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Agriculture in Afghanistan: a journey from livelihood to development

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ABSTRACT

Agriculture is vital to Afghanistan's economy and the livelihoods of its people, particularly in rural areas. This study examines Afghanistan's agricultural journey, focusing on how sustainable practices can transform it from subsistence to a thriving industry. Using case studies from the UK, Mexico, India, and the Philippines, we explore the successful strategies of the Green Revolution—mechanization, high-yield seeds, and chemical fertilizers—that bolstered food security and economic stability. Afghanistan faces unique challenges, including rapid population growth, prolonged droughts, and high food costs, which necessitate tailored sustainable practices. Our findings reveal critical areas for intervention, such as improved water management, mechanized equipment, and research collaboration, to ensure long-term agricultural sustainability. By implementing these recommendations, Afghanistan can overcome obstacles and promote a resilient agricultural sector that not only meets food demand but also enhances economic prosperity.

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INTRODUCTION

The Green Revolution, or the Third Agricultural Revolution, was a period of technology transfer initiatives that greatly increased agricultural production (Nelson, Ravichandran, & Antony, 2019). Findings began in the early 20th century and spread globally until the 1980s. In the late 1960s, farmers transformed traditional agriculture into contemporary agriculture by using chemical fertilizers, pesticides, controlled irrigation systems, tractors, new cultivation methods, and high-yielding varieties of wheat and rice grains (Hazell, 2020). The developing complex followed this strategy with conditional agricultural loans, privatization policies, support for small farmers, and chemical fertilizer production (Gaud, 2023). One of the key leaders, Dr. Norman Ernest Borlaug, an agronomist in the Department of Plant Pathology from the United States of America, later known as the "Father of the Green

Revolution," was instrumental in promoting high-yielding wheat and rice seeds. In 1970, he received the Nobel Peace Prize for his specialized services in agriculture, which saved the lives of billions of people from starvation in Mexico and India. Another important scientific figure was the Chinese scientist Yuan Lengping, whose work on hybrid rice varieties became a lifesaver. Also, the Radefler Foundation and the United States Development Agency (USAID) play an important role in promoting and supporting the efforts. In 1960, William Gadd, head of the United States Development Agency, called it the Green Revolution and added that "the development of new agriculture is a revolution. We leave" (Mousumi, 2023).

METHODOLOGY

This study adopts a comparative case study approach to analyze agricultural practices and their impacts across several countries. By examining historical and contemporary agricultural advancements in the UK, Mexico, India, the Philippines, and Afghanistan, this research seeks to identify sustainable practices applicable to Afghanistan's agricultural context.

Data Collection

Secondary data from scholarly articles, government reports, and international agricultural development records provide insights into the Green Revolution's methods, including mechanization, high-yield seeds, and chemical fertilizers. Additionally, statistical data on Afghanistan's agricultural output, land use, and demographic trends were sourced from the National Department of Information and Statistics and relevant government publications.

Data Analysis

Using thematic analysis, we categorize and compare best practices, challenges, and outcomes in each case study. A cross-country comparison highlights patterns in successful agricultural interventions, considering context-specific factors such as climate, socio-economic conditions, and technological access. Findings are synthesized to propose context-sensitive recommendations for sustainable agricultural development in Afghanistan.

Sampling

Countries were selected for their diverse climates, agricultural histories, and development levels, allowing for a comprehensive analysis of practices adaptable to Afghanistan's agricultural sector.

FINDING AND DISCUSSION

CASE STUDIES

In this section, we explore agricultural transformations across various countries, each of which faced significant challenges in times of food crisis. These cases provide insight into the diverse strategies that emerged to address food shortages, enhance yield resilience, and ensure survival in the face of adversity. By examining the unique obstacles and solutions that shaped agricultural policies and practices in each region, we gain a deeper understanding of the adaptive responses that have influenced their agricultural landscapes.

UK

The agricultural revolution and the concept of sustainable agriculture can trace their roots to Britain, spanning from the mid-17th century to the late 19th century. However, this early revolution differs significantly from the modern agricultural transformations we see today. According to Overton (Overton, 1996), the English Agricultural Revolution was a complex interplay of social, economic, and agricultural changes. Key factors included the introduction of crop rotation, improvements in livestock breeding, the privatization of land through the elimination of common land rights, the development of a national market free from tariffs and trade barriers, and advancements in transportation, drainage, and land reclamation. These changes led to an increase in cultivated land and the conversion of uncultivated land into productive farming areas. Until the early 19th century, England was a leading grain exporter. However, by the 19th century, as the population tripled, the industrialization trend surpassed agricultural capacity, leaving domestic needs unmet.

Mexico

In the 1950s, Mexico faced widespread poverty, hunger, and food shortages, struggling to meet even half of its domestic food needs. Through the Rockefeller Foundation, Dr. Norman Ernest Borlaug encouraged Mexican farmers to improve wheat seed varieties that were more disease-resistant, which helped boost local agricultural productivity. This marked the beginning of the Green Revolution in agriculture. Dr. Borlaug experimented with new wheat varieties, developing disease-resistant strains that could endure harsh climates and pioneering genetic improvements in crops that laid the foundation for modern plant breeding. This revolution not only alleviated Mexico's food shortages but also transformed it into one of the world's largest wheat and corn exporters by 1960 (Mousumi, 2023). The success was so profound that Mexico established the International Wheat and Maize Improvement Center to promote the development and distribution of modified wheat and sorghum seeds.

The impact extended beyond wheat, as the combination of high investment in agricultural research, infrastructure, market development, and supportive policies fostered genetic improvements in other crops, including corn and rice, and spread to additional countries. According to Pingali (Pingali, 2012), this first agricultural revolution occurred between 1966 and 1985, setting a global precedent for sustainable crop productivity.

India

Mousumi (Mousumi, 2023) notes that Dr. Borlaug's impact extended far beyond Mexico; soon, many developed and developing countries adopted the results of his research. India, which has 157.35 million hectares of cultivated land (Nelson, Ravichandran, & Antony, 2019), became one of the beneficiaries of high-yield seed advancements. In the early 1960s, as India faced severe population pressure and famine, Borlaug, in collaboration with the Ford Foundation, introduced a new high-yield rice variety called IR8. With proper irrigation, financing, and artificial fertilizers, IR8 rice dramatically increased yields, enabling Indian farmers to harvest approximately ten tons of rice per hectare—a tenfold increase over

traditional rice varieties. This breakthrough not only saved India from famine but also positioned it as one of the largest rice producers globally, marking the start of the country's Green Revolution.

Philippines

In the 1960s, the Philippines, plagued by poverty and hunger, relied on traditional rice cultivation methods until 1966, when it sought assistance from the International Rice Research Institute (IRRI). By adopting high-yielding varieties (HYVs) and promoting modern seeds, IRRI began its work in a small village in Laguna province as a test case. The success in this region quickly expanded across Laguna, transforming agricultural output. Under traditional cultivation, Philippine farmers harvested less than 1.5 tons of rice per hectare; by the mid-1970s, this yield had more than doubled to 3.5 metric tons per hectare. Over three decades, farmers in the Philippines adapted three types of rice varieties suitable for both dry and wet climates, with seed distribution initially starting at just one kilogram of rice per farmer.

Despite initial successes, the IRRI faced challenges, notably in 1974 when the tungro virus outbreak reduced yields by a third, causing skepticism among farmers about modified seeds. Nevertheless, the Philippine Department of Seed and Grain Promotion, in collaboration with IRRI, effectively controlled the virus and restored farmers' confidence, leading to increased yields once more. Hayami et al. (Hayami & Kikuchi, 1999) observed that no significant issues arose from 1980 to 1996. The success of this agricultural revolution was supported by resistant seed varieties, increased pesticide use, and modified fertilizer composition, with nitrogen levels increasing from 13 to 90 kilograms per hectare, alongside other nutrients such as phosphate and potassium. Although the resistance of plants led to reduced pesticide usage over time, Pingali et al. (Pingali, Hossain, & Gerpacio, 1997) argue that excessive pesticide use can harm the environment by reducing populations of natural pest predators.

A pivotal factor in the agricultural transformation of the Philippines, according to Barker et al. (Barker, Herdt, & Duff, 1972), was the shift from using water buffaloes for plowing to employing mechanized tractors. This transition marked a significant advancement in productivity and efficiency. Barker credits the World Bank with playing an essential role in promoting this mechanization, as it launched an initiative in the 1950s to modernize agriculture by providing loans to farmers, enabling them to purchase tractors and other machinery. This modernization effort contributed to the sustained success of the agricultural revolution in the Philippines, facilitating higher yields and greater resilience in the agricultural sector.

Pakistan

Pakistan is one of the third world countries with a large population and suffered a lot from poverty and hunger in the middle of the 20th century. Based on the studies conducted by Evenson et al. (Evenson, Altaf, & Malik, 2005), it shows that Pakistan was also affected by the agricultural revolution after 1960 and started to cultivate high-yielding seeds of wheat and rice. It obtained good and tangible results and enabled Pakistan to export these two food items in the world. He adds that despite the remarkable successes in this field, Pakistan has not succeeded in the genetic revolution that can succeed in combining the DNA of plants using genetic engineering technology, due to the lack of food safety policy. In five-year

periods from 1960-2000, he studied the increase in wheat, rice, sorghum, millet, beans (sorghum) and potatoes and found a three-fold increase in wheat, a two-fold increase in rice and potatoes, and a relative increase in other legumes.

Africa

The continent of Africa, having a population of 1.4717 billion in 54 countries, has been suffering from poverty, hunger, malnutrition and low yields for decades. However, the Alliance for a Green Revolution in Africa (AGRA) was founded in 2006 to transform agriculture, reduce hunger, improve nutrition and adapt to climate change. But until now, Africa produces 25.7 million tons of wheat annually and imports another 54.8 million tons from abroad (Ajakaiye & Janvry, 2010). Hunt's studies show that an improvement in the sector: increasing resource commitments for agricultural research; development of rural infrastructure for water, roads, and storage; development of institutions focusing on increasing market efficiency; organizational change that guarantees land rights to small and medium owners is promising (Hunt, 2011). Toennessen et al. (Toennessen, Adesina, & DeVries, 2008) in the studies they have conducted, the lack of success and the challenges of lack of access to grain self-sufficiency in Africa are caused by low agricultural performance, lack of food security, slow economic growth, increasing population, The lack of productivity of agricultural products compared to what was experienced in Asia and Latin America, the destruction of agricultural land for residential areas, the growing population's demand for more food, the depletion of agricultural land of essential nutritious plants, and the feeding of the poor and vulnerable population.

Countries like Indonesia, China, Tunisia, Morocco, Thailand, and Sri Lanka also experienced positive outcomes from the Green Revolution, which significantly contributed to food security and self-sufficiency, particularly in staple crops like wheat and rice. This movement helped shape contemporary agricultural practices, embedding sustainable production methods into their agricultural histories. The adoption and spread of the Green Revolution varied in pace across these countries, reflecting each nation's unique approach and challenges in implementing these agricultural advancements.

Agriculture in Afghanistan

Agriculture is crucial to both human well-being and economic growth in Afghanistan. According to the National Statistics and Information Authority (NSIA, Statistical Yearbook 2018, 2019), approximately 71.1% of Afghanistan's population resides in rural areas, where agriculture serves as the primary source of livelihood. The country's total agricultural land spans an estimated 9,610 thousand hectares, including 3,995 thousand hectares of dry land, 2,493 thousand hectares of irrigated land, 1,781 thousand hectares of forests, 1,341 thousand hectares of dryland, and 265 thousand hectares dedicated to permanent crops.

Data from the National Statistics and Information Authority (NSIA, Statistical Yearbook 2018, 2019) on four major food items highlights the intricate relationships among total production, yield per hectare, population, imports, and cultivated area. For instance, Table 1 reveals a complex relationship: in the case of wheat, there is a strong negative correlation

between wheat production and yield per hectare (-0.98), a strong positive correlation between production and cultivated area (+0.99), and between production and population (+0.95). Additionally, wheat production and imports show a moderate negative correlation (-0.43). These patterns reflect a multifaceted interaction between production metrics and external dependencies.

Table 1. Foods statistics from 2016-2018

Year	**2016**				**2017**				**2018**			
Population	**31,575,018**				**32,225,560**				**32,809,171**			
Items	Domestic prod. (in 10^3 MT)	Import (in 10^3 MT)	Cultivated area (hectares)	Product per hectare (in Kg)	Domestic prod. (in 10^3 MT)	Import (in 10^3 MT)	Cultivated area (hectares)	Product per hectare (in Kg)	Domestic prod. (in 10^3 MT)	Import (in 10^3 MT)	Cultivated area (hectares)	Product per hectare (in Kg)
Wheat	3613	٢٣٠٧	١٦٣٥٠٠٠	٢٢١٠	٤٨٩٠	١٤٣٧	٢٥٣٤٠٠٠	١٩٣٠	٥١٨٥	٢٢١٣	٢٦٦٨٠٠٠	١٩٤٣
Rice	٣٥٢	٢٢٢	١١٧٥٣٩	٢٩٩٦	٣٨٣	٢٠٥	١٢٧٥٣٠	٢٩٩٩	٤٤٠	٢٨٨	١٤٧٥٥٥	٢٩٧٩
Corn	١٠٧	٥٢	٧٢٤٣٩	١٤٧٣	١٨٥	٤١	٩٤٩١٠	١٩٤٦	٢٧٢	٣٩	١٤٠٤٩٨	١٩٣٤
Oat	٥٧	٣٧	٨٤١٤٧	٦٧٥	١٢٤	٢٩	٨٤٠٧٠	١٤٧٠	١٢٨	٩	٨٦٠٩٩	١٤٨٤

However, this overview is limited by the absence of data on critical factors, such as modified seeds, pesticide use, irrigation techniques, temperature, types of chemical fertilizers, mechanized equipment, and the workforce involved in production. While sustainable agriculture is not yet institutionalized in Afghanistan, its foundation can be traced back several decades. The initial steps toward agricultural modernization began with the introduction of chemical fertilizers under the country's second five-year plan in 1966, followed by the establishment of the Electric Fertilizer Company in Mazar-e-Sharif in 1974, an investment of $48 million supporting an annual production of 105,000 tons of urea fertilizer. Mechanization gained momentum with the introduction of tractors in 1979. According to World Bank data (The World Bank, 2023), Afghanistan now has the lowest number of tractors per hundred square kilometers of arable land, as illustrated in Figure 1, which compares Afghanistan with neighboring countries such as Pakistan, Iran, and Sri Lanka. Figure 2 provides a detailed view of tractor density specifically within Afghanistan.

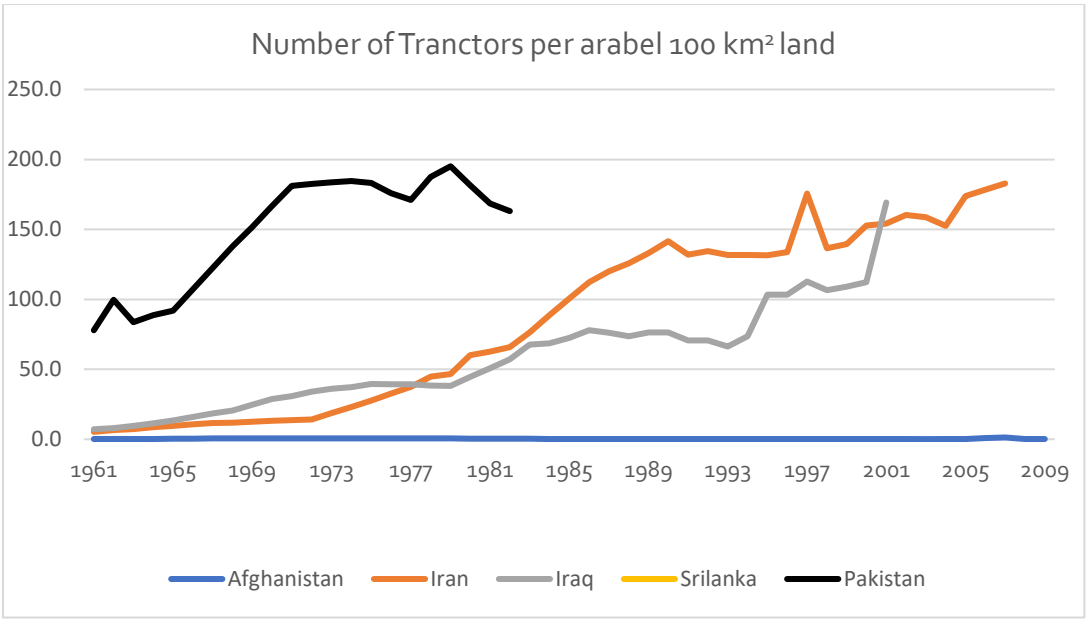

Figure 1. Comparison of Tractor Density (tractors per 100 sq. km of arable land) between Afghanistan, Pakistan, Iran, and Sri Lanka

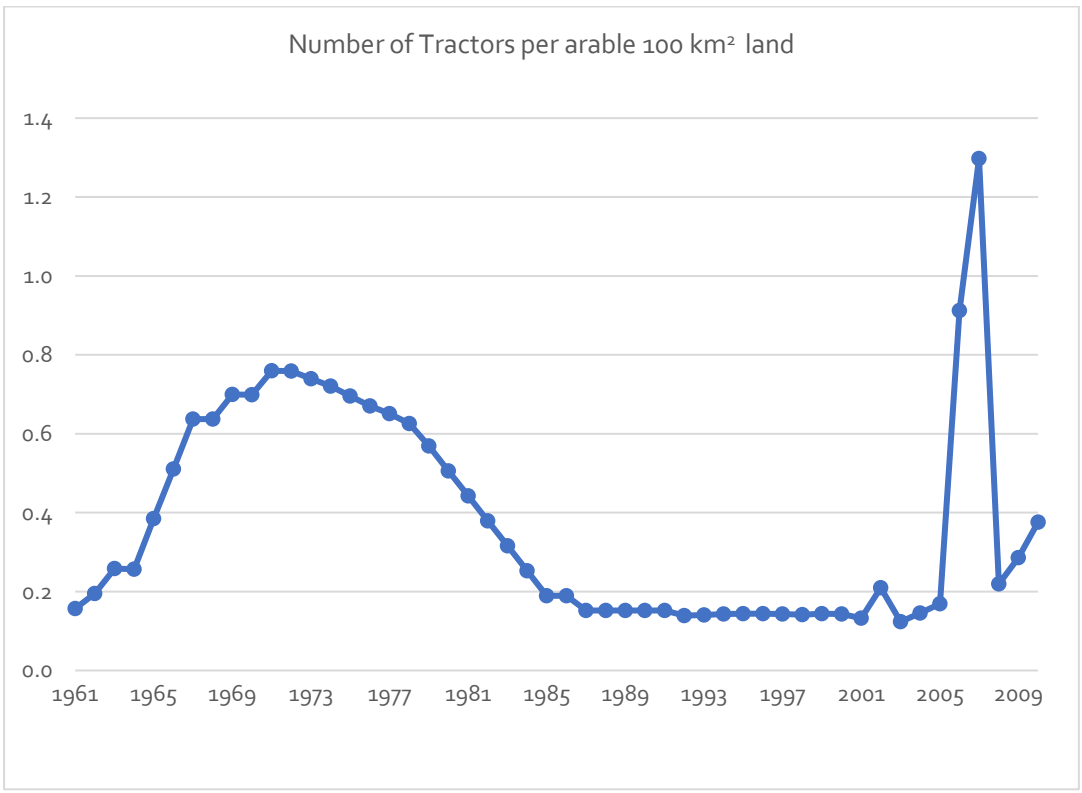

Figure 2. Tractors density in Afghanistan (tractor per 100 m2 arable land)

The first tractors that entered the country were the four-wheeled Messi Ferguson type. In 2010, tractors for horticulture, the number of which may reach several thousand, were also imported into the country along with agricultural tractors. Due to the non-existence of data and the fact that wars are the result of Soviet aggression, the mechanization coefficient cannot be determined. Between 1981-2001, Afghanistan's agriculture experienced a rapid growth. In 2012, the National Bureau of Statistics and the Ministry of Rural Development

conducted a national risk and vulnerability survey with the financial assistance of the World Food Organization (WFP) and the Asian Bank through technical support from (AREU). The results of the survey showed that 57% of the population has very little food diversity, which is the strongest indicator of vulnerability (NRVA (2003), 2004). The results of this survey were used in the first national development strategy of Afghanistan, and a 30% increase in investment in the agriculture sector was predicted (I-ANDS, 2004) and based on that, the master plan for Afghanistan's agriculture was formed 2006-2010. This master plan included food security, horticulture, livestock, natural resource management, irrigation system, policy reforms, human resource development for sustainable growth and agricultural pest management. In accordance with this plan, the Ministry of Agriculture and Livestock of Afghanistan undertook projects such as HLP and OFWMP to strengthen the agriculture system. Also, the use of high-yielding seed eggs, especially during the last twenty years, was the measures that have been taken in this direction. However, Afghanistan is not able to meet the needs of food items and must import from abroad, which is clearly seen in Table 1.

Unfortunately, the new figures from the last three years were not available to the researcher, so we could have presented a relatively clearer picture. But if the attention is turned only from Table 1 to the figures in 2019, on average, Afghanistan needs about 7.4 million metric tons of wheat annually. Among them, 70.1% of domestic and the remaining must be procured from abroad. While there is potential for enough internal facility capacity.

DISCUSSION

The agricultural revolution was a gradual transformation in the traditional farming system that started in the 18th century in Britain and later in the second half of the 20th century, it quickly spread to most of the developed and developing countries. From the studies of the countries, the main factors that contributed to this complex evolution are:

1) New Laws: The new laws allowed farmers to take over the public land that was previously used as pastureland and turn it into agricultural land, to cultivate and raise animals safely.
2) Mechanized systems: the invention of more efficient mechanized systems for cultivation, harrowing, sowing, irrigation, harvesting, threshing. These tools help simplify the farming process, making them easier, faster, and more efficient.
3) Introducing new products: Introducing new products for alternative cultivation, such as turnips and clovers, which inject nitrogen into the soil and strengthen soil fertility.
4) Transportation and transportation system: Improved transportation system.
5) Chemical fertilizer: distribution of chemical fertilizer and even in many cases as a loan to farmers
6) High-yielding seeds: distribution of high-yielding seeds to farmers, especially wheat and rice.
7) Genetic modification of seeds: so that the seeds are resistant to diseases, conditions, and climate. (Let's not forget that sperm sex change causes serious problems for the environment. For this reason, sperm sex change has been banned in some countries)

8) Agricultural Pest Control: Distributing pesticides to farmers and creating opportunities to access them helped protect crops from pests, insect attacks, weeds, and diseases and increase plant yields.
9) Strengthening extension interactions with research centers: Extension and research are two important factors in the development of agriculture. Extension centers help farmers to keep up-to-date with the latest agricultural knowledge and improve their productivity. Research centers seek to develop new knowledge in the field of agriculture.

CHALLANGES

The Green Revolution transformed agriculture in the 20th century by introducing advancements in plant genetics, modern irrigation systems, chemical fertilizers, and pesticides to boost crop yields, enhance food production, and reduce poverty, hunger, and unemployment. However, this approach also presents several challenges, which will be briefly discussed.

- Environmental destruction: the use of pesticides and fertilizers can cause environmental destruction, including erosion of soil, water, and destruction of natural habitats.
- Inequality: The population was not divided equally between the rich and the poor.
- Water management: With the expansion of irrigation areas, water management required skills that were not always available.
- Water resources: In cases of excessive use of Kiwi fertilizer, it has caused water resources in the region or another region.
- Air: Air problems caused by ammonia, methyl bromide, burning of crop residues such as rice straw and unpleasant odors in areas with intensive agricultural production.
- Groundwater: Indiscriminate use of groundwater in agriculture causes the water level to drop, which has many consequences

RECOMMENDATIONS

Afghanistan's growing population, climate change, limited access to international transportation, and energy shortages underscore the need for a strategic, science-based approach to agriculture. A dynamic application of strategic management is essential to ensure Afghanistan's active presence in the global arena. Under current conditions, a modern, responsive agricultural system has the potential to transform Afghan agriculture from a survival-based activity into a thriving industry. Drawing on the successes of the 20th-century Green Revolution and advancements of the 21st century, the following recommendations are proposed to catalyze a new agricultural revolution, with a particular focus on precision agriculture in Afghanistan.

1. The experiences of countries in the field of agricultural revolution in the 20th century and the lessons learned should be used as much as possible.

2. The results of surveys such as necessity-based survey, land survey and other surveys conducted in the agriculture sector should be used in order to avoid wasting time.
3. An agricultural plan of at least ten to twenty years with the cooperation and participation of all domestic stakeholders (such as farmers, ranchers, agricultural employees, seed and fertilizer companies, sellers, agricultural financial institutions, agricultural consultants, agricultural product consultants, collectors, agricultural processing companies, distributors, transport companies) and international (WFP, FAO, WB, ADB, OIC) should be compiled.
4. Instead of single-crop culture (only wheat or rice), attention should be paid to multi-crop culture.
5. Qush Tipeh canal, which transforms about 500,000 hectares of uncultivated and barren land into arable land, should be fully used in three categories of completely private sectors, for medium and low-income peasant cooperatives.
6. Clearing agricultural lands from remaining mines.
7. The chemical fertilizer factory of Mazar-e-Sharif should be strengthened and chemical fertilizer with specific nitrogen, phosphorus, and potassium (NPK) compounds should be produced and distributed according to the needs of the land. The methods of safe use of chemical fertilizers and pesticides should also be taught to farmers. The unsafe use of pesticides may cause human risks such as poisoning and even cancer, as WHO and UNEP reported more than one million people poisoned by pesticides in 1989 (Pimentel, 1996).
8. In developing the agricultural strategic plan, the use of the achievements of the smart agriculture revolution 4.0, which includes the use of Internet of Things (IoT) tools and is useful for achieving full potential (Javid, Haleem, Singh, & Suman, 2022), should be introduced. The use of agricultural technology such as the Internet of Things, thermal and humidity sensors, artificial intelligence, connections, internals, blockchain technology has revolutionized the agricultural revolution in the 21st century.
9. Water management: Adjust water consumption based on soil moisture. Agricultural water management and especially the use of underground water should be applied separately in the current conditions of climate change and drought. Farmers should see the necessary training.
10. Strengthening extension interactions with research centers: Extension and research are two important factors in the development of agriculture. Extension centers help farmers to keep up to date with the latest agricultural knowledge and improve their productivity. Research centers seek to develop new knowledge in the field of agriculture.
11. Mechanization of agriculture benefits of mechanized agriculture such as increasing efficiency, improving products, reducing labor costs, greater safety and reducing adverse environmental effects should be taught. For the tractor to enter the country, a regular program should be carried out by setting the target every year and the

amount of power required (how much power). Additionally, people should be trained in the tractor repair department.

12. The position of the indicators of the complete management of the agricultural chain should be determined in the strategy.
13. Farmers should cooperate in promoting and building greenhouses and cold stores as a controlled environment for the growth of agricultural products.
14. Farmers should be trained and supported with loans in promoting and using the agrovoltaic system or in other words the simultaneous use of land for the purpose of farming and producing electric energy from the sun.
15. Investing in agricultural canals to install solar panels, which have multifaceted effectiveness, including the production of large amounts of electricity and preventing the evaporation of millions of cubic meters of water per year because of evaporation.
16. Due to climate change, non-monsoon rains are increasing. Therefore, to control this water, necessary measures should be taken by digging pits to inject rainwater into the ground.
17. The increasing population of the country has affected residential houses. Every day, residential houses are built on top of irrigated agricultural land and the area of cultivated land is reduced, it requires that plans for residential areas at the level of districts and large villages be considered and general development is done instead of horizontal development.
18. Farmers' access to international markets should be facilitated. 20. The landowning families in the provinces, according to the prevailing custom, dedicate agricultural lands to Hazira. In this way, each family wants to have a separate presence. It may be better to dedicate arable land in each district for the burial of public bodies to prevent the island presences that cause the destruction of agricultural lands. The country's increasing population, climate change, Afghanistan's limitations to the international transportation system, lack of energy, the system of seeking superiority in the world, effective and continuous presence in the world arena more than ever requires a suitable and scientific strategy, the application of strategic management. And it is dynamic. In the current conditions and existing capacities, a contemporary and responsive agricultural system can transform agriculture in Afghanistan from an activity of fighting for survival to a profitable business.

CONCLUSION

The Green Revolution significantly boosted food production but also led to unintended negative consequences. To address these issues, a second Green Revolution is needed, emphasizing sustainable agriculture that is both environmentally responsible and socially equitable. This new approach should prioritize organic farming methods, water conservation, and biodiversity promotion. Additionally, it should empower small farmers and encourage inclusive growth within the agricultural sector.

Agriculture is essential to Afghanistan's economy, with nearly 70% of the population living in rural areas and primarily engaged in farming. As the backbone of the nation's economy, the agricultural sector can benefit greatly from improved crop production—especially for staples like wheat and rice, which are heavily imported. Key strategies for a successful second Green Revolution in Afghanistan include optimized use of chemical fertilizers (NPK), effective irrigation systems, appropriate pesticide use, and enhanced collaboration between research centers and farmers. Expanding rural coverage, strengthening advisory services, decentralizing resources, equitable land distribution, and integrating information technology are also critical.

Implementing these initiatives through a strategic, science-based framework, informed by international experiences, can foster crop growth, alleviate poverty and hunger, and generate diverse employment opportunities. Afghanistan has the chance to build a sustainable agricultural model that not only supports marginalized farmers but also preserves natural resources. This second Green Revolution will enable Afghanistan to create a resilient, inclusive agricultural sector that is ecologically sustainable and economically productive.

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