

Understanding the Role of Women in Driving Agriculture 5.0

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The evolution to Agriculture 5.0 coincides with the emergence of Society 5.0 (Fig.1). The society 5.0, a system that heavily integrates internet and real space finds an agreement between increasing economic opportunities and solving social problems. In 2016, the Japanese government adopted it through the Cabinet Office's Council for Science, Technology, and Innovation as a tangible representation and embrace of the Fourth Industrial Revolution (Fujii et al., 2018).

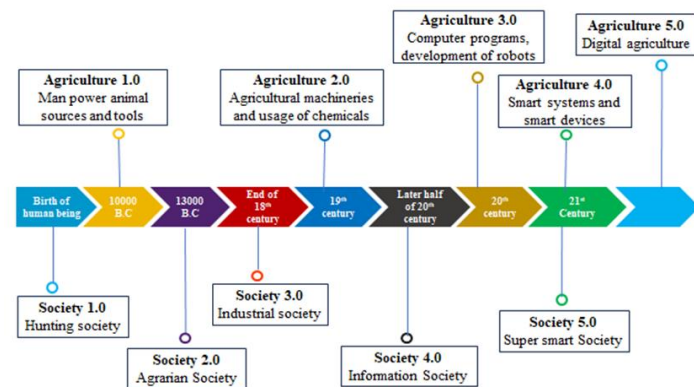


Fig.1 Revolution of society and agriculture

The Evolution of Agriculture: From Early Cultivation to Agriculture 5.0

Agriculture has evolved significantly from its early stages of basic land cultivation and animal husbandry into the technologically advanced systems we see today. The journey of agriculture can be traced through several key phases, starting with "Agriculture 1.0," which relied heavily on manual and animal labor. Due to the primitive tools used, such as sticks and stones, productivity was low, and farming was labor-intensive. The introduction of "Agriculture 2.0" marked a shift towards the use of machinery, albeit in a basic form. This era saw the early adoption of chemical inputs, which improved efficiency and production levels but also brought about negative consequences such as environmental damage, chemical contamination, and wasteful energy consumption. By the mid-20th century, advances in computing power revolutionized agriculture, giving rise to "Agriculture 3.0." This phase saw

improvements in machinery and more precise farming practices, leading to reduced chemical usage, more efficient irrigation, and better overall farm management. In recent years, we have entered the era of "Agriculture 4.0," characterized by the integration of advanced technologies like the Internet of Things (IoT), Big Data, Artificial Intelligence (AI), cloud computing, and remote sensing (Wolfert et al., 2017).

As we look to the future, agriculture faces the immense challenge of increasing productivity by 70% by 2050 to meet the demands of a growing population and a rising middle class with a taste for resource-intensive foods (FAO, 2009). Experts predict that farmers in the next generation will need to produce more food than humanity has ever grown since the first agricultural revolution 10,000 years ago. This task is complicated by issues such as rising rates of both malnutrition and obesity, as well as the fact that 30% of the world's food supply is currently wasted (Gustavsson et al., 2011). However, there are opportunities for positive change. Shifting to healthier, more sustainable diets could not only improve public health but also reduce the demand for arable land, thereby preserving biodiversity and increasing carbon sequestration. Balancing the need for affordable, nutritious food with the responsibility of protecting the ecosystems that sustain us is critical for the future of agriculture. To achieve this balance, we must continue advancing through the stages of the Digital Agricultural Revolution, moving towards what is now being called "Agriculture 5.0." This next phase envisions an even greater reliance on precision farming, biotechnology, and sustainable practices to ensure a future where agriculture is both productive and environmentally sound.

Women in agriculture: Battling land degradation and inequality

Women are the driving force behind society, particularly in rural areas where they shoulder both paid and unpaid labour. From farming and business to managing the home, their contributions are

immense, yet often undervalued. In many rural communities, women work more hours than men, especially in essential tasks like child care, household maintenance, water collection, cooking, and sanitation. These responsibilities become even more demanding as climate change, erratic weather, and environmental disasters strain agricultural productivity and daily life.

In the poorest regions of world, agriculture serves as the primary source of income for 80% of working-age women. Globally, one-third of the population depends on agriculture for their livelihood, yet this sector faces a critical challenge: soil degradation. Over half (52%) of the world's farmland has already been lost, and women are leading efforts to restore these damaged lands (UN Women, 2018). Despite their central role in food production and distribution, women face stark inequalities in accessing vital resources like technology, financial services, and land ownership. While they make up nearly half of the global agricultural workforce and produce up to 80% of the food in developing countries, only 20% of the world's landowners are women. This imbalance leaves them disproportionately vulnerable to environmental crises, such as forced displacement, food and water shortages, and the consequences of land degradation.

Women's reliance on natural resources for food production, their higher risk of poverty, and their limited social and economic power mean that they bear the brunt of these challenges. The United Nations Convention to Combat Desertification (UNCCD) emphasizes that as cultivable land becomes increasingly scarce, women are more acutely affected due to their deeper involvement in agriculture and lower access to resources.

Shaping Agriculture 5.0: Women at the Forefront of Innovation and Sustainability

Agriculture 5.0 has four different features as shown in Fig. 2. These topics are discussed in relation to the role of women in addressing these characteristics.

Sustainable Intensification and Technological Integration

To sustainably meet the growing demand for food, we must focus on increasing agricultural production using less land and fewer resources. This approach, known as sustainable intensification, is an

area of research aimed at enhancing productivity while minimizing the environmental impact of farming. Technological innovations, particularly in digital technologies and biotechnologies, are expected to play a crucial role in achieving these goals. In the future, advancements such as "smart tractors" and genetically modified crops will allow for more efficient farming, leading to higher yields with fewer inputs. However, the potential benefits of these capital-intensive technologies may be limited in regions with insufficient financial resources and educational infrastructure. In such areas, alternative solutions that are more accessible and cost-effective will be necessary to promote sustainable agricultural practices.



Fig. 2 Features of Agriculture 5.0

The critical role of women in agriculture, particularly in soil conservation and land management, has long been recognized. Studies have shown that when women are empowered to make decisions about land use, both soil health and agricultural productivity improve. Gender-smart agriculture, which integrates gender equality into farming practices, is essential for advancing both women's empowerment and climate resilience. Supporting women in agriculture by closing the gender gap in productivity not only benefits their communities but also enhances their capacity to adapt to climate change. Ensuring that women have equal access to women friendly technology is vital for reducing their labor burden and increasing their productivity. In many cases, this can improve household nutrition by diversifying crop production. By providing women with the tools, they need to succeed, we can create more sustainable and resilient agricultural systems that benefit everyone.

Empowerment and Upskilling in the Agricultural Workforce

While the technologies of the Digital Agricultural Revolution hold great promise, they cannot be considered a one-size-fits-all solution. In many regions, especially in developing countries, empowering women, improving market access, and employing affordable, context-specific technologies may prove more effective in advancing food security. Relying solely on high-tech solutions in Agriculture 5.0 without addressing the social and political dimensions of food systems will likely lead to limited success.

Agriculture employs over 80% of rural female workers, highlighting the critical need for education and training in areas such as food processing and other agriculture-related skills. Providing women with access to these opportunities is essential for fostering economic growth and food security. Supporting self-help groups (SHGs) with better access to loans, markets, and skill development programs can help rural women unlock their full potential, leading to financial inclusion, diversified incomes, and enhanced skills.

Climate change adds further complexity to these challenges. As men and younger people migrate in search of better opportunities, women are left with increased workloads and responsibilities. This is particularly evident in rainfed farming regions, like those found in parts of India, where women must travel longer distances to gather fuel, feed, and water for livestock, while also managing erratic crop harvests. These factors can make women hesitant to adopt new agricultural methods, fearing that doing so might increase their already heavy workloads. To ensure true progress, it is essential to focus not only on technological integration but also on the empowerment and upskilling of women. By addressing their specific challenges and providing them with the resources they need, we can foster more resilient agricultural systems and promote sustainable development.

Addressing Food Wastage and Distribution

A critical component of creating sustainable food systems is addressing the twin challenges of food waste and distribution. These issues are complex and vary greatly depending on the region. In some areas, particularly in lower-income regions, food waste

primarily occurs at the farm level due to inadequate storage and preservation techniques. In contrast, in wealthier regions, food waste is more prevalent at the consumer end, such as in grocery stores, restaurants, and households. This creates a "wicked problem" where, as countries develop the infrastructure to reduce on-farm food loss, they simultaneously face increasing food waste later in the food value chain due to consumer habits and oversupply.

Agriculture 5.0 aims to tackle these challenges by improving food distribution and reducing waste across all stages of the supply chain. Women play a central role in these efforts, as they are often responsible for managing household food consumption, handling post-harvest processing, and participating in local food markets. They also lead initiatives to reduce food waste, preserve food, and advocate for more sustainable food systems. By ensuring efficient use of resources and fair distribution, women contribute to a more sustainable approach to managing the global food supply.

Empowering women in these roles is key to making food systems more resilient and sustainable, as they possess a deep understanding of local consumption patterns and food preservation practices. Their involvement is critical to achieving the goals of Agriculture 5.0, which seeks not only to increase food production but also to ensure that food is distributed equitably and used efficiently to reduce waste.

Sustainable Livestock Management

In planning for the future of food systems, it is crucial to recognize the significant environmental impact of our food choices, particularly concerning livestock. The production of cattle, for example, requires far more resources—land, water, and energy—than plant-based food sources to deliver the same nutritional value. This realization has driven a global movement toward "plant-forward" diets, which encourage reducing animal consumption to lower the strain on planetary health. However, it's important to balance this shift with an understanding of the essential role animal agriculture plays in sustainable ecosystems.

Livestock, particularly grazing animals like cattle, are vital for nutrient cycling, particularly nitrogen, and for maintaining the health of pasture ecosystems. Moreover, animal farming is a crucial

source of livelihood for nearly one billion people globally, many of whom live in impoverished regions. Therefore, sustainable livestock management is not just about reducing the environmental footprint but also about supporting the economic well-being of rural communities.

In countries like India, where approximately 12 million self-help groups (SHGs) exist, 88% of which are composed entirely of women, livestock farming plays an integral role in both environmental sustainability and economic stability (NABARD, 2022). The SHG-Bank Linkage Project (SHG-BLP), initiated in 1992, has connected these groups to financial institutions, enabling them to access small loans for ventures such as livestock farming and tailoring (NABARD, 2020). Empowering women through these initiatives is crucial to supporting sustainable livestock practices, which can enhance both food security and environmental resilience.

Conclusion

Finally, it can be concluded that women have a crucial role in promoting sustainable and inclusive agriculture practices in Agriculture 5.0. By utilizing their existing knowledge and adopting modern technologies, they may contribute to narrowing the productivity disparity and encouraging responsible environmental management. Enabling women in agriculture not only improves food security but also promotes resilience against climate change, guaranteeing a better and more enduring future for everyone.

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