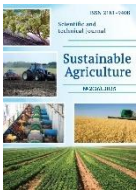
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Modern Tools for Improving the Effectiveness of Agricultural Production in the Republic of Uzbekistan

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a r t i c l e i n f o

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a b s t r a c t

This study addresses the challenges faced by agricultural sector of Uzbekistan Republic, particularly in terms of water scarcity, inefficient farming practices associated with low productivity, and the adoption of modern technologies including innovative field machinery. Key areas such as irrigation systems, field equipment, seed quality, land preparation, Integrated Pest Management (IPM), and marketing strategies are analyzed to identify their impact on productivity and sustainability. The research aims to evaluate the effectiveness of these elements in improving agricultural practices and ensuring long-term growth.

The study utilizes a descriptive research method with general overview and observations. It focuses on analyzing existing agricultural practices, technologies, and their outcomes across various regions of Uzbekistan. The research also examines the perceptions of farmers regarding the adoption of new technologies and their challenges.

The results reveal that modern irrigation systems significantly improve water efficiency and crop yields, while the use of quality seeds enhances overall productivity. Field equipment and land preparation methods contribute to higher efficiency, though challenges such as cost and access remain. The implementation of IPM strategies reduces pesticide use and fosters sustainability, and sales and marketing improvements, particularly through online platforms, increase market reach for farmers.

In conclusion, adopting modern technologies, improving infrastructure, and providing better training to farmers are essential steps for increasing agricultural productivity and sustainability in Uzbekistan. Overcoming barriers to access and education will be crucial to realizing the full potential of these innovations.

1. INTRODUCTION

The Republic of Uzbekistan located in the heart of Central Asia bordering with Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan and in the south with the small part of North Afghanistan. The total territory of the country is approximately 448,900 square kilometers making it the 56th largest country in the world by land area. Nevertheless, deserts cover roughly two-thirds of the land area of the country. Continental climate – hot summers and cold winters with low precipitations greatly influencing on vegetable production, therefore the country relies heavily on irrigation (mainly furrow irrigation) due to low rainfall, especially in desert regions.

Uzbekistan is most populated country among the other countries in Central Asia and it is experiencing a significant population growth, as of January 2024[1], its 36.8 million inhabitants make up almost half of the region's total population. Prognosed to reach over 40 million by 2030. Moreover, half of the population lives in the countryside [2]. This demographic shift presents both opportunities and challenges, particularly in the realm of food security. As the population expands, the demand for food will increase, necessitating enhancements in agricultural productivity, distribution, and sustainable practices. Balancing population growth with sustainable food systems will be vital for Uzbekistan's future resilience and development.

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Agriculture plays a vital role in Uzbekistan's economy, contributing significantly to food security, employment, and export revenues. However, the sector faces a variety of challenges, including water scarcity, outdated farming techniques, and inefficient resource use. These issues threaten the productivity and sustainability of agriculture in the country. With an increasing demand for higher yields and more sustainable farming practices, it is crucial to explore modern solutions that can help address these challenges.

In recent years, the adoption of advanced agricultural technologies has emerged as a key solution to enhance productivity and efficiency. Technologies such as modern irrigation systems, the use of quality seeds, improved field equipment, Integrated Pest Management (IPM), and advanced marketing strategies have the potential to transform the agricultural landscape of Uzbekistan. While these technologies offer substantial benefits, the extent of their adoption remains uneven, and barriers such as limited access to resources, lack of training, and inadequate infrastructure persist.

This article aims to explore the current state of agricultural practices in Uzbekistan, focusing on the role of modern irrigation, field equipment, seed quality, land preparation methods, and marketing strategies. By evaluating the effectiveness of these technologies and identifying key challenges, the study seeks to provide recommendations for improving the agricultural sector's sustainability, productivity, and global competitiveness. Ultimately, this research highlights the critical need for investments in education, infrastructure, and technology to ensure the future success of Uzbekistan's agriculture.

2. LITERATURE REVIEW

The Agricultural Annual Report of 2023[3], published by the Ministry of Agriculture of the Republic of Uzbekistan, reveals that to meet the country's internal demand, the principle of "One Circuit – One Product" was applied, resulting in agricultural production being carried out on a total area of 349,000 hectares. A total of 155,700 hectares of vegetables, 73,300 hectares of melons and gourds, and 120,000 hectares of potatoes were cultivated, with potato production increasing by 27,000 hectares compared to 2022. Additionally, drip irrigation systems were implemented on 7,400 hectares, and sprinkler systems were installed on 300 hectares (In total water saving technologies were applied for 500,000 hectares [4] and saved 3 billion cubic meters of water resources) to support more intensive farming methods. Necessary to note that 905,700 hectares [5] were used for the autumn cultivation.

The SWOT analysis of Anna Pashkevich in the "CA markets 2024" [6] report by Delphy BV shows that climatic conditions, low cost for growing crops (labor costs), Government support to exporters can be strong part in agricultural production in Uzbekistan.

H.C.Buriev, V.I.Zuev and S.M. Medzhitov in the "Country Reports: Uzbekistan" [7] part of the book "Vegetable Production in Central Asia" (by Thomas J.Kalb, Ravza F.Mavlyanova) Page 117: "Global trends indicate a consistent increase in vegetable production. Over the last 5 years, production levels increased by 20%. The need to increase vegetable and melon production is important for all countries in the world but especially in Uzbekistan, where there are high population growth rates (2,4% per year, leading to a doubling of the population every 30 years) and a great need for high value enterprise in agriculture. Approximately 60% of the total population lives in rural areas and there are about 4,3 billion hectares of irrigated land, out of which about 213,000 hectares (4,9%) are occupied by potato, vegetable and melon crops. Currently, per capita supplier of potatoes, vegetables and melons are lower than the recommended levels of 68 kg for potato and 166 kg for vegetables and melons (Oripov and Bozorov 2002).

3. METHODS:

The study will use mainly descriptive method of research. The descriptive method is a way of studying something by observing and recording what's happening, without trying to change or influence it. Instead of asking "why" something happens, it focuses on describing "what" is going on. For example, a researcher might watch how students interact in class, or gather answers from surveys to understand people's behaviors.

The following aspects include complete descriptive method:

- Observation: Study subjects without interference.
- Data Collection: Use methods like surveys or case studies.
- Non-manipulative: No changes made to the environment or variables.
- Goal: To accurately describe phenomena.

The descriptive method uses variables by sequence. There are: Irrigation, field equipment, quality seeds, land preparation, IPM, Sales and Marketing.

4. RESULTS

Irrigation – an artificial application of water to soil or land to last biological survival of a plant. It is used to supplement natural rainfall, especially in areas where water is scarce or rainfall is insufficient or unpredictable. Irrigation helps ensure that plants receive the right amount of moisture, promoting healthy growth, increasing crop yields, and supporting agricultural productivity.

Irrigation is crucial in many regions, especially in arid (excessively dry) and semi-arid climates, where it ensures a stable water supply for agriculture, enabling farmers to grow crops year-round and maintain food security (physical and economic access to sufficient safe and nutritious food that meets human's dietary needs).

Irrigation is important because it helps us grow food, even when nature doesn't always cooperate. Imagine being a farmer in a dry region, where the rains come sporadically, sometimes not at all. Without water, crops can wither and die, leaving farmers and their families without the food they depend on. Irrigation steps in as a lifeline, delivering water to the soil when it's needed most, ensuring that plants can thrive even in the driest conditions.

For farmers, irrigation is the difference between a successful harvest and a failed one. It allows them to grow enough food to feed their communities, and in some cases, it means they can grow crops year-round. This consistency is crucial in a world where the weather can be unpredictable and crops need a steady supply of water to flourish.

But irrigation isn't just about survival. It's also about growth and opportunity. By ensuring that crops get the right amount of water, farmers can increase their yields, often growing more food with less land. This can lead to better incomes and more opportunities for families, especially in rural areas where farming is the backbone of the economy.

Additionally, as our climate changes, irrigation becomes even more vital. In places where rainfall patterns are shifting and droughts are becoming more common, irrigation offers a way to adapt. It allows farmers to continue their work without waiting for the rain, reducing the risk of crop loss due to climate changes beyond their control.

In short, irrigation helps provide stability in the face of an uncertain world. It's about more than just watering plants — it's about supporting livelihoods, strengthening food security, and ensuring that people can continue to feed themselves and their families, no matter what the weather has in store.

There are various methods/types of irrigation used in Uzbekistan, including surface irrigation (where water is applied directly to the soil surface via furrows where crops are growing or to the flat basin type of growing e.g. rise, onions, radish, kohlrabi and so on), drip irrigation (where water is delivered directly to the root zone of plants through a network of tubes and emitters), and sprinkler systems (which distribute water in the form of small droplets, similar to rainfall), center-pivot irrigation system (irrigation in which equipment rotates around a pivot and crops are watered with sprinklers). Each method has its benefits and is chosen based on factors such as water availability, crop type, and environmental conditions.

Today Uzbekistan facing many problems with irrigation due to several reasons. They are related with the history of the country with

political socio-economical background (turning the east part of Kyzyl-Kum desert into cotton cultivation land to enhance the cotton production and increase the indicators as a post-Soviet Republic of USSR), climate change (short winters, low precipitation with hot summers, traditional irrigation methods (waste a significant amount of water due to the evaporation, seepage and runoff which is inefficient especially in water scarce region), old infrastructure of irrigation water delivery (canals and pipes are outdated and poorly maintained, leading to water losses and irregular supply to farms), soil salinization (excessive irrigation [8], especially the regions with the poor drainage leads to the accumulation of salt in the soil, reducing its fertility and making it harder to grow crops, normally the salt washed in late autumn in spring via applying much water), lack of modern technology: although more efficient systems like drip and sprinkler irrigation exist, they are not widely adopted due to high installation costs, lack of technical knowledge, and limited access to modern equipment and not reached infrastructure. These adds stress to the already strained water resources.

The effectiveness of using modern irrigation technologies, such as drip, pivot and sprinkler systems, has been proven to significantly improve water efficiency, increase crop yields, and promote sustainable agriculture. Here are the key benefits:

1.Water Conservation: Modern irrigation methods, particularly drip irrigation, deliver water directly to the plant's root zone, reducing evaporation and runoff. This ensures that water is used more efficiently, especially in water-scarce areas like Uzbekistan, where every drop count. Also, the using the drip irrigation helps to the grower to estimate appropriate mineral fertilizers and work directly close by with the plants.

2.Increased Crop Yields: By providing plants with a steady, controlled supply of water, modern irrigation systems support healthier crops and better growth. This often results in higher yields compared to traditional methods, helping farmers meet the growing demand for food.

3.Reduced Water Waste: Unlike traditional surface irrigation, where water can be lost through evaporation or seepage, modern systems optimize water use. For instance, sprinkler systems can distribute water evenly over large areas, while drip irrigation targets specific plants, minimizing waste.

4.Lower Energy Costs: Many modern irrigation systems, such as solar-powered pumps for drip irrigation, reduce energy consumption by relying on renewable energy sources. This makes irrigation more cost-effective and environmentally friendly in the long run.

5.Improved Soil Health: Modern irrigation technologies prevent overwatering, which reduces soil erosion, salinization, and the risk of nutrient leaching. As a result, the soil remains fertile and productive, benefiting long-term agricultural sustainability.

6.Adaptability to Climate Change: Modern systems are more resilient to the challenges posed by climate change, such as erratic rainfall and drought. They allow farmers to better manage water resources, ensuring crops receive the right amount of moisture, regardless of unpredictable weather patterns.

7.Cost Savings in the Long Term: Although initial installation costs can be high, modern irrigation systems lead to long-term savings. By reducing water waste, energy consumption, and labor costs, farmers often see a return on investment through increased efficiency and higher crop production.

Quality seeds. The seed - the embryonic stage of the plant life cycle and one of the important tools to each farmer/grower in the world. There is nothing can grow without seeds. Of course, today modern technologies can populate plants without germs but in total without a genetical material which is carried by seeds or any other forms it is impossible.

For many years farmers who grows the crops via seeds learned how to keep and produce the seed materials for next season's cultivation. Nevertheless, using the same plant and getting open pollinated seeds from it for many decades make the seed material very week in terms of getting high yield, less diseases, germination in general. Therefore, today many seed companies are available worldwide, research institutions in improving the seed quality, genetically and technically. They are so called "quality seeds".

Using quality seeds in agriculture is like giving your crops the best start in life. Just like how people need good nutrition to grow strong and healthy, plants need high-quality seeds to reach their full potential. These seeds are specially selected for their ability to grow well, resist diseases, and thrive in the local environment, whether it's hot, dry, or prone to pests.

When farmers plant quality seeds, they're ensuring that the majority of the seeds will sprout and grow into healthy, productive plants. Imagine the farmer who has sown hundred seeds of cabbage where he must get one hundred cabbage heads with two kilograms of average weight. Only twenty seeds out of one hundred were germinated, it means forty kilograms of cabbage heads he can harvest. With quality seeds you can get higher germination percentages This leads to more food being produced, which is crucial as the world's population grows. These seeds also have built-in resilience, meaning they're less likely to fall victim to disease or pests, reducing the need for harmful chemicals and making farming healthier for both the environment and the farmer.

Another benefit of quality seeds is that they are adapted to local conditions, whether it's the soil type, temperature, or rainfall pattern. This means farmers can grow crops that are well-suited to their land, resulting in better yields and less risk of crop failure. Plus, quality seeds produce crops that are uniform, meaning they all mature at the same time and they are similar in size, which makes harvesting more efficient.

In Uzbekistan, the situation with quality seeds is slowly improving. The growing dynamics also sensible in the export volumes of fresh vegetables [9]. The biggest part of the vegetables export produced from the imported high-quality seeds. Due to the crop variety characteristics such as maturity (growing days after planting or sowing seeds towards harvesting), internal and external quality (shape, color, structure of the flash), flavor, resistance to the diseases (tolerances of the plants to some diseases or even pests), storing ability (possibility of the crop for long storages), transportability, shelf-life (length of time a vegetable remains fresh, edible, and safe to consume after being harvested or purchased) many varieties became well-known.

But many farmers still face challenges. For years, the country has relied heavily on imported seeds, especially for high-value crops like potatoes and vegetables. But still many farmers, especially in rural areas, don't always have easy access to certified, high-quality seeds. Instead, they often reuse seeds from previous harvests, but this can lead to a decline in quality over time. This is a tough cycle, as lower-quality seeds mean lower yields, and the cycle of reusing seeds can continue to hurt crops as mentioned above. But those who has an access and the information about the quality seed importance, facing the problem with regional climatic conditions or market infrastructure.

In addition, while the country is taking steps in the right direction, there's still much to be done to ensure that all farmers have access to quality seeds. Moreover, there is a need for better education and support especially in rural communities, to show how quality seeds can make real difference in their lives and livelihoods. In the end, using quality seeds is not just about improving the quantity of crops—it's about making farming more sustainable. It means using fewer resources like water, pesticides, and fertilizers, and creating a healthier, more resilient farming system for the future. If these challenges are addressed, Uzbekistan could see a brighter future for its agriculture, with healthier crops, more reliable harvests, and stronger food security for all.

Field equipment. Field equipment in agriculture refers to the tools and machines used on farms for a variety of tasks, including land preparation, sowing/planting, irrigation, fertilizing, pest control, harvesting, and post-harvest processing. These machines are crucial for improving efficiency, increasing productivity, and reducing manual labor on farms. Field equipment ranges from simple hand tools like hoes and rakes to more complex machinery like tractors, plows, harvesters, and irrigation systems. Modern field equipment is designed to handle large-scale precise farming operations, make farming practices more intensive and efficient, and ensure better use of resources.

Types of Field Equipment. One of the main tools in field equipment is – tractors. Tractors are one of the most versatile and essential pieces of equipment on the farm. Depending on farmland size and elements attached to the tractors, the tractors can be chosen with appropriate power (horse powers). Innovative tractors are allowing the big farmlands over the three hundred hectares to manage with couple of people. Tractors used for plowing, tilling, planting, irrigation, and hauling. Depending on land size the tractors can be equipped with different attachments, such as plows, harrows, cultivators and seeders, to carry out a wide range of farming tasks.

Plows: Plows are used to break up and turn over the soil, preparing it for planting. They are crucial in improving soil aeration, promoting water absorption, and reducing weeds.

Seeders and Planters: These machines are used for planting and sowing seeds in rows. Seeders distribute seeds at the right depth and spacing, improving germination and yield rates. Modern seeders and planters are highly precise, ensuring even distribution of seeds and reducing wastage. Some seeders are already equipped with specific tools in order to put on the drip irrigation systems just after sowing. This helps reduce labor time and costs to apply the drip irrigation systems by hand labor.

Sprayers: This element used to apply pesticides, herbicides, and fertilizers to crops. They help in controlling pests and diseases and in delivering nutrients effectively. Modern sprayers are equipped with GPS systems and sensors for precise application, reducing chemical waste and improving crop health. The capacity of the sprayers also ranges depending on land size.

Harvesters: Harvesters are machines designed to gather mature crops from the field, separating the edible parts from the rest of the plant. Combine harvesters, for instance, can harvest grains like wheat, corn, and rice in a single pass, improving efficiency and reducing the labor required.

Rotary cultivators or passive cultivators: This element is used mainly for secondary tillage to stir and pulverize the soil either before planting (to aerate the soil and prepare a smooth, loose seedbed) or after the crop has begun growing (to kill weeds by uprooting them).

Post-Harvest Equipment: After harvesting, field equipment is used for cleaning, sorting, and packaging crops. This equipment plays a vital role in maintaining crop quality and minimizing damage and waste during the post-harvest phase.

Uzbekistan is an agricultural country, and agriculture plays a key role in its economy. The use of field equipment in the country has been evolving, with a focus on modernizing agriculture to boost productivity and ensure sustainable food production. However, there are both advancements and challenges in this area.

Improved Access to Equipment: Over the past decade, Uzbekistan has made significant progress in improving access to agricultural machinery, especially tractors and harvesters. The government has supported farmers by offering subsidies and facilitating easier access to credit for purchasing equipment. Additionally, there has been an increase in the importation of modern machinery, as well as efforts to improve local manufacturing capabilities for agricultural tools.

Growing Demand for Modern Machinery: As Uzbekistan moves towards more mechanized farming practices, the demand for modern field equipment has risen. The country is increasingly adopting high-tech equipment such as precision seeders and planters, GPS-guided sprayers, and automated harvesters, which help reduce labor costs and improve efficiency. Larger-scale farms are beginning to see the benefits of this technology in terms of increased yields and faster work.

Lack of Infrastructure for Small-Scale Farmers: While modern field equipment is being introduced, small-scale farmers in Uzbekistan face challenges in accessing it. High costs, a lack of credit options, and limited availability of equipment in remote areas hinder their adoption of new machinery. These farmers still rely on manual labor or basic tools, which significantly reduces productivity.

High Costs: The cost of modern field equipment remains a major obstacle for many farmers in Uzbekistan. While larger agribusinesses can afford to invest in advanced machinery, small and medium-sized farmers struggle with the high upfront cost of purchasing equipment. Furthermore, ongoing maintenance costs can be prohibitively expensive.

Inadequate Training and Knowledge: Even with access to modern machinery, many farmers in Uzbekistan lack the technical knowledge to operate and maintain it effectively. This gap in skills can lead to suboptimal use of equipment, reducing its potential benefits.

Limited Availability and Access: Access to field equipment remains uneven across the country. Farmers in rural areas, particularly in remote regions, often face difficulties in obtaining the necessary machinery and spare parts. Distribution networks for modern equipment are not yet widespread enough to serve the needs of all farmers.

Dependence on Outdated Equipment: Despite advancements, many farmers still rely on outdated machinery. This includes older tractors and harvesters that are prone to breakdowns and inefficient fuel usage, resulting in higher operational costs and lower productivity. Necessary to emphasis that outdated machinery also waste the seed material via overspending all sowing norms.

Poor Infrastructure: The lack of proper roads, storage facilities, and maintenance centers makes it difficult for farmers to utilize and maintain modern field equipment effectively. Without these essential infrastructures, the full potential of advanced machinery cannot be realized.

Effectiveness of Using Modern Field Equipment in Crop Production.

The effectiveness of modern field equipment in crop production in Uzbekistan is clear, though its full potential is still unfolding. Modern machinery like combine harvesters, tractors, and planters allows farmers to work more efficiently and cover larger areas in a shorter amount of time. This leads to increased yields per hectare and reduced labor costs, particularly in large-scale operations.

Precision agriculture technologies, such as GPS-guided equipment and automated irrigation systems, have greatly improved the accuracy of planting, watering, and fertilizing. This not only increases crop yields but also minimizes the use of water, fertilizers, and pesticides, making farming more sustainable.

With mechanization, Uzbekistan's farmers can reduce their reliance on manual labor. This is particularly beneficial during peak planting and harvesting seasons, when labor shortages can be a significant problem.

Modern post-harvest equipment ensures that crops are processed, cleaned, and stored more efficiently, reducing food waste and improving the quality of produce. This is vital for increasing the profitability of agricultural production.

Integrated Pest Management (IPM)

Integrated Pest Management (IPM) is an environmentally sustainable approach to managing pest populations in agricultural systems. The primary goal of IPM is to reduce the use of chemical pesticides and minimize their negative impacts on human health, the environment, and non-target species. IPM involves a combination of practices that work together to prevent and control pest outbreaks. These all practices include:

1.Biological Control: Using natural predators, parasites, or pathogens to control pest populations.

2.Cultural Control: Adjusting farming practices such as crop rotation, intercropping, and choosing resistant plant varieties to reduce pest pressure.

3.Mechanical and Physical Control: Using barriers, traps, or physical removal methods to keep pests in check.

4.Chemical Control: Applying chemical pesticides as a last resort, and when necessary, using targeted and less toxic formulations.

5.Monitoring and Decision Making: Regularly monitoring pest populations and making decisions based on scientific thresholds rather than routine pesticide application.

Uzbekistan, like many other countries, faces challenges in managing pest populations in agriculture due to its extensive reliance on conventional pesticide use. The country has a large agricultural sector, especially in cotton and grain production, where pest control is a critical

concern. However, there is a growing recognition of the need for sustainable pest management practices, and efforts to adopt IPM are increasing.

While IPM has been implemented in certain regions and by progressive farmers, it has not been widely adopted across the country. The traditional reliance on chemical pesticides remains strong, especially for crops like cotton, which are prone to pest infestations. This has led to an overuse of chemical pesticides, causing environmental and health concerns.

Also, it is necessary to emphasis that awareness of IPM among farmers in Uzbekistan remains a challenge. While there is some knowledge about the concept, many farmers continue to use chemical pesticides due to a lack of information on alternative methods. This is compounded by the limited availability of expertise and resources needed for implementing IPM effectively on a large scale.

Application of IPM in Uzbekistan can significantly reduce the overuse of pesticides. By employing biological (promoting the use of natural predators and resistant plant varieties) and cultural control methods, farmers can reduce the frequency and quantity of chemical pesticide applications. This leads to reduced synthetic chemicals, environmental contamination, better soil and water quality, contributing to a healthier environment and promoting biodiversity.

Of course, there are always economic benefits for the growers in using IPM. Although implementing IPM can require initial investments in training and changes to farming practices, in the long run, it can lead to cost savings by reducing pesticide costs and improving crop health. It also reduces the risk of pesticide resistance, which can result in the need for stronger and more expensive chemicals over time while the world tendency of agricultural production moving more and more towards organic production.

Problems and perspectives of IMP implementation in Uzbekistan.

The transition to IMP can be costly for local farmers, especially for small private land owners who makes the main export of vegetable export in agricultural segment of the Republic. The biggest issue to success of IPM is the lack of infrastructure for supporting biological control methods, such as the production and distribution of natural predators or pheromone traps. Of course, there are some farmers who produces indoor vegetable production who able to effort themselves but many farmers are far away from it. This lack of infrastructure can make it difficult to scale IPM practices effectively. Also, necessary note about lack of necessary knowledge and training to implement IPM strategies particularly in rural areas. The longstanding reliance on chemical pesticides has created a mindset among many farmers that pesticides are the primary or only solution to pest problems. This become as a part of traditional agricultural reliance on chemical which can hinder the adoption of IPM implementation. The important issue for future is overuse of pesticides without proper knowledge can lead to pest becoming resistant, making pest control even more difficult and expensive for the future.

As the perspective for the future for IMP implementation in Uzbekistan largely depends on stronger government policies and initiatives that encourage the adoption of sustainable practices. The government can incentivize IPM adoption through subsidies for alternative pest control technologies, better extension services, and more support for research into pest management alternatives. Expanding education and training programs will be critical in increasing the adoption of IPM. Demonstration farms, workshops, and online resources can help farmers learn the benefits of IPM and how to implement it effectively. Increased investment in research is essential to improve pest management techniques, develop region-specific IPM strategies, and create more efficient and cost-effective solutions for farmers. This includes developing resistant crop varieties and enhancing biological control methods. Moreover, Uzbekistan can benefit from collaborating with international agricultural organizations and experts who have experience in implementing IPM in similar climates and regions. This would provide access to global knowledge, best practices, and technical expertise. Also, collaboration with international or with local private companies specializing in IPM products, such as biocontrol agents and monitoring technologies, could provide farmers with more affordable and accessible options. Public-private partnerships could be crucial in scaling up IPM efforts.

Marketing and sales. The last an important process in whole chain of agricultural production - sales. Marketing and sales in Uzbekistan, particularly in the vegetable sector, are crucial aspects of the growing agricultural economy. These processes determine how products are distributed, how value is added to them, and ultimately, how farmers and producers achieve a profitable return. The marketing and sales landscape in Uzbekistan is evolving, with a mix of traditional and modern methods, including both online and offline channels, which cater to different segments of the market.

Local farmers of Uzbekistan for the last decades learned to work with several type of fruit and vegetables. Applying new rare vegetable crops not common for local kitchen, new varieties to these crops. Depending on their characteristics like maturity and transportability they are well known today. Because of climatic conditions and applied new growing methods (using film covers to get early product) growers producing early products starting from mid-February month. Due to the earliness of some products growers has a good potential in neighboring countries. Therefore, most of the local growers already working with contractors. Of course, traditional markets, also known as "bazars" or "markets," are still the dominant form of vegetable sales in Uzbekistan. These markets are scattered across cities, towns, and villages, serving as the primary outlet for smallholder farmers. In these markets, farmers sell their products directly to consumers, wholesalers, and retailers. Traditional marketing techniques in these markets often include mouth to mouth marketing where customers trust local farmers and vendors, and positive reviews or personal recommendations influence purchasing decisions.

But still wholesalers are key players in Uzbekistan's vegetable sales system. They often buy large quantities of vegetables from local farmers or traders at bulk prices and distribute them to supermarkets, retail outlets, or export markets. These wholesalers act as intermediaries between small producers and larger commercial buyers, such as grocery stores, supermarkets, and food processing companies. The wholesale market is crucial in reaching larger urban areas, where supermarkets and modern retail outlets are growing in importance.

Year by year rise of digital technology and the internet has started to shift the marketing and sales strategies in Uzbekistan, although traditional methods still dominate. In recent years, e-commerce has begun to play a bigger role in marketing vegetables, particularly in urban centers like Tashkent, Samarkand, and Bukhara. Social media platforms such as Instagram, WhatsApp (in some cases with international customers), Facebook and Telegram have become popular tools for marketing of agricultural products too. Farmers and retailers use these platforms to connect with customers, showcase their products, and provide updates on the availability of fresh produce or stock in storages. Moreover, online ordering and delivery services are also available though they are still limited. But they are becoming more common, especially in larger cities. This allows customers to purchase fresh vegetables from the comfort on their homes.

The hobby market, involving small-scale, home-based or organic farming, is also growing in Uzbekistan. Many individuals or small groups are focusing on organic produce, and there is increasing consumer interest in locally grown, organic vegetables. Farmers often target niche markets via social media or local farmer's markets to cater to this demand. Most of the time the crops (celery stem, mangold, broccoli, chicory salads and so on) are famous for their untraditional method of use for healthy oriented consumption in front of customers.

Despite the growth of both traditional and modern sales methods, there are several challenges facing the marketing and sales of agricultural products in Uzbekistan. One of the biggest issues is logistics, as a part of supply chain the infrastructure for this is still underdeveloped, especially in rural areas. The lack of adequate transportation, refrigeration, pre-harvest cooling storage facilities results in significant post-harvest losses. Limited consumer education – where

the consumer interest in organic and fresh produce is rising, there is still limited awareness about the benefits of consuming locally grown and organic vegetables or fruits. This lack of education may prevent some segments of the population from seeking out healthier options.

5. DISCUSSION

The findings of the study highlight the significant advancements and regular challenges in the agriculture sector of Uzbekistan. By examining key variable – irrigation, field equipment, quality seeds, IPM and marketing strategies -it is clear that while modern technologies and methods are increasingly adopted, but their application remains uneven, especially in comparing with international practices.

In Uzbekistan, the shift from traditional furrow irrigation to modern methods such as drip or sprinkler systems has demonstrated significant improvements in water efficiency and crop yields. But still these practices are applied in the small scales, and still behind leading countries with similar conditions. The challenges such as high costs for installation, and limited technical experience slowing down widespread adoption. Addressing these barriers is important, because the water scarcity issues are still remaining in the country.

In fact, the dependence on the hand labor in Uzbekistan becomes as an important issue too. Because, for the harvesting season there are difficult to find labor force, as they needed everywhere. Hand labor costs eventually more expensive than renting mechanical equipment. Thus, using of modern field equipment in the country increases the productivity and reduces labor dependency. But small-scale farmers often lack access to advanced machinery due to high costs and limited availability in some regions. At the same time European countries have extensively adopted precision resources use and reduce operational costs. Creation of subsidies and supporting with no duties for modern machinery during the import could help Uzbek farmers fulfill the gap.

The application of high-quality seeds plays an important role in improving crops yields in Uzbekistan. Because the seeds bred not only for the quality of the end product, but also increased or created resistance to specific pest and diseases. However, the dependence on imported seeds creating challenges including high costs and limited availability in some areas. Uzbekistan could benefit from investing in education of plant breeding, research and production facilities to reduce seed dependence on imported seed materials.

Application of IPM practices in a young stage, with most farmers relying heavily on chemical pesticides. This contrasts with countries like India [9] and Brazil, where government-supported IPM programs have successfully reduced pesticide use and promoted sustainable practices. Expanding farmer education and providing financial support or stimulation for adopting IPM could accelerate its implementation in Uzbekistan, reducing environmental and health risks.

Uzbekistan's marketing strategies are developing, with traditional bazaars and existing alongside with new e-commerce platforms. However, infrastructures like the lack of cold storage facilities and efficient logistics systems results in significant post-harvest losses. In contrast, developed countries have integrated digital marketplaces and advanced supply chain infrastructure to connect farmers with consumers efficiently. Strengthening Uzbekistan's marketing infrastructure and leveraging digital platforms could improve market access and profitability for farmers.

Local and International Comparisons. Comparing Uzbekistan's agricultural real picture with international experiences or standards, it is evident that while the country has made progress, substantial gaps remain in infrastructure, resource accessibility, less support from the government and the important thing is – advanced agricultural knowledge of growers. For instance, using of high-quality seeds still need a good soil preparation in sowing with precise sowing machinery where we far behind from the countries with advanced sowing agricultural technologies. Moreover, next to that the investments in modern machinery and irrigation systems are far lower than in developed countries, limiting the scalability of sustainable farming practices.

To address these challenges, Uzbekistan must prioritize investments in education, infrastructure, and technology. Establishing demonstration farms, fostering public-private partnerships, and collaborating with international agricultural organizations and commercial companies could accelerate the adoption of modern agricultural practices. Additionally, tailored financial mechanisms, such as microloans and subsidies, could empower small-scale farmers to access advanced technologies and improve productivity.

In summary agricultural sector of Uzbekistan has a huge potential where it uses still small part with low efficiency and by learning from international practices and adapting them to local conditions, Uzbekistan can build a more resilient and stable agricultural system.

6. CONCLUSION

In conclusion, the future of agriculture in Uzbekistan depends on the successful integration of modern technologies and sustainable practices that address both current challenges and future opportunities. Advancements in irrigation systems, quality seed usage, modern field equipment, Integrated Pest Management (IPM), and evolving marketing strategies have the potential to significantly improve agricultural productivity, sustainability, and profitability. However, to fully realize these benefits, it is crucial to overcome challenges related to infrastructure, access to resources, and most importantly, education and training. Investing in farmer education and providing comprehensive training programs on new technologies, best practices, and sustainable farming methods are essential for ensuring the effective adoption of these innovations. By enhancing skills, improving awareness, and fostering continuous learning, Uzbekistan can empower its farmers to increase efficiency, reduce costs, and improve yields. With a focus on education and technology access, Uzbekistan can build a more resilient, efficient, and competitive agricultural sector, ensuring long-term food security, environmental sustainability, and economic growth. The continued development of Uzbekistan's agricultural systems will be vital not only for the country's domestic needs but also for its global position in the agricultural market and with the right investments and strategies, Uzbekistan can build a more resilient and sustainable agricultural system, ensuring food security while protecting the environment.

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