firewood, piles, bark, fruits, nuts and foliage for animals, nectar, or pollen for bees, etc. protecting and revitalising the soil, and increasing biodiversity. In traditional systems the trees are forests such as oak, poplar, cypress, or fruit trees such as walnuts, olives, almond trees, which are used to produce fruits or for timber. Under the trees are cultivated agricultural plants such as cereals, legumes, vegetables, industrial and hay plants (annual or perennial herbaceous e.g. legumes or woody plants) or meadow plants and animals coexist. In new approaches, trees are systematically planted to produce fruit and timber technique by

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adjusting the density and layout of the trees to match the needs of the subfloor vegetation (competition light, humidity, nutrients) and the need to mechanise production".

What is Mixed Farming?
"Mixed agriculture combines agricultural and livestock production benefiting from the diverse ecological and economic interactions created by this combination. The cultivation of plant species and the parallel rearing of animals to produce animal products enables the farmer to make efficient use of the available resources and energy of his system. Some of the products of plant production and residues of food processing can be used as animal feed Or. Perennial cultivation of grass crops for hay such as alfalfa or the combination of alfalfa with grasses is often applied, for example. During this cultivation (alfalfa, for example, up to 5 years) the soil remains untreated, contributing to the development of a rich root system, the increase of the organic matter of the soil and the development of a beneficial soil structure. Especially grass plants belonging to the legume family enrich the soil with the nutrient element nitrogen. Grass plants can be turned into hay but there is also the option of direct grazing. It may also be that after harvesting the main crops (e.g. wheat) there may be grazing of the remnants of the crop. Through grazing but also through the collection of manure in the stables, livestock farming can contribute to the fertilisation of the fields. This requires fewer imports of fertiliser and feed and creates more closed cycles of nutrients and organic matter with a positive impact on the surrounding environment. At the same time, an alternative source of income from either crop production or livestock production is maintained, reducing the dependence of the producer on a single production product".

The survey is structured in different parts (see Annex 1) and is collecting information about Individual/Household characteristics (7 Questions); FARM characteristics (9 Questions); Supply Chain Characteristics (4 Questions) and Expectation about future conditions (1 Question).

The last part of the survey was structured to collect information about the current adoption of agroforestry or mixed farms independently (4 Questions). Question 29 explores if farmers are currently adopting agroforestry, while question 41 is mixed farms as defined in the above-mentioned description. Then, we have added a branch for current non-adopters to know their started adoption about AF (question 32) or MF (question 45). Both stated adoptions are asked under the following alternative policy and market conditions:

a) the maintenance of the current Basic Payment Scheme (BPS) and Countryside Stewardship (*status quo*)
b) Introduction of new schemes to reimburse the compensation cost for the adoption of Agroforestry or Mixed-Farm
c) introduction of a carbon market that will pay for the amount of carbon storage
d) abolishment of all Basic Payment Scheme (BPS) and Countryside Stewardship

Then, in other cases (i.e. a farmer is currently adopting AF or MF), the survey asked a farmer to maintain the innovative farming system under the same policy and market conditions. Both decisions of new adoption and maintenance are framed in the next ten year.

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6 Results

6.1 Supply chain features

This paragraph delineates the various structures and preferences within the supply chains from the farmers' perspectives. The former is elucidated by examining the present composition of sales channels regarding the economic value of farm products sold. Conversely, the latter is explored by detailing farmers' opinions on the current supply chains, focusing on relevant features. The results offer a comparative analysis of the current participation in AF or MF.

Finally, the last section will provide an overview of motivational factors affecting entering a new value chain. Table 3 compares the selling channels for those participating in Agroforestry (AF) and not (Conv), while for Mixed Farm this is shown in Table 4.

Table 3. Share of economic value sold amount of different sells comparing Agroforestry system and conventional one (Q27)

Sales channels	Wood		Arable		Livestock	
	Conv[a]	AF[b]	Conv[a]	AF[b]	Conv[a]	AF[b]
Cooperative	9.23*	10.41*	11.05*	14.62*	9.86***	27.08***
Producer organisation	4.92	3.68	4.30	2.38	4.71	1.14
Inter-branch organisation	0.86	0	0.05	0	0.45	1.31
Wholesale firms	0.02	0	0.01	0	0.05	0
Farmers' union	0.62	0	0.03	0	0.11	0
Geographical indications	4.17	6.72**	0.80**	7.28**	10.75*	6.09*
Individual sales to local markets (i.e. farmers' markets or final consumers)	1.61	1.30	2.57	0.87	3.25	2.18
Individual sales to independent retailers/restaurants	0.124	0	2.17	0	0.33	0
Individual sales to supermarkets	10.63	11.31**	9.03**	3.28*	12.55*	18.41*
Individual sales to processors	2.89	1.75	8.90	3.19	3.27**	0.13**
Other, reused on the farm	9.49***	20.10***	17.89*	26.58*	6.11	2.82
Other, self-consumption	4.36	0	2.95	0	10.65**	1.64***
Other	11.07*	2.07*	17.33*	3.87*	6.91	9.53

[a]Conv (Non agroforestry farming system) ;[b]AF = Agroforestry farming system ; ttest: *** sign. at 0.01; ** at 0.05; * at 0.1

Table 3 presents the main differences in sales channels for farmers currently involved in agroforestry and those who are not. The table describes the percentage of each farm's product/harvest sold for the three main outputs: wood, arable, and trees. Table 3 shows the results of t-tests comparing the average values across the two farm typologies. It indicates that sales channels between the two are quite similar, with a slightly higher share of timber being sold through cooperatives (+1%), followed by individual sales to supermarkets (+1%), mainly available for firewood. Farmers currently engaged in agroforestry demonstrate a consolidation of their resources on the farm (+10.50%), with less relevance on other uses (-9%). In contrast, wood productions are used internally within the household for self-consumption among non-agroforestry farmers. This suggests a more thoughtful farm structure in utilising these products as farm inputs.

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The results suggest that selling channels for arable products are also differentiated between agroforestry (AF) and non-agroforestry (non-AF) farms. For example, AF farmers show higher engagement with collective sales channels, such as cooperatives (+7.24%) or producers' organisations (+3.50%). Conversely, non-AF farms indicate more individual sales, for example, with forward actors along the supply chain such as processors (+6%).

The selling channels for livestock products indicate significantly higher differentiation compared to the other two farm products. Livestock products sold may be relevant mainly for those farms classified as Agro-silvopastoral systems (see also D5.1 for a detailed description of its diffusion in the EU). The results highlight that livestock products are sold mainly through cooperatives or directly to supermarkets for AF farmers, while non-AF farms show more sales through the Protected Designation of Origin (PDO) or other geographical indications.

Table 4 presents the share of economic value sold among different sales channels for non-Mixed-farm (Conv) and Mixed Farm (MF)

Table 4. Share of economic value sold amount of different sells comparing Mixed Farm system and conventional one (Q27)

Sales channels	Wood		Arable		Livestock	
	Conv[a]	MF[b]	Conv[a]	MF[b]	Conv[a]	MF[b]
Cooperative	6.72**	12.62**	8.30**	15.54**	5.00***	21.51***
Producer organisation	4.09	5.48	2.49**	15.79**	1.91**	6.83**
Inter-branch organisation	0.01**	1.58**	0	0.09	0.42	0.79
Wholesale firms	0.02	0	0.02	0	0.07	0.01
Farmers' union	0.47	0.56	0.03	0.02	0.16	0.01
Geographical indications	0.90	4.18	7.85	7.56	6.76**	13.88***
Individual sales to local markets, (i.e. farmers' markets or final consumers)	0.76	2.49	1.43	3.33	0.95***	5.61***
Individual sales to independent retailers/restaurants	0.14	0.05	0.09*	0.21*	0.01*	0.60*
Individual sales to supermarkets	5.73***	16.67***	8.00*	3.23*	10.32*	17.20*
Individual sales to processors	1.45	4.22	4.98*	1.60*	2.18	3.49
Other, reused on the farm	6.33***	16.86***	14.51***	24.81***	6.63	4.36
Other, self-consumption	2.94	4.55	3.01	1.86	12.81*	5.01*
Other	14.51**	4.63**	16.69	13.80	3.98*	10.82*

[a]Conv (Non mixed farming system) ;[b]MF = Mixed Farming system ; ttest: *** sign. at 0.01; ** at 0.05; * at 0.1

Table 4 highlights the main similarities and differences between mixed farm and conventional systems. The results show quite similar tendencies for agroforestry, as reported as well in table 3. Particularly, mixed farms exhibit very high reuse of wood and arable products on-farm, resulting in an increased integration among different farming activities. In addition, the findings indicate a much higher engagement with collective sales channels, which can be explained by the outsourcing of human and physical resources of external networks as a form of social capital (see database about the influence of social capital in affecting adoption of sustainable farming systems or practices, see for example Bartolini and Vergamini, (2019); Datoon et al., (2023); Kresna et al., (2024).

Unlikely livestock products, which represent primary outputs for mixed-farm systems, the selling channels are highly diverse compared to conventional farming system. The results highlight clear strategies for

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marketing various livestock products in the market with higher expected unitary prices, utilising channels such as cooperative, geographical indication, or alternative market networks (i.e. farmers markets, supermarkets, or restaurant/individual retailers). Our findings support the results of D5.2, confirming the distinct characterisation of supply chain between conventional and agroforestry/ mixed-farm system.

This section will present the farmers' opinion about the current supply chain. Table 5 compares the opinion between conventional farms and those currently involved in agroforestry or mixed-farm. The opinions were gathered by asking farmers various statements related to supply chain characteristics, collecting information on their level of disagreement (low score) or agreement (high score) with these statements.

Table 5. Statement about current supply chain (Q30)

Sales channels	Agroforestry		Mixed Farm	
	No	Yes	No	Yes
I do not have alternative options to the current supply chain	3.14	3.13	3.13	3.14
The current SC provides an acceptable price to alternative buyers	3.00***	3.34***	3.07	3.05
The current SC provides more stable prices from year to year than alternative buyers	2.83***	3.47***	2.88	2.93
The current SC provides more possibilities for negotiating prices	2.80**	2.33**	2.87***	2.73***
This sale agreement provides more possibilities for negotiating the characteristics of the agreement rather than prices	2.89	2.59	2.85	2.84
The costs associated with the current supply chain are too high	3.57	3.57	3.48	3.57
The production standards requirements are too restrictive	3.34***	2.49***	3.18	3.21
The current supply chain requires the purchase of external inputs	3.19***	2.41***	3.07	3.07
The current supply chain does not support a diversification strategy	3.24***	2.46***	3.11	3.12

ttest: *** sign. at 0.01; ** at 0.05; * at 0.1

Table 5 presents the results of the statistical t-test of means, highlighting the statistically significant differences among farming systems. Values lower (higher) than 3 indicate disagreement (agreement) with the statement. The results reveal that agroforestry farmers hold opinions distinct from those of mixed farmers regarding their current supply chain. Agroforestry farms consider the level of price stability in the supply chain more acceptable compared to conventional farms. Consequently, our findings affirm that agroforestry reduces the risk of market fluctuations and is perceived as more advantageous. This is particularly significant in the context of the ongoing debate about farm gate prices and farmers' bargaining power (Malak-Rawlikowska et al., 2019).

From the other side, farmers involved in agroforestry report higher difficulties in negotiating prices compared to the conventional farming system. Finally, farmers' opinions on the flexibility of the supply chain differ significantly between agroforestry and conventional farming systems. Most agroforestry farmers find production standards less restrictive, consider the dependence on external inputs less relevant, and perceive more possibilities for developing diversification strategies. We speculate that reduced dependence on external inputs and the ability to operate with less restrictive standards are often strategies that forward actors along the supply chain employ to enhance farmers' positions and serve as adaptation strategies to

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reduce vulnerability to external conditions (Fałkowski et al., 2017; Starobin, 2021). In contrast, farmers' opinions on the current supply chain for mixed farming systems do not show marked differences from those of conventional farming systems."

6.2 Factor influencing adoption of sustainable farming system

This section will present the factors' affecting the faming system choice. Table 6 compares the opinion between conventional farms and those currently involved in agroforestry or mixed-farm. The opinions were gathered by asking farmers various statements related binding factors, collecting information on their level of disagreement (low score) or agreement (high score) with these statements.

Table 6. Factors influencing choice of farming system (Q31)

Binding factors	Agroforestry		Mixed Farm	
	No	Yes	No	Yes
Adverse climatic conditions or pests (e.g. hail, drought, floods, animal disease)	4.17***	4.57***	4.28	4.19
Fluctuation in the price of inputs from year to year (seeds, fertilisers, pesticides, fuel, energy, feed, etc.)	4.23	4.31	4.27	4.22
Reduction of dependence by external inputs	3.97	4.04	3.93	4.03
Severe drop in market prices of agricultural production	4.30	4.35	4.25	4.37
Access to credit/liquidity	3.40	3.54	3.53	3.32
Change the regulations the farm's activities need to abide by (e.g. nitrate, water and pesticides regulations)	3.99***	3.26***	3.87	3.88
Changes in the single farm payment (CAP payments under Pillar I)	3.95	4.15	3.75***	4.20***
Changes in agri-environmental payments and RDPs	3.79	3.78	3.63*	3.94*
Increasing autonomy in the supply chain	3.86**	3.35**	3.85	3.71
Increasing integration with other supply chain actors (retailers)	3.70***	2.96***	3.58	3.58
Needs to shorten the supply chain	3.87***	3.13***	3.83	3.68
New markets for public goods (carbon storage etc.)	3.94	3.98	3.93	3.97

ttest: *** sign. at 0.01; ** at 0.05; * at 0.1

Table 6 presents the results of the statistical t-test of means, highlighting the statistically significant differences among farming systems. Values lower (higher) than 3 indicate disagreement (agreement) with the statement regarding the relevance of factors affecting the choice of farming systems.

It is noteworthy that entering agroforestry does not seem to be affected by rent-seeking but rather by the purpose of improving farmers' resilience with respect to climatic or market conditions. Farmers across the observed farming systems (agroforestry, mixed-farm, and conventional) have different binding factors. In fact, the decision to enter agroforestry is strongly influenced by the attempt to reduce exposure to changes

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in climate and new pest diseases or by reducing the influence of external regulations on the farming system. These results are quite relevant as they indicate the significance of agroforestry.

Entering a mixed farm seems more driven by policy and profitability activities, as one of the main factors to enter these systems is first pillar or second pillar payments. It is worth noting that expectations about shortening the supply chain or developing new market opportunities, such as through the carbon market, do not affect the decision to enter agroforestry or mixed farm systems.

6.3 Farmers behaviour in front of AF/MF adoption

6.3.1 Model specification

The deliverable describes barriers and enablers to adopting a new farming system (i.e. AF/MF). These are estimated in two steps:
a) identification of farmers category in front of AF/MF adoption and
b) estimating significant explanatory variables.

Based on stated responses, it is possible to identify the different attitudes between adopters and non-adopters. Following the seminal work of Morris and Potter, (1995), farmers' attitudes towards adopting sustainable farming systems (i.e. AF/MF) can be disentangled into the following four categories:

1) Active adopters
2) Passive adopters
3) Conditional non-adopters
4) Resistant non-adopters.

The classification proposes a way to understand the adoption towards sustainable practices or farming systems, including farmers' motivations and preferences and the elements of profitability or costs (Bartolini et al., 2021; Wilson, 1996). Based on these categories, adopters can distinguish between active and passive. The 'active adopters' are the most committed participants; environmental innovations and personal attitudes, beliefs, moral and ecological concerns, and lifestyles are the main drivers of their behaviour (Dessart et al., 2019). The 'passive adopters' are mainly driven by profitability; thus, the incentive setting or market profitability are the main drivers of their behaviour (Wilson, 1996). The current non-adopters are distinguished based on their potential to switch to adopters under different conditions. The 'conditional non-adopters are not currently engaged in AF/MF, but adoption has higher opportunity costs as they perceive it unprofitable. Finally, "the resistant not adopters" will never adopt AF/MF under any new market condition as they are reluctant to these new systems for different reasons such as lack of trust in the institutions, practices, other farmers or low social capital or they are resistant to any change (Wilson, 1996).

Thus, using the current level of adoption in AF/MF and expected behaviour under new conditions, we can derive the four typologies as the combination of the two. Table 7 presents how farm typologies are built using current and intended adoption.

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Table 7. Definition of farming typologies

Current adoption of AF/MF	**Intended adoption under new condition**	
	YES	NO
YES	1 Active adopters	2 Passive adopters
NO	3 Conditional non-adopters	4 Resistant non-adopters

Information about adopting AF/MF is described using a discrete variable. This variable is built using the four categories of adoption. The determinants of AF/MF adoption were estimated using a multinomial logit model. This model explains the probability of a farm household strategy concerning change in farming systems. The analysis is conducted by repeating a multinomial model twice and using the stated intentions about adopting agroforestry (model 1) and mixed farm (model 2). The dependent variable has the same structure in both models, with all four options[3].

Assuming that is an on-observed utility function for the *i-th* farm in j*-th* farming typology and that this function is derived by an observable portion of utility that is a linear combination of the explanatory variable (μ_{ij}) and by the error term, which is not observable formally (Werbeek, 2004).

Given that it is independent and has a Gumble distribution, the probability that the farm will adopt a new farming system is with $j = 1,2,\cdots,M$ alternatives.

Under this notation, it is implied that and $\sum_{j}^{M} P_{ij} = 1$.

Assuming that is a linear function, it is possible to write $x_{ij}^{'}\beta = \mu_{ij}$, where the matrix $x_{ij}^{'}$ contains the set of the covariates. Under the above assumptions of linearity and error distribution, it is possible to rewrite a normalised form of probability calculation:

$$P_{ij} = \frac{\exp\{x_{ij}^{'}\beta\}}{\sum_{j}^{M}\exp\{x_{ij}^{'}\beta\}} \text{ for each alternative.}$$

The probability of the $i-th$ farmer belongs to a specific category j between a set of M alternatives is a function of the explanatory variables $x_{ij}^{'}$ and the β coefficients (Greene, 2000).

When significant, the positive/negative sign of the coefficient can be interpreted as the increment/decrement of the probability of a farm being in a specific group. The non-significant implies that the covariates are indifferent to the likelihood of belonging to each farm typology.

[3] All alternative options positively successful the Hausman test of independence of irrelevant alternatives for both models.

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6.3.2 Descriptive analysis of stated intention about new farming system

The data used were obtained from a survey of over 400 farm households in six case study areas and in three different climatic areas. The survey (annex 1) contains an essential description of farm structure questions and farm household characteristics questions. During the interview farmers were asked about their intentions concerning adoption of AF/MF considering four alternative policy and market conditions. In the following tables, the stated intentions regarding changes in agroforestry adoption.

Table 8. Stated adoption under new CAP policy regime in the 2030 (BPS and AECs/CS) for AF

Current Adoption		Stated adoption in 2030 assuming maintenance of the current policy regime (status quo)				
		Extremely Likely	Likely	Neutral/ I don't know	Unlikely	Extremely Unlikely
Yes	#	30	9	5	6	4
	%	55.56	16.67	9.26	11.11	7.41
No	#	13	77	67	65	63
	%	4.56	27.02	23.51	22.81	22.11

Table 8 displays the current adoption in Agroforestry (AF) in the first column, while the remaining four columns illustrate the projected adoption in 2030, assuming the maintenance of the current policy regime (status quo). Approximately 72% of current AF adopters are highly likely (55.56%) or likely (16.67%) to keep their adoption by 2030. Conversely, 19% of those interviewed indicate an unlikelihood (11.11%) or extreme unlikelihood (7.41%) of maintaining their current AF adoptions. On the other hand, approximately one-third of farmers express an intention to introduce agroforestry systems on their farms. Notably, 45% of farmers are contemplating not adopting it by 2030.

Table 9 outlines the projected adoption in 2030, taking into account the introduction of policy measures or new schemes to reimburse compensation costs for the adoption of agroforestry. These policy regimes can be considered like agri-environmental climatic measures.

Table 9. Stated adoption under new public policy regimes in the 2030 for AF

Current Adoption		Stated adoption in 2030 assuming new schemes to reimburse the compensation cost for adoption Agroforestry				
		Extremely Likely	Likely	Neutral/ I don't know	Unlikely	Extremely Unlikely
Yes	#	29	12	5	2	6
	%	53.70	22.22	9.26	3.70	11.11
No	#	17	77	61	62	68
	%	5.96	27.02	21.40	21.75	23.86

The introduction of a new measure represents a viable option to sustain current adoption in 2030, as 75% of the current adopters express their intent to maintain it. Approximately 3% of the surveyed farmers consider reimbursing compensation costs associated with current Agroforestry (AF) practices a viable measure to encourage AF retention. However, under this new scenario, only a few farms (4) are likely to opt for the introduction of AF. This result suggests that compensatory payments may present a weak incentive for the diffusion of AF as seem have a small effect on change farmers behaviour.

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Table 10 outlines the projected adoption in 2030, considering the introduction private market to pay for the amount of carbon storage. These policy regimes can be considered like effect of carbon market to AF.

Table 10. Stated adoption under new private carbon market in the 2030 for AF

Current Adoption		Stated adoption assuming new carbon market that will pay for the amount of carbon storage				
		Extremely Likely	Likely	Neutral/ I don't know	Unlikely	Extremely Unlikely
Yes	#	16	22	13	1	2
	%	29.63	40,74	24.07	1.85	3.70
No	#	9	71	90	59	56
	%	3.16	24.91	31.58	20.70	19.65

The introduction of a carbon market serves as a new incentive for a significant number of farmers, offering payments for their contribution to carbon storage. However, this financial aspect introduces risks for farmers. The introduction of a carbon market serves as a new incentive for a significant number of farmers, offering payments for their contribution to carbon storage. However, this financial aspect introduces risks for farmers. Both extreme opinions have lower frequencies, with neutral or slightly positive views on the increase in Agroforestry (AF). These results support previous findings on the role of risk in innovation adoption. Farmers who are risk-averse may scale back mitigation strategies or sustainable practices in the face of uncertainties in associated payments (see for example Adger et al., (2021; Nainggolan et al., (2023)). In the face of increasing uncertainties, the establishment of a private market appears to decrease the willingness to engage in agroforestry (-3%). The impact of uncertainty in diminishing the willingness to adopt sustainable practices can be explained by the specificity of investment, the low reversibility of investment in AF, and the long time frame of decision-making. Farmers may prefer to wait and postpone their decision about AF (Bartolini and Viaggi, 2012; Di Corato and Zormpas, 2022).

Table 11 outlines the projected adoption in 2030, considering a complete abolishment of all policy and regulation payment.

Table 11. Stated adoption with a policy abolishment in 2030 for AF

Current Adoption		Stated adoption assuming abolishment of all Basic Payment Scheme (BPS) and Countryside Stewardship				
		Extremely Likely	Likely	Neutral/ I don't know	Unlikely	Extremely Unlikely
Yes	#	10	5	12	3	24
	%	18.52	9.26	22.24	5.56	44.44
No	#	12	31	101	69	73
	%	4.20	10.84	35.32	24.13	25.52

The results clearly indicate a reduction in the willingness to introduce or maintain Agroforestry (AF) in the absence of all types of policies. Less than 50% of those who initially stated their intention to maintain or introduce AF under the current policy regimes in 2030 will choose not to do so. These results are particularly

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interesting as they underscore the significant contribution of the current policy regimes. These policies play a crucial role in incentivising the adoption and maintenance of AF or in shaping the policy direction towards sustainability (Kugelberg et al., 2021; Kugelberg and Bartolini, 2024).
In the following table, the stated intentions regarding changes in mixed farm adoption.

Table 12. Stated adoption under new CAP policy regime in the 2030 (BPS and AECs/CS) for MF

Current Adoption		Stated adoption in 2030 assuming maintenance of the current policy regime (status quo)				
		Extremely Likely	Likely	Neutral/ I don't know	Unlikely	Extremely Unlikely
Yes	#	61	56	32	12	13
	%	35.06	32.18	18.39	6.90	7.47
No	#	3	18	38	44	61
	%	1.83	10.98	23.17	26.83	37.20

Table 12 displays the current adoption in Mixed Farm (MF) in the first column, while the remaining four columns illustrate the projected adoption to 2030, assuming the maintenance of the current policy regime (status quo).
Approximately 67% of current Mixed Farming (MF) adopters express a high likelihood (35.56%) or likelihood (32.18%) of maintaining their adoption by 2030. In contrast, 13% of those interviewed indicate an unlikelihood or extreme unlikelihood of continuing their current MF adoptions. Farmers' expectations to sustain their behaviour up to 2030 are lower compared to Agroforestry (AF). These results could be explained by a significantly higher number of undecided farmers. Mixed Farm system seem have a low appeal among those farmers not currently involved, as only a small number of farmers show interest in adopting it.
Table 13 outlines the projected adoption in 2030, taking into account the introduction of policy measures or new schemes to reimburse compensation costs for the adoption of mixed farm. These policy regimes can be considered like agri-environmental climatic measures.

Table 13. Stated adoption under new public policy regimes in the 2030 for MF

Current Adoption		Stated adoption in 2030 assuming new schemes to reimburse the compensation cost for adoption Mixed Farms				
		Extremely Likely	Likely	Neutral/ I don't know	Unlikely	Extremely Unlikely
Yes	#	60	61	35	7	11
	%	34.48	35.06	20.11	4.02	6.32
No	#	9	30	30	39	55
	%	5.52	18.40	18.40	23.93	33.74

Table 13 indicates that there is a slight increase in the maintenance of Mixed Farming (MF) compared to the status quo scenario (+3%) and a decrease in dismissals (-3%). The introduction of new measures with the aforementioned purposes results in a significant increase in the willingness to adopt MF (+10%) while reducing the neutral option regarding future statements.
Table 14 outlines the projected adoption in 2030, considering the introduction private market to pay for the amount of carbon storage. These policy regimes can be considered as carbon market for MF.

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Table 14. Stated adoption under new private carbon market in the 2030 for MF

Current Adoption		Stated adoption assuming new carbon market that will pay for the amount of carbon storage				
		Extremely Likely	Likely	Neutral/ I don't know	Unlikely	Extremely Unlikely
Yes	#	33	56	36	24	13
	%	19.19	32.56	26.75	13.95	7.56
No	#	8	32	34	37	53
	%	4.88	19.51	20.73	22.56	32.32

As mentioned earlier for Agroforestry (AF), the introduction of a carbon market, where private entities offer payments to farmers based on their contribution to carbon storage, has the effect of increasing uncertainties, especially for those currently adopting it. The uncertainties associated with the farming practices that the market will reward as well as on the price level for carbon sequestration can lead to a higher increase in neutral responses. It is worth noting that this also influences increasing considerations of abandonment for those currently involved (+7% compared to the status quo). Moreover, the introduction of the carbon market has negative effects on the willingness to be involved in mixed farms, as there is a negative perception of the livestock sector in terms of CO_2 emissions. Table 15 outlines the projected adoption in 2030, considering a complete abolishment of all policy and regulation payment.

Table 15. Stated adoption with a policy abolishment in 2030 for MF

Current Adoption		Stated adoption assuming abolishment of all Basic Payment Scheme (BPS) and Countryside Stewardship				
		Extremely Likely	Likely	Neutral/ I don't know	Unlikely	Extremely Unlikely
Yes	#	15	32	59	30	38
	%	8.62	18.39	33.91	17.24	21.84
No	#	5	11	39	46	62
	%	3.07	6.75	23.93	28.22	38.04

The maintenance of a mixed farm system strongly depends on public support. Without any policy or regulation, the farms that will maintain it are reduced to 26%, while a substantial portion of farms (39%) are likely or very unlikely to keep it. Like Agroforestry (AF), the abolishment of any policy support results in very low interest in adopting Mixed Farming (only 10 % is likely, very likely to adopt it).

To synthesise the stated intention and provide a classification according with the four farm typologies presented the Tables. We employ a Multiple Correspondence Analysis (MCA). Figure 3 and Figure 4 present the output of the MCA. The panels A of each figure show the categories of active and passive adopters of AF and MF respectively, the conditional-non-adopters and the resistant non-adopters' categories of both AF and MF have been presented in Panel B.

The distance between the categories is related to the similarity of their response patterns. By examining the closeness among the categories, each figure makes it possible to identify the associations and disassociations between categories, wherein categories clustered together represented associations. For instance, the active adopters of both AF and MF practices (Panel A of both Figure 3 and Figure 4) under the *current_bps* scenario

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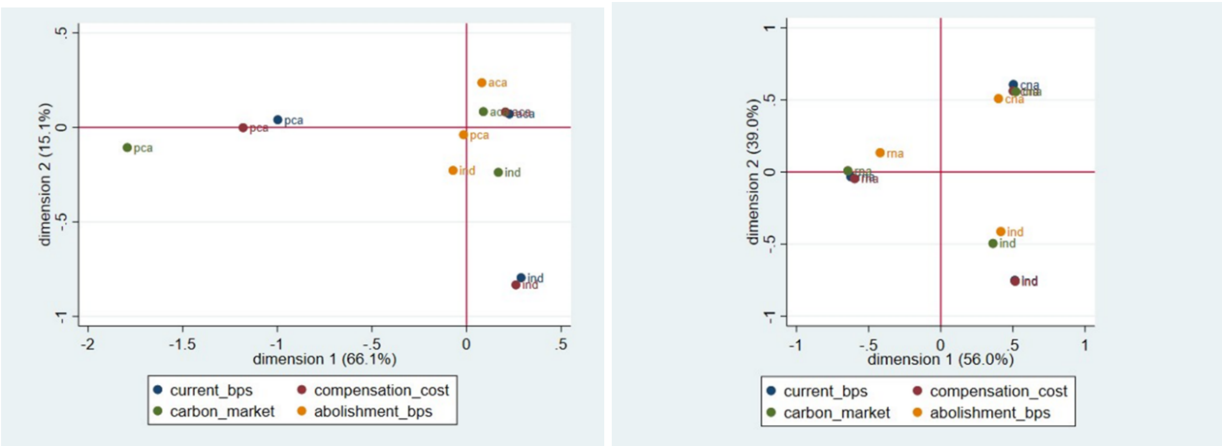
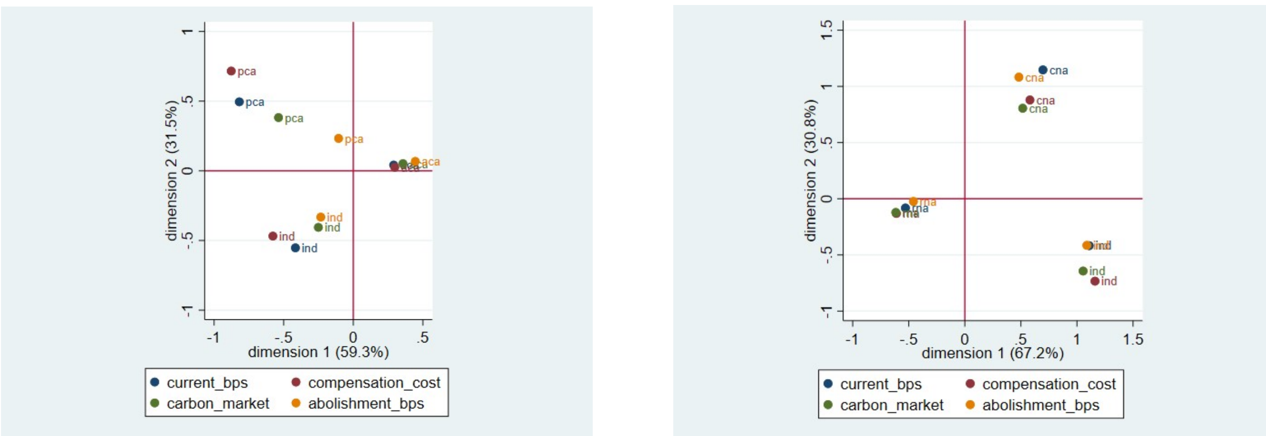
are close to the active adopters under the other policy scenarios. Conversely, the passive and indifferent categories are far from the active adopters and describe two different groups of farmers.
The same pattern is observed in panel B of Figure 3 and Figure 4, where conditional non-adopters (*cna*) of AF as well as conditional non-adopters of MF are closely grouped under all future scenarios but far from resistant non-adopters (*rna*) and indifferent (*ind*) adopters of both considered farming systems (i.e. AF and MF).



A) Active and passive adopters categories B) Conditional-non adopt. and resistant-non-adopters categories

Figure 3. MCA plot for agroforestry.
Note: aca= active adopters; pca= passive adopters; ind= farmers indifferent; cna=conditional-non-adopter; rna =resistant-non-adopters to future scenarios



A) Active and passive adopters categories B) Conditional-non adopt. and resistant-non-adopters categories

Figure 4. MCA plot for Mixed farm.
Note: aca= active adopters; pca= passive adopters; ind= farmers indifferent; cna=conditional-non-adopter; rna =resistant-non-adopters to future scenarios.

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6.4 Econometric analysis

6.4.1 Descriptive statistics

According to the literature review section and the conceptual framework developed in D5.1, the driver of adoption can be distinguished in farm, farm household characteristics, in the current configuration of the supply chain and the farmers perception about that. Table 16 present the descriptive statics of the variables used in the two econometric models.

Table 16. Descriptive statistics with categories, variables, observations, mean SD, Min and Max.

Category	Variable (Code)	Variable (Description)	Obs	Mean	Std. Dev.	Min	Max
Dependent variable (Agroforestry model)	Agroforestry (categorical)	1 = Active adopter.	20	NA	NA	1	5
		2 = Passive adopter.	32				
		3 = Indifferent.	89				
		4 = Conditional non-adopter.	56				
		5 = Resistant non-adopter.	195				
Dependent variable (Mixed Farming model)	Mixed Farming (categorical).	1 = Active adopter.	72	NA	NA	1	5
		2 = Passive adopter.	89				
		3 = Indifferent.	87				
		4 = Conditional non-adopter.	23				
		5 = Resistant non-adopter.	121				
Household characteristics	Holding_successor (to have a successor) (dummy)	1= yes	181	0.46	NA	0	1
		0= no	211				
	External_worker (to have non-farm worker)	Unit of labour	392	1.783	12.673	0	246.92
	Farming Income (household gross revenue from farming >= 50%) (dummy)	1=yes	301		NA	0	1
		0=no	91	0.77			
Farmer characteristics	Age of farmer (categorical)	18-20	1	4.5	NA	1	7
		21-30	24		NA	1	7
		31-40	58		NA	1	7
		41-50	81		NA	1	7
		51-60	155		NA	1	7
		61-70	61		NA	1	7
		71-80	12		NA	1	7
	Agricultural_education (educational in agri-food field) (dummy)	1=yes	157	0.4	NA	0	1
		0=no	235				

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	Legal status of the farm (categorical)	0 other	82	1	NA	0	2
		1 individual	227				
		2 co-owner	83				
Farm characteristics	Livestock (continuous)	Unit of animals	392	47.36	183.72	0	2804
	Agro_climatic_environmental_schemes_participation(dummy)	1=yes	119	0.3	NA	0	1
		0=no	273				
	Organic production (dummy)	1=yes	71	0.18	NA	0	1
		0=no	321				
	Diversified (activity different from crop cultivation and animal farming) (dummy)	1=yes	223	0.57	NA	0	1
		0=no	169				
	Positive_op_sc (posititive opinion on current supply chain)	Standardised variable (Factor 1)	392	0	1	-2.37	2.44
	Negative_op_sc (negative opinion on current supply chain)	Standardised variable (Factor 2)	392	0	1	-2.64	2.28
	Land managed (continuous)	Hectares of land managed	392	81.83	55.17	0	224
	Policy payments (Basic payments schemes and/or countryside stewardship payments of RDP) (dummy)	1=yes	217	0.55	NA	0	1
		0=no	175				
	Technical advice assistance (dummy)	1=yes	140	0.64	NA	0	1
		0=no	252				
Country	Country_1 (dummy)	1=Germany	136	0.35	NA	0	1
		0=otherwise	256				
	Country_2 (dummy)	1=Serbia	114	0.29	NA	0	1
		0=otherwise	278				
	Country_3 (dummy)	1=Greece	64	0.16	NA	0	1
		0=otherwise	328				
	Country_4 (dummy)	1=United Kingdom	16	0.04	NA	0	1
		0=otherwise	376				
	Country_5 (dummy)	1=Italy	62	0.16	NA	0	1
		0=otherwise	330				

The dependent variables for both econometric models are categorical variables representing farm typologies concerning the adoption of AF or MF. In accordance Table 16, farmers are classified into four different

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categories: "*active adopters*", "*passive adopters*", "*conditional non-adopters*", and "*resistant non-adopters*". Additionally, we have included a table with fifth category: "*indifference*", which contains opinions not positioned for at least one of the proposed scenarios. The latter will be instrumentally used as based outcomes for the econometric models. Table 16 presents the frequency for agroforestry and mixed farm dependent variables.

The second category of explanatory variables describes household characteristics and comprises variables that can illustrate the interplay between household characteristics and farming-related strategies. It includes variables enabling an explanation of whether the farm has a farm household successor, the amount of household labour employed on the farm, and a dummy variable about external labour. Finally, belonging to this category is the amount of household income obtained from farming activities. These variables can be used to explain household investment in farming activities (Boncinelli et al., 2018; Marino et al., 2021).

The third category of explanatory variables describes farmers' characteristics, such as whether farmers hold professional agricultural education, the age of the farmers, and a categorical variable about legal status (individual, co-owner, or other).

The fourth category of covariates includes farmers' characteristics related to farm structure, specialisation, as well as farmers' opinions about the current supply chain. We consider farm specialisation under two main perspectives: having or not having livestock and having or not having differentiated activities. The former is considered using both a dummy for livestock and the calculation of herd size on Livestock Size Unit, while the latter involves counting the number of diversified activities on each farm. This category also includes some indicators of intensity by applying a variable measuring the land operated and the use of technical advice assistance. Additionally, a variable measuring whether the farm is currently producing organic or not can be used as a proxy for environmental awareness or the quality of productions. This category also contains policy payments variables, summing payments from both pillars (Policy payments) and whether the farm is currently participating in agro-environmental and climatic schemes (*AECS_participation)*.

The variables *positive_op_sc* and *Negative_op_sc* are obtained by employing principal component analysis on data collected on farmers' opinions about the current supply chain (see Annex 2 for a detailed description of principal component analysis). PCA was employed to reduce the complexity of farmers' opinions and generate simplified information for use in economic exercises. The variable *Positive_op_sc* is one of the new factors generated through PCA and combines all variables that describe a positive opinion on the current supply chain. Thus, a lower value could lead to a higher willingness to change the farming system. Conversely, the (negative opinion on the current supply chain) factors information positive opinion on the current supply chain. Finally, dummies for each country in the survey are added to consider country-specific conditions.

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6.4.2 Modelling results

Table 17 and 18 present the Multinomial model results, for agroforestry and mixed farm respectively.

Table 17. Multinomial logit regression for Agroforestry adoption under future scenarios.

	AA/Indifferent	PA/Indifferent	CNA/Indifferent	RNA/Indifferent
Legal_status	-0.281	**0.971***	0.129	**0.605***
	(0.612)	(0.506)	(0.376)	(0.333)
External_worker	-0.110	-0.175	0.001	0.009
	(0.144)	(0.173)	(0.022)	(0.016)
Farming income	0.097	-0.085	**-0.836***	-0.083
	(0.933)	(0.765)	(0.505)	(0.439)
Agricultural education	0.319	**1.350****	**1.461****	**1.097****
	(0.726)	(0.669)	(0.569)	(0.427)
Positive_opinion_sc	0.031	-0.467	0.318	-0.166
	(0.314)	(0.306)	(0.223)	(0.181)
Negative_opinion_sc	-0.448	-0.428	**0.408***	**0.315***
	(0.389)	(0.323)	(0.231)	(0.188)
Age of farmer	-0.026	**-0.042***	**-0.028***	-0.004
	(0.026)	(0.024)	(0.017)	(0.016)
Land managed (hectares)	**0.029****	**0.019****	**0.024*****	**0.023*****
	(0.009)	(0.008)	(0.006)	(0.006)
Livestock	-0.005	**0.002*****	0.001	0.001
	(0.004)	(0.001)	(0.001)	(0.001)
Agro_clim_env_sc	-0.188	0.934	0.624	0.665
	(0.854)	(0.761)	(0.781)	(0.597)
Policy payments	0.938	1.152	0.411	0.529
	(0.824)	(0.990)	(0.523)	(0.404)
Organic	**1.962****	1.267	0.301	0.519
	(0.989)	(0.853)	(0.807)	(0.626)
Technical advice	0.227	**2.173****	**1.603*****	**0.655***
	(0.594)	(0.880)	(0.480)	(0.388)
Diversified	**2.300****	**1.754*****	0.482	**0.890****
	(0.756)	(0.589)	(0.475)	(0.399)
Germany	**11.429*****	**12.745*****	**14.732*****	**2.191*****
	(0.992)	(1.185)	(0.700)	(0.658)
Greece	**14.322*****	**14.262*****	**14.379*****	**1.945*****
	(1.273)	(1.270)	(0.959)	(0.671)
Serbia	**11.632*****	**11.798*****	**14.234*****	0.657
	(1.397)	(1.419)	(0.928)	(0.764)
Italy	**14.432*****	**14.764*****	**13.430*****	**1.608****
	(1.042)	(1.313)	(1.177)	(0.731)
_cons	**-17.198*****	**-18.855*****	**-16.690*****	**-4.234*****
	(1.925)	(2.060)	(1.466)	(1.140)

Note. Indifferent is the base outcome. It indicates farmers who are indifferent to maintaining or adopting Agroforestry practices Robust standard error is in brackets. Wald chi2 = 1751.13. Pseudo R2 = 0.34 *p<=10%; **p<=5%***p<=1%.

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The results of the MNL model for AF adoption are presented in **Error! Reference source not found.**. The first thing observed is that as the availability of land increases, the probability of belonging to each category of adopters increases compared to farmers who are indifferent to any proposed policy scenario. Moreover, except for Serbian-resistant non-adopters, the probability of belonging to each category increases in Germany, Greece, Italy, and Serbia, compared to the United Kingdom. In particular, the probability of being an active adopter (AA) of AF also increases if the farm is an organic farm (1.962 *p=0.047*) and it carries out other commercial activities different from crop cultivation and animal farming (2.300 *p=0.002*). The negative opinion about the supply chain where the farmer operates increases the probability of being a resistant-non-adopter (RNA) (0.315 *p=0.094*), as well as the individual farm (0.605 *p=0.069),* the presence of at least one household member educated in agriculture (1.097 *p=0.010),* the availability of technical advice (0.655 *p=0.091*) and the carrying out of activities different from cultivation and livestock (0.890 *p=0.026*). The latter aspect also increases (1.754 *p=0.003*) the probability of being a passive adopter (PA) of AF practices, meaning those farmers who currently adopt the AF but have stated not to want to continue this practice under at least one of the four proposed future scenarios. The probability of being a passive adopter of AF also increases in individual farms with respect to the co-owner (0.971 *p=0.055*), with at least one household member educated in agriculture (1.350 *p=0.044*) and with the availability of technical advice (1.350 *p=0.044*).
Moreover, if the livestock increases the probability of abandoning (passive adopters) (0.002 *p=0.002*) AF practices under at least one future scenario increases too. Conversely, the probability decreases if the age of the farmer increases (-0.042 *p=0.084*). As for the conditional-non-adopter (CNA) of AF practices, meaning farmers who currently do not adopt AF practices but who declared to probably adopt AF under at least one of the proposed scenarios, the probability of being in this category decreases if more than 50% of household gross revenue comes from farming activities (-0.836 *p= 0.098*) and if the age of farmer increases (-0.028 *p=0.100*). Conversely, agricultural education (1.461 *p=0.010*) and the availability of technical advice (1.603 *p=0.001*) increase the probability of being a conditional-non-adopter of AF. Lastly, it is interesting to note that the negative opinion about the supply chain where the farmer operates increases the probability of being a conditional-non-adopter (0.408 *p=0.078*).

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Table 18. Multinomial logit regression for Mixed Farming adoption under future scenarios.

	AA/Indifferent	PA/Indifferent	CNA/Indifferent	RNA/Indifferent
Legal_status	0.441	0.374	-0.039	0.603
	(0.445)	(0.415)	(0.604)	(0.378)
External_worker	0.012	0.003	0.004	**-0.100***
	(0.015)	(0.016)	(0.017)	(0.057)
Farming_income	0.207	-0.213	-0.219	-0.134
	(0.554)	(0.488)	(0.639)	(0.444)
Agricultural education	**1.533*****	**0.910***	**1.288****	**0.964****
	(0.491)	(0.522)	(0.647)	(0.447)
Positive_opinion_sc	-0.014	-0.085	-0.027	-0.274
	(0.235)	(0.225)	(0.242)	(0.187)
Age of farmer	-0.012	-0.024	-0.024	-0.013
	(0.018)	(0.017)	(0.021)	(0.016)
Land managed (hectares)	**0.020*****	**0.017*****	**0.018****	**0.017*****
	(0.006)	(0.006)	(0.007)	(0.005)
Livestock	0.484	**1.041***	0.335	-0.080
	(0.668)	(0.607)	(0.715)	(0.564)
Agro_clim_env_sc	**1.362****	1.008	**2.152****	0.674
	(0.711)	(0.662)	(1.047)	(0.626)
Policy payments	0.358	0.482	1.029	0.565
	(0.548)	(0.503)	(0.736)	(0.433)
Organic	1.192	0.782	0.047	0.958
	(0.732)	(0.687)	(1.267)	(0.674)
Technical advice	**1.033****	**0.826***	**1.769*****	**0.762***
	(0.496)	(0.458)	(0.663)	(0.428)
Diversified	**2.352*****	**2.050*****	0.640	0.612
	(0.598)	(0.450)	(0.592)	(0.394)
Germany	0.133	**13.427*****	**13.656*****	**13.776*****
	(0.756)	(0.710)	(0.856)	(0.530)
Greece	-0.331	**12.142*****	**12.393*****	**14.039*****
	(0.877)	(0.949)	(1.673)	(0.528)
Serbia	0.353	**12.736*****	**15.086*****	**13.545*****
	(0.813)	(0.850)	(1.053)	(0.603)
Italy	0.573	**13.727*****	**11.965*****	**12.822*****
	(0.935)	(0.826)	(1.809)	(0.714)
Cons	**-5.230*****	**-15.951*****	**-17.967*****	**-15.499*****
	(1.553)	(1.362)	(1.701)	(1.129)

Note. Indifferent is the base outcome. It indicates farmers who are indifferent to maintaining or adopting Mixed farming practices Robust standard error is in brackets. Wald chi2 = 2703.95. Pseudo R2 = 0.25 *p<=10%; **p<=5%***p<=1%. To improve the statistical analysis, "Livestock" is included as a dummy variable while "Negative_opinion_sc" is excluded.

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The results of the MNL model for MF adoption are presented in Table 18. Results show a positive effect of agricultural education, availability of land managed, and the availability of technical advice on the probability of belonging to each category of adopters compared to farmers who are indifferent to any proposed policy scenario.

Moreover, except for the active adopter (AA) of mixed farming, the probability of belonging to passive adopters, conditional, and resistant non-adopters increase in Germany, Greece, Italy, and Serbia, compared to the United Kingdom. Moreover, the probability of being an AA also increases if the farm adopts agro-climatic and environmental schemes (1.362 *p=0.055*) as well as if the farmer carries out other commercial activities different from crop cultivation and animal farming (2.352 *p=0.000*). The diversification of activities also increases the probability of belonging to the passive adopters (PA) category (2.050 *p=0.000*) which also increases if the farm performs livestock activity (1.041 *p =0.086*). As for the conditional non-adopts (CNA) of mixed farming, meaning those farmers who currently do not adopt the MF practice but most probably will adopt it in the future, the probability of belonging to CNA of MF increases if the farmers already adopted agro-climatic and environmental schemes (2.152 *p=0.040*).

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7 Discussion

The adoption of Mixed Farming (MF) and Agroforestry (AF) signifies a significant departure from conventional farming practices towards more sustainable and diversified systems. Additionally, these systems take a longer time to yield benefits compared to traditional agriculture, as they involve multiple components with varying maturation periods. Our deliverable addresses AF/MF adoption from two different but integrated perspectives: supply chain analysis and adoption factors. The transition to a sustainable farming system is complex and poses several challenges, such as understanding how complexity and mixedness are adapted at the farm level and what new values farmers can share and deliver along the supply chain. This would call for recognition by consumers or upstream supply chain actors of these values, as well as a willingness to pay for them.

Our results describe that the current supply chain poorly supports the recognition of value attached to AF/MF, but the adoption of AF/FM can be seen as a diversification strategy with a growing recognition of independency from external inputs and a seeking of unconventional sale channels to add higher value to farm products. Complex decision-making is another parameter to consider for AF/MF adoption, as farmers must navigate numerous options and often modify their systems over time, introducing uncertainty. Achieving self-sustainability and self-diffusion in MF and AF takes more time compared to earlier agricultural innovations. Social and economic factors significantly influence adoption decisions, with farmers considering increased productivity, risk reduction, and economic viability.

We find that both individual farm-level adoption decisions and macro-level diffusion patterns affect the adoption of AF/MF. Farm-level adoption examines factors influencing a household's decision to adopt innovations, such as social, economic, and cultural factors, as well as farm strategy factors. The perceptions of innovations and communication channels, on one hand, and profitability, investment risks, and economic forces driving adoption are key parameters to frame a farmer's strategy.

We conclude that these studies have highlighted the importance of factors like wealth, risk, household preferences, and resource endowments in adoption decisions. Our results pinpoint that the transition toward a sustainable system is a rather reversible process. If benefits are not recognised or policy measures are weak, this transition toward sustainable farming systems will be revised. Our results emphasise also that the current structure of the supply chain and policy does not affect the intention about future adoption but rather external policies and changes in market and environmental conditions (input prices, pest controls) are relevant parameters to incentivise MF/AF adoption.

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Annex 1 - Survey

Survey Flow

Standard: Block 14 (2 Questions)
Block: PRELIMINARY INFORMATION *if filling out survey online, please skip this page (3 Questions)
Standard: CONTACT DETAILS AND GENERAL INFORMATION (2 Questions)
Standard: Individual/Household characteristics (7 Questions)
Standard: FARM characteristics (9 Questions)
Standard: Supply Chain Characteristics (4 Questions)
Standard: Expectation about future conditions (1 Question)
Standard: 5 Stated adoption of Agroforestry (2 Questions)

Branch: New Branch
If
If Are you currently adopting agroforestry? yes Is Selected

Block: current adoption agroforestry (2 Questions)
Standard: maintenance agroforestry (1 Question)

Branch: New Branch
If
If Are you currently adopting agroforestry? No Is Selected

Standard: future adoption agroforestry (1 Question)

Standard: Stated adoption of Mixed Farm system (2 Questions)

Branch: New Branch
If
If Are you currently adopting mixed farming? yes Is Selected

Standard: current adoption mixed farming (2 Questions)
Standard: maintenance mixed farming (1 Question)

Branch: New Branch
If
If Are you currently adopting mixed farming? No Is Selected

Standard: future adoption mixed farming system (1 Question)

Page Break

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Start of Block: Block 14

Q39 AGROFORESTRY
What is agroforestry production? Agroforestry systems combine arboreal with annual crops and/or meadow plants and grazing on the same land surface. With the right organisation this multifunctional approach can increase the productivity of the system compared to a more conventional way of production, as it can produce many different products such as timber, firewood, piles, bark, fruits, nuts and foliage for animals, nectar or pollen for bees, etc. protecting and revitalising the soil, and increasing biodiversity. In traditional systems the trees are forests such as oak, poplar, cypress, or fruit trees such as walnuts, olives, almond trees, which are used for the production of fruits or for timber. Under the trees are cultivated agricultural plants such as cereals, legumes, vegetables, industrial and hay plants (annual or perennial herbaceous e.g. legumes or woody plants) or meadow plants and animals coexist. In new approaches, trees are systematically planted for the production of fruit and timber technique by adjusting the density and layout of the trees so as to match the needs of the subfloor vegetation (competition light, humidity, nutrients) and the need to mechanise production.

MIXED FARMING
What is mixed farming? Mixed agriculture combines agricultural and livestock production benefiting from the diverse ecological and economic interactions created by this combination. The cultivation of plant species and the parallel rearing of animals for the production of animal products enables the farmer to make efficient use of the available resources and energy of his system. Some of the products of plant production and residues of food processing can be used as animal feed Or. Perennial cultivation of grass crops for hay such as alfalfa or the combination of alfalfa with grasses is often applied, for example. During this cultivation (alfalfa, for example, up to 5 years) the soil remains untreated, contributing to the development of a rich root system, the increase of the organic matter of the soil and the development of a beneficial soil structure. Especially grass plants belonging to the legume family enrich the soil with the nutrient element nitrogen. Grass plants can be turned into hay but there is also the option of direct grazing. It may also be that after harvesting the main crops (e.g. wheat) there may be grazing of the remnants of the crop. Through grazing but also through the collection of manure in the stables, livestock farming can contribute to the fertilisation of the fields. This requires fewer imports of fertiliser and feed and creates more closed cycles of nutrients and organic matter with a positive impact on the surrounding environment. At the same time, an alternative source of income from either crop production or livestock production is maintained, reducing the dependence of the producer on a single production product.

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Q40 Country

- ○ Germany (1)
- ○ Greece (2)
- ○ Italy (3)
- ○ Netherlands (4)
- ○ United Kingdom (5)
- ○ Serbia (6)

End of Block: Block 14

Start of Block: PRELIMINARY INFORMATION *if filling out survey online, please skip this page

Q1 Questionnaire number* if filling out survey online, please skip this page

____

Q2 Name of interviewer *if filling out survey online, please skip this page

____

Q3 Date

____

End of Block: PRELIMINARY INFORMATION *if filling out survey online, please skip this page

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Start of Block: CONTACT DETAILS AND GENERAL INFORMATION

Q5 Municipality

____

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Q6 Postal Code

____

End of Block: CONTACT DETAILS AND GENERAL INFORMATION

Start of Block: Individual/Household characteristics

Q16 How many members in your household (including yourself) are?

	please indicate the number (1)
Younger than 18 (1)	
Between 18 and 65 (2)	
Older than 65 (3)	

Q10 Does any (at least one) member of the household have a formal education in agriculture or related subjects? (e.g. agronomy, animal production, veterinary medicine (farm animals), forestry)

- ◯ Yes (1)
- ◯ No (2)

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Q11 How many members of your household are working in the agricultural holding (including yourself)?

	please indicate the number (1)
Full time (1)	
Part-time (2)	
Seasonal (3)	
Others (4)	

Q12 Would you define the legal status of your holding:

- ◯ Single owner (1)
- ◯ Co-owner together with a spouse (2)
- ◯ Co-owner as a member of joint ownership (private partnership) (3)
- ◯ Co-owner as a member of limited liability company (4)
- ◯ Tenant (5)
- ◯ Manager (6)
- ◯ Other, please specify (7) ____
- ◯ Does not answer/Does not want to answer (8)

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Q13 What is your age?

- 18-20 (1)
- 21-30 (2)
- 31-40 (3)
- 41-50 (4)
- 51-60 (5)
- 61-70 (6)
- 71-80 (7)
- More than 80 (8)
- Prefer not to say (9)

Page Break

Q15 Thinking about the future, do you already have an idea about the holding successor (after yourself)?

- Yes, a successor in my family (1)
- Yes, a successor not in my family (2)
- Not decided yet/never thought about it (3)
- Does not answer/Does not want to answer (4)

Q16 What percentage of your total household gross revenue comes from farming (on average)?

- (1)
- 10-29% (2)
- 30-49% (3)
- 50-69% (4)
- 70-89% (5)
- >90% (6)

End of Block: Individual/Household characteristics

Start of Block: FARM characteristics

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Q17 How many workers does the holding have?

	Number (1)
Nr. of full-time external workers: (1)	
Nr. of part-time and other external workers (2)	
Nr. of seasonal workers (3)	
Prefer not to say (4)	

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Q18 Could you please indicate the hectares of land managed?

	owned (1)	rented-in (2)	rented-out (3)
Arable area (1)			
Fruit/Trees area (2)			
Forest area (3)			
Fallow/permanent pasture (4)			

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Q19 What is the main specialisation of the holding?

- ◯ Cereals, oilseed and protein crops (e.g., legumes/pulses) (1)
- ◯ General field cropping (e.g. root crops) (2)
- ◯ Horticulture (3)
- ◯ Vineyards (4)
- ◯ Fruit (including citrus fruit) (5)
- ◯ Olives (6)
- ◯ Various permanent crops combined (7)
- ◯ Dairy (8)
- ◯ Beef (9)
- ◯ Dairy and Beef (10)
- ◯ Sheep, goats and other grazing livestock (11)
- ◯ Poultry (12)
- ◯ Mixed cropping (13)
- ◯ Mixed livestock, mainly grazing livestock (14)
- ◯ Mixed livestock, mainly granivores (15)
- ◯ Field crops-grazing livestock combined (16)
- ◯ Various crops and livestock combined (17)
- ◯ Forestry (18)
- ◯ Other (19) ____

Q20 If includes livestock, please specify how many animals are kept on your farm

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	# of animals (1)
Dairy cows (1)	
Beef cows (2)	
Fattening cattle (including veals) (3)	
Sows and hogs (4)	
Fattening pigs (5)	
Adult sheep or goats (6)	
Poultry (n. adults depending on species) (7)	
Poultry (n. of broilers) (8)	

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Q21 Is the farm engaged in agri-climatic-environmental schemes

◯ Yes (1)

◯ No (2)

Q22 Could you please state how many hectares or herd sizes of the holding land area were covered by the environmental contract/programme in 2022?

	hectares of land area/number of animals (1)
area under agri-environmental contracts (1)	
herd size (2)	

Q23 Does the farm produce organic products ?

◯ yes (1)

◯ No (2)

◯ other (3) ____

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Q24 Is the holding regularly assisted by an advisory/extension service

- ☐ Yes, with a specific environmental-related focus (1)
- ☐ Yes, generical technical advisory/extension service for crops related activities (2)
- ☐ Yes, generical technical advisory/extension service for livestock related activities (3)
- ☐ Yes, generical technical advisory/extension service for trees/forestry related activities (4)
- ☐ No (5)

Q25 Could you please state what was the amount of payments received from the Common Agricultural Policy in 2022?

	Amount of payments (€) (1)
Amount of payments received under the Basic Payment Schemes (BPS) (1)	
Amount of payments received under the Countryside Stewardship (2) (or RDPS)	
Other (3)	
None (4)	

End of Block: FARM characteristics

Start of Block: Supply Chain Characteristics

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Q27 Could you please indicate to whom and what percentage the holding sells its products/harvest (the customer) to (total = 100%). Please provide details for each production component referring to the economic value of your production

	Cooperative (1)	Producer organisation (2)	Inter-branch organisation (3)	Wholesale firms (14)	Farmers' union (4)	Geographical indications and traditional specialities in the European Union (e.g. PDO/PGI/TSG) (5)	Individual sales to local markets, including farmers' markets or final consumers (6)	Individual sales to independent retailers/restaurants (7)	Individual sales to supermarkets (8)	Individual sales to processors (9)	Other, reused on the farm (10)	Other, self-consumption (11)	Other (12)
Woody (trees and shrubs) (1)													
Arable (2)													
Livestock (3)													

Q28 Does the agricultural holding carry out any other commercial activity different from crop cultivation and animal farming?

○ Yes (1)

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○ No (2)

Q29 Does the agricultural holding carry out any other commercial activity different from crop cultivation and animal farming?

	Click to write Column 1	
	yes (1)	no (2)
Contract work using farm labour and/or machinery (1)	○	○
Food processing & manufacturing (2)	○	○
Retailing (ex direct sell) (3)	○	○
Recreational services (4)	○	○
Energy production (5)	○	○
Carbon storage (6)	○	○
Wood production (7)	○	○
Others (8)	○	○

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Q30 Please rate from 1 to 5 how much do you agree with the following statements regarding the current supply chain. Please, refer to the supply chain where you sell the majority of your farm's produce.

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	disagree (1)	Somewhat disagree (2)	Neutral (3)	Somewhat agree (4)	Agree (5)	Prefer not to say (6)
I do not have alternative options to the current supply chain (i.e. to who I sell my product) (1)	○	○	○	○	○	○
The current supply chain provides an acceptable price to alternative buyers (2)	○	○	○	○	○	○
The current supply chain provides more stable prices from year to year than alternative buyers (3)	○	○	○	○	○	○
The current supply chain provides more possibilities for negotiating prices (4)	○	○	○	○	○	○
This sale agreement provides more possibilities for negotiating the characteristics of the agreement rather than prices (e.g. duration, time of payments, quantity/quality delivered) (5)	○	○	○	○	○	○

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The costs associated with the current supply chain are too high (e.g. storage, transport, marketing and promotion, commission on sales) (6)	○	○	○	○	○	○
The production standards requirements (e.g. quality, harvest time; minimum quantity etc.) are too restrictive (7)	○	○	○	○	○	○
The current supply chain requires the purchase of external inputs (8)	○	○	○	○	○	○
The current supply chain does not support a diversification strategy. (9)	○	○	○	○	○	○
Other, please specify (10)	○	○	○	○	○	○

End of Block: Supply Chain Characteristics

Start of Block: Expectation about future conditions

Q31 To what extent might the following factors influence your choice of farming system?

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	Not at all (1)	Slightly important (2)	Moderately important (3)	Very important (4)	Extremely important (5)	Don't Know (6)	Prefer not to say (7)
Adverse climatic conditions or pests (e.g. hail, drought, floods, animal disease) (1)	◯	◯	◯	◯	◯	◯	◯
Fluctuation in the price of inputs from year to year (seeds, fertilisers, pesticides, fuel, energy, feed, etc.…) (2)	◯	◯	◯	◯	◯	◯	◯
Reduction of dependence by external inputs (3)	◯	◯	◯	◯	◯	◯	◯
Severe drop in market prices of agricultural production (4)	◯	◯	◯	◯	◯	◯	◯
Access to credit/liquidity (5)	◯	◯	◯	◯	◯	◯	◯
Change the regulations the farm's activities need to abide by (e.g. nitrate, water and pesticides regulations) (6)	◯	◯	◯	◯	◯	◯	◯

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Changes in the single farm payment (CAP payments under Pillar I) (7)	○	○	○	○	○	○	○
Changes in agri-environmental payments and RDPs (8)	○	○	○	○	○	○	○
Increasing autonomy in the supply chain (9)	○	○	○	○	○	○	○
Increasing integration with other supply chain actors (retailers) (10)	○	○	○	○	○	○	○
Needs to shorten the supply chain (11)	○	○	○	○	○	○	○
New markets for public goods (carbon storage etc..) (12)	○	○	○	○	○	○	○
Other, please specify (13)	○	○	○	○	○	○	○

End of Block: Expectation about future conditions

Start of Block: 5 Stated adoption of Agroforestry

Q28 The project investigates mixed farm and agroforestry farm typologies. Based on that definition we define AGROFORESTRY as the practice of deliberately integrating woody vegetation (trees or shrubs) with crop and/or animal systems to benefit from the resulting ecological and economic interactions, based on a prior definition of Burgess et al. (2015).

____

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Q29 Are you currently adopting agroforestry?

- ◯ yes (1)
- ◯ No (2)

Q31 please indicate which share of your operating land is covered by this farming system

____

Q33 Please indicate which share of your herd size belongs to this farming system

____

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Q39 Please indicate how is likely that you will maintain AGROFORESTRY in the next ten years considering the following future policy conditions:

	Extremely Likely (1)	Likely (2)	Neutral (3)	Unlikely (4)	Extremely Unlikely (5)	I don't know (6)
the current Basic Payment Scheme (BPS) and Countryside Stewardship (1)	○	○	○	○	○	○
Introduction of new schemes to reimburse the compensation cost for adoption Agroforestry (2)	○	○	○	○	○	○
introduction of carbon market that will pay for the amount of carbon storage (3)	○	○	○	○	○	○
abolishment of all Basic Payment Scheme (BPS) and Countryside Stewardship (4)	○	○	○	○	○	○

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Q32 Please indicate how is likely that you will adopt AGROFORESTRY in the next 10 years considering the following future policy conditions:

	Extremely Likely (1)	Likely (2)	Neutral (3)	Unlikely (4)	Extremely Unlikely (5)	I don't know (6)
the current Basic Payment Scheme (BPS) and Countryside Stewardship (1)	○	○	○	○	○	○
Introduction of new schemes to reimburse the compensation cost for adoption Agroforestry (2)	○	○	○	○	○	○
introduction of carbon market that will pay for the amount of carbon storage (3)	○	○	○	○	○	○
abolishment of all Basic Payment Scheme (BPS) and Countryside Stewardship (4)	○	○	○	○	○	○

End of Block: future adoption agro-forestry

Start of Block: Stated adoption of Mixed Farm system

Q40 The project investigates the mixed farm and agroforestry farm typologies. Based on that definition we consider MIXED FARMING as the practice of deliberately integrating crop and livestock production to benefit from the resulting ecological and economic interactions (Püttsepp et al., 2020).

Q41 Are you currently adopting mixed farming?

- yes (1)
- No (2)

Q42 please indicate which share of your operating land is covered by this farming system

____

Q43 Please indicate which share of your herd size belongs to this farming system

____

End of Block: current adoption mixed farming

Start of Block: maintainance mixed farming

Q44 Please indicate how is likely that you will maintain MIXED FARMING system in the next ten years considering the following future policy conditions:

	Extremely Likely (1)	Likely (2)	Neutral (3)	Unlikely (4)	Extremely Unlikely (5)	I don't know (6)
the current Basic Payment Scheme (BPS) and Countryside Stewardship (1)	○	○	○	○	○	○
Introduction of new schemes to reimburse the compensation cost for adoption mixed farming (2)	○	○	○	○	○	○
introduction of carbon market that will pay for the amount of carbon storage (3)	○	○	○	○	○	○
abolishment of all Basic Payment Scheme (BPS) and Countryside Stewardship (4)	○	○	○	○	○	○

End of Block: maintainance mixed farming

Start of Block: future adoption mixed farming system

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Q45 Please indicate how is likely that you will adopt MIXED FARMING in the next 10 years considering the following future policy conditions:

	Extremely Likely (1)	Likely (2)	Neutral (3)	Unlikely (4)	Extremely Unlikely (5)	I don't know (6)
the current Basic Payment Scheme (BPS) and Countryside Stewardship (1)						
Introduction of new schemes to reimburse the compensation cost for the adoption Mixed Farm (2)						
introduction of carbon market that will pay for the amount of carbon storage (3)						
abolishment of all Basic Payment Scheme (BPS) and Countryside Stewardship (4)						

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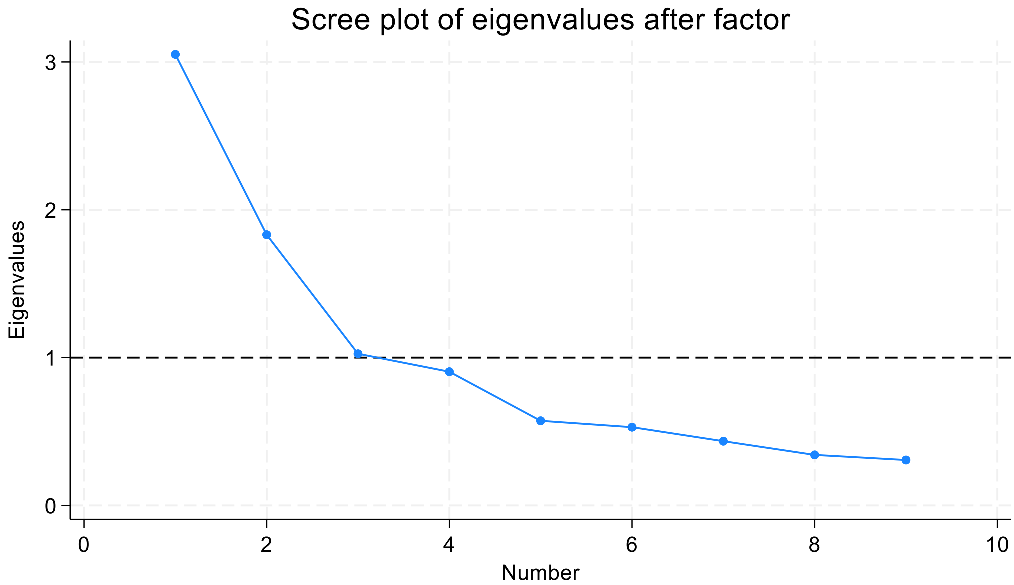
Annex 2 – Results of PCA



Note: Rotated factor loading varimax blank (0.6)

Item description	Factor_1 Positive opinion	Factor_2 Negative opinion	Factor_3 Indifferent	Uniqueness
1_I do not have alternative options to the current supply chain (i.e. to who I sell my product)			0.895	0.191
2_The current supply chain provides an acceptable price to alternative buyers	0.751			0.318
3_The current supply chain provides more stable prices from year to year than alternative buyers	0.667			0.369
4_The current supply chain provides more possibilities for negotiating prices	0.832			0.291
5_This sale agreement provides more possibilities for negotiating the characteristics of the agreement rather than prices (e.g. duration, time of payments, quantity/quality delivered)	0.826			0.285
6_The costs associated with the current supply chain are too high (e.g. storage, transport, marketing and promotion, commission on sales)		0.601		0.524
7_The production standards requirements (e.g. quality, harvest time; minimum quantity etc.) are too restrictive		0.784		0.355
8_The current supply chain requires the purchase of external inputs		0.795		0.366
9_The current supply chain does not support a diversification strategy		0.729		0.384

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