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Agricultural Transformation Towards Achieving the Sustainable Development Goals

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Abstract. The threats to achieving sustainable growth and development of agriculture vis a vis the sustainable development goals (SDGs) call for intensifying agricultural innovations. This paper highlights some advances in the agricultural transformation towards achieving the SDGs. Agriculture is being transformed via increasing productivity, enhancing natural resources, fostering inclusive growth, improving resilience to climate change, and adopting appropriate governance. Moreover, agricultural productivity is being enhanced through high value addition, job creation, access to resources, finance, and service must be enhanced. In championing these aspirations, ensuing Agriculture 5.0 in conjunction with the Industrial Revolution 4.0 will be at the forefront. The agricultural sector, needs to be connected to markets, agricultural income needs to be diversified, and the knowledge base of agricultural stakeholders needs to be strengthened through skilling. Resource optimization is essential for protecting natural resources. Empowering marginalized groups, social protection, sustainable land tenures could spur the socio-economic growth of farmers. Climate change and ecosystem challenges need to be handled to build resilience. These narratives must be supported by strengthened by policies.

1. Introduction

Rapidly growing global population poses significant challenges on the sustainability of agricultural systems. Therefore, sustainable agricultural systems need transformation to produce enough food to meet the rapidly increasing demand. Doubling agricultural productivity through best agricultural practices is needed to increase income to minimize large scale poverty so that malnutrition can be minimized in agriculture-based economies (Skoet and Stamoulis, 2006).

Sustainable development of agriculture is challenged by many factors; however, climate change is viewed as one of the most critical challenges that affect agricultural productivity hence needs attention at present.

Agricultural policies and appropriate reforms are vital to align the agriculture sector with the SDGs. Policies that incentivize sustainable practices needs to be designed to facilitate equitable sharing and access to resources by all the farmers (FAO, 2019). Innovations and technology transfer can be promoted and accelerated by public-private partnerships (Meissner, 2019). Stakeholder collaborations and community participations can facilitate adoption of sustainable practices (Maryono et al., 2024; Wayan and Nyoman, 2021). This paper highlights some advances in the agricultural transformation towards achieving the SDGs.

2. Enhancing Productivity, Employment, and Value Addition in Food Systems

Productivity enhancement, employment and high value addition can be achieved through facilitating access to resource needs of production and finance and services, connecting smallholders to markets, encouraging production and income diversification and building knowledge and capacities of the producers (FAO, 2018).

Investments in basic infrastructure facilities such as roads, markets, transportation, telecommunications and storage capacity, provision of access to resources, services and finance, investments in modernization, advanced technologies and mechanization are important (Rahman, 2022) in achieving agricultural transformation. Precision agriculture (Naresh et al., 2024), high yielding improved crop varieties (Naresh et al., 2024), advances in biotechnology (Ammar et al., 2021) and innovations in mechanization (Elbashir, 2024) and water management (Smith et al., 2023) have considerably increased agricultural yields.

In the transformation process, the farmer income needs to be improved which can be assisted connecting the farmers with markets with higher diversification, efficiencies, transparent, and competitive (Reardon et al., 2009).

Processing and improving product quality through agricultural modernization and value addition to agricultural products increase the income of the agricultural sector. Agricultural extension services play an important role in the dissemination of vital agricultural innovations through which farming communities, especially, the capacity of rural communities is empowered and strengthened (Zwane, 2020).

Policies on agricultural subsidies, access to credit, agricultural insurance, development of rural infrastructure, etc. play crucial role in agricultural transformation. Research and development, extension services, and information transfer, and market access also significantly contribute to enhancing productivity in agriculture.

According to Roser (2023), 25% of world labor force is employed in agriculture. However, demand for labor has reduced due to mechanization and technological innovations. There is a need to transform low yielding small scale subsistence farms to high yielding profitable farms (Fan et al., 2013) to generate employment and income to subsistence farmer families. This requires transforming the agricultural labor to an efficient and productive workforce through which agriculture systems could be shifted to higher value-added activities such as agribusinesses and agricultural processing (Bhandari, 2024). Once the agricultural productivity is increased, it will lead to creation of employment in agriculture related support services and industries such as food processing, packaging, distribution and marketing (Urugo et al., 2024).

Reduction of postharvest losses is important in preventing losses and ensure profits. Infrastructure developments such as road networks, cold storage, appropriate and timely transportation networks, etc. can minimize postharvest losses and can improve access to markets.

3. Sustainable Natural Resource Management

Agriculture relies on natural resources such as soil, water, and air, and biodiversity. Degradation of these natural resources, temporal and spatial shortages and scarcity of natural resources, and loss of biodiversity influences agricultural productivity and food security. Agricultural productivity is challenged due to degradation of soil caused by erosion, compaction, nutrient depletion, and accumulation of toxic chemicals such as heavy metals, traces of agrochemicals, salts etc. Conservation and protection of soil health and restoring land is important in maintaining soil productivity to sustain agriculture. Watershed management and sustainable land and soil management within the context of integrated management approaches engaging land users and local communities are important management aspects that are needed in the transformation of agriculture.

In transforming agriculture to achieve sustainable development goals, waste and loss of agricultural produce and food needs to be minimized. Waste and loss of agricultural produce

affect both producers and consumers due to, waste of resources, increase in food prices threatening food security and increasing greenhouse gas emission.

In the protection and sustainable management of natural resources, it is important to conserve biodiversity and protect ecosystem functions. Ecosystem services such as role of insects in pollination, pest control through beneficial insects and microorganisms, nutrient cycling, nitrogen fixation, regulation of water, minerals and nutrients are important in sustaining agricultural productivity.

4. Improving Livelihoods and Inclusive Economic Growth

Commercial farming through improved agricultural productivity increases income of agricultural community thereby reducing poverty. In improving livelihoods, the farmers and agricultural communities should be empowered where inequalities among different strata needs to be eliminated. Secure tenure rights is a prerequisite to transform the underprivileged farmers.

Access to improved inputs such as quality high yielding seeds, fertilizers and agrochemicals, timely and sufficient irrigation, advanced and appropriate farming techniques, and innovative technologies (Tadele, 2017) are the factors influencing agricultural transformation that is pivotal in increasing agricultural productivity.

To enhance the income of the farmers, value chains that link farmers to the markets is essential. Such value chains should provide farmers with better price for their products with minimum transaction costs (Pingali et al., 2005). Integration of rural or small-scale farmers into larger value chains can give them better access to stable and profitable markets by which they can get better income and escape poverty (Hanf and Gagalyuk, 2018).

5. Adapting Governance for Emerging Agricultural Challenges

The most important intervention to address agricultural challenges is effective governance (Minkman et al., 2022). The transformation process needs to incorporate aspects of agricultural governance related to policies, institutions, and practices that manage resources used in agriculture to face these challenges. The governance should ensure equitable distribution of resources and benefits responding to external challenges (Lockwood et al., 2010).

Due to expansion of population, many people migrate to urban centers with the expectation of employment and other benefits leading to shortage of labor in the rural agriculture sector. To cater to these changes, there needs a balance in rural and urban developments with better governance. Policies are needed to be formulated to cater to these demographic changes.

Climate change has increased temperature, carbon dioxide concentration, altered rainfall patterns, quantity and distribution, increased adverse weather events, increased incidents of pests and diseases etc., which have directly affected agricultural productivity (Habib-ur-Rahman et al., 2022). Agricultural transformation is vital to support agricultural sector to adapt to climate change impacts. Adapting farming systems to climate change is crucial and this can be achieved through adaptive governance, climate smart farming and sustainable management of natural resources (Azadi et al., 2021).

Globalization increased the access to markets; however, this market integration may provide opportunities while posing some challenges (Nájera, 2017). Globalization exposes local farmers to global price volatility, which also increases competition from more advanced agricultural producers (Arita et al., 2014). Hence, nations should take appropriate actions to mitigate such risks via governance. Implementation of trade policies can stabilize prices and provide safety nets to local and small-scale producers. Hence an enabling environment to implement technological advancements in agricultural transformation is essential which needs strong governance systems in place (Lewis and Rudnick, 2019). The governance systems should

ensure equitable access to finance, training, capacity building, and information dissemination among all the stakeholder to promote agricultural transformation (McGuire et al., 2024).

6. The Way Forward

With the ever-increasing human inquisitiveness which is churning or uncovering innovativeness and inventiveness, evolving new techniques could propel agricultural systems to new heights or horizons beyond the existing soilless agriculture. Among the new and forthcoming zeniths are agrivoltaics, seawater farming, desert agriculture, algae feedstock, Climate Smart Agriculture (CSA), carbon farming or regenerative agriculture, circular farming, integrated organic farming, agroforestry, and many more. Agrivoltaics are credited for cultivating crops or rearing animals under or near solar panels to maximize land use efficiency and agricultural outputs yet developing or promoting renewable energy. Moreover, this practice contributes to decarbonization the environment. Seawater farming entails development of crop varieties via for example, genome modification techniques such as paddy which are capable or having the capacity tolerate saline environments to maximum arable land and water use efficiency. Desert agriculture is a farming system of manipulating crop genome materials, biological systems, and induced growth regulators to monitor crop growth and development in deserts. To encourage waste management and utilization, algae feedstock approach in the livestock and fishery industries could be pivotal because it will leverage on the use of algae from the aquaculture and agricultural farms noted for causing eutrophication through excessive use high protein fish feeds and nitrogen and phosphorus fertilizers as a substitute of nutritious food source for livestock as feeds and fishmeal. Thus, this approach feeds positively into the global environmental cleanup. On the other hand, CSA will ensure effective and efficient management of farmlands and forests yet counterbalancing the adverse effects of climate change on agricultural productivity.

7. Conclusion

Achieving sustainable agricultural transformation is a multidimensional process that enhances productivity, generates employment, and adds value to food systems while ensuring long-term sustainability. This transformation is driven by improved farming practices, technological advancements, and well-designed policy interventions that address contemporary agricultural challenges.

Modernization in agriculture reshapes labor dynamics by increasing efficiency, creating opportunities in agribusiness, and expanding employment in value-added sectors such as food processing and marketing. The sustainable management of soil, water, and other natural resources, along with the integration of biodiversity-friendly practices, is essential for long-term agricultural resilience.

Inclusive policies that support marginalized communities and encourage youth participation in agriculture are critical for fostering equitable economic growth. Furthermore, strong governance is necessary to address challenges arising from population growth, urbanization, climate change, and globalization, ensuring that agricultural systems remain adaptable and resilient in an ever-changing world.

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