NATURE & SCIENCE
August 2026, Volume 8, Issue 4, pp. 71–77
DOI: https://doi.org/10.36719/2707-1146/67/71-77

Innovative Technologies as a Tool for Improving Occupational Safety in Georgian Agriculture

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Abstract. *Agriculture is a strategic sector of the global and national economy, yet work in this field remains associated with a high risk of injuries and occupational hazards worldwide. Much agricultural work is carried out in the presence of mechanical, chemical, and natural hazards, making occupational safety particularly important. In the era of modern technological transformation, the implementation of innovative digital systems that not only improve production efficiency but also promote a safe working environment is becoming increasingly important. Occupational safety in modern agriculture is no longer viewed solely in terms of the use of personal protective equipment and compliance with regulations. It is increasingly linked to innovative management, digital solutions, and preventative approaches. The use of technology enables continuous monitoring of the working environment, proactive risk assessment, and the development of a safety culture. The purpose of this study is to evaluate the role of innovative technologies in improving occupational safety in agriculture. The study employed a qualitative and descriptive-analytical approach. International scientific literature, official reports, and secondary data were analyzed, and a comparative analysis was conducted to assess the opportunities and barriers associated with the implementation of innovative technologies in Georgian agriculture. The study's findings demonstrate that the use of artificial intelligence, the Internet of Things, precision and smart farming technologies, and drones reduces human involvement in high-risk processes, improves monitoring of the work environment, and helps prevent occupational hazards. However, the widespread adoption of these technologies in Georgia remains hampered by limited financial resources, the high proportion of smallholder farms, a lack of digital skills, and challenges related to technological infrastructure. Based on the study, relevant conclusions and recommendations were developed that can be used in developing occupational safety and technology development policies in the agribusiness sector.*

Keywords: *agriculture, occupational safety, innovative technologies, precision farming, smart farming, artificial intelligence, Internet of Things (IoT), drones*

Introduction

Agriculture is one of the strategic sectors of the world and Georgian economy, playing an important role in ensuring food security, employment growth and social and economic development of regions. Despite technological progress, the agricultural sector is still characterized by a high level of production risks.

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Received: 6 April 2026; Accepted: 11 July 2026; Published online: 25 August 2026

Agricultural workers are daily exposed to mechanical, chemical, biological and natural hazards, which increases the likelihood of industrial injuries and occupational diseases. In these conditions, ensuring labor safety in the rural economy ceased to be a mere legal requirement and became one of the necessary conditions for the sustainable development of the agricultural sector.

Safety of work is the protection of workers from negative consequences of work during work. The right to life and health is a constitutional human right. The right to safety of work includes the right of workers to safe and healthy working conditions. Labor and health protection is important for all countries.

Therefore, in recent years, innovative technologies such as precision agriculture, intelligent agriculture, artificial intelligence, the Internet of Things, unmanned aerial vehicles (drones), sensor systems and robotics have been rapidly developing in the agricultural sector. These solutions allow you to monitor agricultural processes in real time, identify potential threats in a timely manner, reduce human participation in high-risk work, and increase the safety of the working environment (Lioutas & Charatsari, 2020).

It is especially important to use innovative approaches in countries where traditional methods of work are still widely used in the agricultural sector and small farms prevail. The Georgian agricultural sector also faces similar problems.

Research by international organizations, including the International Labor Organization (MOT), the Food and Agricultural Organization (FAO, 2022; FAO, 2023), the European Union Agency for Occupational Safety and Health (EU-OSHA) and the Organization for Economic Cooperation and Development (OESR), confirm that the introduction of modern technologies significantly reduces occupational risks, increases the efficiency of work processes and promotes the development of a safety culture. However, the level of use of technological innovations varies in different countries and depends on financial opportunities, infrastructure, digital skills and government support mechanisms.

Agriculture in Georgia is one of the priority sectors of the economy, where, despite some progress in the field of labor protection, the effective management of occupational risks remains an urgent problem. The aim of our study is to assess the role of innovative technologies in improving occupational safety in agriculture, analyze international experience and the current situation in the Georgian agricultural sector, and identify key challenges and prospects for the development of technology adoption (Saiz-Rubio & Rovira-Más, 2020).

The study's scientific novelty lies in its examination of the use of innovative technologies not only in terms of improving production efficiency but also in terms of occupational safety management tools. Using Georgia as an example, we analyze the key factors limiting the adoption of modern technologies and present recommendations that can be used both in public policy planning and in improving the practices of farms and agribusinesses. The concepts of "precision farming" and "smart farming" are widely used in modern scientific literature. Although these approaches are closely related, there are distinct differences. Precision farming is primarily based on spatial data-driven management and aims to optimize resource use using GPS technologies, geographic information systems (GIS), and sensor devices. "Smart agriculture," on the other hand, is a broader concept that encompasses artificial intelligence, the Internet of Things (IoT), big data, cloud technologies, and automated control systems.

Analysis of scientific research in recent years shows that the development of digital and automated technologies impacts not only agricultural productivity but also modern approaches to occupational

safety and health management. According to scientific sources, the integration of artificial intelligence and IoT technologies enables real-time monitoring of agricultural processes, early detection of threats, and prompt decision-making. These systems facilitate the safe operation of equipment and reduce direct human involvement in high-risk operations.

One important area for reducing labor risks in agriculture is the development of agricultural robotics. Modern robotic systems are used or are being actively developed for processes such as harvesting, sowing, weed control, crop monitoring, and yield assessment. Robotics reduces heavy physical workload, improves operational precision, and creates the opportunity to reduce human involvement in potentially hazardous working conditions.

In the modern agricultural sector, the use of unmanned aerial vehicles (drones) is particularly important. Unmanned aerial vehicles are effectively used for remote monitoring of agricultural fields, early detection of plant diseases, targeted application of agrochemicals, and crop assessment. The use of these technologies reduces direct human exposure to pesticides and other harmful substances, thereby reducing occupational risks. Modern occupational safety and health concepts are no longer limited to the use of personal protective equipment or the formal implementation of safety regulations. Modern approaches are based on preventive management, continuous risk assessment, the use of digital technologies, and the continuous monitoring of work processes.

The International Labour Organization (ILO, 2022; ILO, 2025) continues to consider agriculture one of the most risky economic sectors. Among the hazards common in this sector, accidents related to the use of agricultural machinery, exposure to chemicals, heavy physical workloads, and new challenges caused by climate change occupy a prominent place. The ILO emphasizes that the integration of technological innovations is an important tool for preventing these risks and improving working conditions. Research by the European Agency for Health and Safety at Work (EU-OSHA, 2021) also shows that digital technologies are significantly changing workplace risk management systems. Smart sensors and monitoring systems enable real-time monitoring of environmental parameters, equipment conditions, and potential hazards. The data obtained helps farmers and managers make timely preventative decisions.

Beyond safety considerations, OECD (2021) research places particular emphasis on the cost-effectiveness of digital technologies. According to the organization, innovative solutions contribute to more efficient resource use, reduced production losses, and simultaneously lower economic costs associated with occupational injuries. Consequently, technological innovation is an important factor not only in the development of production but also in the sustainability and competitiveness of agribusiness (Wolfert et al., 2017).

Much of the existing research on Georgia's agricultural sector focuses primarily on production efficiency, agricultural policy issues, export opportunities, and financial support mechanisms. Despite increased attention to agricultural modernization and technological development in recent years, relatively little research has been devoted to occupational safety and health issues, particularly the impact of innovative technologies on reducing occupational risks in the agricultural sector.

Employment indicators in Georgia's agricultural sector have undergone some changes in recent years. According to the National Statistical Office of Georgia (2024), a downward trend in the number of workers in the agricultural sector was observed between 2022 and 2025. For example, in 2022, approximately 229,200 people were employed in agriculture, accounting for 17.9% of total employment in the country. In subsequent years, the sector's share of employment fluctuated between 15% and 19%, and by 2025, the number of workers reached 218,300.

In 2025, a trend toward strengthening state oversight of labor safety in the agricultural sector was identified. According to the Labor Inspectorate Service, the number of inspections conducted and the percentage of violations identified by employers that were rectified increased. Specifically, 4,312 inspections were conducted, 2,045 facilities were inspected, and 24,690 orders to rectify the violations identified were issued. This demonstrates the gradual development of legislative and supervisory mechanisms for occupational safety in Georgia (Klerkx et al., 2019).

At the same time, inspection results indicate that full compliance with safety requirements remains a serious challenge. The large number of violations identified points to the need for strengthened preventative measures, where technological solutions can play a significant role—particularly in the early identification of risks, control of work processes, and improved protection of human health (Trendov et al., 2019).

Georgian agriculture has seen some progress in the adoption of modern technologies. Various government programs have facilitated the modernization of agricultural machinery, increased mechanization, and support for farms. However, the availability and use of technology remain uneven. In particular, small and medium-sized farms suffer from financial and technological constraints, so a significant portion of work processes is still performed manually or using outdated equipment. Several innovative approaches are underway in the country. In particular, satellite monitoring systems are being introduced to enable remote analysis of weather, soil moisture, and plant health data. Local companies are using soil scanners and agro-drones that accurately measure soil composition and plant health. Agrometeorological sensors are also used to collect temperature and humidity data in real time.

Furthermore, with the support of international organizations, including the Food and Agriculture Organization of the United Nations, Georgian livestock farmers use mobile apps to manage feed rations and simplify animal identification. The Ministry of Environmental Protection and Agriculture (2021), in collaboration with the European Union and the FAO, is implementing projects to promote and develop climate-resilient agriculture, and the Georgian Innovation and Technology Agency is funding agritech startups supporting the digital transformation of the sector.

The level of adoption of innovative technologies varies across Georgia's regions. In Kakheti, where viticulture is well-developed, the use of modern equipment and digital monitoring systems is more widespread. In Shida Kartli, the focus is on irrigation systems and modern fruit-growing technologies. In Samegrelo, where hazelnut production is the leading industry, digital disease monitoring systems are being implemented, although the use of occupational safety technologies is still limited. In Imereti, where small and medium-sized farms predominate, adoption is progressing relatively slowly (Rose et al., 2021).

These differences demonstrate that a single model of technological development will not be effective for Georgia. Each region requires an approach tailored to local conditions. This study fills this research gap, with the primary goal of assessing how innovative technologies can reduce occupational risks in the Georgian agricultural sector and promote a safe working environment.

Research Methodology

This study is based on a qualitative and descriptive-analytical approach, aiming to assess the role of innovative technologies in improving occupational safety in agriculture, using the Georgian agricultural sector as an example.

The study utilized several key methods. First, it analyzed international scientific literature on precision farming, artificial intelligence, the Internet of Things, robotics, drones, and automated systems. Secondary data analysis was also conducted, using official data and reports from the National Statistical Office of Georgia, the Labor Inspection Service, the International Labor Organization, the European Agency for Safety and Health at Work, and the Organization for Economic Cooperation and Development.

Furthermore, a comparative analysis was used, comparing international experience with Georgian reality to identify opportunities and barriers associated with the implementation of innovative technologies.

Results and Discussion

An analysis of the study's results revealed that innovative technologies offer significant opportunities for improving occupational safety in agriculture. Based on international experience and an assessment of the Georgian agricultural sector, several key areas for implementing modern technologies, improving occupational safety, and managing risks were identified. The first area involves automation and robotics, which reduce human involvement in high-risk tasks. The use of robotic systems is particularly effective in operations involving heavy physical exertion, repetitive actions, or unfavorable working conditions. Automation of harvesting, seeding, and weed control reduces physical strain and contributes to improved process safety.

The second area involves sensor technologies and the Internet of Things, which improve preventative risk management. Systems based on these technologies enable real-time monitoring of environmental conditions, equipment status, and production process safety parameters. This approach changes the traditional safety management model and moves from a reactive system to a preventive one. The third area involves the use of drones, which reduce chemical and physical risks. The use of drones in agricultural monitoring and targeted application of agrochemicals reduces direct human contact with pesticides and the need to work in hard-to-reach areas (Zhang & Kovacs, 2012).

At the same time, an analysis of the Georgian agricultural sector revealed a number of systemic problems and barriers. The excessive proportion of small farms limits access to modern technologies, while a lack of financial resources leads to a low level of automation. Additional obstacles include a lack of digital skills, which leads to inefficient use of technologies, and limited availability of services in the regions, which slows the spread of innovations.

Particular attention should be paid to the use of outdated agricultural machinery, which often lacks operator protection systems or rollover protection. The improper use of pesticides and agrochemicals also remains a serious problem, especially on small farms, where personal protective equipment is not fully utilized. Furthermore, an insufficient occupational safety culture was identified on family farms. The study found that the main barrier to the dissemination of innovative technologies in Georgia is not only their cost. Equally important are the lack of information, low levels of digital skills, and insufficient understanding that technology serves not only to increase productivity but also to protect people's lives and health.

Suggestions

Based on the study results, the need for practical and institutional steps was identified. First, it is necessary to strengthen government support for small and medium-sized farms in the implementation of technologies directly related to occupational safety. Government co-financing programs should

include not only general agricultural equipment but also GPS systems, drones, sensor devices, and safety monitoring technologies.
Second, it is necessary to develop continuous professional development programs for farmers. Training should be practically oriented and include both the use of innovative technologies and compliance with modern occupational safety standards.

Third, it is necessary to strengthen cooperation between universities, research institutes, and agribusinesses. The implementation of joint pilot projects will facilitate the rapid adoption of innovations and the accumulation of local academic and practical experience.

Fourth, it is advisable to create a unified digital information platform where farmers can easily access information on modern technologies, safety requirements, government programs, and practical recommendations. Fifth, special attention should be paid to regional municipalities where the technological gap is most acute. These regions should be the ones where pilot projects should be implemented that clearly demonstrate the practical impact of innovative technologies in terms of improving both occupational safety and production efficiency.

Conclusion

Based on the conducted research, it is possible to draw several fundamental analytical conclusions. Improving labor safety in agriculture at the modern stage is no longer considered only within the framework of traditional administrative and inspection control. In the era of digital and automated technologies, an effective model of ensuring safety is moving from a threat response mode to automated, preventive risk management.

Analysis of the Georgian agro-sector shows that there is a structural imbalance in the country between technological progress and the level of labor safety. The introduction of innovations in large commercial farms directly affects the improvement of the working environment and the reduction of risks, while in small and family farms, which predominate in the sector, technological backwardness leads to the maintenance of a high level of labor risks.

Accordingly, technological innovations are not only a tool for increasing economic productivity, but also a mechanism for social and labor protection. The process of modernization of the agricultural sector in Georgia will be effective only if technological policy is integrated with national labor safety standards.

Declaration of Competing Interests

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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