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Women in Traditional Agriculture and Digital Agriculture: Past, Present and Future

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Abstract

Women hold a pivotal position in agricultural systems worldwide, making substantial contributions to food production, household nutrition, and rural livelihoods. Traditionally, they have been actively engaged in farming activities, undertaking labor-intensive responsibilities such as planting, weeding, harvesting, and post-harvest processing. Despite this, their efforts have frequently been undervalued due to prevailing social, economic, and institutional barriers. In recent years, the rise of digital agriculture technologies—including precision farming, mobile-based advisory services, remote sensing, and agricultural data platforms—has significantly reshaped agricultural production systems. While this shift creates new avenues for enhancing women's empowerment and productivity, it also introduces challenges such as restricted access to digital tools, limited training opportunities, and inadequate financial support.

This review paper explores the changing role of women in agriculture through three key perspectives: their historical involvement in traditional farming systems, their present participation in modern agricultural practices, and their future prospects within digital agriculture. Drawing on secondary data sources, reports from international organizations, and academic literature, the study evaluates gender-based disparities in access to agricultural resources, adoption of technology, and participation in decision-making. The findings reveal that women represent approximately 41–43% of the global agricultural workforce, yet they continue to encounter significant obstacles related to land ownership, access to credit, and agricultural extension services (FAO, 2023). Addressing these inequalities through inclusive digital agriculture initiatives has the potential to substantially improve agricultural productivity and strengthen food security.

The study ultimately emphasizes that empowering women through their integration into digital agricultural ecosystems—supported by targeted training, enabling policies, and improved access to technology—is crucial for promoting sustainable agricultural development and achieving gender equality.

Keywords: Women in agriculture, digital agriculture, gender equality, rural development, agricultural technology, food security

1. Introduction

Agriculture continues to be a vital sector underpinning global livelihoods and economic stability. As reported by the World Bank, it engages about 26% of the world's workforce and serves as a source of income for over 2.5 billion individuals, especially in developing nations (World Bank, 2022). In numerous rural areas, agriculture functions as the main foundation for food supply, employment, and economic activity. Within this context, women contribute significantly to maintaining agricultural production and supporting rural economies.

Historically, women have been central contributors to agricultural activities including crop production, livestock management, seed preservation, post-harvest processing, and food preparation. Their involvement in farming systems is deeply embedded in rural livelihoods and household food security. Women farmers also contribute significantly to biodiversity conservation through indigenous agricultural practices such as crop rotation, intercropping, and organic fertilization.

Despite these contributions, women farmers often face numerous structural constraints that limit their productivity and economic empowerment. These include unequal access to land ownership, agricultural credit, training programs, extension services, and modern farming technologies. The Food and Agriculture Organization estimates that women own less than 15% of agricultural land worldwide, highlighting a major gender disparity in agricultural resource distribution (FAO, 2011).

Over the past few decades, agriculture has undergone major changes driven by technological progress. The introduction of digital innovations such as remote sensing, artificial intelligence, the Internet of Things (IoT), and mobile-based advisory platforms has opened up new possibilities for enhancing both productivity and sustainability in farming. This shift, commonly known as digital agriculture or smart farming, allows farmers to obtain real-time insights into weather conditions, soil status, crop health, and market prices.

However, the adoption of digital agriculture technologies has not been equally distributed across genders. Women farmers often face additional barriers in accessing digital technologies due to limited digital literacy, lack of financial resources, and socio-cultural restrictions. This situation has created what is commonly known as the digital gender divide in agriculture.

Understanding the evolving role of women in agriculture, from traditional farming systems to modern digital agriculture, is essential for designing inclusive

agricultural policies and achieving global development goals such as the Sustainable Development Goals (SDGs). This chapter examines women's contributions to agriculture historically, analyzes their participation in contemporary agricultural systems, and evaluates the opportunities and challenges associated with digital agriculture.

The main objective of this chapter is to analyze the role of women in agriculture across traditional and digital agricultural systems.

2. Women in Traditional Agricultural Systems

2.1 Historical Role of Women in Agriculture

Women have long held a vital position in agricultural production systems worldwide. From the earliest stages of farming societies, they have actively participated in a wide range of activities that support food production and household food security. In many traditional communities, agricultural work has been divided along gender lines, with men typically handling physically demanding tasks such as land clearing, plowing, and building irrigation infrastructure. Meanwhile, women have taken responsibility for equally important but labor-intensive activities including sowing seeds, transplanting, weeding, harvesting, and post-harvest processing. These contributions have been essential for maintaining agricultural output and ensuring a steady food supply for both households and communities (FAO, 2011).

In developing regions, women continue to play a central role in agriculture, particularly within smallholder farming systems where family labor is crucial. According to the Food and Agriculture Organization, women are responsible for producing between 60% and 80% of food crops in many developing countries, especially in subsistence farming systems that depend heavily on household labor (FAO, 2011). Their responsibilities often go beyond crop production to include livestock management, food processing, storage, and the marketing of agricultural goods. In rural settings, women also contribute significantly to household nutrition by cultivating fruits, vegetables, and other food items that complement staple crops. As a result, their involvement supports not only agricultural productivity but also overall family well-being and food security.

Despite these substantial contributions, women farmers frequently encounter various challenges that hinder their productivity and limit their economic prospects. In many contexts, access to key resources such as land ownership, agricultural finance, improved technologies, and extension services remains restricted for women. Social and institutional constraints often reduce their participation in decision-making related to farm management and resource distribution. Consequently, women tend to work on smaller plots and depend more on traditional farming methods. Research indicates that enhancing women's access to resources and knowledge could lead to notable improvements in agricultural

productivity while also helping to alleviate rural poverty and food insecurity (FAO, 2011).

Women also make a significant contribution to agriculture through their rich indigenous knowledge of natural resource management. Over generations, they have developed deep insights through continuous interaction with local environments. This knowledge encompasses areas such as soil fertility management, crop selection, seasonal planting patterns, pest control strategies, and water conservation methods. In many rural communities, women are primarily responsible for selecting and preserving seeds for future use. By choosing seeds based on factors like yield, taste, and resistance to pests or drought, they help sustain genetic diversity and strengthen the resilience of agricultural systems.

Traditional practices maintained by women include crop diversification, mixed cropping, preparation of organic fertilizers, and seed conservation methods. Growing multiple crops within the same field reduces the risk of total crop failure and enhances soil health. The use of organic inputs such as compost and animal manure, often prepared from locally available materials, supports soil fertility while minimizing dependence on chemical fertilizers. Seed preservation ensures the continued availability of locally adapted crop varieties that can better withstand environmental changes and climatic stress. These practices play a crucial role in promoting sustainable agriculture, conserving biodiversity, and ensuring long-term food security in rural areas.

Moreover, women act as key custodians of traditional agricultural knowledge, passing it from one generation to the next. Through informal learning and daily community interactions, they share valuable knowledge related to farming techniques, food preparation, and the use of medicinal plants with younger members of their families. This transfer of knowledge helps safeguard cultural heritage while maintaining sustainable agricultural practices. Increasingly, there is growing recognition of the need to incorporate women's traditional knowledge into modern agricultural development initiatives to support more sustainable and climate-resilient farming systems.

2.2 Traditional Agriculture in Sri Lanka

Sri Lanka has a long and rich history of agricultural development that dates back more than two thousand years. Agriculture has historically been the foundation of the country's economy and rural livelihoods. Ancient Sri Lankan civilizations developed sophisticated irrigation systems to support agricultural production in areas with seasonal rainfall. During the Anuradhapura and Polonnaruwa kingdoms, large reservoirs, canals, and irrigation tanks were constructed to collect and distribute water for paddy cultivation. These ancient irrigation networks enabled farmers to cultivate rice on a large scale and supported the development of highly organized agricultural societies in the dry zone regions of the country. The

irrigation technology developed during this period is considered one of the most advanced hydraulic engineering achievements in ancient Asia.

Traditional agriculture in Sri Lanka has always been closely connected to rural community life, environmental sustainability, and resource sharing. Paddy cultivation has been the dominant agricultural activity in many parts of the country, particularly in rural villages. Farmers traditionally practiced collective labor systems such as “attam” or “shramadana,” where community members worked together during important farming stages such as land preparation, planting, and harvesting. These cooperative farming practices strengthened social bonds within rural communities and ensured efficient use of labor during critical agricultural periods.

Women have historically played an important role in Sri Lankan agriculture, particularly in paddy cultivation, vegetable farming, and home garden management. In many rural households, women participate actively in agricultural tasks such as seed preparation, transplanting rice seedlings, removing weeds, harvesting crops, and processing grains after harvest. According to the Department of Census and Statistics of Sri Lanka, women represent approximately 38% of the agricultural labor force, highlighting their substantial contribution to the agricultural sector. Furthermore, about 19% of agricultural households in Sri Lanka are headed by women, indicating that women are increasingly involved in farm management and agricultural decision-making processes.

Women’s contributions are particularly visible in the plantation sector, which plays a significant role in Sri Lanka’s export economy. In tea plantations, women constitute the majority of the labor force and are primarily responsible for tea plucking, which requires skill, patience, and careful selection of young tea leaves. Tea plucking is a labor-intensive activity that directly influences the quality and productivity of tea production. Women also participate in other plantation activities such as sorting, grading, and processing tea leaves. In the plantation sector, women workers represent approximately 55–60% of the total workforce, emphasizing their importance in maintaining the productivity of Sri Lanka’s tea industry.

Another important component of traditional agriculture in Sri Lanka is the home garden farming system, which is commonly practiced in rural households. Home gardens are small-scale agroforestry systems located near households where farmers cultivate a diverse range of crops including vegetables, fruits, spices, medicinal plants, and ornamental plants. These systems often mimic natural forest ecosystems by incorporating multiple plant species with different heights and growth patterns. Home gardens contribute significantly to household food security, nutrition, and income generation by providing families with fresh produce throughout the year.

Women are typically the primary managers of home gardens in Sri Lanka. They are responsible for selecting crop varieties, planting and maintaining crops, managing soil fertility, and harvesting produce for household consumption or local markets. Through their management of home gardens, women help maintain agricultural biodiversity by cultivating a wide range of traditional plant varieties that may not be commonly grown in commercial agriculture. Home gardens also provide medicinal plants used in traditional health practices, demonstrating the integration of agriculture, nutrition, and health in rural households.

In addition to their agricultural contributions, ³³ women play an important role in ²⁶ preserving traditional knowledge related to food preparation, seed selection, and natural resource management. Many traditional Sri Lankan farming practices emphasize environmental sustainability, including the use of organic fertilizers, crop rotation, and mixed cropping systems. Women's knowledge of these practices helps promote sustainable land management and reduces reliance on chemical fertilizers and pesticides. As global concerns about environmental degradation and climate change continue to grow, traditional agricultural knowledge maintained by women is increasingly recognized as valuable for developing sustainable farming systems.

Overall, women's involvement in traditional agricultural systems in Sri Lanka is wide-ranging and multifaceted. They engage in activities such as crop cultivation, plantation work, home garden management, food processing, and supporting household nutrition. Despite encountering challenges including restricted land ownership and limited access to resources, women remain central to sustaining agricultural production and supporting rural livelihoods. Therefore, acknowledging and strengthening their contributions through appropriate policies, education, and improved access to resources is crucial for advancing sustainable agricultural development in Sri Lanka.

Table 1: Women in Sri Lankan Agriculture

Indicator	Value
Women in agricultural workforce	38%
Women in plantation sector	55–60%
Female-headed agricultural households	19%
Women land ownership	16%

3. Women in Contemporary Agriculture

3.1 Agricultural Modernization

Agricultural modernization has significantly transformed farming systems across the world through the introduction of advanced technologies such as

mechanization, improved crop varieties, chemical fertilizers, irrigation technologies, and modern pest-management practices. These innovations have contributed to higher crop yields, improved efficiency, and greater overall agricultural productivity. However, modernization has also reshaped agricultural labor structures and gender roles within farming systems. In many developed regions, mechanization has reduced the demand for manual labor, particularly in physically intensive tasks such as ploughing, harvesting, and land preparation. Despite this shift, women remain central to agricultural production, particularly in developing countries where smallholder farming systems dominate and the adoption of advanced technologies is still limited. Across the world, women represent a substantial share of the agricultural labor force and are involved in numerous farming operations such as planting, weeding, harvesting, managing livestock, and handling post-harvest activities (World Bank, 2022; FAO, 2023).

However, women farmers continue to experience structural inequalities that constrain their productivity. A major concern is the gender productivity gap, which describes the lower average output observed among female farmers compared to their male counterparts. Evidence suggests that women's productivity is typically 20–30% lower than that of men, not due to differences in ability, but largely because of unequal access to essential resources such as land, credit facilities, agricultural inputs, extension support, and modern technologies (World Bank, 2022; FAO, 2023). In addition, women often face social and institutional challenges, including biased inheritance practices, limited educational opportunities, and reduced involvement in agricultural decision-making processes. Research further indicates that if women were provided with the same level of access to productive resources as men, farm yields managed by women could rise by approximately 20–30%, which could increase total agricultural production in developing countries by 2.5–4% and contribute significantly to reducing global hunger (FAO, 2023; World Bank, 2022). Consequently, reducing gender inequalities in agriculture is widely acknowledged as a key approach to enhancing productivity, fostering rural development, and strengthening global food security.

3.2 Women and Food Security

Women play a crucial role in ensuring household and community food security, particularly in rural and agrarian societies. Their contributions extend beyond agricultural production to include food processing, storage, preparation, and household nutrition management. In many developing countries, women are primarily responsible for producing subsistence crops, managing small livestock, and processing food products that sustain household consumption. Through these activities, women directly influence the availability, accessibility, and nutritional quality of food within households. Research has shown that empowering women in agriculture can significantly improve food security outcomes because women tend to prioritize household well-being when allocating resources. For example, studies indicate that women often reinvest a large proportion of their income in

family welfare, including food, healthcare, and children's education, thereby improving overall household nutrition and long-term human development (UN Women, 2021; World Bank, 2023).

Moreover, ⁶women's participation in agricultural decision-making has been associated with enhanced dietary diversity and improved nutritional outcomes for children. Studies indicate that when women have greater control over agricultural income and resources, households tend to adopt ³¹better food consumption practices and experience lower levels of malnutrition. ²Women also play an essential role in safeguarding traditional agricultural knowledge, including practices such as seed selection, management of crop diversity, and food preservation methods, all of which support sustainable food systems and strengthen resilience to climatic and economic challenges (FAO, 2023). Therefore, promoting the empowerment of women farmers through better access to land ownership, financial services, agricultural education, and modern technologies is widely recognized as a crucial approach to improving food security and alleviating poverty on a global scale.

3.3 Gender Inequality in Access to Agricultural Resources

Although women make substantial contributions to agricultural production, they continue to face significant disparities in access to essential resources. These inequalities are visible in areas such as land ownership, access to credit, modern technologies, extension services, and participation in agricultural markets. Among these challenges, land ownership stands out as one of the most critical barriers. In many developing countries, cultural traditions, inheritance systems, and institutional structures tend to favor men as the primary landowners, thereby ⁶limiting women's ability to control land and make independent farming decisions. ²According to the Food and Agriculture Organization (FAO), women account for less than 15% of landholders worldwide, despite representing a considerable portion of the agricultural workforce (FAO, 2023). The absence of secure land rights often makes it difficult for women to obtain formal credit, benefit from government ⁶⁸subsidies, or participate in agricultural development initiatives that require proof of land ownership.

Access to agricultural inputs and extension services also demonstrates a significant gender gap. Women farmers are less likely to receive training on improved farming practices, climate-resilient technologies, and sustainable agricultural techniques. Agricultural ³⁵extension programs often target male farmers, assuming that ⁶⁴they are the primary decision-makers in farming households. As a result, ⁵women frequently rely on traditional knowledge and informal networks to obtain agricultural information. In addition, women typically have less access to financial services such as bank loans and agricultural insurance due to lack of collateral, lower income levels, and institutional discrimination within financial systems (World Bank, 2022). These barriers reduce women's productivity and limit their ability to expand agricultural activities or adopt modern technologies.

In addition, women farmers frequently face difficulties in accessing markets and fully engaging in agricultural value chains. Constraints such as limited transportation options, social norms that restrict mobility, and weaker bargaining power often hinder their ability to reach more profitable markets. Consequently, many women sell their produce within local markets at lower prices or depend on intermediaries who take a significant portion of the profits.

Tackling these disparities requires the implementation of gender-responsive agricultural policies that ensure equitable access to land ownership, financial services, education, and modern farming technologies. Strengthening women's access to these productive resources can enable governments and development agencies to boost agricultural productivity while advancing gender equality and fostering rural economic development (FAO, 2023; World Bank, 2022).

3.4 Women's Role in Sustainable Agriculture and Climate Resilience

Women play a vital role in advancing sustainable agricultural practices and enhancing climate resilience within rural communities. As key managers of household food production and natural resources, they often hold extensive knowledge of local ecosystems, crop diversity, and traditional farming methods. This expertise is especially important in the face of climate change, which increasingly threatens agriculture through rising temperatures, irregular rainfall patterns, and more frequent extreme weather events. Women farmers commonly implement diversified cropping systems, water conservation methods, and soil management practices that help sustain productivity while safeguarding natural resources (FAO, 2023).

In many rural settings, women oversee small-scale farms and home gardens that support both food security and biodiversity. These farming systems typically include intercropping, mixed farming, and the cultivation of indigenous crop varieties that are better adapted to pests, diseases, and climate variability. By maintaining crop diversity and conserving traditional seeds, women strengthen the resilience of local food systems and reduce reliance on external agricultural inputs. Additionally, they play an important role in managing natural resources, including water, forests, and land, through sustainable practices (UN Women, 2021).

Despite these contributions, women are among the groups most vulnerable to the impacts of climate change. Limited access to land, financial resources, climate information, and modern agricultural technologies restricts their ability to adapt effectively to environmental changes. As a result, gender inequalities can heighten the risks women face during climate-related events such as droughts, floods, and crop losses. Strengthening women's involvement in climate adaptation initiatives, agricultural training, and decision-making processes is therefore crucial for building resilient farming systems. Policies that improve women's access to climate-smart technologies, extension services, and financial support can

significantly enhance their capacity to cope with environmental challenges while promoting sustainable rural development (FAO, 2023; UN Women, 2021).

3.5 Women's Participation in Agricultural Decision-Making

Women's engagement in agricultural decision-making plays a critical role in shaping farm productivity, household well-being, and broader rural development. Although women contribute extensively to farming activities and food production, their influence over key decisions often remains limited. In many rural communities, traditional gender norms grant men primary authority over decisions related to land use, crop choices, marketing, and financial management. Consequently, women's knowledge, skills, and perspectives are frequently underutilized in agricultural planning and management. Research indicates that when women are actively involved in decision-making, both agricultural productivity and household welfare improve, as women often emphasize sustainability and food security (FAO, 2023).

At the household level, women typically manage tasks such as seed selection, planting, weeding, harvesting, food processing, and livestock care. However, despite their substantial contributions, they may have limited control over income and productive resources. Studies show that women's decision-making power is closely linked to factors such as land ownership, education, access to finance, and involvement in farmer organizations (World Bank, 2022). Women who possess secure land rights or receive agricultural training are more likely to take part in decisions related to crop management, investment in farm inputs, and marketing. In contrast, those without such access are often confined to labor-intensive roles with minimal influence over farm operations.

Women's participation in community-level agricultural institutions—such as farmer cooperatives, water user groups, and rural development committees—also tends to be restricted. Social norms, institutional barriers, and time constraints associated with household responsibilities can limit their involvement. However, evidence suggests that when women are included in community decision-making and agricultural governance, programs become more effective and inclusive. Enhancing women's representation in leadership roles and farmer organizations can therefore improve policy outcomes and strengthen rural development efforts (UN Women, 2021). Promoting gender equality in decision-making is essential to ensure that women's knowledge and contributions are fully recognized and incorporated into agricultural development strategies.

3.6 Policies and Programs Supporting Women Farmers

In recent years, both governments and international development agencies have placed growing emphasis on empowering women farmers through focused policies and development programs. These efforts are designed to close gender gaps in agriculture by enhancing women's access to land ownership, financial services, farming inputs, training opportunities, and agricultural markets. Policy measures

that advance gender equality in rural development play a crucial role in enabling women to actively engage in agricultural production and benefit from technological and structural improvements in the sector. In many countries, legal reforms have been introduced to improve women's rights to land ownership and inheritance, which are essential for strengthening their economic independence and participation in agricultural decision-making (FAO, 2023).

Targeted development initiatives for women farmers typically aim to expand access to agricultural extension services, technical capacity building, and climate-resilient farming methods. Through these programs, women gain practical knowledge in areas such as improved crop production, pest and disease management, irrigation systems, and sustainable resource utilization. Alongside this, microcredit facilities and rural financing schemes have been established to reduce financial constraints that prevent women from investing in agriculture. Access to such financial support allows women farmers to acquire quality seeds, fertilizers, equipment, and livestock, ultimately improving their productivity and household income (World Bank, 2022).

Global institutions including the Food and Agriculture Organization (FAO), UN Women, and the World Bank have also launched international programs focused on advancing gender equality in agriculture. These initiatives prioritize women's empowerment through education, leadership training, and greater involvement in agricultural value chains. Support for women-led cooperatives, producer groups, and rural enterprises has been especially effective in improving market access and increasing women's bargaining power within agricultural systems (UN Women, 2021). In addition, the adoption of gender-sensitive agricultural policies that incorporate women's needs into national development planning contributes to sustainable growth, poverty alleviation, and enhanced food security. Strengthening institutional and policy support for women farmers remains essential for achieving inclusive and long-term agricultural development worldwide.

4. Digital Agriculture

Digital agriculture is the integration of digital technologies and data-based tools into farming systems with the aim of enhancing efficiency, productivity, and sustainability. It encompasses the gathering, storing, and analysis of agricultural information using advanced technologies such as Geographic Information Systems (GIS), satellite imagery, unmanned aerial vehicles (drones), artificial intelligence (AI), big data analytics, and mobile-based advisory applications. These technologies allow farmers to monitor crop growth, soil conditions, weather patterns, and market information in real time, enabling more precise and informed decision-making. For instance, GIS and satellite imagery help analyze spatial information about soil and crop health, while drones provide high-resolution aerial data for monitoring crop conditions and detecting pests or diseases. Artificial

intelligence and big data analytics further process large volumes of agricultural data to generate predictive insights that support farm management and yield optimization. Mobile agricultural advisory platforms also play an important role by delivering timely information, recommendations, and market updates directly to farmers through smartphones, improving access to knowledge and extension services. Overall, the integration of these digital tools enhances resource efficiency, reduces production risks, and promotes sustainable farming practices by enabling farmers to make evidence-based decisions throughout the agricultural value chain (Fuentes-Peñailillo et al., 2024; Sarker, 2023; Wikipedia, 2025) .

The adoption of digital agriculture technologies varies depending on the type of technology and the level of infrastructure available. Mobile agricultural advisory services show the highest adoption rate, with approximately 65% of farmers using mobile platforms to access farming information, weather forecasts, and market prices. Precision agriculture technologies, which include GPS-based field mapping and variable-rate input application, have an adoption rate of about 30%, as they require specialized equipment and technical knowledge. AI-based crop monitoring systems, which analyze images and sensor data to detect diseases, nutrient deficiencies, and growth patterns, have a lower adoption rate of around 20% due to higher implementation costs and technological complexity. Drone technology currently has the lowest adoption rate at about 10%, mainly because of regulatory restrictions, high initial investment, and the need for skilled operators. Despite these differences, the overall adoption of digital agricultural technologies continues to grow as costs decrease and digital infrastructure improves, contributing to increased productivity, better resource management, and more sustainable agricultural systems (Fuentes-Peñailillo et al., 2024; Sharma, 2025)

Table 2: Adoption of Digital Agriculture Technologies

Technology	Adoption Rate (%)
Mobile advisory services	65
Precision agriculture	30
AI crop monitoring	20
Drone technology	10

5. Women in Digital Agriculture

Women have a vital presence in agricultural production systems, especially in developing countries where they make major contributions to food production, household nutrition, and rural livelihoods. However, despite their essential role, many women farmers encounter significant obstacles in adopting and using digital agricultural technologies. A key issue is the digital gender gap, which describes the unequal access to and usage of digital tools between men and women. In rural areas, women often have lower levels of digital literacy, reduced access to formal education, and fewer opportunities for technical training, all of which limit their ability to effectively use smartphones, mobile applications, and online farming

platforms. Economic constraints further intensify this challenge, as women typically earn less and have limited control over household finances, making it harder to afford internet services and digital devices. Moreover, in many rural societies, cultural and social norms restrict women's mobility and autonomy, reducing their exposure to technology and digital services. Reports from the International Telecommunication Union show that women in rural regions are considerably less likely to access mobile internet compared to men, with a persistent digital divide across developing countries. Evidence suggests that rural women are approximately 23% less likely to use mobile internet than their male counterparts, highlighting ongoing disparities in digital inclusion (ITU, 2022).

Nevertheless, digital technologies offer strong potential to empower women in agriculture and improve both their economic opportunities and social status. Mobile-based farming applications, digital extension systems, and online trading platforms allow women farmers to obtain essential information that was previously difficult to access. Through these tools, they can receive timely updates on weather conditions, market pricing, pest outbreaks, and improved farming practices, enabling more informed decision-making and reduced production risks. Digital marketplaces also help women connect directly with buyers and input suppliers, minimizing dependence on intermediaries and improving their negotiating power in agricultural trade. In addition, online learning systems and mobile advisory services contribute to enhancing women's agricultural knowledge and digital competencies, which can lead to higher productivity and greater resilience to climate change impacts. Studies by the Food and Agriculture Organization indicate that expanding women's access to digital agricultural tools can significantly boost farm output, increase income generation, and improve food security in rural areas (FAO, 2023). Furthermore, programs that promote inclusive digital training, affordable connectivity, and locally tailored agricultural technologies are essential for closing the digital gender gap and ensuring that women farmers benefit equally from digital transformation. Therefore, adopting gender-sensitive policies and inclusive innovation strategies is crucial for empowering women and achieving sustainable agricultural development in the digital era.

6. Comparative Analysis: Sri Lanka and Other Countries

Sri Lanka's agricultural sector shows notable parallels with other developing nations such as India and Kenya, especially regarding women's involvement in farm labour, land ownership distribution, and the adoption of digital agricultural technologies. In Sri Lanka, women account for around 38% of the agricultural workforce and are actively engaged in crop production, post-harvest handling, livestock management, and household-level food production. Although their contribution is substantial, women continue to encounter systemic barriers that restrict their access to key productive resources and limit their participation in agricultural decision-making. Constraints such as inadequate land ownership rights, limited access to credit facilities, and insufficient exposure to modern

agricultural technologies continue to hinder women's productivity and economic empowerment in rural communities (FAO, 2018; World Bank, 2016). Similar trends are evident in India, where women make up approximately 42% of the agricultural workforce, yet their ownership of land and access to productive assets remains significantly lower than that of men (FAO, 2011).

Land ownership is a key factor influencing farmers' ability to access credit, agricultural subsidies, extension services, and investment opportunities. In Sri Lanka, women own only about 16% of agricultural land, which restricts their ability to make independent decisions regarding agricultural production and investment. Similarly, in India, women's land ownership is estimated at approximately 13%, reflecting deep-rooted socio-cultural and institutional barriers that limit women's inheritance rights and property ownership (FAO, 2011). In contrast, Kenya shows relatively higher female participation in both agricultural labour and land ownership. Women make up around 50% of the agricultural workforce and own approximately 20% of agricultural land, partly due to land reform initiatives and gender-focused rural development programs implemented in recent decades (World Bank, 2019). Meanwhile, developed countries such as the Netherlands demonstrate a different agricultural structure characterized by larger commercial farms, greater access to capital, and higher levels of gender equality in land ownership. In the Netherlands, women own approximately 26% of agricultural land, reflecting more inclusive institutional frameworks and stronger property rights (OECD, 2019).

Another important dimension of comparison is the adoption of digital agriculture technologies, which include precision farming, satellite-based monitoring, digital advisory platforms, and data-driven farm management systems. Sri Lanka currently falls into the low adoption category, as many farmers continue to rely on traditional farming methods and have limited access to digital tools and agricultural information systems. Factors such as limited rural internet connectivity, low digital literacy among farmers, and insufficient technological infrastructure contribute to the slow adoption of digital agriculture technologies in the country (GSMA, 2023). India and Kenya demonstrate moderate levels of digital agriculture adoption, with the increasing use of mobile-based advisory services, digital marketplaces, and mobile financial platforms that support farmers in accessing market information and agricultural inputs. However, challenges such as digital inequality, affordability of technology, and limited infrastructure still remain in these countries. In contrast, the Netherlands is widely recognized as a global leader in high-tech agriculture, utilizing advanced technologies such as artificial intelligence, automated greenhouse systems, precision irrigation, and smart supply chains to improve productivity and sustainability (OECD, 2019).

Overall, this comparative analysis highlights that Sri Lanka shares several structural characteristics with other developing agricultural economies, including a reliance on smallholder farming systems, limited female land ownership, and

relatively low digital agriculture adoption. While ¹⁰ women play a vital role in agricultural production, gender disparities in resource access and technological inclusion continue to hinder their full economic participation. Addressing these challenges through policy reforms, gender-inclusive land ownership policies, and investments in digital agriculture infrastructure could significantly enhance productivity, rural livelihoods, and gender equality within Sri Lanka's agricultural sector.

Table 3: Global Comparison

Country	Women Workforce (%)	Land Ownership (%)	Digital Agriculture
Sri Lanka	38	16	Low
India	42	13	Medium
Kenya	50	20	Medium
Netherlands	28	26	High

7. Case Studies

7.1 Sri Lanka Tea Plantation Case

Sri Lanka's tea plantation sector is among the country's most important agricultural industries, making ³¹ a major contribution to economic growth and sustaining rural livelihoods. It provides direct and indirect employment to more than one million individuals and ⁷² plays a key role in generating foreign exchange through exports. A distinctive feature of this industry is the high proportion of female workers, who represent close to 60% of the plantation labour force. Women are mainly engaged in physically demanding tasks such as plucking tea leaves, collecting harvested foliage, and sorting leaves prior to processing. These activities are crucial in ensuring the quality standards and global reputation of Sri Lankan tea. However, despite their critical contribution to production, women plantation workers often face several socio-economic challenges. These include relatively low wages, limited access to training and education, and restricted opportunities for promotion into ⁷² supervisory or managerial positions within plantation management structures. ⁷² Gender inequality is also evident in the division of labor, where women are largely confined to fieldwork while men tend to occupy factory, technical, and administrative roles. Additionally, women workers often face difficulties related to health, housing conditions, and limited access to social services within plantation communities. Addressing these disparities is important for improving the welfare of plantation workers and ensuring sustainable development in Sri Lanka's tea sector (Ranaraja, 2009; Central Bank of Sri Lanka, 2019).

7.2 Kenya Mobile Agriculture Case

Kenya has emerged as a leader in the use of digital technology to support agricultural development, particularly through mobile-based agricultural information systems. One of the most prominent examples is M-Farm, a mobile platform developed to help smallholder farmers access reliable market information. Smallholder farmers in many developing countries often face challenges such as lack of access to accurate market prices, dependence on middlemen, and limited bargaining power when selling their produce. M-Farm addresses these issues by providing farmers with real-time price information through SMS services or smartphone applications. By simply sending a text message, farmers can check the current market prices of various agricultural products in different markets. This allows them to make informed decisions about when and where to sell their crops. In addition to price information, the platform also enables farmers to collectively sell their produce by connecting them with buyers and allowing them to aggregate their harvests to negotiate better prices. This reduces the influence of intermediaries and improves farmers' income opportunities. Furthermore, mobile agricultural services like M-Farm have helped improve communication between farmers, buyers, and agricultural experts, thereby increasing efficiency in agricultural marketing and knowledge sharing. The success of such digital innovations demonstrates how mobile technology can empower rural farmers, improve market transparency, and support agricultural productivity in developing countries (Abass, Omwenga, & Oguya, 2011; Aker & Mbiti, 2010).

7.3 India Agricultural Technology and Women Farmers Case

India has achieved notable advancements in incorporating digital technologies into its agricultural sector with the aim of supporting smallholder farmers and enhancing overall productivity. Agriculture continues to be a primary source of employment in the country, with almost half of the national workforce engaged in farming and related activities. Women are an essential part of this agricultural system, actively participating in tasks such as sowing, weeding, harvesting, and post-harvest operations. Despite their important contributions, many women farmers still encounter challenges, including restricted access to land rights, limited opportunities for agricultural training, and inadequate access to modern farming technologies. To address these challenges, India has introduced several digital agricultural initiatives, including mobile-based advisory services, digital market platforms, and weather information systems. One prominent example is the eNAM (National Agriculture Market), a government-supported online trading platform that connects farmers with buyers across different states. Through eNAM, farmers can access transparent market prices, sell produce digitally, and reduce dependence on intermediaries. In addition, mobile advisory services provide farmers with weather forecasts, pest management guidance, and crop management techniques. These technological initiatives help improve farmers' decision-

making, increase income opportunities, and promote inclusive ³ agricultural development, particularly for smallholder and women farmers in rural areas (Government of India, 2022; FAO, 2021).

7.4 New Zealand Sustainable Agriculture Case

New Zealand is internationally regarded for ⁵⁸ its highly developed and environmentally sustainable agricultural systems. The agricultural sector is a key pillar of the national economy, with strong emphasis on dairy production, sheep farming, and horticultural activities. Farmers across the country widely utilize advanced technologies and sustainable land management approaches to enhance productivity while preserving natural resources. Precision farming methods are commonly applied, including satellite-based monitoring, GPS-guided farm operations, and data-driven management systems. These innovations allow efficient monitoring of soil health, improved water management, and optimized application of fertilizers.

In addition, New Zealand strongly prioritizes environmental protection within its agricultural policies. National strategies are designed to reduce greenhouse gas emissions and safeguard water quality. For instance, the dairy sector has adopted improved nutrient management and waste control systems to reduce environmental degradation. Continuous collaboration between farmers, governmental bodies, and research organizations has further supported the development of innovative and practical farming solutions. Consequently, New Zealand is often viewed as a global benchmark for achieving a balance between high agricultural productivity, environmental conservation, and responsible resource use (OECD, 2020; Ministry for Primary Industries, 2022).

7.5 Australia Smart Farming and Agricultural Innovation Case

Australia has developed a highly advanced agricultural sector that emphasizes technological innovation and climate-resilient farming practices. Due to its large land area and varying climate conditions, Australian agriculture relies heavily on modern technologies to increase efficiency and sustainability. One key ⁵ development is the adoption of precision agriculture systems, which use sensors, satellite imagery, and data analytics to monitor crop growth, soil moisture levels, and livestock health. Farmers also use automated machinery, drones, and digital farm management platforms to optimize production and reduce labor costs. Additionally, Australia has implemented several smart farming initiatives that support farmers in adapting to climate change and water scarcity. Government-supported programs and research organizations work closely with farmers to develop drought-resistant crop varieties and improve irrigation efficiency. These technological innovations allow farmers to maximize productivity while conserving natural resources. Australia's experience demonstrates how advanced agricultural technology and research-driven policies can help maintain a competitive and sustainable agricultural sector in challenging environmental

conditions (CSIRO, 2021; Australian Government Department of Agriculture, 2022).

8. SWOT Analysis

8.1 Strengths

Rural communities often possess strong agricultural knowledge that has been developed and transferred through generations of farming practices. This traditional knowledge includes understanding local soil conditions, seasonal weather patterns, crop management, and pest control, which contributes to more resilient farming systems. In many developing regions, there is also a high level of participation in subsistence farming, where households produce food primarily for their own consumption. This helps improve food security and reduces dependency on external markets. Additionally, community knowledge networks—such as farmer groups, local cooperatives, and informal knowledge-sharing systems—play a crucial role in spreading agricultural innovations and best practices. These networks allow farmers to exchange experiences, share resources, and collectively respond to agricultural challenges, thereby strengthening rural livelihoods (FAO, 2017; World Bank, 2019).

8.2 Weaknesses

Despite these advantages, many rural farming communities continue to experience important structural constraints. One of the most pressing issues is restricted access to land ownership, particularly among marginalized populations and women farmers. In several areas, existing land tenure systems limit secure access to productive land, which in turn discourages smallholders from making long-term investments in agricultural development. Another key limitation is low levels of digital literacy, which reduces farmers' ability to effectively use modern agricultural information systems, digital extension platforms, and online trading services. In addition, many farmers face difficulties in accessing formal financial services and credit facilities due to inadequate collateral, weak banking networks, or broader financial exclusion. These financial barriers significantly restrict their ability to invest in improved seeds, fertilizers, irrigation infrastructure, and advanced farming technologies (IFAD, 2021; FAO, 2018).

8.3 Opportunities

There are several emerging opportunities that can help improve agricultural productivity and rural livelihoods. One major opportunity is the rapid growth of digital agriculture technologies, including mobile-based advisory services, precision farming tools, and digital market platforms that connect farmers directly with buyers. These technologies can improve decision-making, reduce production risks, and increase market access. Another important opportunity is the adoption of climate-smart farming practices, which focus on increasing productivity while enhancing resilience to climate change and reducing greenhouse gas emissions.

Practices³³ such as improved water management, drought-resistant crops, and sustainable soil management can significantly benefit smallholder farmers. Additionally, women entrepreneurship programs are increasingly being promoted by governments and development organizations to empower women in agriculture and rural businesses. These initiatives provide training, financial support, and market access opportunities, helping women generate income and contribute more actively to local economies (FAO, 2020; World Bank, 2021).

8.4 Threats

Nevertheless, a number of external pressures continue to hinder the progress of rural agricultural development. Among the most serious is climate change⁷⁶, which brings rising temperatures, unpredictable rainfall patterns, prolonged droughts, and frequent flooding, all of which negatively affect agricultural output and food security. Smallholder farmers are especially at risk because many depend primarily on rain-fed farming systems with limited resilience to climatic shocks.

Another major concern is the digital gender gap, where women have less access than men to digital technologies, internet services, and ICT-related training. If this inequality is not addressed, it can significantly reduce the effectiveness and inclusiveness of digital agriculture initiatives. In addition, wider economic disparities further intensify rural poverty, making it more difficult for small-scale farmers to compete with large commercial producers or secure the resources needed for sustainable farming practices (UN Women, 2020; IPCC, 2022).

9. PESTLE Analysis

9.1 Political

Government policies⁷⁹ play a crucial role in shaping women's access to agricultural resources and digital technologies. In many developing countries, national agricultural and rural development policies influence the availability of extension services, subsidies, and digital infrastructure that support women farmers. However, policy implementation often lacks a gender-sensitive approach, which can limit women's access to training programs, information services, and government-funded agricultural technologies. Supportive political initiatives—such as gender-inclusive digital agriculture policies and targeted capacity-building programs—can significantly improve women's participation in technology-driven agriculture (FAO, 2011; World Bank, 2019).

9.2 Economic

Economic constraints remain one of the major barriers affecting women's ability to adopt digital tools in agriculture. Women farmers frequently have lower income levels, limited access to credit, and fewer financial assets compared to men. These financial limitations make it difficult for them to purchase smartphones, internet services, agricultural applications, or other digital technologies that could improve

farm management and productivity. Additionally, women often face challenges in accessing formal banking services and agricultural loans due to lack of collateral such as land ownership. Addressing these economic barriers through microfinance programs, subsidies, and financial inclusion initiatives can enhance women's ability to adopt digital technologies in agriculture (FAO, 2011; GSMA, 2020).

9.3 Social

⁸ Cultural and social norms play a major role in shaping women's involvement in agriculture and their ability to access digital technologies. In many rural settings, traditional gender expectations often place women in charge of household responsibilities while limiting their authority in farming decisions and the adoption of new technologies. These norms can also restrict women's freedom of movement, reduce their access to training opportunities, and limit participation in farmer groups where agricultural knowledge and innovations are commonly shared.

In addition, lower ²² levels of literacy and insufficient digital skills among women further contribute to the widening digital divide between genders. Addressing these challenges requires a strong focus on promoting gender equality, expanding access to education, and implementing training programs that are specifically designed to be inclusive of women. Such measures are essential for enhancing women's participation in digital agriculture and ensuring more equitable technological adoption in rural communities (UN Women, 2020; FAO, 2018).

9.4 Technological

Advancements in digital technologies have created significant opportunities for improving agricultural productivity and empowering women farmers. Mobile applications, digital advisory services, precision agriculture tools, and online market platforms allow farmers to access ⁵⁹ real-time information about weather conditions, crop management, pest control, and market prices. These technologies can help women make more informed farming decisions, reduce production risks, and improve market access. However, the benefits of these innovations depend on women's ability to access digital infrastructure, affordable devices, and relevant training programs that enhance their digital literacy (World Bank, 2019; GSMA, 2020).

9.5 Legal

⁵⁷ Legal systems, especially those governing land ownership and property rights, have a major impact on women's involvement in agriculture and their adoption of digital farming technologies. In many areas, women continue to encounter formal or customary restrictions that prevent them from owning, inheriting, or exercising control over land. The absence of land rights often creates additional barriers for women, making it difficult for them to access agricultural credit, government support programs, and extension services that require proof of land tenure.

Strengthening legal safeguards for women's land ownership and ensuring fair access to productive agricultural resources can enhance their financial stability and enable greater investment in digital agriculture innovations (FAO, 2011; UN Women, 2020).

9.6 Environmental

Environmental conditions, especially climate change, have a profound impact on agricultural production systems and the livelihoods of rural populations. Increasing temperatures, unpredictable rainfall, prolonged droughts, and more frequent extreme weather events all contribute to reduced farm productivity and greater uncertainty for farmers. Women farmers tend to be disproportionately affected by these environmental stresses, as they often have limited access to resources, insufficient climate-related information, and reduced involvement in agricultural decision-making processes. Digital tools such as climate information services, early warning systems, and weather forecasting applications can support women farmers in adapting to climate variability by delivering timely alerts and promoting more resilient and sustainable farming practices (FAO, 2018; World Bank, 2019).

10. Future Prospects

The future direction of agriculture is being shaped by fast-growing digital innovations such as artificial intelligence (AI), robotics, the Internet of Things (IoT), and precision farming systems. These advanced tools allow farmers to observe crop growth, soil conditions, and weather changes in real time, which enhances decision-making, improves resource efficiency, and boosts productivity while minimizing environmental harm. AI-driven systems and machine learning applications are increasingly used for functions such as crop disease identification, irrigation scheduling, and yield forecasting. At the same time, robotic technologies and autonomous machinery are being deployed for agricultural operations including planting, crop monitoring, and harvesting. Collectively, these developments are expected to modernize conventional farming into highly efficient, data-oriented smart agriculture systems capable of tackling major global issues such as climate change, food insecurity, and labor shortages (Hasan et al., 2022; Casini et al., 2026).

In addition, the use of satellite data, drones, and sensor-based monitoring in precision agriculture enables more accurate application of water, fertilizers, and pesticides. This reduces wastage of resources while improving overall sustainability in farming systems (Jafrani et al., 2025). However, realizing the full benefits of these technologies requires the active inclusion of women, who constitute a large share of the global agricultural workforce, in digital agricultural systems. Strengthening women's participation through digital literacy initiatives, targeted training programs, and inclusive design of technologies can help reduce the digital gender gap and ensure more equitable access to innovation. When

women are ²⁸involved in the development and use of agricultural technologies, they contribute significantly ⁷⁴to sustainable farming practices, climate adaptation, and rural development, thereby strengthening overall food systems (Ozor et al., 2025; Sheeba & Christopher, 2023). Consequently, fostering gender-inclusive digital agriculture is essential for achieving long-term sustainable development and ¹⁶ensuring that the benefits of technological advancement are shared across all groups within the agricultural sector.

11. Conclusion

Women have long been integral to agricultural production systems, making substantial contributions through activities such as crop farming, livestock care, food processing, and maintaining household food security. However, despite their significant role, their work is often not fully recognized due to social, cultural, and institutional constraints that restrict their access to land, financial services, education, and key agricultural resources. ⁴⁷The Food and Agriculture Organization of the United Nations highlights ⁵that women make up a large share of the ¹⁶agricultural workforce in developing regions, yet they continue to experience unequal access to productive assets and limited participation in decision-making processes.

As agriculture rapidly evolves ³⁰through the adoption of digital technologies—including mobile advisory platforms, precision farming tools, online marketplaces, and climate information systems—new possibilities are emerging to improve productivity, expand market access, and strengthen resilience among farming communities. Nevertheless, the persistent digital gender gap remains a major challenge, preventing many women from fully benefiting from these advancements due to limited digital skills, high costs of devices, and inadequate internet access. Bridging this gap requires ensuring equal access to digital infrastructure, agricultural training, extension services, and financial support. Promoting gender-responsive policies, expanding digital literacy initiatives, and encouraging women's active involvement in agricultural decision-making are essential steps toward improving productivity and achieving global food security and sustainable rural development (FAO, 2011; FAO, 2017; World Bank, 2019).

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