

Agricultural Productivity and Changing Cropping Patterns in Jammu and Kashmir with Special Reference to Sustainable Agricultural Development

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ABSTRACT

Agriculture remains one of the most important components of the rural economy of Jammu and Kashmir and continues to provide employment, income, food, and livelihood security to a substantial proportion of the population. The agricultural system of the region is characterized by considerable geographical and climatic diversity, ranging from the subtropical plains of Jammu to the temperate and high-altitude environments of the Kashmir Valley and mountainous areas. This diversity has resulted in distinct cropping systems, production practices, and levels of agricultural productivity across different parts of the region. During recent decades, agriculture in Jammu and Kashmir has experienced significant changes in cropping patterns, driven by population growth, changing food preferences, market opportunities, technological development, irrigation expansion, government interventions, and increasing awareness of high-value crops. Traditional cereal-based systems have increasingly been complemented or replaced in some areas by horticultural crops, vegetables, pulses, oilseeds, and other commercially valuable crops. At the same time, agricultural productivity continues to be constrained by fragmented landholdings, limited irrigation, climatic variability, soil degradation, inadequate post-harvest infrastructure, market fluctuations, and increasing pressure on natural resources. Climate change has emerged as an additional challenge through changing precipitation patterns, temperature fluctuations, extreme weather events, and altered water availability. This review examines the major trends in agricultural productivity and changing cropping patterns in Jammu and Kashmir and evaluates their implications for sustainable agricultural development. Particular attention is given to regional variations, crop diversification, resource-use efficiency, climate resilience, technological interventions, and the socioeconomic dimensions of agricultural transformation. The review argues that sustainable agricultural development in Jammu and Kashmir requires a shift from production-oriented agriculture toward diversified, climate-resilient, resource-efficient, market-oriented, and environmentally sustainable farming systems.

Keywords: Agricultural productivity, cropping pattern, crop diversification, Jammu and Kashmir, sustainable agriculture, climate change.

1. Introduction

Agriculture occupies a distinctive position in the economic and social structure of Jammu and Kashmir. Despite the expansion of tourism, services, construction, and other non-agricultural sectors, farming continues to constitute an important source of livelihood for rural households and plays a major role in maintaining regional food security. The importance of agriculture is particularly evident in rural areas where household income, employment, livestock production, horticulture, and food consumption remain closely connected

with agricultural activities. The sector is, however, not uniform across the region. The considerable variations in altitude, temperature, precipitation, soil characteristics, terrain, length of the growing season, and irrigation availability have produced highly differentiated agricultural systems [1]. The Jammu region is characterized by a mixture of subtropical and intermediate climatic conditions, while the Kashmir Valley has a temperate climate that supports cereals, horticultural crops, vegetables, and other crops adapted to cooler growing conditions. The mountainous areas present additional constraints because of steep slopes, limited cultivable land, transportation difficulties, and dependence on rainfall. Consequently, agricultural productivity varies substantially from one district and agro-climatic zone to another. Such regional variation is important when evaluating agricultural development because policies and technologies suitable for one part of Jammu and Kashmir may not necessarily be appropriate for another [2]. Agricultural transformation in Jammu and Kashmir has also involved significant changes in cropping patterns. Traditionally, food grains, particularly rice, wheat, maize, and other cereals, occupied a dominant position in the agricultural system. Over time, however, increasing commercialization and the development of horticulture have encouraged farmers in many areas to allocate greater portions of land to high-value crops. Apple, walnut, almond, cherry, pear, vegetables, saffron, and other horticultural products have become important components of the agricultural economy,

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particularly in the Kashmir Valley and selected mountainous areas. This transition reflects the growing importance of market-oriented agriculture and the potential for higher returns from limited land resources.

The transformation of cropping patterns has both positive and negative implications. Crop diversification can improve farm income, reduce dependence on a single crop, create employment, and strengthen resilience against certain market and climatic risks. However, excessive specialization can also increase vulnerability to crop-specific diseases, price fluctuations, changing consumer demand, and climatic shocks. Similarly, intensification of agriculture may increase productivity in the short term but can contribute to soil degradation, declining water resources, excessive fertilizer use, and biodiversity loss when natural-resource constraints are ignored [3]. The challenge, therefore, is not simply to increase agricultural production. The central question is how Jammu and Kashmir can achieve higher and more stable agricultural productivity while maintaining soil health, water resources, biodiversity, farm livelihoods, and ecological sustainability. This review examines this broader question by analyzing the evolution of agricultural productivity and cropping patterns and considering the pathways through which agricultural development can become more sustainable and climate resilient.

2. Agricultural Diversity and Regional Characteristics

The agricultural geography of Jammu and Kashmir is strongly influenced by variations in altitude and climate. These environmental differences create a series of agro-ecological conditions within a relatively compact geographical region. The lower areas of Jammu generally experience warmer conditions and support crops such as wheat, rice, maize, pulses, and oilseeds, while the temperate conditions of the Kashmir Valley support rice, wheat, maize, vegetables, and a wide range of horticultural crops. At higher elevations, agricultural production becomes increasingly constrained by shorter growing seasons and difficult terrain, although specialized crops and livestock systems remain important for local livelihoods [4]. The diversity of agricultural environments creates opportunities for crop diversification but also makes agricultural planning more complex. A crop that performs well in the irrigated plains may not be suitable for rain-fed or mountainous areas. Similarly, the economic value of horticultural production varies according to altitude, market access, transportation infrastructure, storage facilities, and climatic suitability. Agricultural development policies therefore need to recognize agro-climatic differences rather than treating Jammu and Kashmir as a homogeneous agricultural region.

Small and fragmented landholdings are another important feature of the agricultural structure. Fragmentation can limit the adoption of mechanization, efficient irrigation systems, protected cultivation, and other modern technologies. It may also increase the cost of cultivation because farmers have to manage several small parcels located at different places. At the same time, small farms can demonstrate considerable flexibility and diversity when farmers combine crop production, horticulture, livestock, and other livelihood activities.

3. Trends in Agricultural Productivity

Agricultural productivity is determined by the interaction of land, labour, capital, technology, water, climatic conditions, soil fertility, and management practices.

In Jammu and Kashmir, productivity improvements have occurred through the introduction of improved varieties, greater use of fertilizers and pesticides, irrigation development, farm mechanization, improved horticultural practices, and expansion of agricultural extension services. Nevertheless, productivity remains uneven across crops and regions. Cereal production continues to be important for food security, particularly rice, wheat, and maize. However, productivity growth in traditional cereal systems can become constrained when cultivable land is limited and production depends heavily on climatic conditions. In rain-fed and mountainous areas, fluctuations in rainfall and temperature can produce considerable year-to-year variation in crop yields. The increasing frequency of extreme weather events further increases production uncertainty. Horticultural crops provide a different productivity pathway because their economic returns per unit of land can be considerably higher than those of conventional cereals under suitable conditions [5]. The development of apple orchards and other fruit crops has therefore contributed to agricultural commercialization in many parts of Kashmir. However, horticulture requires substantial investment in orchard establishment, irrigation, plant protection, storage, transportation, grading, and marketing. Its long-term sustainability is also dependent on maintaining soil quality and adapting orchards to changing climatic conditions [6]. Productivity should consequently be evaluated not only in terms of yield per hectare but also in terms of economic return, resource-use efficiency, environmental impact, and stability over time. A farming system that produces high yields while consuming excessive quantities of water, fertilizers, and pesticides may not necessarily represent sustainable productivity.

4. Changing Cropping Patterns

One of the most important transformations in the agricultural economy of Jammu and Kashmir is the gradual diversification of cropping patterns. Cropping patterns reflect the proportion of cultivated land devoted to different crops and are influenced by ecological conditions, food requirements, prices, government policies, irrigation, technology, and farmer preferences. Historically, cereals occupied a central position because they provided food security and were relatively well adapted to local production systems. Rice has traditionally been important in the Kashmir Valley, while wheat and maize have been major crops in different parts of the region. Over time, however, increasing commercialization has encouraged farmers to consider crops with higher market value [7]. The expansion of horticulture represents one of the most significant components of this transformation. Fruit cultivation, particularly apple production, has become an important source of farm income in Kashmir. Walnut, almond, pear, cherry, and other fruit crops have also contributed to diversification. In suitable locations, vegetables and spices have expanded because of their market demand and potential for generating higher returns within relatively small landholdings. This transition from predominantly subsistence-oriented production toward increasingly commercial agriculture has important implications for rural development. Higher-value crops can improve household income and create employment throughout the agricultural value chain. At the same time, dependence on commercial crops can expose farmers to price volatility, transportation disruptions, storage limitations, and market uncertainty.

The sustainability of crop diversification therefore depends on the development of reliable value chains rather than simply encouraging farmers to replace one crop with another.

5. Horticultural Transformation and Agricultural Commercialization

Horticulture has emerged as a major pillar of agricultural transformation in Jammu and Kashmir. The region's climate provides favorable conditions for several temperate fruits, and horticultural production has created extensive economic linkages involving farmers, labourers, traders, transporters, processors, wholesalers, retailers, and exporters. Apple cultivation is particularly significant. The crop provides relatively high returns compared with many traditional field crops and has therefore influenced land-use decisions and household livelihood strategies. The expansion of horticulture also demonstrates how agro-climatic specialization can create regional comparative advantages.

However, horticultural development faces several structural challenges. Orchards are vulnerable to temperature fluctuations, hailstorms, unseasonal rainfall, frost, drought, pests, diseases, and other climatic stresses. Changes in winter chilling requirements associated with warming temperatures may also affect the suitability and productivity of some temperate fruit varieties. In addition, traditional orchards may have lower productivity than modern high-density systems where appropriate rootstocks, irrigation, pruning, training, and nutrient management are adopted [8]. The transition toward modern horticulture therefore requires careful consideration of environmental and socioeconomic conditions. High-density orchards, efficient irrigation, integrated pest management, improved planting material, weather-based advisory systems, and post-harvest infrastructure can contribute to productivity while reducing resource wastage.

6. Climate Change and Agricultural Productivity

Climate change represents one of the most significant emerging challenges for agriculture in Jammu and Kashmir. The agricultural sector is highly dependent on climatic conditions, and changes in temperature, precipitation, snowfall, frost, drought, and extreme weather can directly influence crop growth and productivity. Changes in temperature can alter crop phenology, water requirements, pest and disease dynamics, and the suitability of particular crops or varieties. In horticulture, temperature changes can influence flowering, fruit set, chilling requirements, and maturity periods. Unseasonal rainfall can damage standing crops and fruits, while intense rainfall events can cause soil erosion, waterlogging, and nutrient losses. The vulnerability of agriculture to climate change is particularly important in areas where irrigation infrastructure is limited. Rain-fed farmers have fewer options for managing rainfall variability and may experience significant yield losses during dry periods.

Mountainous areas can be especially vulnerable because of difficult terrain and limited access to alternative livelihood opportunities [9]. Climate adaptation must therefore become an integral component of agricultural planning. Crop diversification, drought- and disease-tolerant varieties, efficient irrigation, soil-moisture conservation, weather forecasting, crop insurance, protected cultivation, and improved farm management can help reduce climate-related risks.

7. Irrigation and Water Resource Management

Water availability is a major determinant of agricultural productivity. Irrigated agriculture generally provides greater control over crop water requirements and can support higher cropping intensity and productivity than purely rain-fed farming. However, water resources in Jammu and Kashmir are increasingly exposed to competing demands from agriculture, households, industry, ecosystems, and climate variability [10]. Efficient irrigation is therefore essential for sustainable agricultural development. Traditional irrigation practices may result in substantial water losses, particularly when water is applied without considering crop requirements or soil moisture conditions. Micro-irrigation systems such as drip and sprinkler irrigation can improve water-use efficiency, especially in horticultural and vegetable production.

Water management should also be integrated with watershed development and soil conservation. In mountainous areas, improving rainwater harvesting, maintaining natural drainage systems, reducing soil erosion, and enhancing soil moisture retention can strengthen agricultural resilience. The objective should be to increase crop productivity per unit of water, rather than simply increasing the total amount of water supplied to agriculture.

8. Soil Health and Sustainable Land Management

Soil represents the foundation of agricultural productivity, yet intensive cultivation can gradually reduce soil quality when nutrient removal exceeds nutrient replacement. Excessive dependence on chemical fertilizers, inadequate organic-matter management, erosion, and inappropriate cultivation practices can negatively affect soil structure and fertility [11]. Maintaining soil organic matter is particularly important for Jammu and Kashmir because it improves water retention, nutrient availability, microbial activity, and resistance to erosion. Incorporating crop residues, compost, farmyard manure, green manures, and other organic inputs can contribute to soil-health management. Integrated nutrient management provides a potential pathway for balancing productivity with environmental sustainability. Instead of relying exclusively on either chemical or organic fertilizers, nutrient application can be based on crop requirements, soil testing, and the integration of organic and inorganic sources. Such practices can improve nutrient-use efficiency while reducing unnecessary input costs and environmental losses.

Table 1: Major agricultural crops, changing trends and sustainability implications in Jammu and Kashmir

Agricultural category	Major crops/products	Changing trend	Major factors influencing change	Implications for sustainable agricultural development
Cereals	Rice, wheat, maize	Gradual shift from exclusive cereal dependence toward diversified production in several areas	Food-security requirements, market returns, irrigation availability and changing farmer preferences	Continued importance for food security, but productivity should be improved through efficient water and nutrient management
Horticultural crops	Apple, walnut, almond, pear, cherry and other fruits	Increasing importance of horticulture, particularly in suitable areas of Kashmir	Higher economic returns, agro-climatic suitability, market demand and commercialization	Higher farm income and employment, but greater attention is required for climate resilience, storage and sustainable orchard management
Vegetables	Potato, tomato, onion, cabbage, cauliflower and other vegetables	Increasing diversification toward commercial vegetable cultivation	Urban demand, market opportunities, short production cycles and higher returns per unit area	Can improve farm profitability and nutritional security while supporting intensive land use
Pulses	Rajma, lentil, pea and other pulses	Relatively smaller share compared with cereals and horticultural crops, with scope for expansion	Soil fertility benefits, food demand, crop rotation and market incentives	Can improve soil fertility, dietary security and cropping-system sustainability
Oilseeds	Rapeseed-mustard and other oilseed crops	Variation across regions with potential for greater diversification	Market prices, agro-climatic suitability and demand for edible oils	Provides diversification and can strengthen domestic edible-oil supply
Spices and niche crops	Saffron and other regionally suitable high-value crops	Increasing emphasis on specialized and high-value production	Premium prices, geographical suitability, branding and export potential	High-value production can raise returns from limited land but requires quality control and climate adaptation
Fodder crops	Maize fodder, oats, berseem and other fodder crops	Closely associated with livestock-based farming systems	Livestock population, feed requirements and mixed farming practices	Supports integrated crop-livestock systems and nutrient recycling
Mixed and diversified systems	Crop-livestock-horticulture combinations	Increasing potential as an alternative to specialized production	Risk reduction, resource recycling and income diversification	Improves resilience, resource-use efficiency and livelihood stability
High-value commercial crops	Fruits, vegetables, spices and selected specialty crops	Increasing commercialization	Consumer demand, improved market access, technology and value-chain development	Strong potential for income growth, provided market volatility and resource pressures are managed

9. Crop Diversification and Sustainable Development

Crop diversification is increasingly viewed as an important strategy for sustainable agricultural development. Diversification can reduce dependence on individual crops and create opportunities for farmers to respond to changing markets and environmental conditions. In Jammu and Kashmir, diversification can involve combinations of cereals, pulses, oilseeds, vegetables, fruits, spices, fodder crops, and livestock [12]. Diversification can also improve dietary diversity and local food security. Pulses and vegetables, for example, provide important nutritional benefits while contributing to more varied agricultural systems. Similarly, integrating livestock with crop production can facilitate nutrient recycling through the use of animal manure and provide additional income sources. Nevertheless, diversification should be based on local agro-ecological suitability and market conditions. Promoting crops solely because they have high prices can create oversupply and subsequent price declines. A sustainable diversification strategy therefore requires market intelligence, processing capacity, cold storage, transportation facilities, and producer organizations.

10. Agricultural Mechanization and Technological Change

Mechanization can contribute to increased agricultural productivity by reducing labour requirements, improving timeliness of operations, and increasing efficiency. However, the small and fragmented landholdings common in Jammu and Kashmir can make conventional large-scale machinery difficult to use economically.

Small-scale and customized farm machinery can provide a more appropriate solution. Equipment suitable for small fields, hilly terrain, orchards, and vegetable cultivation can help overcome some of the limitations associated with farm fragmentation. Custom hiring centres and cooperative machinery services may also allow small farmers to access machinery without bearing the full cost of ownership [13].

Digital technologies offer another emerging opportunity. Mobile-based agricultural advisories, remote sensing, weather forecasting, digital market information, precision agriculture, and farm-management applications can improve decision-making. The usefulness of these technologies, however, depends on digital connectivity, farmer literacy, affordability, and the availability of locally relevant information.

11. Agricultural Markets and Post-Harvest Management

Increasing agricultural commercialization makes market access increasingly important. Farmers may achieve high productivity but still receive low returns if they lack access to efficient markets, storage facilities, processing units, transportation, grading, and price information. This challenge is particularly relevant to horticulture because fruits are perishable and require rapid movement from orchards to consumers. Inadequate cold-chain infrastructure can lead to significant post-harvest losses and reduce farmer income. Developing integrated value chains can therefore enhance the benefits of agricultural diversification. Improved packhouses, cold storage, controlled-atmosphere storage, processing facilities, grading and standardization, branding, and direct marketing can increase value realization. Farmer Producer Organizations and cooperative marketing arrangements may also improve farmers' bargaining power.

12. Constraints to Agricultural Productivity

Agricultural development in Jammu and Kashmir faces a combination of environmental, structural, technological, and socioeconomic constraints. Land fragmentation limits mechanization and economies of scale, while mountainous terrain increases transportation and cultivation costs. Irrigation remains unevenly distributed, creating greater vulnerability among rain-fed farmers. Climatic variability is another major constraint.

Extreme rainfall, drought conditions, frost, hailstorms, and temperature fluctuations can cause substantial production losses. Pest and disease outbreaks may become more difficult to predict under changing climatic conditions. Limited access to quality planting material, insufficient extension services, inadequate storage and processing facilities, market instability, and fluctuating input costs further affect farm profitability. These constraints interact with one another, meaning that addressing only one problem may not produce sustained improvements in agricultural livelihoods.

13. Towards Climate-Resilient and Sustainable Agriculture

Sustainable agricultural development in Jammu and Kashmir requires a multidimensional approach that combines productivity enhancement with resource conservation. Climate-resilient agriculture should prioritize crops and varieties suited to changing climatic conditions while reducing unnecessary dependence on water and chemical inputs [14]. Integrated farming systems offer considerable potential. Combining crops, horticulture, livestock, beekeeping, fisheries, and other suitable activities can diversify income and improve resource recycling. Crop residues can be used as livestock feed or compost, while livestock manure can contribute to soil fertility [15]. Agroforestry and soil-conservation measures can also play an important role in mountainous areas. Trees can reduce erosion, improve soil stability, provide additional products, and contribute to carbon sequestration. However, species selection should be based on ecological suitability and potential competition with agricultural crops for water and nutrients.

14. Policy and Institutional Perspectives

Government policies have an important role in determining the direction of agricultural transformation. Agricultural policies should increasingly focus on productivity, profitability, resilience, and environmental sustainability simultaneously [16]. Extension systems need to provide farmers with location-specific information rather than generalized recommendations. Farmers in high-altitude areas, irrigated plains, horticultural belts, and rain-fed regions face fundamentally different production challenges [17]. Greater investment is also needed in agricultural research, particularly research addressing climate adaptation, improved varieties, horticultural technologies, soil health, water efficiency, pest management, and post-harvest processing. Collaboration among universities, research institutions, government departments, farmer organizations, and private enterprises can accelerate the adoption of appropriate technologies.

16. Conclusion

Agriculture in Jammu and Kashmir is undergoing a significant transformation characterized by changing cropping patterns, increasing commercialization, expansion of horticulture, technological development, and growing emphasis on high-value agricultural commodities. These changes provide important opportunities for increasing farm income, employment, and regional economic development. At the same time, agricultural productivity remains constrained by fragmented holdings, uneven irrigation, difficult terrain, climatic variability, soil degradation, market instability, and inadequate post-harvest infrastructure. The changing agricultural landscape demonstrates that productivity and sustainability cannot be treated as separate objectives.

Increasing yields without conserving soil and water resources may generate short-term gains but can undermine long-term agricultural resilience. Similarly, crop diversification without adequate markets and infrastructure may increase rather than reduce economic vulnerability.

A sustainable agricultural pathway for Jammu and Kashmir should therefore be based on climate-resilient crop production, scientifically planned diversification, efficient irrigation, improved soil management, modern horticulture, appropriate mechanization, digital agricultural services, stronger value chains, and greater participation of farmers in decision-making. Regional differences must remain central to agricultural planning because the environmental and socioeconomic conditions of Jammu, Kashmir Valley, and mountainous areas differ considerably.

The future agricultural strategy should ultimately seek to maximize productivity per unit of land, water, energy, and other resources, while simultaneously protecting the ecological foundations on which agriculture depends. Such an approach can enable Jammu and Kashmir to move from conventional production-oriented agriculture toward a more diversified, profitable, resilient, and environmentally sustainable agricultural system.

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