



An overview on the role of Indian traditional agriculture practice in climate change adaption

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Abstract

Global agricultural systems face hitherto unheard-of hazards due to climate change, especially in temperature-sensitive areas like South Asia. India's agriculture is extremely susceptible to climate variability and catastrophic weather events since it is heavily reliant on monsoon dynamics, temperature regimes, and the availability of natural resources. However, decades of ecological adaptation and community-based experimentation have shaped India's long-standing heritage of traditional agricultural practices. Biodiversity, soil regeneration, water conservation, crop diversification, and group resource management are all prioritized in these traditional systems.

The adaptive significance of traditional Indian agricultural techniques in mitigating climate-induced vulnerabilities is critically examined in this research. The study investigates how mixed cropping, indigenous seed preservation, agroforestry, organic nutrient management, and decentralized water collection improve resilience to climate variability using agroecological theory, indigenous knowledge systems, and regional case studies. The study makes the case that combining conventional agricultural knowledge with cutting-edge climate adaption techniques can greatly improve socioeconomic stability, environmental sustainability, and food security. Building climate-resilient agriculture in India requires acknowledging ancient traditions as dynamic adaptive systems rather than as outdated techniques.

Keywords: Climate change adaptation, indigenous knowledge systems, traditional agriculture, agroecology, resilience, India, sustainable farming, biodiversity

Introduction

In India, agriculture is more than just a business; it is the cornerstone of civilization, ingrained in ecological awareness, seasonal cycles, and cultural customs (Tamuli, 2025) [13]. Indian farmers have historically created context-specific agricultural methods for a variety of agroclimatic zones, including humid tropical regions, hilly areas, and arid deserts. Through communal experimentation, ecological pattern recognition, and intergenerational knowledge transfer, these systems emerged (Malapane, *et al* 2024) [9]. However, climate change is posing increasing obstacles to modern agriculture. Production hazards have increased due to rising temperature variability, changing monsoon patterns, falling groundwater levels, and extreme weather. Due to a lack of adaptive resources, smallholder farmers who make up the majority of India's agrarian population are disproportionately impacted (Harvey, *et al* 2014 & Touch, *et al* 2024) [7, 14].

Modern agricultural intensification has contributed to ecological imbalances, soil degradation, water scarcity, and decreased biodiversity even while it has raised yields through chemical inputs, enhanced irrigation, and high-yielding cultivars (Pretty & Bharucha, 2014) [11]. These elements make people more susceptible to climate stress. Traditional farming methods, on the other hand, place a strong emphasis on ecological balance, diversity, and minimal reliance on outside inputs qualities that strongly correspond with the concepts of climate adaptation. This study investigates how India's traditional agricultural systems serve as options for climate adaptation and considers how they might be incorporated into modern policy frameworks.

Climate Change and Agriculture in India

The agriculture sector in India is extremely sensitive to the weather. Important dangers associated with climate change include:

1. Variability in Rainfall

With its delayed onset, uneven spatial distribution, and brief, strong rainfall events, the Indian monsoon has grown more unpredictable (2025a) [2]. Such inconsistency increases the likelihood of floods and droughts, disturbs sowing patterns, and lowers crop output.

2. Increasing Temperatures

Increases in temperature have an impact on crop phenology, shorten growth seasons, and shorten grain-filling times (Ahmed, *et al* 2026) [4]. In crops like wheat and rice, heat stress during flowering drastically lowers yields.

3. Severe Weather Occurrences

Heat waves, droughts, floods, and cyclones are becoming more frequent and intense (Poynting, 2025). These occurrences cause long-term soil deterioration, livestock mortality, and crop devastation.

4. The Spread of Diseases and Pests

Increased crop losses result from the expansion of pest habitats and changes to insect life cycles caused by warmer temperatures (Subedi, *et al* 2023) [12]. In light of these difficulties, initiatives for climate adaptation must concentrate on improving ecological resilience, decreasing reliance on inputs, and bolstering socioeconomic stability areas in which traditional agriculture provides important insights.

India's Customary Agricultural Methods

1. Systems of Intercropping and Mixed Cropping

The resilience of farming systems is increased by the numerous significant agronomic and ecological advantages that mixed cropping and intercropping systems offer. Diversification, which lowers production risk by growing several crops in a single field, is one of the main benefits

(Vajiram, 2025)^[15]. The survival of the remaining crops can ensure at least a partial harvest and minimize financial losses for farmers in the event that one crop fails due to drought, pests, or other climate pressures. Furthermore, adding leguminous crops like pulses contributes significantly to increased soil fertility (Rajput *et al.*, 2025)^[16]. Through symbiotic bacteria in their root nodules, these crops naturally fix atmospheric nitrogen, providing the soil with vital nutrients and lowering the need for chemical fertilizers.

Additionally, by offering shade and reducing direct sunlight exposure to the soil surface, the canopy variety produced by cultivating crops with varying heights and leaf morphologies aids in reducing soil moisture loss (Castro-Bedriñana, 2026)^[17]. This helps retain soil moisture and lowers evaporation, which is especially advantageous in areas that are prone to drought and rain. Improved soil structure and health are also facilitated by the diversity of root systems among various crops (Xing *et al.*, 2025)^[18]. In order to prevent nutrient depletion in a single zone and improve soil aeration and stability, crops with deep and shallow roots use moisture and nutrients from several soil levels (Xing *et al.*, 2025)^[18]. When combined, these features make mixed cropping systems very successful in advancing sustainable agriculture and enhancing farmed systems' ability to adapt to changing climate conditions.

2. Native American Crop Types (Landraces)

Native crop varieties, also known as landraces, have a number of adaptive characteristics that make them ideal for growing in climatically changing environments. These traditional cultivars' ability to withstand environmental challenges like drought and salinity is one of their most important traits. This allows them to thrive and yield even in areas with little rainfall or saline soils (Panda *et al.*, 2021)^[19]. Additionally, because these types have developed over time in intimate association with the surrounding ecology, they naturally demonstrate resistance to numerous local pests and illnesses (Hatt & Döring, 2023)^[20]. This resilience encourages environmentally friendly farming methods and lessens the need for toxic pesticides.

The capacity of native crops to flourish on marginal soils, such as those with low fertility, rocky terrain, or restricted nutrient supply, is another crucial characteristic (Shahid & Al-Shankiti, 2013)^[21]. This flexibility enables farmers in areas with limited resources to successfully grow crops without significantly depending on outside inputs. Additionally, traditional crop types are frequently prized for their high nutritional content, which greatly enhances food security and dietary diversity (Banerjee *et al.*, 2024)^[22]. For instance, millets like ragi (finger millet) are very high in vital elements like calcium, iron, and dietary fiber, which makes them both nutritionally advantageous for human health and climate resilient.

3. Methods for Conserving Water and Soil

India's traditional water management practices show the profound ecological knowledge that farming communities have gained to deal with climate variability and water constraint. The Khadin system, which is used in Rajasthan, involves building earthen embankments across slopes to collect surface runoff during the monsoon season (Prasad *et al.*, 2004)^[23]. During the dry season, the collected water gradually seeps into the soil, supplying enough moisture for agricultural production. The Johad, a little earthen check dam that is frequently seen in Rajasthan and other regions of North India, is another significant traditional building. In

order to increase the amount of water available for home and agricultural use, johads are made to store rainfall and aid in groundwater recharge (Hussain *et al.*, 2014)^[24].

Tank irrigation systems have long been essential to agricultural water management in South India, especially in areas like Tamil Nadu and Karnataka (Deka & Balamurugan, 2023). In order to provide a steady supply of irrigation water during dry seasons, these tanks community-managed reservoirs collect and store rainwater. When combined, these age-old methods of conserving water increase soil moisture, raise groundwater levels, and make agricultural systems more resilient in areas where water shortage is a problem.

4. Integrated Farming Systems and Agroforestry

Agroforestry systems significantly improve the resilience and sustainability of agricultural landscapes through ecological contributions. Carbon sequestration is one of the main advantages; trees assist to slow down climate change by absorbing carbon dioxide from the atmosphere and storing it in their biomass and the surrounding soil (2025b)^[26]. Additionally, trees boost soil fertility by accumulating leaf litter, which breaks down over time and adds vital minerals and organic matter to the soil. Additionally, agroforestry systems are crucial for regulating the microclimate in agricultural regions (Quandt *et al.*, 2023)^[27]. Trees help regulate soil moisture levels, provide shade, and lessen temperature swings, all of which improve crop development conditions. Additionally, trees serve as natural windbreaks, lessening the impact and speed of powerful gusts that can harm crops and erode soil (Smith *et al.*, 2021)^[28]. Agroforestry improves agricultural productivity and environmental stability through these ecological processes.

5. Conventional Nutrient and Pest Management

Traditional agricultural systems confront a number of structural limitations that restrict their widespread acceptance and viability in the contemporary agricultural landscape, despite their many strengths and adaptive advantages. One significant issue is that legislative frameworks frequently favor high-input, chemical-intensive farming technologies, such as mechanization, synthetic fertilizers, and high-yielding cultivars, which might marginalize conventional farming practices (Cakmakci *et al.*, 2025)^[29]. Additionally, because commercial markets frequently favor homogeneous, high-volume commodities, market mechanisms tend to undervalue traditional crops like millets and indigenous variations, which reduces the financial incentives for farmers to continue growing traditional crops.

Urban migration, especially among younger generations, is a major worry since it weakens the intergenerational transfer of indigenous farming traditions and causes a progressive loss of traditional knowledge (Ramavhunga, 2025)^[30]. Additionally, the scalability and economic effectiveness of some traditional practices are limited by the fragmented landholdings that are prevalent in India. Lastly, indigenous agricultural knowledge is less recognized in official agricultural research and policy institutes due to a lack of scientific validation and research documentation (Pandey *et al.*, 2017)^[31]. In order for traditional agricultural systems to effectively contribute to climate-resilient and sustainable agriculture, these structural hurdles must be addressed.

Traditional Practices' Role in Climate Adaptation

The following are the various roles played by the traditional practices in the adaptation of climate change:

S.No.	Traditional Practices	Adaption of Climate Change
1	Ecological Stability and Biodiversity	System stability is improved by ecological diversity. Compared to monocultures, diverse farms are less vulnerable to catastrophic pest outbreaks or climate shocks (2026) [3].
2	Water Efficiency and Security	Conventional water harvesting methods improve infiltration and decrease runoff (2023) [1]. Crop survival during dry spells is enhanced by moisture conservation.
3	Preservation of Genetic Resources	Crop genetic diversity is safeguarded via native seed systems (Behl, <i>et al</i> 2025) [5]. This genetic pool is essential for creating cultivars that can resist changing climate conditions.
4	Economic and Social Resilience	Conventional methods lower manufacturing costs and lessen reliance on outside resources (Hamadani, <i>et al</i> 2021) [6]. In times of crisis brought on by climate change, community institutions enhance the ability to adapt collectively.
5	Co-benefits of Climate Mitigation	Carbon storage in soils and biomass is increased by the addition of organic matter and tree-based systems (Krause, <i>et al</i> 2025) [8]. This increases productivity while reducing greenhouse gas emissions.

S.No.	Frameworks	Particulars
1	Documentation and Research	Agroecological research is required to systematically document indigenous practices.
2	Sovereignty of the Seed	Enhancing local seed banks protects farmer sovereignty and biodiversity.
3	Rewarding Ecosystem Services	Adoption of agroforestry may be promoted by payments for ecosystem services, such as carbon credits.
4	Market Connections	Farmers' income is increased by promoting traditional crops like millets through value chains and certification.
5	Extension Services	Climate-smart innovations and conventional knowledge should be included in training programs.

Integrating Traditional Practices into Climate Policy

Frameworks for climate adaptation need to shift toward inclusive agricultural transformation.

Discussion

Conventional farming methods are examples of ecologically rational adaptive systems. It is crucial to modernize, scientifically validate, and include these methods into more comprehensive agricultural transformation initiatives rather than romanticizing tradition. The most promising solution is a hybrid one that combines indigenous knowledge with climate forecasts, precision irrigation, and sustainable market mechanisms.

Conclusion

Ecological resilience, socioeconomic sustainability, and adaptive intelligence are all embodied in Indian traditional agriculture systems. These methods offer context-specific solutions that can improve environmental stability and food security in the age of climate change. Instead of viewing traditional agriculture as a marginal relic, policymakers, scholars, and development professionals must acknowledge it as a strategic asset. Building a resilient and sustainable agricultural future in India would require incorporating traditional knowledge into climate adaption measures.

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