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ROLE OF CROP DIVERSIFICATION APPROACH IN SUSTAINABLE AGRICULTURE

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Over the past five decades, the primary focus of agricultural development has been on increasing production and ensuring food security. This objective was successfully achieved through the collaborative efforts of farmers, agricultural scientists, and policymakers, culminating in the 'Green Revolution' and the 'Rainbow Revolution'. These initiatives significantly enhanced agricultural productivity and contributed to self-sufficiency, transforming the agricultural landscape and improving the livelihoods of millions of farmers. Despite these successes, the intensification of agriculture has also brought about challenges such as soil degradation, water scarcity, and biodiversity loss. Consequently, crop diversification has emerged as a critical strategy for sustainable agricultural development. By integrating a variety of crops, including legumes, fruits, vegetables, and traditional varieties, farmers can enhance soil health, optimize resource use, and increase resilience to pests, diseases, and climate variability. It improves soil fertility through practices like crop rotation and intercropping, which enhance the soil's nutrient profile and reduce dependency on chemical fertilizers. Diverse cropping systems also promote ecological balance, reducing the incidence of pest outbreaks and minimizing the need for pesticides. Furthermore, diversification provides economic stability to farmers by reducing the risks associated with market fluctuations and crop failures, thereby ensuring a more reliable income. In conclusion, while the Green and Rainbow Revolutions have laid a strong foundation for agricultural productivity and food security, the path forward must embrace sustainable practices. Crop diversification stands out as an indispensable approach for fostering a resilient and sustainable agricultural system, capable of meeting future food demands while safeguarding environmental health.

The Green Revolution introduced high-yielding varieties of staple crops, advanced irrigation techniques, and the extensive application of chemical fertilizers and pesticides.

These technological advancements led to a substantial increase in crop yields, particularly in developing countries, thereby alleviating food shortages and enhancing economic stability. The Rainbow Revolution expanded agricultural productivity beyond cereals to encompass a diverse array of horticultural crops, livestock, and fisheries, promoting a more holistic approach to agricultural development.

Agricultural diversification, also referred to as crop diversification, involves the incorporation of new crops or cropping systems into existing farmland, considering the varying returns on investment. This transition from traditionally grown, less profitable crops to more profitable ones enables farmers to enhance their production and generate additional income. Diversification in agriculture can entail a shift in cropping patterns or the expansion into non-farming activities such as poultry farming and animal husbandry (Joshi *et al.*, 2004). By diversifying, farmers are able to broaden their production base, thus increasing their economic resilience and stability.

Crop diversification generally refers to the practice of cultivating a variety of crops within a farming system to enhance sustainability, reduce risk, and improve productivity. According to the Food and Agriculture Organization (FAO), crop diversification is defined as the addition of new crops or cropping systems to agricultural production on a farm (FAO, 2017). This practice encompasses a wide range of farming patterns, including the cultivation of both food and non-food crops, conventional and organic farming, and high-value and low-value crops.

Diversification in agriculture extends beyond field crops to include livestock, fisheries, and forestry products (Deogharia, 2018). To meet the increasing consumer demand for diverse agricultural products such as coarse cereals, pulses, vegetables, fruits, oilseeds, grains, and sugarcane, crop diversification strategies are designed to shift from the regional dominance of a single crop to the regional production of multiple crops. This approach not only maximizes the utilization of available resources but also contributes to the overall stability and sustainability of agricultural systems.

Reasons for Crop Diversification

There are various factors of traditional farming, which have triggered the need of crop diversification in India. Plenty of old farming methods and principles which were profitable

in the past are now failing to produce desired results. Some of the reason for crop diversification in India are listed below:

1. **Degradation of natural resources** such as cultivable land, water scarcity, and soil.
2. **Climate Change** effecting the yield and quality of regional crops
3. **Decreasing employment** in agriculture business.
4. **Increasing price of food.**
5. **Decreased or plateaued yield of rice-wheat cropping systems.**
6. **Decreased level of organic carbon** in soil in Indo-Gangetic Plains (IGP).
7. **Deficiency of nutrients** such as nitrogen, phosphorus, potassium, sulphur, Boron, etc in soil (Noticeably, in rice based cropping systems).
8. **Decrease in income and purchasing power** of farmers.
9. **Resistance of weeds to herbicides.**
10. **Increase in insect pest and diseases.**
11. Inability to exploit new agricultural produce **export opportunities.**

Classification of Crop Diversification

It can be broadly classified into two categories:

- a) **Horizontal crop diversification:** This kind of crop diversification aligns with farmer's basic understanding of agricultural diversification i.e. not to depend on just one crop. Small farmers with small pieces of land can benefit most from horizontal crop diversification. Instead of cultivating a single crop, this involves multiple crops or a mix of crops. In this way, they are able to earn more through increasing crop diversity.
- b) **Vertical crop diversification:** Combined with multiple cropping, vertical crop diversification involves the incorporation of industrialization. This kind of agricultural diversification practice is suitable for relatively big farmers with enough finance and land. Instead of just farming multiple crops, farmers also setup facilities for downstream activities such as milling, processing or packaging. This can also include activities like livestock rearing, forestry, poly-house, horticulture etc.

Types of Crop Diversification

Diversification types	Description of diversification	Main characteristics
Increased structural diversity	Makes the crops within the field more structurally diverse e.g. strip cropping,	Farm level same land unit
Genetic diversity in monoculture	Growing mixed varieties of a species in a monoculture.	Farm level same land unit
High-value crops	A shift from less profitable and sustainable crop or cropping system to more profitable and sustainable system.	Farm level same land unit
Crop rotations	Temporal diversity through crop rotations.	Farm level different spaces, different times
Polyculture	Growing two or more crop species and wild varieties within the field. Spatial and temporal diversity.	Farm level different spaces, different times
Diversify field with non-crop vegetation.	Growing weed strips or vegetation banks in and alongside crops.	Farm level, different spaces
Mixed farming	Crops and animal husbandry.	Farm level, different spaces, different times
Agroforestry	Growing crops and tree species together.	Farm level, different spaces, different times
Mixed landscapes	Development of diversified landscapes with multiple ecosystems	Larger scale, spatial and temporal.

Benefits of Crop Diversification

1. Crop diversification is beneficial not only as a modern farming technique but also for its capacity to mitigate various agricultural challenges arising from environmental changes, landscape variations, disease and pest dynamics, government policies, and fluctuating supply and demand trends.
2. It significantly reduces farmers' risk by diversifying income sources, unlike traditional farming methods where crop failure could result in the complete exit of a farmer from the market.
3. Small farmers benefit significantly as the total yield from multiple commercial plants and crops increases.
4. Multiple cropping systems or multi-tier cropping systems substantially increase employment opportunities within the agricultural sector.
5. Crop diversification enhances the income of small farms by optimizing the use of available land for a variety of high-value crops.

6. It aids in balancing and meeting food demand by producing a wider range of food products.
7. Crop diversification contributes to increased production of high-quality fodder for livestock animals.
8. It reduces the potential for pests, insects, and weeds to develop resistance to pesticides and herbicides.
9. Crop diversification helps maintain the quality of natural resources, including soil nutrients and soil fertility.
10. It helps minimize environmental pollution caused by excessive use of herbicides and pesticides.
11. Crop diversification creates new agri-business opportunities for emerging entrepreneurs interested in food processing and expands possibilities for exporting crops and vegetables.
12. It involves the introduction of different crops that can complement each other in terms of resource utilization, pest and disease resistance, and market demands.

Conclusion

Promotion of sustainable agricultural practices that complement crop diversification, such as agroforestry, integrated pest management, and organic farming can enhance the overall benefits of diversified cropping systems. Implementation systems to monitor and evaluate the impacts of crop diversification on agricultural productivity, environmental health, and socio-economic conditions will help in refining strategies and demonstrating the benefits to stakeholders. By leveraging these strategies, the agricultural sector can make significant strides towards more resilient, sustainable, and productive farming systems through the practice of crop diversification.

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