

Sustainable Agricultural Development Through Education and Extension

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ABSTRACT

Objective: The objective of this study is to examine the emergence and implementation of sustainable agriculture, highlighting the new health risks for workers in the agricultural and food processing industries, and evaluating the critical role of agricultural extension and education in achieving sustainable agricultural practices.

Methodology: This study utilizes a comprehensive review of existing literature on sustainable agriculture, agricultural extension, and the Green Revolution. The research involves analyzing the interactions between agricultural production, environmental impact, and socio-economic factors. It also includes a critical examination of case studies and theoretical developments in rural and agricultural development.

Findings: The findings reveal that the Green Revolution, while significantly increasing agricultural productivity, has led to numerous environmental and socio-economic issues. These include geographical and socio-economic inequalities, health risks from increased use of chemicals, and unsustainable energy consumption. Sustainable agriculture emerges as a response to these challenges, emphasizing reduced chemical inputs, ecological balance, and energy efficiency. The study highlights the crucial role of agricultural extension and education in promoting sustainable practices and addressing the new health risks associated with traditional agricultural methods.

Conclusion: The study concludes that sustainable agriculture is essential for addressing the environmental and socio-economic drawbacks of the Green Revolution. Effective agricultural extension and education programs are vital for fostering sustainable agricultural practices, ensuring food security, and enhancing the quality of life for rural communities. Government support and investment in research and education are necessary to achieve these goals.

Keywords: *Agricultural Development, Education and Extension, Sustainable Agricultural Development.*

1 Introduction

The development of the agricultural sector, driven by the increasing population and limited resources, necessitates the efficient use of resources and improved productivity of production factors (Huang et al., 2020; Kosior, 2017; Zamora, 2017). This is essential for the agricultural sector to not only meet current food demands but also to fulfill its broader economic functions. As one of the most critical productive sectors, agriculture carries a significant responsibility in supplying the required food. The sector faces two main challenges: an increasing population and decreasing production resources (Heinert & Roberts, 2016).

Agricultural extension and education play vital roles in enhancing productivity and promoting sustainable agricultural development, serving as foundational pillars of the agricultural sector (Danso-Abbeam et al., 2018; Fiaz et al., 2018; Kosior, 2017). Agricultural extension and education involve services or systems that, through educational initiatives, help farmers improve their farming methods and techniques, thereby increasing productivity and income, enhancing their standard of living, and uplifting the living standards of rural communities. Essentially, agricultural extension and education are not just structured programs but educational processes aimed at conveying useful information to farmers, enabling them to learn and achieve better livelihoods for themselves and their families (Kosior, 2017; Lindner et al., 2020; Lynam & Mukhwana, 2020). It is described as a school with the goal of boosting the productivity of producers of natural resources and agricultural products through rational human development investments. By fostering voluntary participation, it encourages self-study and continuous learning, respecting the role of individuals as agents of development and creating an environment conducive to learning. This leads to professionalism, self-sufficiency, and national food security through efficient and productive forces (Klerkx, 2020; Raina, 2020). Thus, this study aims to examine the emergence and implementation of sustainable agriculture, highlighting the new health risks for workers in the agricultural and food processing industries, and evaluating the critical role of agricultural extension and education in achieving sustainable agricultural practices.

2 Methods and Materials

2.1 Study Design

This study employs a comprehensive literature review and analytical approach to investigate the emergence and implementation of sustainable agriculture, the associated health risks for workers in agricultural and food processing industries, and the role of agricultural extension and education. The research design incorporates both qualitative and quantitative analyses of secondary data from various sources, including academic journals, books, and reports on sustainable agriculture, the Green Revolution, and agricultural extension.

2.2 Data Collection

Data for this study were collected from multiple sources:

- Literature Review: Extensive review of existing literature on sustainable agriculture, the Green Revolution, and agricultural extension. Sources included peer-reviewed journal articles, books, and government and NGO reports.
- Case Studies: Examination of specific case studies that illustrate the impacts of the Green Revolution and the implementation of sustainable agricultural practices.

2.3 Analytical Framework

The study employs an analytical framework that integrates ecological, socio-economic, and technological perspectives. The framework includes:

- Ecological Analysis: Assessment of the environmental impacts of traditional and sustainable agricultural practices, focusing on energy consumption, soil health, water use, and biodiversity.
- Socio-Economic Analysis: Examination of socio-economic inequalities, health risks, and the economic viability of sustainable agriculture. This includes evaluating the distribution of benefits and costs among different stakeholders in the agricultural sector.
- Technological Analysis: Evaluation of the technological aspects of sustainable agriculture, including advancements in agricultural practices, pest management, and energy efficiency.

3 The Concept of Agricultural Extension and Education

Agricultural extension and education constitute informal education provided to rural inhabitants and agricultural enthusiasts, familiarizing them with new technologies to increase production, productivity, and income, thereby improving the living standards of agricultural producers and achieving agricultural and rural development goals (Heinert & Roberts, 2016).

Agricultural extension is defined as purposeful assistance in decision-making and shaping ideas. Experts regard it as a professional communication intervention designed by institutions to induce voluntary behavioral changes in farmers, based on collective or social interests. The goal of agricultural extension is to meet agricultural development objectives and enhance farmers' living standards, especially those of smallholder farmers and the poor, by simplifying and applying research and technology findings to increase production, reduce costs, and earn higher incomes. In developing countries, agricultural extension is a crucial element for achieving agricultural and rural development goals, often implemented through government systems and, more recently, private extension activities to train farmers in various ways. However, in some regions, this objective remains unmet. Many agricultural experts face unemployment post-graduation due to inadequate practical experience and theoretical content taught at universities. Consequently, they often fail to contribute effectively to agricultural growth and development, becoming theorists and statisticians rather than practitioners, leading to inefficiencies in applying their knowledge. This issue underscores the need for significant progress in this area (Lynam & Mukhwana, 2020; Raina, 2020).

4 Promoting Agricultural Education and Its Importance

Promotion in agricultural education is an educational process planned and implemented as non-formal education. This training is optional and voluntary, primarily targeting rural people and agricultural operators. Its goals include guiding rural populations, consulting with them to identify and solve life problems, and providing information and knowledge application to enhance farm efficiency and improve living standards through intellectual empowerment and skill development.

Promotion is viewed from various perspectives: philosophically, as a non-classical school of education;

operationally, as a process; functionally, as a purposeful relationship; and in nature, as a system. The nature of the promotion process implies that activities are interconnected, each related to preceding or subsequent actions, and many are multifunctional and multi-purpose. Functionally, promotion involves purposeful communication aimed at transferring information to improve knowledge levels, attitudes, and behaviors. As a system, promotion includes components such as audience promoters, information technology, and communication methods. Its stability and effectiveness depend not only on internal interactions but also on interactions with the external environment. Thus, the promotion system is a communication system designed to induce voluntary changes in behavior through non-classical education and conscious intervention processes. Wherever behavioral changes are required, promotion will be necessary (Iyer, 2019).

5 Promotion in Agricultural Development

Promotion, in the context of both agriculture and other scientific fields, involves the dissemination of research findings that address societal problems and needs, with the aim of improving the intellectual and material conditions of people's lives. This concept is rooted in the idea of guidance and is intended to develop professional thinking and abilities. Agricultural promotion is a manifestation of economic growth and development and a productive culture within society. It has been adopted by many countries to foster cultural and spiritual development, raise public knowledge and awareness in various fields, including technical affairs such as electricity, machinery, and water supply, as well as economy, medicine, and housekeeping (Atinkut, 2019; Huang et al., 2020).

Experiences have shown that agriculture supports and stimulates rural development because it is the primary source of production and income in rural areas. The promotion of agriculture enhances human capabilities, playing a crucial role in agricultural development. By increasing farmers' incomes and reducing the disparity between urban and rural areas, agricultural promotion helps create dynamic and prosperous rural communities. In such societies, research becomes a fundamental condition for the balanced growth of cities and villages, ultimately contributing to the political and social stability of the entire society (Fiaz et al., 2018).

Agricultural education and promotion programs, along with the teaching of appropriate skills to villagers, are key factors in rural development when designed and

implemented to meet the specific needs and conditions of rural communities. These programs can address three main problems prevalent in rural areas of the developing world: low production, income inequality, and lack of participation in civic activities. Education is essential for human development, enabling individuals to control economic, social, cultural, and political resources effectively (Lynam & Mukhwana, 2020; Moyo & Salawu, 2018; Roberts et al., 2020).

It is widely acknowledged that the human factor is the most fundamental element in the development process. Extension organizations, which carry out educational tasks, have gained a better understanding of issues over time. Regardless of the development strategies adopted in various countries, there is a consensus on the significant role of agricultural promotion in improving agriculture in developing countries. Promotion is a flexible tool that can adapt to diverse situations and is often more effective among farmers than government interventions. Extension services are responsible for maintaining direct contact with farmers, often serving as the only link between government agencies and rural populations. One of the key objectives of promotion is to reduce regional and social inequalities (Iyer, 2019).

Agricultural extension acts as a tool to assist farmers, fostering interest and motivation, and empowering them to improve their livelihoods. Extension promotes its objectives through various means:

- Increasing production
- Reducing production costs
- Improving product quality by understanding seed and livestock types, pest and disease management, and adhering to proper principles in animal husbandry and crop production
- Standardizing products
- Enhancing marketing knowledge and eliminating intermediaries
- Replacing or combining agricultural lands to increase fertility and optimize the use of production tools

Given the importance of promotion, it is evident that it is a constructive force that should be strengthened and developed to fulfill its mission of increasing public awareness and knowledge about agricultural products. Throughout history, agriculture has been a fundamental source of nourishment, employment, and income. The survival and prosperity of nations have depended on it, as evidenced by various religious texts and historical records

that highlight the virtues of agricultural prosperity and the critical role of farmers in economic and social life.

Economists assert that human abilities, which are acquired through education, are akin to capital goods that must be invested in to increase their productivity. While physiological and hereditary abilities are relatively equal among individuals, acquired abilities, which are developed through education, must be enhanced to enable individuals to exceed their innate capacities.

Current evidence indicates that the level of acquired abilities among farmers in developing countries is low, despite the agricultural sector's significant share of employment. For instance, the share of agriculture in Iran's GDP at the end of the last development program was 8%, while the labor force in agriculture constituted 34.3%, indicating low labor productivity and a lack of acquired capacity among farmers to increase their efficiency. These facts underscore the critical importance of education in agricultural development and the pressing need for farmers to receive education to enhance their acquired power and productivity (Bastan et al., 2018).

6 Research and Promotion Position

Research and extension are integral components of the agricultural knowledge and information system. Alone, and without interaction with each other and the farmers' system, they cannot effect lasting changes in the agricultural sector. Strong links between research and other stakeholders in agricultural systems are essential to ensure the appropriateness of agricultural technologies and their widespread dissemination among farmers. Effective communication mechanisms between the components of the agricultural knowledge system are crucial for the transfer of information and technologies. The nature of these relationships significantly affects efficiency and performance in production and transmission. Poor performance in this system often results from communication problems and weak interaction mechanisms, impacting the overall efficiency of the agricultural knowledge and information system (Beyadegie, 2019; Iyer, 2019).

6.1 *The Role of Extension in Achieving Goals of the Extension and Consulting Services Network*

Establishing the groundwork for delegating tasks to technical and engineering consulting offices.

Developing executive instructions (e.g., tender, award, supervision) for use in provinces.

Defining contracts with specialized parent companies in accordance with existing restrictions and conditions (e.g., city planning council).

Gradual assignment of tasks.

Empowering human resources in technical and engineering consulting offices.

Justifying the human factors in the extension network to ensure proper plan implementation.

Designing technical and engineering consulting offices.

6.2 Objectives of Agricultural Extension and Education

Educate individuals to identify and evaluate their needs and problems.

Help individuals acquire the training and skills needed to address their needs and problems effectively.

Convince individuals to utilize the necessary training and skills (Heinert & Roberts, 2016; Klerkx, 2020; Raina, 2020).

6.3 The Role of Extension in Agricultural Education and Rural Development

Education is the foundation of development, and extension education is critical for realizing the education of villagers, thereby forming the basis of rural development. Extension science emerged due to the necessity of the times. Historically, one significant factor in the Allied victory in World War II was the robust agricultural extension movement in the United States. During the war, while European farms were ravaged, American farmers, through comprehensive extension training, operated in a safe environment, compensating for the inadequacies of their European counterparts. This effort reassured the Allies in terms of supplying food, a critical factor in their strength and reliance.

Today, agricultural extension and education are interdisciplinary and systemic sciences. They bridge experimental agricultural sciences with the human and social realities of the world. The durability and dynamism of extension science depend on fundamental, developmental, and applied research and the dissemination of these findings through various media. Despite the long history of traditional agricultural extension in the country and its cultural roots, modern agricultural extension as an imported science has seen less development. This field faces significant weaknesses in the availability of Persian

language resources and specialized books (Beyadegie, 2019; Iyer, 2019).

6.4 Emergence of Sustainable Agriculture

Shepherd (1998) identifies four major theoretical developments in rural development: 1) sustainable agricultural development, 2) sustainable local institutions, 3) a fundamental shift in project-based approaches, and 4) gender perspectives (Bastan et al., 2018; Iyer, 2019; Moyo & Salawu, 2018; Raina, 2020). The concept of sustainability in agriculture has become a significant aspect of sustainable development, driven by the historical implementation of Green Revolution programs and modern agricultural practices. Criticisms of these practices highlight numerous adverse environmental and social effects, including:

- Water pollution from pesticides and nitrates, soil erosion, livestock losses, damage to wildlife habitats, and health problems related to drinking water contamination.
- Food and animal feed contamination with pesticide residues, nitrates, and antibiotics.
- Damage to farms and natural resources through pesticides, affecting farmers and the public, and disrupting ecosystems and wildlife.
- Atmospheric pollution from ammonia, nitrous oxide, methane, and combustion materials, contributing to ozone depletion and global warming.
- Overuse of natural resources, leading to groundwater depletion, damage to wild plants and orchards, reduced waste absorption capacity, stagnation, and increased salinity (Moyo & Salawu, 2018; Raina, 2020).

The trend towards standardization and specialization in agriculture, resulting in the loss of traditional seed cultivars.

7 New Health Risks for Workers in the Agricultural and Food Processing Industries

Shepherd (1998) outlines several criticisms of the Green Revolution, which provided a foundation for introducing the concept of sustainability in agriculture. These criticisms include geographical inequalities, socio-economic disparities, employment and wage inequities, food security contradictions, and threats to human health and the environment. Numerous studies have highlighted the negative impacts of traditional agriculture and the Green Revolution (Iyer, 2019).

The definition and implementation of sustainable agriculture address the increase in energy consumption per bushel of production, including the energy required for producing chemicals and machinery, and the depletion of energy reserves. The output-to-input energy ratio has become less favorable, dropping from 3 in the 1940s to less than 1.8 in the 1980s. Land use strategies relying on unlimited concentrated energies are unsustainable in the long run. Hidden costs of agriculture, such as the high energy consumption of the Green Revolution, are substantial. For example, producing each kilogram of grain under Green Revolution conditions requires 3 to 10 MPa of energy, while sustainable agriculture consumes only 0.5 to 1 MPa of energy (Bastan et al., 2018).

Sustainable agriculture is a relatively new response to the declining quality of natural resources essential to modern agriculture. Agricultural production has evolved from a purely technical subject to one with social, cultural, political, and economic dimensions. Despite the controversies surrounding its definition, sustainability represents a set of dependencies within agriculture, arising from the co-evolution of socio-economic and natural systems. Understanding sustainable agriculture requires studying the interactions between agriculture, the environment, and social systems (Bastan et al., 2018; Iyer, 2019; Moyo & Salawu, 2018; Raina, 2020). Through a deeper ecological understanding of agricultural systems, better management practices aimed at sustainability can be developed.

Potential solutions to environmental problems include reducing or eliminating chemical inputs through improved plant nutrition management and pest control using organic methods. Despite numerous environmental research projects, high technological pressures still focus on mitigating symptoms rather than addressing the root causes of ecological imbalance. The prevalent philosophy views pests, nutrient deficiencies, and other factors as primary causes of low productivity, rather than signs of deeper systemic issues. Sustainable agriculture, however, applies ecological principles to design and manage crop ecosystems, emphasizing minimal chemical input, energy efficiency, and the synergistic interactions within agricultural systems (Moyo & Salawu, 2018; Raina, 2020).

The goals of sustainable agriculture are closely tied to its definitions and can be summarized as follows:

- Ensure food security and improve food quality while considering future generations' needs.
- Protect water, soil, and natural resources.
- Conserve on-farm and off-farm energy resources.

- Maintain and enhance farmer profitability.
- Sustain rural community vitality.
- Conserve biodiversity.
- Achieve social acceptability (Bastan et al., 2018).

Several agricultural methods contribute to sustainability:

- Periodic Agriculture: Sequential planting of different crops in a fixed rotation order.
- Low-Input Agriculture: Reducing input use.
- Ecological Agriculture: Managing the ecosystem to maintain ecological balance without increasing input use.
- Alternative Agriculture: Meeting system needs through material cycling.
- Biological Agriculture: Preserving the activity of living organisms and their components.
- Biodynamic Agriculture: Viewing farms as integrated organisms to achieve balance and equality, treating soil, plants, and animals as a self-sustaining system.
- Organic Farming: Treating the farm as a living organism, avoiding chemical fertilizers, pesticides, hormones, and genetic modifications, and optimizing natural inputs (Bastan et al., 2018).

Agriculture plays four critical roles in the economic growth and development of any country:

- Providing food security and reducing food poverty and economic vulnerability.
- Supplying raw materials for industry and aiding the development of related production activities.
- Exporting goods to earn foreign exchange for importing capital goods and expanding economic activities.
- Maintaining and improving the living environment through sustainable production methods and optimal resource use.
- Achieving these tasks within agricultural production activities fosters the development and sustainability of the sector (Bastan et al., 2018).

8 Conclusion

Sustainable agriculture is a biological process that seeks to emulate key features of natural ecosystems while maximizing yield. It increases nutrient cycling efficiency and utilizes solar energy as the primary source. Agricultural extension and education are crucial pillars for achieving sustainable agriculture by:

- Evaluating the agricultural extension and education sector and promoting it to the public, especially rural farmers.
- Enhancing the connection between extension agents and advanced research centers.
- Supporting government initiatives to mechanize agriculture.
- Stabilizing agricultural product prices to regulate farmer incomes.
- Investing in advanced research centers.
- Providing farmers with adequate information about global scientific advancements through extension services.

Authors' Contributions

Not applicable.

Declaration

In order to correct and improve the academic writing of our paper, I have used the language model ChatGPT.

Transparency Statement

Data are available for research purposes upon reasonable request to the corresponding author.

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Declaration of Interest

The author reports no conflict of interest.

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Ethical Considerations

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