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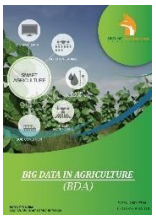

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REVIEW ARTICLE

IMPACT ON THE LIVELIHOOD OF RURAL FARMERS DUE TO THE ADOPTION OF MODERN AGRICULTURAL TOOLS AND TECHNOLOGY IN NEPAL

Binisha Paudel*, Sunil Regmi

Agriculture and Forestry University, Chitwan, Nepal
Corresponding author E-mail: binishapaudel24@gmail.com

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ABSTRACT

Nepal mainly relies on agriculture for their livelihood, where 1/3 of the country's GDP is generated from agriculture. Although agriculture is a major source of income for most Nepalese people, it is still lagging behind modern tools and technology. It is due to various reasons, such as high initial investment, poor knowledge, lack of awareness, small land holdings, subsistence farming, and ignorance of the government on the agriculture sector. One of the major reasons for low productivity is small and fragmented land holdings which cause obstacles and challenges to employing large machinery and modern technology as it is not desirable to fully exploit the resources, rather it will increase the cost of production. Employment of mechanization is mainly found in terai areas that are near the market and also found in the rural area that has connectivity to the roads. Mechanization helps to exploit the resources, land, labor, time, and energy resulting in increased agricultural production, productivity, profitability, and living standard of the farmers. Modern agriculture tools and technology include new varieties, irrigation pumps, drones, precision agriculture, climate-smart agriculture, Internet of Things (IoT), machinery (tractor), Animal-drawn implements (moldboard plow, disc harrow, disc plow), etc. The Extension system plays a crucial role in the adoption of modern agricultural tools and technology. It also acknowledges and aware the local people about the existence and use of various tools and technology and provides the training and skills to employ these tools at the local level. The government of Nepal also facilitates different projects and programs related to skill development and training toward the modernization of the agricultural system such as the Prime Minister Agriculture Modernization Program (PMAMP). The adoption of modern tools and technology enhances the productivity and living standards of rural farmers in several ways. It helps to maximize the efficiency of resource use, minimize waste and environmental effects, analyze the amount of nutrients in the soil, estimate crop water requirements, etc. Farmers are now able to monitor and identify their needs and problems themselves, optimize balanced doses of fertilization, track crop health and pest infestation, etc thus improving crop quality.

KEYWORDS

GDP, Modern agriculture tools and technology, agricultural system.

1. INTRODUCTION

Nepal is a small landlocked country where the majority of the population depends mainly on agriculture for their livelihood. Over two-thirds of the population in Nepal gets their earnings from agriculture, which is responsible for one-third of the country's GDP (MoF, 2013). Most of Nepal's families have less than 0.8 hectares of agricultural land. Due to the small and fragmented land holdings and shortage of alternative work options in the nation, most farmers practice subsistence farming. Most still engage in traditional farming methods due to poor investment capacity, a lack of market potential, and inadequate infrastructure. In the case of Nepal, agriculture is now the occupation of the old people and women because most young people leave the country and go abroad in search of better opportunities. There are three main farm power i.e. animal power (36.3%), human power (40.5%), and mechanical power (20%) followed in the agricultural system of Nepal (Shrestha, 2011). Recently, people have started using mechanical power in agriculture to mitigate the shortage of labor, lower production costs, and encourage the commercialization of agriculture (Gauchan and Shrestha, 2017).

Major mechanical tools used in rural areas include manual tools (like spade, hoe, sickle, etc.), animal-drawn implements (like a traditional wooden plow, iron moldboard plow, wooden plank, disc harrow, etc), and mechanical power-powered machinery (like a tractor) (Shrestha, 2011). Rice is the dominating crop of the country which is mostly mechanized throughout its entire lifecycle, including nursery bed preparation, transplantation, irrigation, manuring, harvesting, threshing, and storage. There is the utilization of different mechanics like a tractor, moldboard plow, combine harvester, thresher, etc. for this kind of operation. It has increased the efficiency of crop production, led to higher productivity, and accelerated the transition from subsistence farming to commercialization (Ghimire and Huang, 2016).

2. TRADITIONAL FARMING PRACTICES IN RURAL NEPAL

Farming is practiced from the low hills around Terai to agricultural plains above 4,000 meters where livestock are still pastured on higher land up to approx 5,200 meters(Schroeder, 2016). Rain-fed agricultural system accounts for over 67% of agriculture practiced in Nepal, despite having plenty of fresh water supply (Engineering, 2021). Summer monsoon is the most significant agricultural season, where 60 to 90 percent of total annual precipitation occurs between June and September (Nayava, 1980). Due to this reason, many farmers face the problem of water scarcity during dry periods. Crop selection is often influenced by

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ambient temperature, which is directly correlated with elevation. In the Kathmandu Valley, farming systems can shift from triple-cropping to double-cropping systems with an elevation difference of less than 300 meters (Schroeder, 2016). Simple manual tools and human labor are the main tools used for field preparation tasks like harrowing, leveling, and plowing. local artists melt and form metal components from iron blanks to create agricultural implements. Human labor is used to perform various operations like the transportation of compost to the fields, agricultural output to the storage spaces, and leftover forest areas for fuel and fodder. (Schroeder, 2016)

3. Modern Agricultural Tools and Technology

The private sector imported four-wheel tractors for agricultural production in the early 1960s, which played a significant role in farm mechanization. Since the 1970s, the landscape of mechanization has drastically changed with the widespread usage of diesel pumps in irrigation and threshers in rice and wheat. Approximately 90% of the total mechanization used in Nepal is concentrated in Terai which is close to the market. It is shallow in the case of hills and mountains because of the poor transportation facilities and the reason for utilizing it on narrow terraces. But in recent years, the use of tractors, power tillers, pump sets, and threshers has increased due to increased road connectivity in rural hills and mountains. Currently, the most popular agricultural equipment used in Terai and market-accessible hills are threshers and small-scale irrigation pumps because they reason that it is useful in saving time, resources, and labor. Mechanization helps to improve the timely agricultural operation by lowering cultivation costs, raising product quality, and fostering an environment that encourages a competitive market price for agricultural commodities. Its main aim is to expand the scope of farming activities and enhance their quality, quantity, and efficiency to increase agricultural production, productivity, and profitability (Gauchan and Shrestha, 2017).

Smart crop management practices help to standardize agriculture production in several ways as they primarily focus on the factors that influence crop yield (Jaramillo et al., 2020). It includes soil monitoring, irrigation facilities, balanced fertilization, integrated weed management, selective use of herbicides and pesticides, etc (Khan et al., 2021). Rainfed farmers use large amounts of seeds for sowing without a technical basis which results in a high plant population leading to weaker plants having limited fertilizer response and susceptibility to plant pathogens. Smart crop management practices set the ideal plant population to produce healthy plants. In traditional agricultural system, farmers typically apply unsafe pesticides to their crops regularly which can result in the destruction of natural enemies as well as secondary pest outbreaks. Therefore, it is necessary to use selective pesticides so that they do not destroy natural enemies. There should be integrated weed management practices which include crop rotation, appropriate soil preparation, use of improved high-yielding seeds, balanced fertilization, and ideal water management. Farmers have to consider certain factors such as the evaluation of the soil, yield potential, crop demand, and environmental offer to determine the ideal fertilizer dosage that would allow crops to absorb all available nutrients in the soil (Jaramillo et al., 2020).

The Internet plays a significant role in early warning systems, weather forecasting, social media marketing, and other aspects of agriculture. In Nepal, there is much land that is possible for cultivation but they were kept fallow instead of cultivation, and large no of indigenous crop varieties are still in their wild form, they were not brought to domestication and selection. Because of this reason, there is the possibility to increase the crop productivity of the country through precision farming which denotes 3R ie at the right time, right place, and in the right amount(M. Shrestha, 2020). The use of technology to assist farmers in managing their fields more accurately and precisely is known as precision agriculture. The use of information technology (IT) in precision agriculture (PA) ensures that the soil and crops receive precisely what they require for maximum health and yield(K.V., 2020). Millions of farmers in Nepal might benefit greatly from clean irrigation through the established technology known as solar-powered irrigation pumps, or SPIPs (A et al., 2017). Unmanned Aircraft Systems (UAS) also known as drones are found to be increasingly used by many agriculturists for various purposes like plant examinations, irrigation, mapping, and monitoring (Rejeb et al., 2022).

4. Adoption of Modern Agriculture Tools and Technology in Nepal

Agricultural extension systems play a significant role in the adoption of new modern agricultural tools and technology among rural farmers who otherwise might not be familiar with tools on their own (Suvedi et al., 2017). The adoption or non-adoption behavior of farmers can be influenced by a variety of factors, which might result in variation and self-selection bias. Similarly, there is little proof that the technology has been effective in mitigating the risk of climate change faced by smallholder farmers (Diwakar et al., 2021). The two factors that consistently affected the degree of adoption of technologies were ethnicity and extension input levels. Those farmers from lower occupational castes are less prone to attempt new technologies, and adoption of new technologies tends to decrease as extension contribution decreases (Floyd et al., 2003). Adoption of these tools and technology helps to exploit the land, labor, time, and money. It also helps enhance the livelihood of farmers in rural areas. In Nepal, farmers hesitate or take a long time to adopt new agricultural technologies like machinery, new varieties, and management practices as they require high initial investment, risks associated with them, lack of awareness, traditional beliefs, etc. According to (A et al., 2017), the farmers having more land (1.85 ha) are more highly interested in modern tools ie solar-powered irrigation pumps than farmers having small land (0.9 ha). Even so, smallholder farmers with less than one hectare of land also make up 30% of total applications.

The adoption of modern agricultural tools and technology is a slow process. According to (Brown et al., 2021), most of the farmers are not ready to adopt these technologies due to their unawareness towards modern gadgets. The research conducted by (Brown et al., 2021), on exposure to nine machines, discovered that only 3% of households were familiar with all nine machines, 66% of households were unfamiliar with at least five of the devices under investigation, and 25% of households were unfamiliar with all nine machines. Therefore, the government of Nepal must emphasize the provision of a strong agricultural extension system to the smallholder farmers of rural areas so that they will be aware of modern tools and technology and can uplift their crop productivity.

5. Impact of Adoption on the Livelihood of Farmers

Since agriculture provides the livelihoods for the majority of smallholder farmers in rural areas, agricultural growth can have a significant impact on reducing rural poverty (Mottaleb, 2018), where agricultural growth can be enhanced through the implementation of modern agricultural tools and technology. Drones, automated irrigation systems, and precision farming tools are modern methods that help farmers monitor and manage their crops more effectively. Higher yields and increased production are the results of this (Olusayo et al., 2019). Drones are remotely piloted aircraft systems that can give real-time information on livestock movements or crop quality, allowing for accurate and efficient decision-making for cultural operations and management (Needs, n.d.). An automated irrigation system's motor is turned on and off by a valve that doesn't require labor to operate (Kansara et al., 2016). Therefore, this technology can help to reduce the labor shortage issue. As compared to traditional agricultural methods, precision agriculture increases yield by precisely utilizing crop management practices (Khadka, 2023). Technology allows farmers to maximize their use of resources such as pesticides, fertilizers, and water.

Farmers can utilize these resources in a targeted way, minimizing waste and environmental effects, by employing precision agriculture techniques (Jat et al., 2021). Farmers can now identify nutritional deficits, track crop health, and spot infections in real time with the help of modern instruments like the Internet of Things (IoT). This facilitates quick response to ensure improved crop quality and higher market value. soil analysis helps to measure the amount of nutrients in the soil, therefore an appropriate amount of fertilizer dose, and different kinds of soil treatment can be done to meet the ideal nutrient level, where farmers can receive the greatest advantage from various soil management practices and fertilizers used (Khan et al., 2021). Estimation of crop water requirements includes the consideration of soil types, pre-existing soil moisture, meteorological factors, and smart irrigation systems. In this case, a variety of modern instruments, including the Internet of Things, are crucial for determining the humidity of the air and soil, which eventually improves crop quality (Khan et al., 2021).

6. Challenges and Limitations of Modern Agricultural Tools and TECHNOLOGY

Modern agricultural tools and technology require high initial investment, technical knowledge, and strong extension service. Agricultural extension programs play a key role in educating farmers about new agricultural tools and technologies, including how they operate, the advantages of utilizing them, how they affect crop productivity and other relevant information. However, not all kinds of farmers have access to these kinds of resources and activities(Suvedi et al., 2017). It is obvious that although reasonable

research programs are conducted for certain commodities, like rice, maize, wheat, etc. There is negligible study conducted on significant commodities like chickpeas, coconuts, sweet potatoes, groundnuts, and cassava(Evenson, 1981) which leads to the development of new technology (high-yielding varieties, precision agriculture, fertilizer dose, critical irrigation stage, etc) only for the major commodities. In the experiment stations, multiple superior varieties were created. However, these newly developed cultivars were not generally adopted since they were prone to numerous local diseases (Evenson, 1981). Compared to traditional cultivation techniques, precision agriculture (which is based on information technology) uses crop inputs in precisely the right amounts to maximize production. In Nepal, agriculture is mainly practiced in small fragmented land which is the biggest problem (Khadka, 2023). Information technology cannot operate in a precise manner in small, fragmented land so precision agriculture is challenging to implement in such a situation.

The "Internet of Things" (IoT) has the potential to modernize agriculture in several ways. IoT in agriculture faces several difficulties the apparatus located at the perception layer needs to be subjected to direct exposure to severe weather conditions, such as intense sunlight, low or excessive humidity, rain, strong winds, vibrations, and other hazards that could ruin electronic circuits (Tzounis et al., 2017). Drones for agriculture have some advantages, but they also have some drawbacks. It has a short flight time of 20 to 60 minutes, is weather dependent, has a high initial cost, has inadequate connectivity in rural areas, requires highly specialized labor, etc (Needs, n.d.).

7. Government Initiatives and Support

Nepal is primarily an agrarian nation, with 88% of the population residing in rural areas where 78% of adult rural residents work in agriculture. Presently, 3.2 million hectares of land are under cultivation in Nepal, with an additional 1.0 million hectares of land that might be used for farming. Thirty-three percent of the country's GDP is derived from the agricultural sector. It makes a significant contribution to employment, particularly in rural areas where agriculture is the primary source of income. Multiple indicators can be used to estimate poverty. Nepal's government employs the cost-of-basic-needs (BCN)1 methodology. The degree to which poverty is measured varies according to government statistics. For instance, according to the 2010 Nepal Living Standard Survey (NLSS), approximately 31% of the population was projected to be living below the national poverty level and 41% to be consuming less than minimum calorie requirements (Joshi et al., 2012). Agricultural mechanization as part of a 20-year vision for agricultural growth was the first comprehensive policy of Nepal focusing on mechanization which was released in 2014 (Brown et al., 2021).

The government of Nepal has used technology-led initiatives as a means of fostering the development of smallholder farmers**.** The government has emphasized technology-led intervention in its strategic plans, programs, and extension services ever since the first attempts at agricultural interventions in 1923 when an irrigation canal was built in Saptari and an experimental farm was established in Kathmandu. The government has recently recognized the hazards associated with climate change and emphasized the promotion of climate-smart agriculture solutions. Government agriculture development policies offer the structure and plans of action required to accomplish particular public objectives. Additionally, they serve as the foundation for developing particular duties and rights for both individuals and groups (Khanal et al., 2020).

PMAMP is a ten-year project designed to modernize Nepal's agricultural system. It is divided into zones, superzones, pockets, and blocks that supervise commodities such as potatoes, rice, wheat, bananas, and vegetables. It also offers several training programs to acknowledge and educate farmers about modern equipment and technology. According to researchers, the government established 86 semi-high-tech greenhouses and 10 high-tech greenhouses in the last few years through the Prime Minister Agriculture Modernization Project (PMAMP) (Diwakar et al., 2021).

8. Prospects and Recommendations

It is estimated that there will be 9 billion people on the planet by 2050, which is 25% more than the present population, and the population living in urban areas is predicted to increase from 49% to 70% by 2050. We should be more careful about food quality and nutritional values because of the ongoing growth of the world's population. By 2050, food production needs to double to meet future demand. To meet the world's food demand by 2050, it is recommended that grain crops and meat output should be expanded from 2.1 billion to 3 billion tons, and from 200 million to 470 million tons, respectively (Khan et al., 2021).

A large number of significant opportunities for the development of sustainable agriculture appear as we look into the future such as

8.1 Innovation and technology

Agriculture will continue to be modernized by technological advances like hydroponics, aquaponics, precision farming, and vertical farming. These technologies can boost output, minimize their negative effects on the environment, and maximize the use of resources. Furthermore, advancements in crop protection techniques, biotechnology, and genetic engineering can support sustainable farming approaches.

8.2 Climate Smart Agriculture

The goal of climate-smart agriculture is to both mitigate and adapt to the effects of climate change. It can be achieved through practices like reducing greenhouse gas emissions, improving soil health, integrated pest management, agroforestry, and conservation agriculture.

8.3 Circular Economy and waste reduction

The idea behind a circular economy is to reduce waste materials, nutrient recycling, and minimize pollution in the environment through composting, using livestock manure as fertilizer, and producing bioenergy from agricultural waste.

8.4 Archaeology and biodiversity conservation

Archaeology focuses a strong emphasis on how ecological concepts are incorporated into agricultural systems. It encourages the use of locally adapted crops, natural pest management, and biodiversity conservation. These techniques promote resilient agriculture to environmental changes and sustainable agricultural development by improving ecosystem services like pollination and soil fertility.

8.5 Policy and institutional support

The promotion of sustainable agricultural development is greatly supported by governments, international organizations, and agricultural institutions. Fostering sustainable agricultural systems requires policy frameworks that support research and extension services, give smallholder farmers access to resources and financing, and promote sustainable practices.

8.6 Demand and consumer awareness

Changing agricultural techniques may result from growing consumer awareness about the adverse ecological and social impacts of food production. There is an increasing demand for locally sourced goods, organic products, and food that is produced sustainably. Customers' changing preferences may encourage farmers to use sustainable methods and encourage market mechanisms that encourage ecologically favorable approaches (El and Saad, 2021).

Federal and non-federal organizations are collaborating to improve IoT applications to maintain food security and safety. Scientists, researchers, and engineers are creating a large number of new tools and technologies to monitor crops and related field data. Many manufacturing companies are contacting us to offer different tools and technologies, such as IoT sensors, robots, and UAVs/drones, to gather real-time data at much higher resolutions. At present, farmers rather than working in the field, need to spend 70% of their time examining the status of the crops. Therefore, to grow the agriculture sector, innovative technology like the Internet of Things (IoT) is needed. "On-site monitoring" features of IoT enable farmers to monitor their crop properties and detect problems at the early growth stages, and it helps producers achieve better results (Khan et al., 2021). To assist farmers in practicing "Precision Agriculture," drones are widely used on farms in developed countries. In a few years, both large and small farms in developing countries will use drones more and more frequently (Debangshi, 2021).

9. Conclusion

Although most of the people in Nepal engage in agriculture production, they cannot even fulfill the country's demand. Every year we have to import large quantities of grains and food crops because of the reason that, most farmers follow traditional farming and subsistence agriculture which cannot properly exploit the resources. Therefore, Nepal has to adopt some modern agricultural tools and technology so that, people no longer have to

rely on importing goods and crops as we have enough resources to produce plenty of agricultural products. At present, the majority of people are interested in optimizing their resources by various methods such as shifting from a rainfall-based agricultural system to irrigation-based agriculture through the installation of different irrigation pumps, many farmers adopt precision agriculture, start using commercial high-yielding variety rather than local variety, and few enthusiastic farmers are even looking for the Internet of Things (IoT) to monitor the field. Many large farmers also employ different kinds of machinery in their crop period to optimize the efficiency of time, labor, and energy and thus result in higher productivity.

The government of Nepal has also established different projects and activities to modernize rural farmers such as the Prime Minister Agriculture Modernization Project (PMAMP), an extension program, and the provision of subsidies. Although few large farmers have adopted different kinds of machinery to enhance productivity in Nepal. Many small farmers still engage in traditional labor-based farming systems because of poor knowledge about modern equipment, high initial investment, small and fragmented land systems, and subsistence farming, which is the major reason for the low average productivity of the country. It results in reliance on bigger nations like China and India for the import of various agricultural commodities and raw materials. These are the major obstacles and constraints of Nepal's agricultural system.

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