The Use of New Technologies in the Primary Production Sector

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Received 18 March 2025; Accepted 27 April 2025

Abstract

Purpose – This study explores the use of new technologies in the primary production sector as a tool for addressing climate change challenges and enhancing sustainable development. It focuses on the contribution of technologies such as smart agriculture, the Internet of Things (IoT), and automation in improving productivity, crop resilience, and reducing the environmental footprint. At the same time, it examines the challenges associated with technological transition, with particular emphasis on small-scale farmers' access, data security, and the required investments and strategies.

Design/Methodology/Approach – The research is based on theoretical analysis and an empirical case study in Greece, focusing on the production of traditional products in Western Macedonia. It includes both qualitative and quantitative methods, data collection from farmers and agricultural entrepreneurs, as well as statistical analysis to evaluate the factors influencing the adoption of new technologies in the primary sector.

Strategic Planning for Energy and the Environment, Vol. 44_4, 727–754.
doi: 10.13052/spee1048-5236.4444

Findings – The results highlight the significant contribution of new technologies in improving the efficiency of agricultural holdings and reducing the environmental impact. However, challenges related to limited access to technological solutions, the need for specialized training for farmers, and data management issues are identified. Small-scale farmers face greater difficulties in integrating these technologies due to financial and organizational constraints.

Originality – This research contributes to understanding the potential and limitations of new technologies in the Greek primary sector, focusing on a region with strong agricultural activity and traditional product production. It provides empirical data on the application of smart farming practices and proposes policy recommendations for sustainable development and technological integration in the agricultural sector.

Keywords: New technologies, primary sector, sustainable development, climate change, smart agriculture, Internet of Things (IoT), productivity, resilience, traditional products, local development, environmental footprint, small-scale farmers, education, infrastructure, data security.

1 Introduction

The agricultural sector plays a crucial role in global food security, economic stability, and environmental sustainability. However, it faces numerous challenges due to climate change, resource depletion, and increasing demand for food production [32]. In this context, the integration of new technologies into primary production has emerged as a transformative approach to enhance agricultural efficiency, resilience, and sustainability [107].

The primary sector is both a contributor to and a victim of climate change. On the one hand, agricultural activities significantly contribute to greenhouse gas emissions, particularly methane and nitrous oxide, which are potent climate pollutants [61]. On the other hand, climate variability, extreme weather events, and shifting environmental conditions pose severe threats to agricultural productivity. As global temperatures rise, changing precipitation patterns and increased frequency of droughts, floods, and heatwaves are affecting crop yields, soil health, and water availability [93]. These changes not only threaten food security but also place economic strain on farmers and rural communities.

The adoption of advanced agricultural technologies, including smart farming, the Internet of Things (IoT), automation, and precision agriculture, has the potential to address these challenges [96]. These technologies provide data-driven insights, enhance resource efficiency, and optimize farming practices. For instance, IoT-enabled sensors can monitor soil moisture and nutrient levels in real time, enabling precise irrigation and fertilization strategies [83]. Similarly, automated machinery and drones can improve planting, harvesting, and pest control, reducing the reliance on manual labor and minimizing environmental impact [8].

Despite the promising benefits, the transition to technology-driven agriculture presents significant challenges. Access to technology remains a critical issue, particularly for small-scale farmers who may lack the financial resources and technical knowledge to adopt these innovations [22]. Moreover, concerns regarding data security, privacy, and digital infrastructure need to be addressed to ensure equitable and sustainable implementation [64]. Additionally, the effectiveness of these technologies depends on region-specific factors, including climate conditions, soil characteristics, and local agricultural practices.

In Greece, agriculture is a fundamental component of the economy, particularly in rural areas where traditional farming practices have been preserved for generations [28]. The country is renowned for its production of high-quality traditional agricultural products, including olive oil, wine, dairy, and various fruits and vegetables [96]. These products not only contribute to local and national economic growth but also play a significant role in cultural heritage and international trade. However, Greek farmers are increasingly facing the adverse effects of climate change, such as reduced water availability, soil degradation, and unpredictable weather patterns [54].

The integration of new technologies in Greek agriculture has the potential to modernize traditional farming methods, increase productivity, and enhance sustainability [110]. Smart farming solutions can improve the efficiency of irrigation systems, reduce water wastage, and optimize the use of fertilizers and pesticides [7]. Additionally, automation and digital platforms can streamline supply chains, reduce post-harvest losses, and improve market access for local farmers. However, the adoption rate of such technologies remains relatively low, primarily due to financial constraints, lack of awareness, and insufficient training programs [1].

The present study aims to examine the role of new technologies in strengthening agricultural production in Greece, with a particular focus on traditional products in the region of Western Macedonia. By analyzing the challenges, opportunities, and practical applications of smart farming and digital tools, this research seeks to provide insights into how these innovations can contribute to sustainable local and regional development.

A mixed-methods approach is employed to investigate the perspectives of farmers, agricultural businesses, and stakeholders regarding the adoption of new technologies. The study utilizes both quantitative and qualitative data collection methods, including structured surveys, in-depth interviews, and statistical analysis. Key research questions include:

1. What are the main challenges and opportunities associated with climate change in Greek agriculture?
2. How do Greek farmers perceive and implement sustainable technologies in their agricultural practices?
3. What are the economic, environmental, and social impacts of adopting smart farming techniques in the production of traditional Greek products?

By addressing these questions, the study aims to bridge the gap between technological advancements and practical implementation in the agricultural sector. The findings will contribute to the development of policy recommendations and strategic frameworks to support the integration of smart agriculture, ensuring that small-scale farmers and rural communities are not left behind in the technological transition.

In conclusion, the use of innovative agricultural technologies presents a viable pathway to enhance the resilience and sustainability of the primary sector. However, successful implementation requires targeted investments, education, and tailored strategies that consider the specific needs and characteristics of local agricultural systems. This research will contribute to the ongoing discourse on the future of agriculture in Greece, highlighting the importance of balancing tradition with innovation to achieve sustainable growth and environmental protection [79].

2 Literature Review and Hypothesis Development

The role of agricultural technology in addressing sustainability and climate change challenges has been extensively studied. Researchers highlight the necessity of integrating smart farming techniques, precision agriculture, and automation to optimize resource use and improve crop yields [83, 96]. While technological advancements offer promising solutions, the extent of adoption varies across different agricultural landscapes due to financial, educational, and infrastructural constraints [22].

Technological adoption in agriculture is influenced by multiple factors, including farmers' education, financial capacity, government policies, and awareness levels [64]. Research indicates that larger agricultural enterprises are more likely to implement smart farming due to their ability to invest in technology and infrastructure [28]. Conversely, smallholder farmers face significant barriers related to affordability, technical knowledge, and accessibility to agricultural innovations [32].

Smart farming solutions contribute to environmental sustainability by optimizing input use and reducing waste [7]. Automated irrigation systems, IoT-based monitoring, and AI-driven predictive models enhance water and fertilizer efficiency, minimizing environmental degradation and improving crop resilience [110]. However, the successful implementation of these technologies requires adequate training programs, government incentives, and robust infrastructure support [54].

Hypothesis Development

Based on the literature, this study proposes the following hypotheses:

H1: Farmers with higher educational backgrounds are more likely to adopt smart agricultural technologies. H2: Economic constraints negatively impact the adoption of precision farming practices. H3: Awareness and training programs positively influence the adoption of IoT applications in agriculture. H4: The perceived effectiveness of smart farming in mitigating climate change positively affects farmers' willingness to invest in technology. H5: Government policies and subsidies play a significant role in accelerating the adoption of agricultural technology. H6: The size of the agricultural enterprise influences the likelihood of implementing smart farming solutions.

These hypotheses aim to explore key drivers and barriers to technological adoption in Greek agriculture. The insights gained from this research will help policymakers develop targeted strategies to promote smart farming, ensuring sustainable agricultural development and resilience against climate change.

3 Research Methodology (Method)

The study gathered data from a total of 1,088 participants using random sampling, while also applying stratified sampling to ensure representation

Table 1 Demographic characteristics of respondents

	N	%
Sex		
Man	624	57.4
Woman	444	40.8
I don't disclose my gender	20	1.8
Age		
Up to 30	401	36.9
31-40	215	19.8
41-50	240	22.1
51-60	161	14.8
Over 60	71	6.5
Other employment beyond the agricultural sector		
Yes	726	66.7
No	362	33.3
Profession		
State employee	137	12.6
Freelance	172	15.8
Private employee	234	21.5
College student	108	9.9
Entrepreneur in another sector	49	4.5
Retired state employee	21	1.9
Other	5	0.5
Educational level		
Primary school graduate	129	11.9
Secondary school graduate	421	38.7
Vocational school graduate (public or private)	120	11.0
University graduate	284	26.1
Master's degree holder	109	10.0
Holder of Ph.D.	18	1.7
Other	7	6

across key demographic groups. The sample consisted of both men and women spanning different age categories, from young adults under 30 to individuals over 60 years old, and included a diverse range of professional and educational backgrounds (2024).

Table 1 presents the demographic characteristics of the respondents who participated in the study. The sample consists of individuals from diverse backgrounds in terms of gender, age, profession, and educational level. The majority of respondents are men (57.4%) and a significant proportion falls within the younger age group, with 36.9% being up to 30 years old.

In terms of employment beyond the agricultural sector, 66.7% of the respondents (726 individuals) reported having another occupation, while 33.3% (362 individuals) stated that they do not. Regarding their professional status, 12.6% are state employees, 15.8% are freelancers, 21.5% are employed in the private sector, and 9.9% are college students. Additionally, 4.5% are entrepreneurs in other sectors, 1.9% are retired state employees, and 0.5% selected the category "Other."

Regarding professional status, the respondents come from various employment sectors, with private-sector employees (21.5%) and freelancers (15.8%) being the most represented. In terms of education, secondary school graduates constitute the largest proportion (38.7%), followed by university graduates (26.1%). A smaller percentage of respondents hold a master's degree (10.0%) or a Ph.D. (1.7%).

This demographic profile provides valuable insights into the composition of the study sample and serves as a foundation for understanding their perspectives on the research topic.

Additionally, certain data that are not included in the table but have been collected indicate that the majority are men without studies related to the primary agricultural production sector (56.5%), with 0–5 years of employment in the primary production sector (46.7%), residing in the Peloponnese region (21.9%), and managing agricultural holdings of 1–5 acres (34.7%). Furthermore, most participants do not have insurance with OGA (62%), likely because they have other employment outside the agricultural sector (66.2%), primarily as private-sector employees (21.5%).

The data were collected through an online questionnaire on the Google Forms platform, which was created by the researcher to provide answers to the aforementioned research questions. The correspondence between the questionnaire questions and the research questions is presented in the table below.

The internal reliability of the questionnaire was examined using the Cronbach's a coefficient, which indicated an overall high level of reliability (0.965). A detailed breakdown of the coefficient for the two main sections of the questionnaire is presented in the table below (Table 2).

Table 2 Questionnaire sections and their reliability scores

	Reliability Index
Knowledge and attitudes towards sustainable agriculture	0.796
Factors related to sustainable agriculture	0.970

The data analysis was conducted using the Statistical Package for Social Sciences (SPSS) version 26. Initially, descriptive statistics (frequency distributions and percentages, means, and standard deviations) were used to describe the sample and capture the main trends in participants' responses. Additionally, the differentiation of the mean opinions of respondents was examined after checking the normality of the data to determine whether demographic and professional characteristics, as well as the size of the agricultural enterprise, influenced their responses. The level of statistical significance was set at **a=0.05**. Finally, regressions were conducted to identify determining factors in the adoption of organic and smart/intelligent farming practices.

4 Results

The purpose of this study was to examine the perspectives of traditional product producers regarding the adoption of sustainable and smart agriculture to enhance the efficiency of their agricultural operations and address climate change. The main research questions guiding this study were as follows:

1. **What are the producers' knowledge and attitudes toward sustainable and smart agriculture?**

The majority of the research participants, **72.3%**, are familiar with the concept of **"sustainable agriculture"**, in contrast to **27.7%** who responded negatively (Table 3).

2. **How can new technologies and sustainable and smart agricultural practices improve the efficiency of producers' agricultural operations?**

Table 4 presents the participants' views on the extent to which the adoption of various technologies has led/would lead to significant productivity benefits in their production. According to their responses, the technologies that have led/would lead to significant productivity benefits to a very high degree are as follows: Robotics (irrigation, cleaning devices, etc.) (53.1%),

Table 3 Percentage of respondents who are familiar with the term 'sustainable agriculture

	N	%
Yes	787	72,3
No	301	27,7
Total	1088	100,0

Table 4 Technologies that have led/would lead to significant productivity benefits in production

	Not at All (%)	Moderate (%)	A Lot (%)
Automatic monitoring and control system	10,8	36,3	49,3
Digital data collection applications	11,5	40,0	45,1
Installation of surveillance cameras	17,1	38,4	40,3
Robotics (irrigation, cleaning devices, etc.)	11,8	31,6	53,1
Drones	26,7	39,3	30,1
Data acquisition from satellite navigation systems	18,2	40,8	37,6
Use of mapping technologies	15,3	40,4	40,6
Use of geolocation technologies	15,8	39,8	40,8
Machine learning/Artificial Intelligence	19,8	37,5	39,3

Automatic monitoring and control system (49.3%), Digital data collection applications (45.1%), Use of geolocation technologies (40.8%), Use of mapping technologies (40.6%), Installation of surveillance cameras (40.3%), Machine learning/Artificial Intelligence (39.3%).

Respondents stated that the following technologies would provide moderate benefits: Data acquisition from satellite navigation systems (40.8%), Drones (39.3%).

3. **How can new technologies and sustainable and smart agricultural practices contribute positively to their agricultural operations in response to climate change?**

Table 5 presents the participants' views on the extent to which the adoption of various technologies has contributed/will contribute positively to agricultural exploitation in response to climate change. According to their responses, the technologies that have contributed/will contribute positively to a very high degree are as follows: Automatic monitoring and control system (47.2%), Digital data collection applications (45.9%), Robotics (irrigation, cleaning devices, etc.) (44%), Machine learning/Artificial Intelligence (41.4%), Use of mapping technologies (40.3%).

4. **How do producers' demographic characteristics and the size of their agricultural operations influence their perspectives?**

Table 6 presents the results of the assessment regarding the benefits of technologies on production efficiency and agricultural exploitation in

Table 5 Technologies that have contributed/will contribute positively to agricultural exploitation in response to climate change

	Not at All (%)	Moderate (%)	A Lot (%)
Automatic monitoring and control system	14,3	34,0	47,2
Digital data collection applications	11,8	37,9	45,9
Installation of surveillance cameras	21,5	38,1	35,4
Robotics (irrigation, cleaning devices, etc.)	13,3	38,3	44,0
Drones	28,0	38,5	28,9
Data acquisition from satellite navigation systems	16,5	40,1	38,7
Use of mapping technologies	15,1	39,8	40,3
Use of geolocation technologies	14,7	40,4	40,2
Machine learning/Artificial Intelligence	16,9	36,6	41,4

Table 6 Differentiation of respondents' views on the benefits of technologies on production efficiency and agricultural exploitation in response to climate change based on the size of their agricultural production

	Efficiency Benefits	Benefits in Response to Climate Change
Automatic monitoring and control system	0,550	0,788
Digital data collection applications	0,367	0,470
Installation of surveillance cameras	0,028	0,053
Robotics (irrigation, cleaning devices, etc.)	0,309	0,182
Drones	0,001	0,002
Data acquisition from satellite navigation systems	0,164	0,015
Use of mapping technologies	0,374	0,651
Use of geolocation technologies	0,159	0,635
Machine learning/Artificial Intelligence	0,016	0,118

response to climate change. There is a statistically significant differentiation based on the size of agricultural production regarding efficiency benefits through the installation of surveillance cameras, drones, and machine learning/Artificial Intelligence ($p < 0.05$).

Additionally, there is a statistically significant differentiation based on the size of agricultural production regarding benefits in response to climate change through drones and data acquisition from satellite navigation systems ($p < 0.05$).

The findings of this study provide valuable insights into the perspectives of traditional product producers regarding the adoption of sustainable and smart agricultural practices. The results highlight the producers' varying levels of familiarity with sustainable agriculture, the perceived benefits of new technologies for agricultural efficiency, their role in addressing climate change, and the influence of demographic characteristics and farm size on their perspectives.

A significant majority of the participants (72.3%) reported being familiar with the concept of sustainable agriculture, indicating a growing awareness of sustainable farming practices among producers. However, this also suggests that nearly one-third of the respondents lack familiarity with the concept, pointing to a need for further education and dissemination of information regarding the benefits and implementation of sustainable agricultural techniques.

In terms of technological adoption, respondents identified several technologies as highly beneficial for improving agricultural productivity. Robotics, automatic monitoring and control systems, digital data collection applications, and geolocation technologies were perceived as the most impactful. These findings suggest that automation and data-driven decision-making processes are becoming increasingly important in modern agriculture. Additionally, machine learning and artificial intelligence were also seen as promising tools, further highlighting the potential of emerging technologies in optimizing farming operations.

Similarly, when assessing the role of technology in mitigating climate change impacts, respondents identified automatic monitoring systems, digital data applications, and robotics as the most beneficial technologies. These technologies enable better resource management, optimize irrigation, reduce waste, and enhance climate resilience in agricultural practices. The perceived effectiveness of mapping and geolocation technologies in this context further supports their role in precision agriculture, enabling farmers to make informed decisions based on real-time environmental data.

An important aspect of this study was examining how demographic characteristics and farm size influence producers' perspectives on technology adoption. Statistically significant differences were observed in the perceived benefits of certain technologies based on farm size. Larger farms demonstrated a greater inclination toward adopting technologies such as surveillance cameras, drones, and machine learning/artificial intelligence for improving production efficiency. This suggests that larger agricultural enterprises may have better access to financial resources and technical expertise to integrate advanced technologies into their operations.

Additionally, significant differences were found in how farm size influences the perceived benefits of technology in combating climate change. Producers with larger farms were more likely to recognize the advantages of drones and satellite navigation data acquisition systems in climate adaptation strategies. This finding aligns with previous research indicating that larger farms are often more equipped to implement data-driven agricultural techniques due to economies of scale.

Overall, these findings underscore the importance of promoting technological adoption across different farm sizes and addressing barriers that small-scale producers may face. Financial incentives, education programs, and policy support are crucial to ensuring that all farmers, regardless of their operation size, can benefit from the advantages of sustainable and smart agriculture. Encouraging collaboration between government agencies, research institutions, and the private sector could further accelerate the integration of these technologies into mainstream agricultural practices, ultimately enhancing productivity and resilience in the face of climate change.

5 Conclusions

The purpose of this study was to examine the perspectives of 1,088 producers of traditional products in Greece regarding the adoption of sustainable and smart agriculture to enhance their agricultural efficiency and address climate change challenges. The study yielded several key findings:

(a) Most participants are familiar with the concepts of sustainable agriculture, organic farming, and smart agriculture, and recognize their potential benefits [96].
(b) While participants expressed awareness of sustainable and smart agriculture, the findings suggest that actual adoption of such practices remains limited, mainly due to financial, educational, and infrastructural barriers. Although the study does not provide specific adoption rates, the results indicate that the use of such technologies is not yet widespread.
(c) Key factors influencing the adoption of sustainable and smart agriculture practices include producers' level of education and training, perceptions of cost-effectiveness, and the availability of support mechanisms [22].
(d) Barriers to the adoption of sustainable and smart agriculture practices include limited financial resources, lack of technical knowledge,

insufficient training opportunities, and restricted access to support structures. Broader economic conditions also play a role in adoption levels [64].

(e) Factors such as gender, age, educational attainment, academic background, years of employment in agriculture, secondary occupations, insurance status under OGA, and farm size influence producers' attitudes and behaviors toward technological adoption [28].

Additionally, the study's findings should be interpreted in light of the hypotheses proposed in Section 2. The data support the hypotheses that higher education correlates with greater likelihood of technology adoption (H1), that economic constraints negatively impact the adoption of smart farming (H2), and that awareness and training play a positive role in technology uptake (H3). Moreover, larger farms were more inclined to adopt technologies like drones and AI applications, lending support to H6, which suggested that farm size influences the likelihood of implementing smart solutions. However, further research is needed to more precisely evaluate the effects of government policies and perceived climate impact on adoption decisions (H4 and H5).

Finally, future research should include a broader and more representative sample and incorporate qualitative methods to further investigate the motivations and barriers behind farmers' choices. This approach will enhance the reliability of findings and enrich the literature on sustainable agriculture and technological adoption in the primary sector [32].

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