Shaping the agricultural future: Engaging stakeholder feedback for the development of agricultural robotic solutions

Maria-Zoi Papantonatou[1,2], George Papadopoulos[1,2], Spyros Fountas[1], Havva Uyar[3,1], Frits Van Evert[4]

[1]Department of Natural Resources Management and Agricultural Engineering, Agricultural University of Athens, [2]Faculty of Crop Science, Agricultural University of Athens, [3] Singular Logic, [4]Agrosystems Research, Wageningen University & Research,

* Maria-Zoi Papantonatou. Email: m.papantonatou@aua.gr

Abstract

Smart farming technologies and robotic solutions may enable farming to move towards a more environmentally friendly agriculture landscape. These solutions, whether already commercially available or still under development, represent the future of agriculture and will play a crucial role in supporting farmers in crop production. The involvement and opinions of farmers, advisors, and agriculture students are vital in ensuring the adoption and smooth transition from traditional to smart, robotic, and data-driven methods. Field demonstrations are an important method to familiarise these stakeholders with the new technologies. Autonomous robotic solutions were presented for weeding and spraying applications developed within the EU-funded project Robs4Crops in Greece. Feedback was collected from farmers, advisors and students who attended the demonstration. The survey aimed to engage them by documenting their opinions and beliefs during these demonstrations. The aim of the study was to present and analyse their feedback on the effectiveness of such demonstrations, the level of understanding of the presented robotic solutions, and insights into challenges and potential solutions for market adoption. The main results of the survey showed a very positive reaction towards the new innovative agricultural robotic solutions. The demonstrations significantly improved the participants' understanding of robotic technologies, with an impressive 100% expressing full agreement and approval of the presented solutions. In addition, 96% reported that their perception of the potential benefits of robotic agriculture was positively altered by the demonstrations, highlighting a transformative effect on their views. This collective agreement of opinion among farmers, advisors, and agricultural students illustrates the effectiveness of the demonstrations in providing valuable information and promoting a more informed perspective on the potential and benefits of robotic agriculture technologies. The findings suggest that such demonstrations could play a key role in accelerating the adoption of smart agriculture technologies, paving the way for a more efficient and sustainable agricultural sector.

Keywords: Robotic solutions, Smart Agricultural Technologies, Farmers' perception, Students' perception, questionnaire survey

1. Introduction

Smart farming technologies, including robotic solutions and precision agriculture technologies are considered as key components to achieve the transition towards a more environmentally sustainable future (Papadopoulos et al., 2024). To ensure a smooth transition from traditional practices to smart, data-driven agriculture, it requires not only innovative technological enhancements but also a comprehensive adoption process through effective strategies and engagement of key stakeholders such as farmers, students, and agricultural advisors (Kanesh et al., 2022). These stakeholders play a crucial role not only as a knowledge base but also as influential decision-makers within the agricultural sector. Their perspectives and involvement are crucial for the adoption and incorporation of smart farming technologies into the current agricultural practices.

Studying the smart farming technologies adoption process and impact is important for an effective transition to a new agricultural framework and thus many studies have been carried out world-wide to identify it. In their study, Kanesh et al. (2022) explored the perceptions and attitudes of farmers towards adopting smart farming technologies in the Batticaloa district of Sri Lanka. They gathered primary data through a questionnaire survey conducted with randomly selected farmers from February to April 2020. To analyse this data, they employed the Technology Acceptance Model to assess how farmers adopt and use precision agricultural techniques. Further analysis using Structural Equation Modelling, preceded by

Confirmatory Factor Analysis, helped them identify significant relationships between various factors. The findings revealed a generally positive perception among farmers regarding the adoption of precision agricultural techniques.

Furthermore, Vrchota et al. (2022) investigated the adoption of precision agriculture technologies among Czech agricultural enterprises. They conducted a questionnaire survey involving 131 farms and employed a Chi-squared test to analyse the data. The survey revealed that 58% of enterprises used intelligent weather stations, 89% utilized unmanned vehicles, and 62% employed navigation and optimisation systems for journey optimisation. These findings underscore a robust willingness among agricultural enterprises to embrace new technologies. They also provide valuable insights for policymakers on the implementation of these technologies and suggest directions for targeted funding towards grants and projects. This study, along with the survey by Kanesh et al., highlights the critical role of farmer engagement in integrating smart farming technologies into daily routines.

Within the EU-funded Robs4Crops project, which aims to develop robotic solutions for spraying applications, demonstrations were conducted in Greece showcasing to farmers, advisors, and students two innovative technologies: a) the autonomous spraying capabilities of a retrofitted tractor, and b) the practical applications and benefits of a Farming Controller (FC) through the use of Digital Twins (DT). These demonstrations were intended to engage directly with participants and enhance their understanding of these agricultural technologies, setting the stage for future improvements. Following the demonstrations, a survey was conducted to gather feedback and assess participants' perspectives on smart agricultural technologies and robotic solutions.

The aim of this study was to present and analyse the results obtained from this survey, assessing the impact of demonstration activities on stakeholders' understanding, perception, and readiness to adopt smart farming technologies. Through structured demonstrations and subsequent surveys among farmers, agricultural advisors, and students, the study sought to identify key drivers of engagement, the educational effectiveness of the demonstrations, and the challenges and barriers to market adoption of robotic farming technologies. Additionally, the study aimed to gather actionable insights to inform future strategies for technology implementation and educational efforts, facilitating smoother integration of innovative agricultural technologies into mainstream farming practices.

2. Materials & Methods

2.1. Online questionnaires survey

To facilitate the survey process, participants were categorised into two distinct groups: a) farmers and agricultural advisors, and b) students. Data collection was carried out through separate online questionnaires using Google forms, each comprising a structured format with a diverse range of questions grouped into specific categories. The breakdown of the survey questions categories used for each group are described below:

Farmers, agricultural advisors: Eleven survey questions were formulated, each tailored to address the following categories: 'Participant Background and Affiliation', 'Evaluation of Demonstration Activities'. 'Factors Influencing Attendance', 'Familiarity and Understanding of Robotic Farming', 'Quality of Information and Perception Change', 'Challenges and Solutions in Market Adoption', and 'Suggestions for Improvement'.

The section 'Participant Background and Affiliation' aimed to categorise the participants based on their professional background and affiliation, helping to understand the diversity of attendees. Subsequently, the questions under 'Evaluation of Demonstration Activities' focused on quality and impact assessment of the demonstrations. Attendance feedback and ratings provided quantifiable measures for satisfaction and perceived effectiveness. The questions under 'Factors Influencing Attendance', explored the motivations for attending the demonstrations providing insights into what drew participants to the event. Following this, the section 'Familiarity and Understanding of Robotic Farming', aimed to understand the participants' knowledge baseline regarding robotics and evaluate how effectively the demonstrations enhanced their understanding as well as the educational impact of the demonstrations. The questions under the 'Quality of Information and Perception' provided feedback to evaluate the quality of information provided and whether the demonstrations influenced attendees' perceptions about the benefits of robotic farming. Lastly, the segment on 'Quality of Information and Perception Change' endeavoured to evaluate the quality of information provided and whether the demonstrations influenced attendees' perceptions about the benefits of robotic farming.

Student engagement: Ten survey questions were formulated, each tailored to address the following categories: 'Familiarity and Understanding of Technologies', 'Demonstration Impact and Perception', 'Interactive Experience and Further Interest', 'Enthusiasm and User-Friendliness', 'Benefits, Challenges, and Enhancements'.

The section 'Familiarity and Understanding of Technologies' aimed to assess participants' initial familiarity with the technologies, thereby providing a context for their level of understanding. Subsequently, the questions under 'Demonstration Impact and Perception' focused on evaluating how the demonstration influenced participants' understanding and perception of the technologies' importance, as well as their opinions on the potential future impact of these technologies. The questions under 'Interactive Experience and Further Interest', delved into participants' interest in hands-on experiences and further educational opportunities related to the technologies showcased. Following this, the section 'Enthusiasm and User-Friendliness', aimed to evaluate participants' enthusiasm for adopting the technologies and assess their perceived ease of use. Lastly, the segment on 'Benefits, Challenges, and Enhancements' endeavoured to identify perceived benefits and potential advantages of the technologies, as well as the obstacles that might encounter when adopting them. Additionally, it gathered students' suggestions on how demonstrations could be enhanced to be more engaging and beneficial.

2.2 Agricultural stakeholders' outreach and Scale-up demonstrations

The demonstrations were conducted in Greece, showcasing the application of autonomous spraying with a retrofitted tractor in a vineyard, alongside the use of a FC enhanced by DT. In total, four demonstrations were held: one for farmers and agricultural advisors in the Kiato region of Peloponnese and three for students at the Agricultural University of Athens.

During these events, detailed presentations were given on the robotic solutions developed under the Robs4Crops project while for the student sessions a focus was given on the features of the FC and integrated DT for educational purposes. At the Kiato event, farmers and agricultural advisors were given the opportunity to witness a live demonstration of autonomous spraying with a retrofitted tractor, showcasing the technology in action. In contrast, at the Agricultural University of Athens, students were engaged through video presentations that not only demonstrated the FC and integrated DT but also included footage of the autonomous spraying technology being applied in vineyards. At the end of the demonstrations a discussion was followed up and then all attendees were invited to complete the online survey.

2.3. Data collection & statistical analysis

This study involved primary data collection from a total of 46 farmers and agricultural advisors, alongside 63 students from the Agricultural University of Athens. Data was obtained using the two online questionnaires and the responses were extracted from Google survey directly into an Excel file for feedback analysis.

For the statistical analysis, descriptive statistical methods were employed to summarize and interpret the participants' responses based on the predefined categories. Data were presented using frequency distributions, percentages, and graphical representations such as bar charts and pie charts to illustrate key findings.

3. Results

3.1. Farmers' Perspective

3.1.1. Participant Background and Affiliation

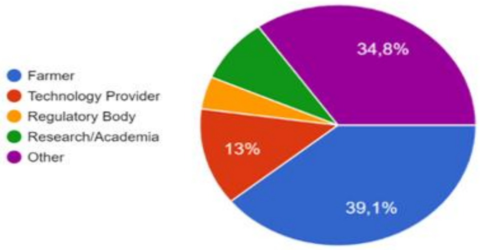


Figure 1: Distribution of Participant Background and Affiliation - Pie Chart

The results of the survey indicated a diverse representation of respondents in terms of their professional roles or affiliations (Figure 1). Farmers constitute the largest percentage, representing 39.13% of the participants, highlighting a significant presence of individuals directly involved in agricultural practices. Technology providers comprise 23.91% of respondents, showing significant interest from those offering agricultural tech solutions. Research/academia professionals account for 19.57%, representing individuals involved in agricultural research and education. Regulatory bodies account for 4.35% of the participants, showcasing a smaller presence. The remaining 13.04% falls into the "Other" category, which implies a variety of roles not explicitly mentioned in the provided options. Overall, the data underscores a diverse and engaged group of participants, encompassing a range of stakeholders from farmers and technology providers to researchers and regulatory bodies.

3.1.2 Evaluation of Demonstration Activities

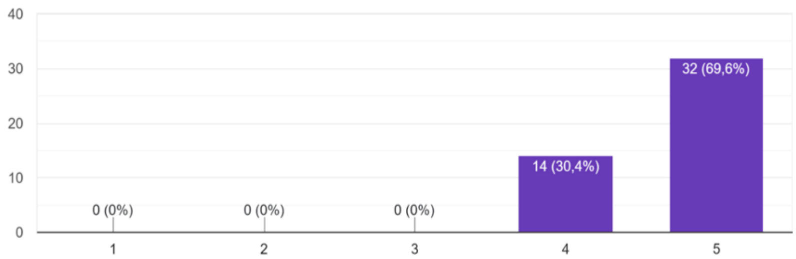


Figure 2: Feedback for the evaluation of demonstration - Bar Chart

Through the feedback collection for the evaluation of the demonstration activities, it has been identified through the answers, that a 69.6% of participants rated the activities as excellent (5/5), while 30.4% gave a very positive rating of 4/5 (Figure 2). The high percentage of top ratings reflects a strong endorsement and suggests that the participants found the demonstrations to be not only satisfactory but also of a particularly high standard.

3.1.3. Factors Influencing Attendance

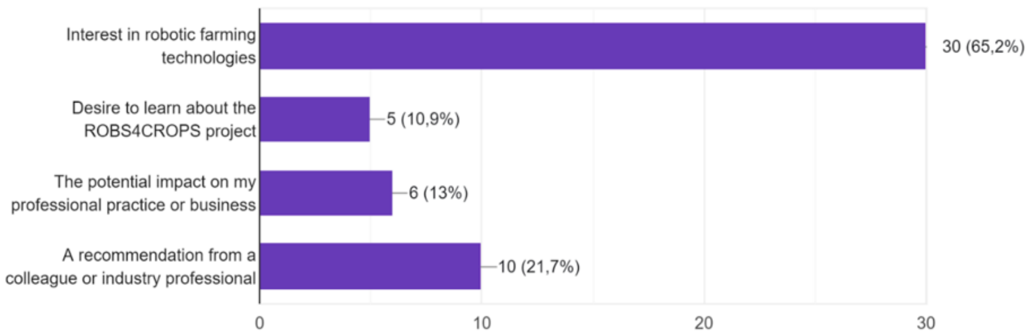


Figure 3: Feedback for the factors affecting attendance - Bar Chart

The survey was designed to capture the multi-faceted reasons for participants' participation and allowed for multiple factor choices. A total of 51 responses were collected, providing insight into the factors influencing participation in the demonstration activities of this demonstration (Figure 3).

A notable 65.2% of the participants stated a high interest in robotic farming technologies as the primary motivator for their participation. This was followed by 13.0% who highlighted the potential impact on their professional practice or business, while 10.9% expressed a specific interest in learning about the ROBS4CROPS project. Notably, recommendations from colleagues or industry professionals significantly influenced the decision of 21.7% of participants.

3.1.4. Familiarity and Understanding of Robotic Farming

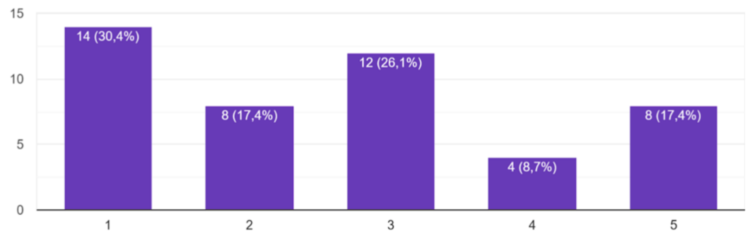


Figure 4: Feedback for Familiarity and Understanding of Robotic Farming - Bar Chart

Participants' responses to the questions regarding their familiarity with robotic farming before attending the demonstrations represent a diverse knowledge landscape (Figure 4). About 30.4% stated limited prior knowledge (rating 1/5), while 17.4% expressed advanced familiarity (rating 5/5). The middle ground (ratings 2/5, 3/5, and 4/5) accounts for 52.17%, illustrating a spectrum of moderate familiarity.

In addition, a subsequent question on whether the demonstrations had improved understanding of the participants received positive feedback of 100% 'yes', indicating the success of the programme in achieving its educational objectives. This collective agreement suggests that the demonstrations effectively provided valuable insights, fostering a more informed perspective on robotic farming technologies among all participants.

3.1.5. Quality of Information and Perception Change

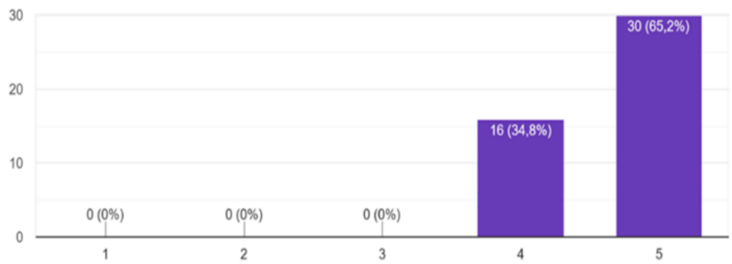


Figure 5: Feedback for Quality of Information and Perception Change - Bar Chart

Participants' feedback on the quality of information and knowledge disseminated during the demonstration activities reflects a highly satisfactory experience, with 65.2% giving the highest rating of 5 and an additional 34.8% rating it a 4 (Figure 5). The combined 100% approval underscores widespread satisfaction with the information presented, suggesting its high value. Moreover, when asked if the demonstrations altered their perception of the potential benefits of robotic farming, a significant 95.7% responded affirmatively. This indicates a transformative effect on their views, emphasizing the program's success in influencing perspectives and fostering a greater appreciation for the advantages of robotic farming.

3.1.6 Challenges and Solutions in Market Adoption

The survey responses reveal a range of challenges anticipated in the market adoption of robotic farming technologies. A recurring concern is the high cost associated with these farming technology innovations, creating financial barriers for farmers. Funding emerges as a potential solution to alleviate this challenge, suggesting a need for financial support mechanisms. Additionally, the insufficient education among farmers, particularly regarding the acceptance and understanding of robotic technologies is also considered as a challenge. The proposed solution involves intensifying educational efforts through seminars and demonstrations to enhance operator knowledge. Other identified obstacles include the high cost of specific products, lack of expertise, and resistance from older generations. To overcome these challenges, strategies such as reducing product costs, providing economical alternatives, and facilitating farmer education are suggested. The survey reveals the importance of addressing constraints and promoting comprehensive initiatives to foster the successful integration of robotic farming technologies into the agricultural landscape.

3.1.7 Suggestions for Improvement

There is a strong agreement among the survey respondents regarding the need for enhanced educational initiatives in future demonstration events or activities related to robotic farming technologies. The suggestions emphasize more active involvement of farmers, revealing the importance of real-life examples showcasing the successful implementation of these technologies in the fields. The desire for easy access to seminars, more free education opportunities, and constant updates reveals the importance of ongoing learning. Additionally, recommendations were made for better presentations, including more tractors and technologies, involving farmers who have first-hand experience with the equipment.

3.2. Students' Perspective

3.2.1. Familiarity and Understanding of Technologies

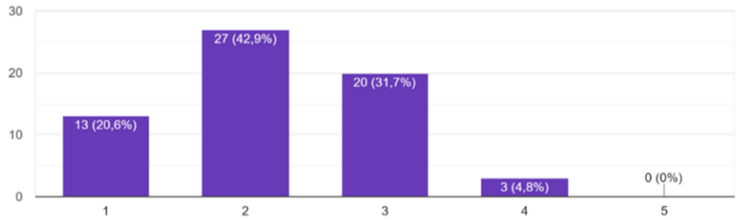
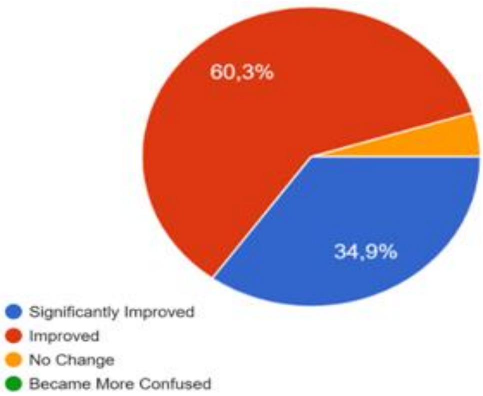


Figure 6: Familiarity and Understanding - Bar Chart

Responses from students regarding their familiarity with robotic farming before the demonstration reflect a varied knowledge landscape (Figure 6). A total of 20.63% reported a lack of familiarity, assigning a rating of 1/5. Limited knowledge (rating 2/5) was indicated by 42.9% of participants. The middle ground, representing moderate familiarity (rating 3/5), accounted for 31.7% of responses. High familiarity (rating 4/5) was expressed by 4.8% of the respondents. Notably, none of the participants claimed to be "Very familiar" with the tools, highlighting a lack of highest-level familiarity with the technologies.

3.2.2. Demonstration Impact and Perception



The responses to the question assessing the impact of the demonstration on students' understanding of the FT combined with DT indicate a substantial positive effect. A significant 60.3% of respondents reported an "Improved" understanding, while 34.9% noted a "Significantly Improved" comprehension. Notably, only 4.8% stated that there was "No Change" in their understanding. This distribution highlights the effectiveness of the demonstration in improving participants' understanding of the FC and DT integration (Figure 7).

Figure 7: Feedback for Demonstration Impact and Perception- Pie Chart.

Furthermore, the responses strongly indicate a positive perception of the integration in shaping the future of agriculture. A significant 63.5% of students rated these tools a "crucial role" in the future of agriculture (rating 5/5), with an additional 30.2% expressing a belief in their significance but with slightly less intensity (rating 4/5). 6.3% of the respondents stated mid-range rating with 3/5. Importantly, no respondents rated lower than 3/5, indicating a strong agreement on the significant role of these technologies in shaping agriculture (Figure 8).

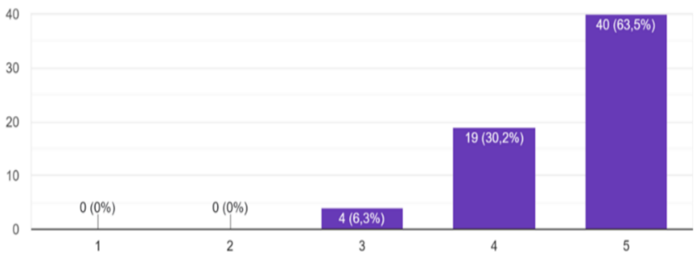


Figure 8: Feedback for Demonstration Impact and Perception- Bar Chart

3.2.3. Interactive Experience and Further Interest

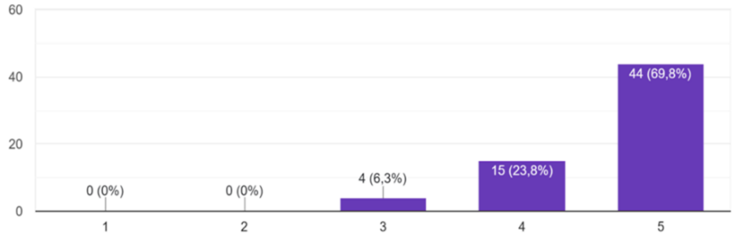


Figure 9: Feedback regarding the Interactive Experience and Further Interest -Bar Chart

Participants' feedback regarding their willingness for an interactive experience with the FC combined with DT indicates a strong positive inclination. A significant 69.8% of respondents rated their interest at 5/5, expressing high enthusiasm for interactive experiences. Additionally, 23.8% rated it 4/5, showing a positive attitude, while only 6.35% gave a mid-range rating of 3/5. (Figure 9) Notably, no participants rated below 3/5. This high percentage of positive responses underscores the potential appeal of incorporating interactive elements into demonstrations.

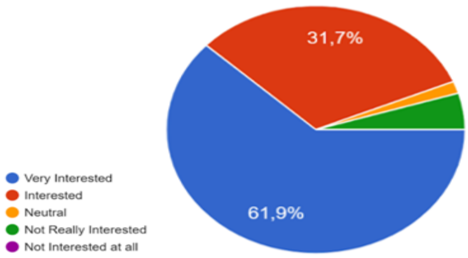


Figure 10: Feedback regarding the Interactive Experience and Further Interest -Pie Chart

Similarly, students' responses indicate strong interest in more in-depth training on the FC combined with DT. Notably, 61.9% of respondents were "Very Interested," and 31.7% were "Interested," while only 6.4% were neutral or less enthusiastic (Figure 10). With 93.6% expressing interest, there is a strong desire for comprehensive educational resources and training opportunities related to these technologies.

3.2.4. Enthusiasm and User-Friendliness

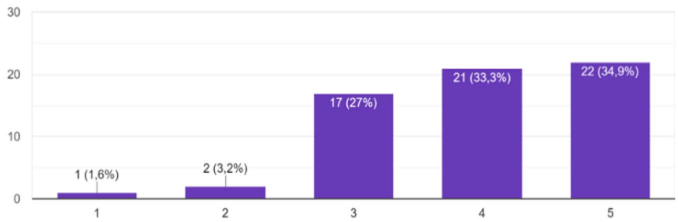


Figure 11: Feedback for Enthusiasm and User-Friendliness - Bar Chart

The students' responses regarding their enthusiasm for engaging with technologies in their future agricultural careers are overall positive. A significant 68.2% of students rated their excitement at 4/5 or 5/5, indicating substantial enthusiasm. Additionally, 27% gave a moderate rating of 3/5, rated it 2/5, and only 1.6% a negative response (Figure 11).

Overall, participants showed a positive outlook on adopting agricultural technologies in their future careers, with many expressing high anticipation for these opportunities. Regarding user-friendliness of the FT and DT the responses suggest a generally positive perception. About 9.5% of students rated it 5/5, and 49.2% rated it 4/5, indicating high satisfaction (Figure 12). Meanwhile, 39.7% gave a moderate rating of 3/5, and only 1.6% rated it 2/5, indicating a less positive view.

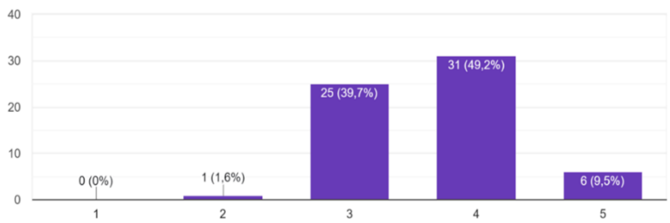


Figure 12: Feedback for Enthusiasm and User-Friendliness - Bar Chart

3.2.5. Benefits, Challenges, and Enhancements

Benefits: Participants' feedback on integrating the FC with DT in modern farming reveals optimistic views on its benefits. Students emphasised reduced input costs, increased efficiency, and environmental sustainability, while highlighting precision agriculture's potential for automation and field management optimization.

Challenges & Proposed Solutions: Survey responses highlight also challenges in adopting these technologies. Common barriers include high costs, financial constraints, limited farmer education, resistance to change, and difficulties in understanding new technologies. Additionally, factors like insufficient land availability and technological illiteracy pose also challenges. Proposed solutions include expanding technology use through funding, implementing eco-schemes, developing user-friendly environments, promoting machinery rental, and organizing practical training sessions. Other suggestions involve government or EU funding, industry cooperation, and continuous education programs. These insights offer valuable strategies to overcome adoption barriers and enhance technology integration in agriculture.

Enhancements: The feedback from students indicates a strong desire for more engaging and beneficial demonstrations of technologies like the FC combined with DT. They expressed the need for more interactive experiences including workshops with practical engagement and real-time exercises in the field while also suggested incorporating educational elements such as seminars and lessons. They seek more interactive, practical, and first-hand experiences to deepen their understanding and engagement with these advanced agricultural technologies.

4. Discussion

This survey indicated a significant shift in participants' views on smart farming technologies and robotic solutions, with 95.7% of them reporting that the demonstrations positively influenced their perceptions. This strong interest mirrors the findings from Jabbari et al. (2023), who reported a 90.91% engagement rate among 550 farmers in Jizan, Saudi Arabia, showing a similar interest in IoT technologies for crop monitoring. Their study linked farmers' awareness of IoT technologies to perceived benefits and willingness to adopt them. Additionally, students identified reduced input costs, increased efficiency, and environmental sustainability as notable benefits aligning with Tey and Brindal (2012) findings, who noted profitability as a major factor for using precision agriculture tools. As supported by Yarashynskaya et al. (2022), younger farmers, in particular, are showing a faster adoption rate due to their higher interest in new technologies. Students' responses strongly indicated a positive perception of the integration in shaping the future of agriculture. A significant 63.5% rated these tools as playing a "crucial role" in the future of agriculture (rating 5/5), while a significant overall 93.6% (69.8% rated their interest at 5/5, 23.8% rated it 4/5) expressed high enthusiasm for interactive experiences, confirming the younger generation's high interest in smart farming technologies.

Despite the high enthusiasm, the survey identified several barriers to adoption, with financial challenges at the forefront. The substantial costs associated with these technologies pose significant hurdles, as also highlighted by Yarashynskaya et al. (2022), who pointed to limited credit availability as a major obstacle due to high initial investments. Therefore, the findings of this study suggest that robust financial support mechanisms are essential to facilitate the adoption of these technologies. Furthermore, the study revealed that education level had a strong impact on technology adoption. The insufficient education among farmers, particularly regarding the acceptance and understanding of robotic technologies, was identified as a significant barrier. Therefore, as also suggested by the participants, intensifying educational efforts through seminars and demonstrations could enhance knowledge and acceptance of new technologies. These findings align with Bai et al. (2022) and Tamirat et al. (2018), whose studies highlighted the importance of socio-economic factors in the adoption of technologies.

5. Conclusion

The survey results highlighted a substantial interest in smart farming technologies, with 65.2% of participants citing it as their main motivator for attending, underscoring their enthusiasm for innovative agricultural practices. The demonstrations significantly improved participants' understanding of robotic technologies, with 100% expressing full agreement and approval of the presented solutions. Additionally, 96% reported a positive change in their perception of the potential benefits of robotic solutions, underscoring the transformative impact of the demonstrations. The evaluation of the demonstration activities also revealed a high level of satisfaction, with 97% of participants rating the activities as excellent (5/5) or very positive (4/5), indicating the successful introduction of new agricultural technologies to stakeholders.

Unlike other surveys, the inclusion of students' opinions, who represent the future of agriculture, proved to be essential revealing a strong interest in integrating these tools into agricultural practices. Furthermore, the vast majority of them (93.6%) expressed the desire for further educational and training opportunities related to these technologies. This high level of interest highlights the importance of engaging the next generation in discussions and initiatives related to modern farming technologies.

Nevertheless, the survey also identified challenges in market adoption, such as high costs and insufficient education, suggesting the need for financial support and intensified educational efforts. Benefits noted by participants included reduced input costs, increased efficiency, and environmental sustainability. Addressing these constraints and promoting comprehensive initiatives are essential for successfully integrating robotic farming technologies into modern agriculture. These insights are invaluable for guiding future research and enhancements, ensuring that the adoption of robotic farming technologies can be effectively supported and expanded.

References

Anastasiou, E., Fountas, S., Koutsiaras, M., Voulgaraki, M., Vatsanidou, A., Barreiro-Hurle, J., ... & Gómez-Barbero, M. (2023). Precision farming technologies on crop protection: A stakeholders survey. Smart Agricultural Technology, 5, 100293.

Papadopoulos, G., Arduini, S., Uyar, H., Psiroukis, V., Kasimati, A., & Fountas, S. (2024). Economic and Environmental Benefits of Digital Agricultural Technologies in Crop Production: A review. Smart Agricultural Technology, 8, 100441. https://doi.org/10.1016/j.atech.2024.100441

Suresh, K., Narmilan, A., Ahmadh Rifai Kariapper, R. K., & Sabraz Nawaz, S. (2022). Farmers' Perception on Precision Farming Technologies: A Novel Approach. *Indian Journal of Agricultural Economics, 77(2), 264-276*

Vrchota, J., Pech, M., & Švepešová, I. (2022). Precision Agriculture Technologies for Crop and Livestock Production in the Czech Republic. *Agriculture, 12(8), 1080.*

Balafoutis, A., Beck, B., Fountas, S., Tsiropoulos, Z., Vangeyte, J., van der Wal, T., Soto, I., Gómez-Barbero, M., & Pedersen, S. M. (2017). Smart Farming Technologies – Description, Taxonomy and Economic Impact.

Van Evert, F., Gaitán Cremaschi, D., Fountas, S., & Kempenaar, C. (2017). Can Precision Agriculture Increase the Profitability and Sustainability of the Production of Potatoes and Olives?. *Sustainability, 9, 1863.*

Jabbari, A., Humayed, A., Reegu, F. A., Uddin, M., Gulzar, Y., & Majid, M. (2023). Smart Farming Revolution: Farmer's Perception and Adoption of Smart IoT Technologies for Crop Health Monitoring and Yield Prediction in Jizan, Saudi Arabia. *Sustainability, 15(19), 14541*.

Bai, A., Kovách, I., Czibere, I., Megyesi, B., Balogh, P. 2022. Examining the Adoption of Drones and Categorisation of Precision Elements among Hungarian Precision Farmers Using a Trans-Theoretical Model. Drones. 6(8):20

Yarashynskaya, A., & Prus, P. (2022). Precision Agriculture Implementation factors and adoption potential: The Case Study of Polish Agriculture. Agronomy, 12(9), 2226. https://doi.org/10.3390/agronomy12092226

Tamirat, T.W.; Pedersen, S.M.; Lind, K.M. Farm and operator characteristics affecting adoption of precision agriculture in Denmark and Germany. Acta Agric. Scand. Sect. B—Soil Plant Sci. 2018, 68, 349–357.

Tey, Y.S., & Brindal, M. (2012). Factors influencing the adoption of precision agricultural tech-nologies: A review for policy implications. Precision Agriculture, 13, 713-730.