

Management Efficiency and Sustainability in Tobacco Production: Evidence from North Macedonia

Katerina Kareska*

University St. Kliment Ohridski – Bitola, Scientific tobacco Institute – Prilep, Republic of North Macedonia

Corresponding author: Katerina Kareska, University St. Kliment Ohridski – Bitola, Scientific tobacco Institute – Prilep, Republic of North Macedonia.

Citation: Kareska, K. (2026). Management Efficiency and Sustainability in Tobacco Production: Evidence from North Macedonia. *Int J Biol Life Sci.* 1(1), 01-15.

Abstract

The main objective of the study is to analyze and propose efficient agricultural and organizational practices that optimize yields, reduce production costs and ensure environmental responsibility.

The research is based on a combination of field data analysis, structured surveys with tobacco producers and economic evaluation of production efficiency. Key management factors, such as soil preparation, fertilization techniques, irrigation systems, pest management and labor organization, were evaluated to determine their impact on productivity and profitability. Statistical and comparative analyses were conducted to identify the correlation between the applied practices and yield optimization.

The findings show that integrated and sustainable management approaches significantly improve tobacco yield and quality, while reducing input costs. Furthermore, farms that apply data-based decision-making standards and environmental production standards achieved greater long-term economic stability and competitiveness.

This paper provides valuable insights for both academics and practitioners in the agricultural sector, highlighting the importance of management optimization in achieving sustainability goals. The results emphasize that effective management practices are not only a path to increased profitability, but also a key driver for maintaining ecological balance and advancing modern tobacco production. The findings provide practical implications for farm management optimization and sustainable agricultural policy.

Keywords: Tobacco Production, Management Practices, Yield Optimization, Sustainable Agriculture, Crop Management

Introduction

Tobacco production is one of the most important agricultural activities in many developing economies, including the Republic of North Macedonia, where it has traditionally played a vital role in rural employment, income generation and export earnings. As a labor-intensive crop, tobacco contributes to the livelihoods of thousands

of smallholder farmers and remains a key component of the agrarian sector in certain regions of Macedonia. Over the past decades, the global tobacco sector has undergone major transformations driven by market liberalization, changing consumption patterns and increasing environmental and regulatory pressures. These dynamics have highlighted the need for more efficient and sustainable management practices to ensure the long-term sustainability of the sector.

Despite its economic relevance, tobacco production faces several challenges that threaten its sustainability and competitiveness. Rising production costs, fluctuating market prices, reduced labor availability, and environmental degradation—such as soil depletion and water scarcity—pose significant risks for producers. In addition, inefficient management practices, limited access to modern technologies, and inconsistent quality control often result in suboptimal yields and reduced profitability. In this context, efficient farm management has become a decisive factor in optimizing productivity, minimizing waste, and ensuring the sustainable use of agricultural resources.

The problem addressed in this study concerns the lack of structured management systems and data-driven decision-making in tobacco production. Many farmers still rely on traditional methods without sufficient adaptation to modern standards of efficiency and environmental responsibility. Consequently, the industry struggles to achieve yield optimization while balancing economic and environmental priorities. Therefore, the research focuses on identifying and evaluating management strategies that can improve performance, reduce resource inefficiencies, and promote sustainability at different stages of the production process.

The main objectives of this study are:

- To analyze current management practices in tobacco production and identify key factors affecting yield and quality;
- To propose optimized management approaches aimed at improving efficiency and reducing production costs;
- To assess the potential of sustainable agricultural techniques - such as precision fertilization, efficient irrigation, and integrated pest management - to minimize environmental impacts; and
- To provide recommendations for the modernization of production systems to enhance the long-term sustainability and competitiveness of the tobacco sector.

The significance of this research lies in its contribution to both academic knowledge and practical applications in agricultural management. By combining empirical data with field observations, the study provides practical insights for farmers, agribusiness policymakers, and industry stakeholders. Understanding how effective management practices impact yield optimization and sustainability can guide the development of training programs, technological interventions, and strategic policies to improve the efficiency and resilience of tobacco farming systems. Ultimately, the findings aim to support the transition to a more sustainable, innovative, and economically viable model of tobacco production suited to the evolving global agricultural environment.

Material and Method

The research applied a structured survey-based methodology designed to collect both quantitative and qualitative data related to management practices, optimization strategies, and sustainability in tobacco production. The survey instrument was carefully

developed to include a combination of closed-ended and open-ended questions, allowing for a comprehensive understanding of farmers' operational methods, resource allocation, and perceptions of effective management in tobacco cultivation.

The target population of the study consisted of individual tobacco producers located in the municipality of Prilep, Republic of North Macedonia — a region recognized for its long-standing tradition and economic dependence on tobacco production. The selection of this area was purposeful, as it represents a significant share of the national tobacco output and provides a relevant case for assessing management efficiency in small and medium-scale farming systems.

A total of 30 individual farmers were surveyed, ensuring adequate coverage and representation of the production structure in the region. The sample size was determined based on accessibility, willingness to participate, and proportional representation of active producers during the 2024 production season. Data collection was performed through direct, in-person administration of the questionnaires, allowing the researchers to clarify questions and ensure the accuracy and completeness of the responses. This approach also facilitated the gathering of additional contextual information regarding the socioeconomic and environmental aspects of tobacco farming.

The quantitative data collected through the structured questions were processed using Microsoft Excel, applying descriptive statistics such as means, percentages, and frequency distributions to identify patterns and relationships between variables. The qualitative data, derived from open-ended responses, were analyzed through thematic categorization and summarized descriptively to capture farmers' opinions, attitudes, and challenges in applying sustainable management practices.

Furthermore, the research incorporated comparative and correlational analysis to explore potential links between applied management techniques and levels of productivity or cost efficiency. This mixed-method approach enhanced the validity and depth of the findings, combining numerical evidence with practical insights.

The study is operational and empirical in nature, aiming to reflect real-time conditions and management approaches currently practiced in tobacco production. By focusing on actual field data and farmer experiences, the research provides a realistic overview of the existing challenges and opportunities for optimizing production and promoting sustainable agricultural practices within the tobacco sector of North Macedonia. The study has an exploratory character due to the sample size.

Results

Table 1 provides an overview of the key challenges affecting the sustainability and efficiency of tobacco production, grouped into three main categories: environmental, economic, and social. The environmental challenges primarily relate to soil degradation, water scarcity, and biodiversity loss, which directly impact the long-term productivity and ecological stability of agricultural systems. Economic challenges are linked to the high cost of production inputs, fluctuating market prices, and dependency on global market trends, all of which threaten farm profitability and financial sustainability. The social challenges highlight persistent issues such as labor shortages, inequality in land ownership, and limited access to agricultural education and training.

Overall, the table emphasizes the multidimensional nature of the challenges in tobacco production, illustrating how environmental degradation, economic pressures, and social constraints are interrelated. Addressing these challenges requires the implementation of integrated management practices and policy interventions aimed at improving resource efficiency, strengthening market stability, and enhancing the social well-being of tobacco-producing communities.

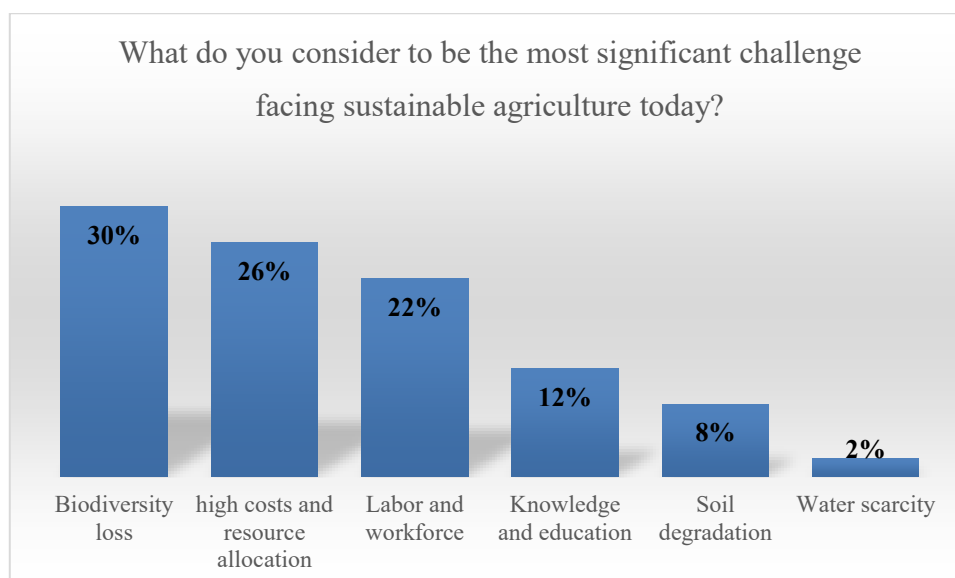
Table 1: Key Challenges Facing Sustainable Agriculture

Category	Challenges	Specific Issues
ENVIRONMENTAL	Soil Degradation	Loss of soil fertility, erosion, nutrient depletion
	Water Scarcity and Quality Issues	Limited freshwater availability, pollution, over-extraction
	Biodiversity Loss and Ecosystem Impact	Decline in species, habitat loss, reduced ecosystem resilience
ECONOMIC	High Costs and Resource Allocation	Expensive inputs (seeds, fertilizers), energy costs, infrastructure investment
	Market Dynamics and Price Volatility	Unstable prices for crops, fluctuations in demand, dependency on global markets
SOCIAL	Labor and Workforce Issues	Worker shortages, fair wages, unsafe working conditions
	Land Access and Ownership	Inequality in land distribution, limited access for smallholders
	Knowledge and Education Gaps	Lack of technical training, limited access to agricultural education and resources

Source: author's view

Based on the survey results, here's a detailed analysis of the responses to the question, "What do you consider to be the most significant challenge facing sustainable agriculture today?"

Figure1:



Source: Author's research

- **Biodiversity Loss (30%)**

Biodiversity loss is identified as the most significant challenge by 30% of respondents, indicating a strong concern about the impacts of decreased biodiversity on agricultural sustainability. This challenge relates to the reduction in species diversity, habitat destruction, and the decline of essential ecosystem services, such as pollination and pest control. The high percentage suggests that many recognize the importance of preserving ecosystems and their role in supporting resilient agricultural systems. Biodiversity is critical for maintaining the natural balance, helping crops resist pests and diseases, and ensuring long-term productivity.

- *High Costs and Resource Allocation (26%)*

The second most significant challenge, according to 26% of respondents, is the high costs and resource allocation required for sustainable agriculture. This reflects concerns over the financial barriers associated with adopting sustainable practices, such as the costs of renewable resources, technology, and environmentally friendly inputs. Farmers may struggle with limited access to credit or funding, especially small-scale farmers, which makes it challenging to invest in sustainable practices. This result suggests that economic support, subsidies, and improved resource allocation could be essential for advancing sustainability in agriculture.

- **Labor and Workforce Issues (22%)**

Labor and workforce issues are identified as a major challenge by 22% of participants. This includes problems like labor shortages, low wages, and unsafe working conditions, all of which can hinder sustainable agricultural practices. Sustainable methods often require more intensive labor and skilled workers, which can be difficult to secure. With many rural communities experiencing workforce declines and younger generations moving to urban areas, addressing these labor issues is crucial to ensure that sustainable agriculture has the necessary human resources.

- **Knowledge and Education Gaps (12%)**

Knowledge and education gaps were considered a significant challenge by 12% of respondents. This response reflects a recognition that sustainable agriculture requires specialized knowledge, from technical skills in precision agriculture to understanding ecological practices. Limited access to education and training can prevent farmers from adopting and implementing sustainable methods effectively. Bridging these gaps through education, training programs, and access to research could help farmers make more informed decisions about sustainable practices.

- **Soil Degradation (8%)**

Soil degradation was marked as a challenge by 8% of respondents. Although soil health is essential for agricultural productivity, it seems less of a concern relative to other issues, likely because it's perceived as a manageable problem with the right practices, such as crop rotation, cover cropping, and organic fertilization. However, continued attention to soil conservation is important, as degraded soil impacts crop yields, water retention, and nutrient availability over the long term.

- **Water Scarcity (2%)**

Water scarcity received the lowest percentage of concern, at 2%, possibly indicating that respondents are either located in areas with adequate water supplies or believe other issues take precedence. However, water scarcity remains a critical global issue, as agriculture is the largest consumer of freshwater resources. In areas where water is a limited resource, implementing water-saving technologies like drip irrigation and rainwater harvesting is essential to ensure sustainable water use.

The survey results indicate that biodiversity loss, high costs, and labor issues are perceived as the most significant challenges in sustainable agriculture. These findings suggest that addressing environmental degradation, economic support, and workforce issues will be essential in creating sustainable agricultural systems. Additionally, while some challenges like water scarcity and soil degradation received fewer responses, they remain crucial elements in the broader context of sustainable agriculture and must still be addressed through targeted interventions and resource management practices.

Based on the survey results, here's a detailed analysis of the responses to the question, "What management practices do you currently implement to optimize tobacco yield on your farm? "

The data reveal a strong emphasis on the use of high-yield tobacco varieties, cited by 63% of respondents, indicating that most farmers rely on genetic improvement and seed selection as the main strategy for increasing productivity. This reflects the continued dependence on traditional yield-enhancing methods rather than on advanced technological interventions.

Only 13% of respondents reported implementing Integrated Pest Management (IPM) practices, suggesting limited adoption of preventive and environmentally sustainable pest-control methods. Likewise, optimized fertilization schedules and efficient irrigation systems were mentioned by only 8% of farmers, revealing a gap in the application of

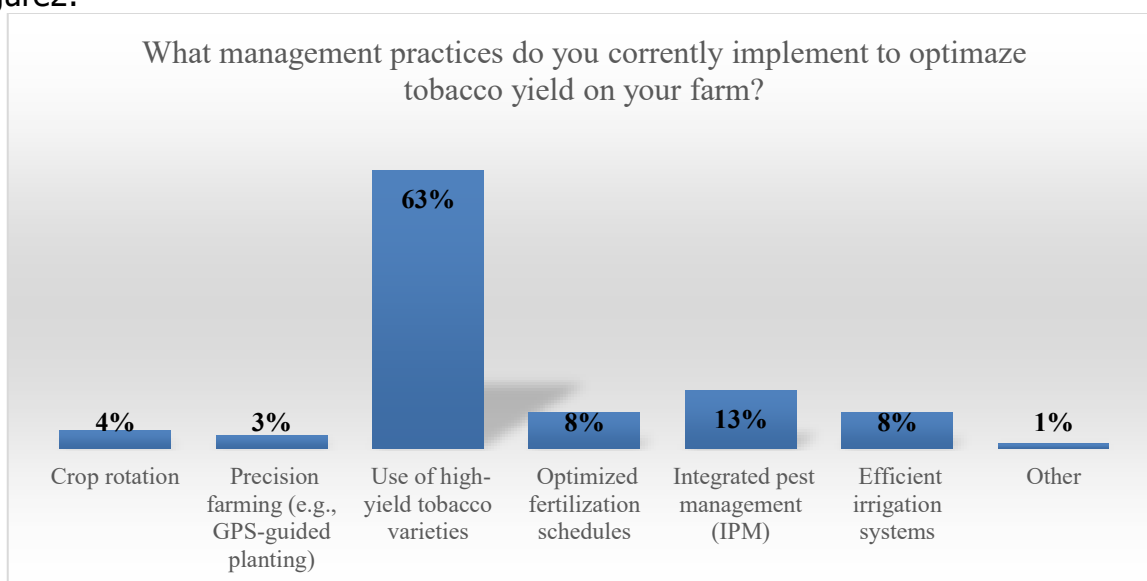
precision nutrient and water management — both of which are crucial for sustainable yield optimization.

Crop rotation (4%) and precision farming techniques such as GPS-guided planting (3%) showed very low adoption rates, highlighting that diversification and technology-based management remain underdeveloped among surveyed tobacco farms. The category “Other” (1%) included isolated mentions of practices such as manual monitoring of soil moisture or use of organic amendments.

Overall, these results demonstrate that Macedonian tobacco producers primarily depend on varietal selection rather than integrated or precision management systems. The low adoption of modern agronomic and digital technologies suggests a need for capacity building, targeted training, and financial support to encourage farmers to implement sustainable yield-optimization practices, including IPM, irrigation efficiency, and precision fertilization.

This finding is consistent with previous research in similar agricultural contexts, where limited access to technology and advisory services constrains innovation adoption. Consequently, strengthening extension services and providing incentives for sustainable management practices should be prioritized within national tobacco development programs.

Figure2:



Source: Author's research

The survey results presented in Figure 3 provide insight into the soil health management strategies implemented by tobacco farmers. When asked “How do you monitor and manage soil health in your tobacco fields?”, respondents demonstrated a moderate level of awareness of soil fertility management, but the overall adoption of systematic monitoring practices remains limited. The most frequently reported practice was organic matter incorporation, indicated by 35% of the respondents. This result suggests that a considerable portion of farmers recognize the importance of maintaining soil fertility through the addition of organic materials such as compost, manure, or crop residues. Organic matter improves soil structure, water-holding

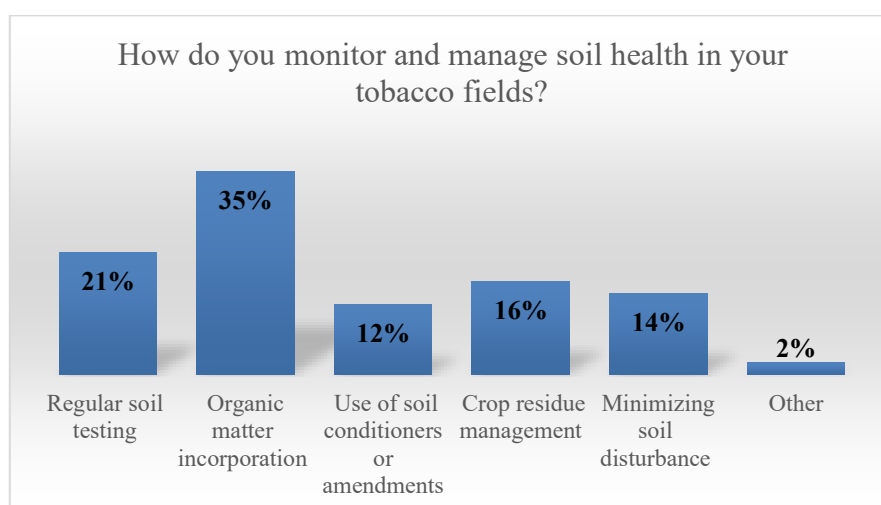
capacity, and microbial activity, thus enhancing the long-term sustainability of tobacco production systems.

Regular soil testing was reported by only 21% of the surveyed farmers, reflecting a relatively low level of data-based decision-making in nutrient management. While soil testing provides critical information for optimizing fertilizer applications and correcting pH or micronutrient deficiencies, its limited use indicates that many producers rely on traditional experience rather than on empirical analysis. The low rate of soil testing may be linked to restricted access to laboratory facilities, insufficient technical training, or the additional costs associated with testing procedures.

Crop residue management (16%) and minimizing soil disturbance (14%) were moderately adopted practices, suggesting that some farmers apply conservation-oriented techniques, but these approaches are far from being mainstream. Reduced tillage and proper residue management are essential for preventing soil erosion and maintaining organic matter balance, which are key to sustainable soil health in tobacco-growing areas. The use of soil conditioners or amendments, reported by 12%, indicates that only a small fraction of farmers actively correct soil pH or structure using liming agents, gypsum, or biological enhancers. The remaining 2% of respondents mentioned "other" measures, including occasional use of microbial inoculants or localized organic soil treatments.

Tobacco producers primarily rely on physical and organic-based soil improvement methods, while analytical and precision approaches such as regular soil testing and targeted soil conditioning are still underutilized. This imbalance highlights the need for greater integration of scientific monitoring with practical field management. Enhancing farmer education, providing subsidies for soil testing, and promoting conservation practices through extension services would significantly improve soil productivity and sustainability. Policymakers and agricultural support institutions should therefore prioritize capacity-building initiatives and incentive mechanisms that foster evidence-based soil health management within the tobacco sector.

Figure3:



Source: Author's research

Figure 4 illustrates the sustainability measures currently implemented by tobacco producers to mitigate the environmental impact of their production systems. The data

show a gradual but uneven transition toward more environmentally responsible farming practices. The most commonly adopted practice was water conservation, reported by 32% of respondents. This indicates that nearly one-third of the surveyed farmers recognize water as a critical resource and have implemented strategies such as drip irrigation, regulated scheduling, or rainwater harvesting to optimize water use. Given the semi-arid climate of the main tobacco-growing regions, this focus on water efficiency is an encouraging step toward sustainable resource management.

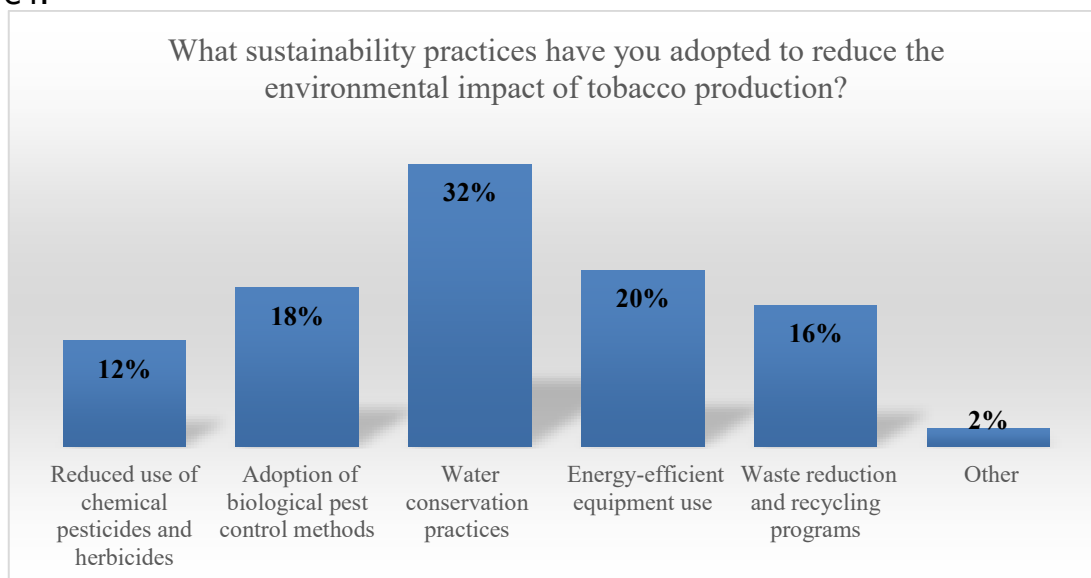
Energy-efficient equipment use was reported by 20% of producers, suggesting moderate awareness of the benefits of reducing fuel and electricity consumption through improved machinery or optimized curing processes. Energy efficiency not only decreases production costs but also contributes to lower greenhouse gas emissions, aligning with global sustainability goals for agricultural systems. However, the relatively modest adoption rate implies that investment costs and limited access to modern technologies may still be barriers for small-scale tobacco growers.

The use of biological pest control methods was adopted by 18% of farmers, while reduced use of chemical pesticides and herbicides was noted by 12%. Together, these findings reveal that integrated pest management (IPM) approaches are still emerging but not yet widespread. The low adoption of chemical reduction strategies may reflect both limited knowledge of alternative pest control methods and the availability of cost-effective biopesticides. Transitioning toward biological pest control and reduced chemical input would require stronger institutional support, including farmer training, demonstration plots, and financial incentives for sustainable inputs.

Waste reduction and recycling programs, implemented by 16% of respondents, indicate growing environmental consciousness among some producers who aim to manage field and packaging waste responsibly. These practices include composting organic residues, reusing curing materials, and minimizing plastic waste. The "Other" category (2%) included isolated mentions of afforestation activities and the use of renewable energy sources.

The results reflect an early stage of sustainability adoption in the tobacco sector. While water management and energy efficiency practices show promising uptake, environmentally integrated measures—particularly those related to pest control, waste management, and chemical reduction—remain underdeveloped. These findings highlight the need for a more comprehensive sustainability framework that combines technological innovation with environmental education. Policy interventions should prioritize access to green technologies, promotion of IPM systems, and capacity-building programs that help farmers align their practices with international environmental standards. Strengthening collaboration between research institutions, agricultural advisory services, and farmers will be key to advancing sustainable tobacco production in North Macedonia.

Figure4:



Source: Author's research

Figure 5 presents the key challenges identified by farmers regarding the implementation of sustainable practices in tobacco production. The results clearly demonstrate that economic and informational barriers are the dominant constraints hindering the transition toward environmentally responsible production systems. The most frequently cited challenge was the high cost of sustainable inputs or technologies, reported by 32% of respondents. This finding highlights the financial burden associated with adopting eco-friendly inputs such as organic fertilizers, biological pest control products, water-efficient irrigation systems, or renewable energy equipment. For many small and medium-sized tobacco producers, limited profit margins and unstable tobacco prices make such investments financially unfeasible without external support or subsidies.

The second most frequently mentioned challenge, indicated by 24% of respondents, was the lack of technical knowledge or training. This points to a significant gap in farmer education and advisory services related to sustainability. Many producers remain unaware of the long-term benefits of sustainable practices or lack the technical capacity to apply them effectively. Extension programs and technical workshops are often limited or outdated, underscoring the need for continuous capacity building and stronger institutional support.

Resistance to change from traditional practices, noted by 19% of respondents, reflects cultural and behavioral barriers that often slow innovation adoption. Tobacco production in the region is characterized by deeply rooted conventional practices passed through generations, and many farmers are hesitant to modify established methods unless tangible benefits are demonstrated. Encouraging peer learning, demonstration fields, and farmer-to-farmer training could help overcome this inertia by showing practical results of sustainable approaches.

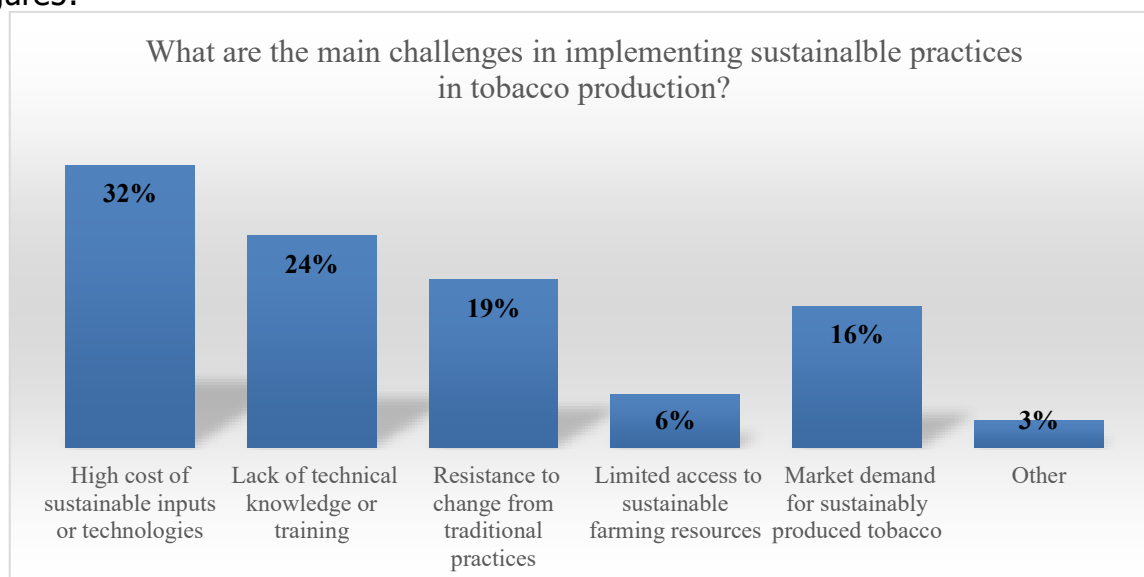
A smaller proportion (16%) identified market demand for sustainably produced tobacco as a limiting factor. This indicates that current market structures do not sufficiently reward sustainable production, and that buyers or processors rarely differentiate tobacco based on its environmental footprint. Strengthening certification schemes and

linking farmers to markets that value sustainable production could provide stronger economic motivation.

Finally, limited access to sustainable farming resources (6%) and other minor issues (3%) were less frequently mentioned but remain relevant in specific local contexts, particularly where infrastructure, credit, or supply chains for sustainable inputs are weak.

While awareness of sustainability is increasing among tobacco producers, progress is constrained by high costs, insufficient knowledge, and limited institutional and market incentives. Addressing these issues will require a multi-level strategy that integrates financial support mechanisms, targeted training programs, and policy incentives to create an enabling environment for sustainable tobacco production. Collaboration among government agencies, research institutions, and the private sector is essential to reduce barriers and ensure a smoother transition toward sustainable agricultural practices.

Figure5:



Source: Author's research

Discussions

The results of this research highlight the complex relationship between management efficiency, economic viability, and sustainability in tobacco production. The findings confirm that Macedonian tobacco producers are aware of the importance of sustainable practices, yet the overall adoption of integrated and technologically advanced management systems remains limited. The predominance of traditional methods—such as the reliance on high-yield varieties instead of precision irrigation or fertilization—reflects both financial and informational constraints. This situation mirrors trends observed in other smallholder-based agricultural systems, where modernization is often slowed by the lack of access to capital, training, and technical support.

The study indicates that biodiversity loss, high input costs, and labor shortages are perceived as the major challenges to sustainable agriculture. These concerns are consistent with global sustainability debates, emphasizing the interdependence between environmental conservation, resource efficiency, and rural livelihoods. In particular, the

prominence of biodiversity loss as a perceived threat demonstrates an increasing environmental awareness among farmers, even if their practical ability to implement biodiversity-friendly measures remains low. The gap between awareness and practice suggests that policy and institutional interventions should focus on enabling conditions—such as affordable access to green technologies and better extension services—rather than solely on awareness campaigns.

Low adoption rates of soil testing, integrated pest management, and precision farming reveal that data-driven decision making is still at an early stage. Farmers continue to rely heavily on experiential knowledge rather than on analytical tools that could improve input efficiency and environmental outcomes. This finding underlines the importance of strengthening the link between research institutions and producers through participatory training programs and demonstration plots. Encouraging collaborative learning and peer-to-peer exchange could also foster greater trust and acceptance of innovative techniques.

The results concerning sustainability measures show that water management and energy efficiency are among the most widely practiced interventions, which is a positive indication of gradual progress toward environmentally responsible production. Nevertheless, the relatively low use of biological pest control, waste reduction, and chemical minimization strategies underscores the need for more comprehensive frameworks that integrate economic, technical, and ecological dimensions. Sustainable tobacco production cannot rely solely on isolated environmental measures; it requires systemic management supported by coordinated public policies and private investment. The research identification of financial and informational barriers as key obstacles provides clear direction for future action. Targeted subsidies, access to credit for sustainable inputs, and continuous education programs would significantly enhance adoption rates. In addition, creating market incentives—such as sustainability certifications or preferential purchasing by processors—could motivate farmers to adopt eco-friendly practices. The research demonstrates that optimizing management practices in tobacco production is not only a matter of improving yields but also of fostering resilience, environmental stewardship, and long-term sectoral competitiveness.

Actionable recommendations based on these findings include:

- Promote integrated crop management by combining high-yield varieties with optimized fertilization, IPM, and efficient irrigation systems to achieve both productivity and environmental benefits.
- Expand access to soil testing and advisory services through government or cooperative programs to improve nutrient management and reduce input waste.
- Support farmer education and field demonstrations that highlight the economic and agronomic benefits of sustainable practices, encouraging gradual behavioral change.
- Facilitate access to financing and subsidies for adopting water-saving technologies, renewable energy equipment, and biological pest control methods.
- Develop market mechanisms and certification systems that reward sustainably produced tobacco, strengthening the link between sustainability and profitability.

The transition toward sustainable tobacco production requires a holistic approach—combining technology adoption, financial support, and capacity building. By addressing

economic, technical, and institutional barriers simultaneously, the tobacco sector can enhance productivity, safeguard environmental resources, and ensure long-term viability for future generations of producers

Conclusion

The findings of this study clearly demonstrate that effective management practices are a key factor in optimizing tobacco production, improving farm profitability, and ensuring environmental sustainability. The study found that while farmers in North Macedonia have a strong understanding of the importance of sustainability, the practical implementation of modern data-driven methods remains limited. Most producers continue to rely on traditional approaches - such as variety selection and manual field management - rather than adopting precision technologies, integrated pest management, or systematic soil monitoring. This imbalance highlights the urgent need for improved education, training, and financial support to encourage farmers to move toward more sustainable and efficient production systems.

The results highlight several key insights. First, biodiversity loss, high production costs, and labor shortages are considered the most significant challenges to sustainable agriculture. Second, while water and energy conservation measures are gaining importance among producers, other components of sustainability – such as waste reduction, biological pest control and soil testing – are still underdeveloped. Third, the limited use of scientific data in decision-making points to a broader institutional gap that must be addressed through stronger collaboration between researchers, policymakers and farmers. These findings highlight the need for integrated management strategies that balance productivity with environmental and social responsibility.

The implications for the tobacco industry are significant. A transition to sustainable and optimized management practices could strengthen the sector's long-term competitiveness, improve product quality and align domestic production with global environmental standards. By integrating sustainability into farm management – through resource efficiency, innovation and environmental stewardship – tobacco producers can ensure greater economic stability and improve their reputation in international markets. In addition, policy measures that provide incentives for the adoption of environmentally friendly technologies and certification schemes could stimulate investment and modernization within the industry.

Future research directions should focus on several key areas. First, further studies should explore the economic feasibility of sustainable technologies and their implications for costs and benefits for small and medium-sized tobacco farms. Second, specific studies could assess how the gradual introduction of precision agriculture, renewable energy systems and biological pest management affects productivity and environmental outcomes over time. Finally, comparative analyses between regions or crop types could provide a broader understanding of best practices applicable beyond tobacco production. Continued research, supported by cross-sectoral collaboration, will be essential to achieve a fully sustainable and competitive agricultural model in the tobacco industry [1-25].

References

1. Altieri, M. A. (2018). *Agroecology: The science of sustainable agriculture* (3rd ed.). CRC Press.
2. Altieri, M. A., Nicholls, C. I., Henao, A., & Lana, M. A. (2015). Agroecology and the design of climate change-resilient farming systems. *Agronomy for Sustainable Development*, 35(3), 869–890.
3. Baffes, J., & Ajwad, M. I. (2015). The determinants of tobacco supply and demand. World Bank Policy Research Working Paper No. 7338.
4. Chatzimpiros, P., & Barles, S. (2013). Nitrogen food-print: N use related to meat and dairy consumption in France. *Biogeosciences*, 10(8), 4711–4721.
5. FAO. (2021). *The State of Food and Agriculture 2021: Making agrifood systems more resilient to shocks and stresses*. Food and Agriculture Organization of the United Nations.
6. Geiger, F., Bengtsson, J., Berendse, F., Weisser, W. W., & Emmerson, M. (2010). Persistent negative effects of pesticides on biodiversity and biological control potential. *Basic and Applied Ecology*, 11(2), 97–105.
7. Godfray, H. C. J., & Garnett, T. (2014). Food security and sustainable intensification. *Philosophical Transactions of the Royal Society B*, 369(1639), 20120273.
8. Kareska, K. (2023). *Entrepreneurship and agribusiness*. Lambert Academic Publishing.
9. Kareska, K. (2024). *Integration of advanced technologies in modern agribusiness*. Lambert Academic Publishing.
10. Kareska, K. (2024). Social implications of tobacco production in the Republic of North Macedonia: A comprehensive analysis. *SSRN Electronic Journal*.
11. Kareska, K. (2024). Economic performance of modern tobacco production in the Republic of North Macedonia. *SSRN Electronic Journal*.
12. Kareska, K. (2024). Challenges and strategic solutions for sustainable development of the tobacco industry in North Macedonia. *SSRN Electronic Journal*.
13. Kareska, K. (2023). SWOT analysis of the tobacco industry in the Republic of North Macedonia. *International Journal of Advanced Natural Sciences and Engineering Researches (IJANSER)*, 7(10), 450–459.
14. Lal, R. (2020). Soil health and climate change: An overview. *Sustainability*, 12(12), 4853.
15. OECD. (2020). *Innovation, productivity and sustainability in food and agriculture: Main findings from country reviews and policy lessons*. OECD Publishing.
16. Pingali, P. L. (2012). Green Revolution: Impacts, limits, and the path ahead. *Proceedings of the National Academy of Sciences*, 109(31), 12302–12308.
17. Popp, J., Pető, K., & Nagy, J. (2013). Pesticide productivity and food security: A review. *Agronomy for Sustainable Development*, 33(1), 243–255.
18. Pretty, J. (2019). *Sustainable intensification of agriculture: Greening the world's food economy*. Routledge.
19. Ray, D. K., Mueller, N. D., West, P. C., & Foley, J. A. (2013). Yield trends are insufficient to double global crop production by 2050. *PLoS ONE*, 8(6), e66428.
20. Rockström, J., Williams, J., Daily, G., Noble, A., Matthews, N., Gordon, L., ... & DeClerck, F. (2017). Sustainable intensification of agriculture for human prosperity and global sustainability. *Ambio*, 46(1), 4–17.

21. Tilman, D., Cassman, K. G., Matson, P. A., Naylor, R., & Polasky, S. (2002). Agricultural sustainability and intensive production practices. *Nature*, 418(6898), 671–677.
22. United Nations. (2022). Transforming food systems for sustainable development: SDG progress report. United Nations Publications.
23. Wheeler, S. A., Zuo, A., & Bjornlund, H. (2013). Farmers' climate change beliefs and adaptation strategies for a water scarce future in Australia. *Global Environmental Change*, 23(2), 537–547.
24. WHO. (2021). Tobacco and its environmental impact: An overview. World Health Organization.
25. Zhang, W., Ricketts, T. H., Kremen, C., Carney, K., & Swinton, S. M. (2007). Ecosystem services and dis-services to agriculture. *Ecological Economics*, 64(2), 253–260.