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Legal Frameworks and Agronomic Innovations: Impact of Climate Change on Food Security Laws and the Role of Climate-Resilient Crops in India

Dr. Shourie Anand Singh[1]* and Dr. Namita Vashishtha[2]

*[1]*Assistant Professor, Faculty of Law, University of Delhi*
[2]Assistant Professor, Faculty of Law, University of Delhi

***Corresponding Author:** Dr. Shourie Anand Singh*
**Assistant Professor, Faculty of Law, University of Delhi*

Abstract

Even though food security laws exist, with one of the prime legislations being the National Food Security Act (NFSA), 2013, Indian legal frameworks are nevertheless not fully inclined to integrating climate change risk into their design and implementation. Thus, the present food security framework does not adequately address the emerging threats posed by climate variability and thus remains limited in its capability to safeguard food security in a changing environment. And while agronomic innovations like climate-resilient crops have shown promise in reducing those risks, their uptake remains patchy because of regulatory, financial, and awareness limitations. Thus, the linkages between legal frameworks and agronomic developments in the Indian context need to be examined in current times.

Introduction

Climate change, as a global issue, threatens agriculture and food security, working against crop production, truncating the growing period, and increasing the occurrence of adverse weather phenomena such as droughts and floods (IPCC, 2022). Because of reduced efficiency and failed crops, climate change is predicted to cut staple crop yields by as much as 30% by the year 2030 (Jain et al, 2015). As the heightened agrarian populace of the country, India is, therefore, highly vulnerable to climate impacts on agriculture, considering also the diverse agro-ecological zones (Kumar et al., 2021).

By modifying temperature and precipitation patterns, such changes place at risk staple crops like rice, wheat, and pulses and by extension threaten the availability and nourishment of food for millions (Singh & Aggarwal, 2020). Such shifts require the urgent implementation of adaptation measures ranging from legal changes to agronomic commitments toward sustainable food security. Climate resilient crops offer a solution to this problem.

Objectives

This article analyses of current food security laws and policies in India in view of their responsiveness to climate change impacts. This paper also assesses the contribution and viability of agronomic innovations with particular focus on climate-resilient crops to improve food security under climate stress as given (Singh & Rao, 2019). It shall also address whether India's legal frameworks address climate-related risks to food security or not by comparing situations in Punjab and Maharashtra. If yes, then to what extent do climate-resilient crops contribute to mitigating food insecurity in India?

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2. Literature Review

Climate change has far-reaching effects on agricultural productivity by Brazier heat, irregular rainfall, and concurrent extremes in weather, thus reducing crop yields and jeopardizing food security (Kumar et al., 2021). In India especially, the effects are especially severe since agriculture depends on monsoon rain and small farmers are vulnerable (Kumar et al., 2021). According to studies, there is still risk of yield decline for staple crops such as wheat and rice, which may heighten insecurity in already vulnerable locations (Singh & Aggarwal, 2020).

2.2 Legal Frameworks on Food Security in India

The National Food Security Act (NFSA), 2013, is landmark legislation that aims to guarantee access to subsidized food by a large part of the population (Sharma, 2020). In contrast, the Disaster Management Act, 2005, provides for managing food-related emergencies caused through natural disasters. However, there are no explicit mechanisms in the existing legal frameworks that deal with the dynamic and long-term risks that climate change poses to food production and distribution (Sharma, 2020). It is such a gap that limits the ability of legislation to respond to changed climate challenges (Das, 2022).

2.3 International Legal Instruments

The importance of attaining food security in climate-resilient agricultural development has been at the fore of various international treaties, for instance, the Paris Agreement under the United Nations Framework Convention on Climate Change (UNFCCC, 2015) and the Agenda 2030-SDGs (UNFCCC, 2015). These global instruments put pressure on countries, including India, to bring in climate adaptation measures into their legal and agricultural policies (Patel et al., 2022).

2.4 Agronomic Innovations

However, cultivation-resilient and climate-resilient crop varieties were developed through scientific and agronomic research. Such as seeds of drought-tolerant crop varieties, flood-resistant varieties, and biofortified varieties that could resist adverse climatic conditions (Singh & Rao, 2019). Since the adoption of these crops in India, it has given good results in the stabilizing of yields and nutritional outcomes, especially in semi-arid and drought-prone regions (Patel et al., 2022). However, despite this advantage, regulatory hurdles and lack of awareness among farmers have prevented the diffusion of these innovations (Das, 2022).

2.5 Gaps in Legal and Agricultural Adaptation

Climate-responsive food security policies confront a plethora of implementation challenges, including fragmented governance, funding gaps, and the lack of some coordination perhaps between agricultural research and legislation (Das, 2022). Technology transfer and dissemination of climate-resilient crops to poor farmers also continue to be hampered by inadequate extension systems and incentive mechanisms for farmers, particularly marginalised ones. Thus, plugging these existing gaps will go a long way towards improving the resilience of India's food system.

3. Methodology

3.1 Research Design

This research combines the doctrinal approach with empirical case studies, through qualitative design, to analyze in an exhaustive manner the food security laws and agronomic innovations in India (Creswell, 2014). The doctrinal approach comprises an exhaustive analysis and scrutiny of existing legal frameworks and policies relevant to food security and climate change, whereas case studies

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bring in practical insights into the adoption of climate-resilient crops in particular states of India (Yin, 2018).

3.2 Data Collection

Like ensuring an elaborate triangulation of data sources, primary sources consisted of legal documents such as National Food Security Act, Disaster Management Act, and related policy papers issued by the Government of India (Sharma, 2020). In addition, agricultural adaptation and climate change reports of the Government will also be reviewed (MoA, 2021-22). Selected case studies of Maharashtra and Punjab look at practical application on climate-resilient crops, exploring the factors affecting their adoption and how they are embedded in legal and policy frameworks at the local level (Patel et al., 2022).

3.3 Data Analysis

The collected qualitative data was analyzed using thematic analysis to identify patterns, themes, and gaps related to legal frameworks and agronomic innovations (Braun & Clarke, 2006). Comparative legal analysis was applied to examine how different laws and policies address climate risks to food security and how they align with international commitments (Stone, 2016). The case studies were analyzed to understand contextual factors affecting the success or limitations of climate-resilient crop adoption and the interplay with relevant legal provisions (Yin, 2018).

- **Legal Documents**: Provide the statutory framework for food security and disaster response in India
- **Policy Papers & Reports**: Offer insights into government-led climate-adaptation strategies in agriculture https://agriwelfare.gov.in/en/Magazine.
- **Academic & News Case Studies**: Illustrate real-world examples of agronomic innovations and their uptake.

4. Analysis

4.1 Evaluation of Food Security Laws under Climate Change Stress

India's National Food Security Act (NFSA) ensures a legal right to subsidized food for nearly two-thirds of the population, representing a major strength in social safety net (Sharma, 2020). Although climate-resilient crops are not specifically mentioned in the NFSA, it does offer a legal guarantee of food access, which necessitates a stable and sustainable agricultural system. Thus, climate-smart agriculture, which includes the use of climate-resilient crop varieties, is essential to long-term success in reaching NFSA's objectives. However, the NFSA lacks explicit provisions for climate-related disruptions such as erratic monsoons or prolonged droughts, reducing its adaptability to shifting agro-climatic conditions. The Disaster Management Act, 2005 provides a framework for disaster response and relief, yet its food security provisions are reactive rather than preventive, focusing on post-disaster relief rather than building long-term resilience in agricultural production. As such, the current food laws perfectly establish distribution while making no provision for climate adaptation measures such as anticipatory action plans or climate risk assessments to be integrated within their very core (Das, 2022).

4.2 Role of Climate-Resilient Crops

Climate resilient crops are tough to beat the negative consequences of climate changes. They are robust and are not affected by heat, drought, floods, pests, salinity etc. Through their weather-stabilizing yields during stress conditions, climate-resilient crop varieties are considered by Singh & Rao (2019) to have been central to agronomic success: drought-tolerant maize, flood-resistant rice, and biofortified millets. Adoption of drought-tolerant sorghum was reported to increase average yields by 15% to 20% during low-rainfall seasons in semi-arid regions of Maharashtra, thereby

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ensuring food and income sustainability for farmers (Patel et al., 2022). Biofortified pearl millet may also act as a potential crop to tackle micronutrient deficiency by resisting heat stress, thereby assisting nutritional security along with yield stability (Patel et al., 2022). However, various impediments that limit their widespread adoption include poor multiplication of seeds, and less varietal trials in diverse agro-ecologies (Singh & Rao, 2019).

4.3 Integration of Agronomic Innovations into Legal Frameworks

Current policies offer several mechanisms to support climate-resilient crops: for instance, the Rashtriya Krishi Vikas Yojana provides grants for seed research, and the Paramparagat Krishi Vikas Yojana incentivizes organic and stress-tolerant farming (Das, 2022). The NFSA's implementing regulations allow state governments to procure climate-resilient varieties under public distribution schemes, but without mandatory targets or dedicated budget lines, uptake remains ad hoc. Furthermore, while extension services are legally mandated under the Essential Commodities Act, their focus has been skewed towards traditional high-yield varieties, limiting dissemination of innovative seed technologies (Das, 2022). Strengthening legal mandates such as embedding minimum procurement quotas for resilient crops-could institutionalize agronomic innovation within food security law.

4.4 Barriers to Effective Implementation

Several barriers impede the translation of law and policy into field-level resilience. Institutional fragmentation between agriculture, environment, and disaster management ministries leads to overlapping mandates and policy incoherence (Das, 2022). Financial constraints—both in R&D funding for crop innovation and in subsidy allocation for smallholder seed purchases—further restrict progress. Knowledge dissemination remains weak: extension agents often lack training in climate-smart practices, and farmers face low awareness of available resilient varieties (Das, 2022). Combined, these institutional, financial, and informational gaps undermine the potential of legal and agronomic measures to jointly enhance food security under climate change.

5. Case Studies

5.1 Maharashtra

In the drought-prone Marathwada region of Maharashtra, the introduction of drought-tolerant maize varieties such as 'DHAN 261' has significantly enhanced yield stability during erratic rainfall seasons. State-level programs under the Rashtriya Krishi Vikas Yojana provided seed subsidies and technical support, leading to a 18 % increase in average maize yields between 2018 and 2021 (Patel et al. 2022). The Maharashtra Agricultural Competitiveness Scheme further bolstered adoption by integrating drought-tolerant seeds into its procurement policies, ensuring that public distribution channels prioritized resilient varieties. However, Water pollution, drainage and waste management, biodiversity, and the use of chemical pesticides and fertilizers are examples of negative measures. The following are some mitigation strategies: a) establish systematic drainage facilities for wastewater generated; b) separate and process solid waste according to its grade, using it to make fertilizer and fish meal as an ingredient in animal feed formulations; c) make sure that drainage network improvements are a standard feature at livestock markets; d) encourage farmers to use special measures like drip irrigation systems and crop management techniques to reduce groundwater usage; and e) prevent polluted waters from reaching recharge points and aquifers.

Despite these gains, farmers report challenges in accessing certified seed stock and limited extension outreach, underscoring the need for strengthened legal mandates on seed quality control and distribution (Das 2022).

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5.2 Punjab

The Green Revolution heritage of Punjab could now be furthered with the recent release of biofortified wheat varieties like the 'PBW 824' with enhanced micronutrient content in addition to heat tolerance. Policy incentives under Pradhan Mantri Annadata Aay Sanrakshan Abhiyan (PM-AASHA) entailed MSP bonanzas for biofortified wheat, giving a bit more than twenty-five percent increase in farmer uptake during the 2020-2022 cropping seasons (Singh & Rao, 2019; Patel et al., 2022). The government of Punjab amended the guidelines for the Public Distribution System to allow procurement under the priority category for biofortified grain so that the procurement mandate would be aligned with the objective of nutritional security (Sharma, 2020). However, some lacunae still exist in promotion through demonstration across farms and farmer training, thereby limiting awareness on the agronomic practices for these new varieties.

5.3 Comparative Insights

A comparative analysis of Maharashtra and Punjab shows that while both states have utilized legal support frameworks to promote climate-resilient crops, their approaches differ largely along lines of focus and efficacy. Maharashtra put out money for seed subsidies and varietal trials in marginal environments, whereas Punjab concentrated on creating price incentives and integrating the system within existing procurement paradigms (Das 2022). Among the key lessons learned are the inclusion of clear procurement targets for resilient varieties within state food security legislation, alongside the need to couple financial incentives with strong extension support systems to ensure farmers are aware of the options available. The best practices highlight the importance of having multi-stakeholder governance platforms that facilitate collaboration between agencies of agriculture, law, and disaster management to navigate institutional silos and achieve policy coherence (Singh & Aggarwal 2020).

6. Recommendations

6.1 Legal Reforms: Enhancing Climate Responsiveness in Food Security Laws

To embed climate adaptation into core food security legislation, the NFSA should be amended to mandate periodic climate risk assessments and anticipatory action plans, ensuring benefit entitlements can adjust dynamically in response to forecasted weather extremes (Das, 2022). Additionally, the Disaster Management Act could be strengthened by incorporating forward-looking measures—such as trigger-based disbursements for seed and input support—rather than purely post-disaster relief. Establishing statutory quotas for procurement of climate-resilient crop varieties under public distribution schemes would institutionalize agronomic innovation within legal frameworks (Das, 2022).

6.2 Policy Measures: Strengthening Support for Agronomic Innovations

Policy instruments should prioritize incentives for both seed developers and farmers. Enhancing seed subsidy schemes under the Rashtriya Krishi Vikas Yojana to cover a greater share of the cost for climate-resilient varieties will reduce adoption barriers (Patel et al., 2022). Introducing tax credits or concessional credit lines for companies investing in stress-tolerant seed R&D can spur private sector participation (Singh & Rao, 2019). Furthermore, aligning minimum support price (MSP) bonuses with resilience traits—similar to Punjab's biofortified wheat incentives—can encourage farmers to cultivate climate-smart crops (Patel et al., 2022).

6.3 Capacity Building: Awareness Programs for Farmers and Extension Services

Strengthening extension networks is critical to bridge the knowledge gap. Training modules on climate-resilient agronomic practices and seed handling should be integrated into existing Krishi Vigyan Kendra curricula, with performance metrics linked to outreach on resilient varieties (Das,

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2022). Farmer field schools and on-farm demonstration plots can showcase real-world benefits, boosting acceptance and peer learning (Singh & Aggarwal, 2020). Digital platforms—like mobile advisories and e-extension—should be leveraged to disseminate timely climate forecasts and crop management guidance, as supported by the reports of Ministry of Agriculture. Krishi Vigyan Kendras or KVKs use need-based trainings, on-farm trials, and demonstrations to evaluate location-specific technological models in agriculture and related businesses. KVK primarily uses a cluster method in its adopted communities to carry out its mandated activities and sponsored program by forming the the NABARD-funded Technology Transfer Clubs (TTCs).

6.4 Research and Development: Funding and Collaboration for Crop Innovation

Sustained funding for participatory breeding programs is needed to develop varieties tailored to local agro-ecologies (Singh & Rao, 2019). Public-private research partnerships, supported by grants from bodies such as the Indian Council of Agricultural Research and the World Bank, can accelerate development of next-generation stress-tolerant seeds (UNFCCC, 2015). Establishing multi-stakeholder innovation hubs—bringing together legal experts, agronomists, and climate scientists—will foster holistic approaches to crop resilience research and policy translation (Das, 2022).

7. Conclusion

Thus, one can say that while India's foundational food security laws—the National Food Security Act and the Disaster Management Act—provide crucial safety nets, they currently lack explicit, proactive mechanisms to anticipate and adapt to climate-induced agricultural disruptions. Empirical evidence from Maharashtra and Punjab highlights how state-level legal support has enabled adoption of drought-tolerant maize and biofortified wheat, yet systemic gaps in procurement mandates and seed distribution constrain scalability (Patel et al., 2022; Das, 2022).

Climate-resilient crops have shown clear benefits in stabilizing yields, improving nutritional outcomes, and bolstering farmer incomes under stress conditions (Singh & Rao, 2019; Singh & Aggarwal, 2020). However, limitations in seed multiplication capacity, extension outreach, and institutional coordination underscore the need for stronger policy incentives and capacity-building initiatives (Das, 2022).

To safeguard India's food security in the face of climate change, integrated approaches are essential. Legal reforms must embed climate risk assessments and mandatory procurement quotas for resilient varieties within national laws. Simultaneously, enhanced policy measures, farmer training programs, and sustained R&D partnerships will ensure that agronomic innovations are effectively translated into field-level resilience (UNFCCC, 2015; Das, 2022). Only by harmonizing law, policy, and agricultural science can India build a robust, climate-adaptive food system.

The year 2023 has been declared the 'International Year of Millets' following the unanimous adoption of the motion by the Indian government in the UN General Assembly in 2021. The "International Year of Millets" will offers a unique opportunity to increase production globally, to encourage better crop rotation use, ensure that millets are processed and consumed efficiently, and promote increased connectivity across food systems in order to promote millets as an essential component of the food basket. Millets are a perfect example of climate resilient crop. The International Year will (i) expand knowledge of the importance of millets for food security and nutrition, (ii) inspire stakeholders to enhance the sustainability and quality of millets' production, and (iii) draw attention to the need for more funding for research and development.

End Notes

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