

Climate Change, Food Security and Livelihoods in Kerala: A Triple Challenge for the 21st Century

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Abstract

Kerala, long regarded as a model of human development in the Global South, now confronts an intensifying triple challenge in the 21st century: climate change, food insecurity and livelihood vulnerability. Rising temperatures, erratic monsoons and an increased frequency of extreme weather events have fundamentally altered the state's ecological and socio-economic landscape. These climatic shifts are no longer distant projections but lived realities that directly undermine agricultural productivity, disrupt marine ecosystems and destabilise rural incomes, thereby threatening the very foundations of food security and sustainable livelihoods. Agriculture, which remains predominantly rain-fed and dominated by smallholders, is very sensitive to climate variability. Paddy cultivation, once central to Kerala's agrarian economy and food system, has witnessed a dramatic contraction in area. Today, Kerala heavily dependent on inter-state imports for rice and are vulnerable to supply shocks. The fisheries sector, faces parallel pressures from climate change. Livelihood vulnerability is compounded by the climate change impacts affects particularly for women and landless labourers. In response, Kerala has initiated a suite of policy measures, including the State Action Plan on Climate Change (SAPCC), the Kerala Climate-Resilient Agri-Value Chain Modernisation (KERA) project and the Kerala State Biodiversity Strategy and Action Plan (K-SBSAP) 2025–2035. The 2026–27 budget allocates ₹2,071.95 crore to agriculture and allied sectors, with dedicated funding for climate-resilient agriculture, paddy revival missions and fisheries transformation. Thus, securing Kerala's future demands an integrated, cross-sectoral approach that strengthens local food systems, diversifies and protects livelihoods, embeds equity and health in adaptation planning and scales up climate finance and innovation. The paper aims to examine the interlinkages among climate change, food security and livelihoods in Kerala. The choices made in this decade will determine whether Kerala navigates the 21st century through deepening vulnerability or emerges as a model of climate-resilient, inclusive and sustainable development for tropical regions worldwide.

Keywords: Climate Change, Food Security, Livelihoods, Kerala, Agriculture, Triple Challenge.

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INTRODUCTION

Kerala, long celebrated as a model of human development in the Global South, now confronts an intensifying triple challenge in the 21st century: climate change, food insecurity, and livelihood vulnerability (Salim *et al.*, 2018; Nair *et al.*, 2026). Rising temperatures, erratic monsoons and an increased frequency of extreme weather events have fundamentally altered the state's ecological and socio-economic landscape, transforming climatic shifts from distant projections into lived realities that directly undermine agricultural productivity, disrupt marine ecosystems, and destabilise rural incomes (Tandon and Chandrasekhar, 2024; Sahadudheen *et al.*, 2026). These changes threaten the very foundations of food security and sustainable livelihoods in a state where agriculture remains predominantly rain-fed and dominated by smallholders,

making it acutely sensitive to climate variability. Paddy cultivation, once central to Kerala's agrarian economy and food system, has witnessed a dramatic contraction in area, leaving the state heavily dependent on inter-state rice imports and vulnerable to supply shocks (Thomas, 2011; Anuradha and Rejimon, 2025). The fisheries sector faces parallel pressures, with warming seas and changing fish migration patterns reducing catches and threatening the livelihoods of over 1.4 million people along Kerala's coastline (Jaffer and Shukoor, 2026). Livelihood vulnerability is compounded by the disproportionate impacts on women and landless labourers, who often lack the resources and social safety nets to adapt to these rapid environmental changes.

In response, Kerala has initiated a suite of policy measures, including the State Action Plan on

Climate Change (SAPCC), the Kerala Climate-Resilient Agri-Value Chain Modernisation (KERA) project, and the Kerala State Biodiversity Strategy and Action Plan (K-SBSAP) 2025-2035. The 2026-27 budget allocates ₹2,071.95 crore to agriculture and allied sectors, with dedicated funding for climate-resilient agriculture, paddy revival missions, and fisheries transformation, reflecting a strategic commitment to embedding equity and health in adaptation planning (GoK, 2026). The Kerala Climate Resilient Agri-Value Chain Modernization (KERA) project, implemented with World Bank support, aims to enhance climate resilience, boost productivity and strengthen market linkages across priority agri-value chains, directly benefiting over 400,000 farmers statewide (World Bank, 2024). The paper aims to examine the interlinkages among climate change, food security and livelihoods in Kerala. The choices made in this decade will determine whether Kerala navigates the 21st century through deepening vulnerability or emerges as a model of climate-resilient, inclusive and sustainable development for tropical regions worldwide.

Climate change in Kerala: From projection to lived crisis

Kerala's climate is no longer a matter of distant projections but a lived crisis unfolding in real time through intensifying heat, erratic monsoons and recurrent extreme weather events. The state has recorded eight of its ten warmest years during 2012–2021, with long warm spells, altered rainfall distribution and increased frequency of floods, droughts, and heatwaves now defining everyday life for millions (Oommen *et al.*, 2022; Paul, 2026). The 2018 floods, described as the worst in a century, affected more than 5.4 million people, claimed over 400 lives, and caused economic losses estimated at over \$3.8 billion (Young *et al.*, 2022), while the 2016 drought severely impacted agriculture and hydrology across northern districts (Aparna and Chithra, 2026). These are no longer one-off anomalies but harbingers of a new climate regime in which disasters that were once considered rare are becoming increasingly frequent (Joy and Mohandas, 2026).

Recent evidence underscores this shift. A 2025 study recalibrated the return period of 2018-scale floods from once in 150 years to once every 25 years, with flood magnitudes projected to increase by 29–40% when climate change vulnerability is factored in (Rahul, 2025). In 2025 alone, Kerala experienced extreme weather on 173 days, including heavy rainfall, flooding, thunderstorms, and lightning (Pandey and Sengupta, 2025). The monsoon, once a reliable lifeline, has become highly uneven, with long dry spells broken by sudden bursts of heavy rain, mini-cloudbursts, and flash floods that overwhelm drainage systems and trigger landslides. These changes are rapidly warming Arabian Sea, which elevates surface temperatures, increases atmospheric moisture, and creates favourable conditions for intense, short-duration rainfall events.

Coastal communities face additional threats from rising sea levels, intensified heatwaves, and accelerating coastal erosion. Studies warn that Tamil Nadu and Kerala coastlines could face increasing environmental and socioeconomic stress over the next 15 years, with implications for public health, housing, transport, and tourism infrastructure (Azim Premji University, 2026). The human costs are profound. Between May and October 2018, India accounted for the world's second-largest disaster displacement, with Kerala being the most-affected state, reporting more than half of the two million disaster displacements that took place in India that year. Children accounted for about 15% of total fatalities, and survivors returning from relief camps faced infectious diseases, malnutrition and declining mental health (Joy and Mohandas, 2026). Thus, Kerala's experience illustrates a broader truth: climate change is not a future threat but a present reality reshaping lives, landscapes and livelihoods.

Food security under stress: The paddy paradox and beyond

Food security in Kerala is increasingly perilous, not because of absolute scarcity but because of structural dependence on external supplies and climate-sensitive production systems. Rice, the state's staple, illustrates this paradox starkly. Paddy cultivation area has collapsed from over 8.75 lakh hectares in 1970–71 to around 1.73–1.80 lakh hectares in 2023–24, with production falling from 7.51 lakh tonnes in 2000–01 to 5.30 lakh tonnes in 2024–25 (Sheeba, 2018; Anuradha and Rejimon, 2025). Despite yield improvements, domestic rice production now meets only about 10% of Kerala's consumption, leaving the state heavily reliant on imports from other states (Arun, 2025). This "paddy paradox"—shrinking area but rising yield - reflects land-use change, labour shortages, water management challenges and increasingly, climate-induced rainfall variability and temperature stress. Unseasonal rains during harvest have forced farmers to leave ripe crops in flooded fields, leading to spoilage, contamination and loss of both food and fodder. Heat stress and altered monsoon patterns are also reducing yields in other crops; for instance, wheat crops in Kerala saw drops of more than 500 kg per hectare during and after flash droughts (Nair *et al.*, 2026). Beyond rice, climate change threatens plantation crops (cardamom, tea, coffee, rubber) through long warm spells and heavy rainfall, while also increasing pest and vector populations that further depress yields (Kumar, 2025). The cumulative effect is a weakening of local food systems, higher price volatility and reduced dietary diversity—especially for low-income households.

Livelihoods at risk: Agriculture, fisheries and coastal communities

- **Agriculture and smallholder vulnerability:** Over 70% of Kerala's agriculture is rain-fed, making it acutely sensitive to monsoon variability and extreme events. The 2016 drought severely impacted agricultural productivity and hydrology, while the

2018 floods caused massive losses across agro-industries and related sectors. For smallholders, climate shocks translate into delayed harvesting, lower grain quality, reduced incomes and in some cases, crops rendered unsafe for consumption. The decline in paddy cultivation has broader livelihood implications. Paddy fields function as wetlands that regulate floods, recharge groundwater and support allied activities. Their loss weakens natural buffers and reduces rural employment, particularly for women and landless labourers (Giridhar *et al.*, 2022; Sumathy *et al.*, 2026).

- **Fisheries and the blue economy under pressure:** Marine fisheries support a large population of small-scale fishers along Kerala's coastline, providing critical income, employment and protein. However, climate-driven ecological instability is reducing fishing days, shrinking stocks and increasing income volatility. Small-scale fishers, who depend on daily catches, face fewer workdays, unstable earnings and growing safety risks, prompting many youths to abandon fishing altogether (Jaffer and Shukoor, 2026). Aquaculture offers some hope, with steady growth in output partially offsetting declines in marine production. Yet, without robust governance, climate-resilient practices and social protection, the sector risks exacerbating inequalities and ecological stress.
- **Coastal erosion, sea-level rise and infrastructure risk:** Rising sea levels and intensified heatwaves threaten not only fisheries but also coastal settlements, tourism infrastructure and critical public assets. Studies warn that Tamil Nadu and Kerala coastlines could face increasing socioeconomic stress over the next 15 years, with implications for public health, housing, and transport. Over 60% of Kerala's coastline is facing severe erosion, driven by sea-level rise, extreme weather and uncoordinated infrastructure projects (Roy *et al.*, 2023). In downdrift locations, hard infrastructure like seawalls and groynes can hasten erosion while endangering nearby communities, roads and railroads. Local livelihoods are impacted by traditional fishing communities' displacement, housing loss and diminishing fish stocks (Vadakepat Menon, 2024; Saikrishnan *et al.*, 2024).

The hidden dimensions of food insecurity

The impacts of climate change on food security extend beyond calories to nutrition, health and gender equity. Erratic monsoons, droughts and floods reduce agricultural productivity, worsen malnutrition and contribute to stunted growth, particularly among rural children. Food scarcity disproportionately affects women, whose nutritional needs are higher due to menstruation, pregnancy, and lactation, yet who often eat last and least in resource-constrained households (Basistha *et al.*, 2025). Mental health is another under-recognised dimension. Post-2018 floods, post-traumatic stress disorder (PTSD), anxiety and depression persisted

for over a year, with women experiencing higher distress levels (Asim *et al.*, 2022). Jose and Fenn (2021) evaluated the post-traumatic stress disorder and resilience among flood affected farmers of Kerala, India and concluded that, following the 2018 and 2019 floods, PTSD was more common among central Kerala farmers in inner Pathanamthitta than in coastal Alappuzha, which is more accustomed to the whims of the sea. Climate-induced crop failures, income shocks and displacement amplify psychological stress, especially among farming and fishing communities.

In short, the hidden dimensions of food insecurity in Kerala, when viewed through the lens of climate change, reveal a complex web of nutritional deficits, gendered vulnerabilities, mental health burdens, and cultural erosion that extend far beyond simple calorie shortages. While the state is often celebrated for its high human development indicators, climate-induced disruptions to agriculture, fisheries and traditional food systems are quietly undermining nutrition, health and equity, particularly among women, children, tribal communities, and small-scale farmers and fishers. One of the most alarming yet under-recognised consequences is the rising prevalence of childhood undernutrition in climate-vulnerable areas. In flood-prone regions of Alappuzha, studies have found that 28.25% of children are underweight, 31% are stunted and 21% are wasted—figures significantly worse than recent state averages (Babu *et al.*, 2025). Girls face disproportionately higher odds of being underweight, stunted, and wasted compared to boys, reflecting deep-seated gender inequalities that limit their access to nutritious food, healthcare, and education.

Women bear a disproportionate burden of this crisis. In paddy cultivation, women undertake most of the menial labour, working long hours in flooded fields under intensifying heat and humidity, which exposes them to heat stress, vector-borne diseases, and physical exhaustion. With every 1°C rise in temperature, paddy yields decline by 10–15%, leading to food and income insecurity that hits women farmers hardest. Surveys in Kerala and neighbouring regions show that women paddy farmers suffer more severe physical and mental health impacts from climate-induced disasters than men, yet they have far less capacity to withstand income losses or access adaptive resources. Female-headed fisher households in Ernakulam district also exhibit higher livelihood vulnerability (LVI-0.40) compared to male-headed households (LVI-0.37), underscoring the need for gender-inclusive climate adaptation and disaster-risk reduction strategies (Natarajan *et al.*, 2024; Jain, 2025).

Mental health is another hidden dimension of food insecurity linked to climate change. Farmers in high-exposure areas report significantly higher rates of depression (49.7% vs 36.0% in low-exposure areas), anxiety, and stress, with increased flooding frequency strongly associated with all three conditions. Droughts,

crop failures, and income shocks trigger psychological distress, particularly among smallholders and landless labourers who lack safety nets. Post-2018 floods, PTSD, anxiety, and depression persisted for over a year, with women experiencing higher distress levels. These mental health impacts, in turn, reduce productivity, weaken household food management, and perpetuate cycles of poverty and malnutrition (Balakrishnan *et al.*, 2025; Basistha *et al.*, 2025; Kaewvijit *et al.*, 2026).

For tribal and indigenous communities, climate change acts as a threat multiplier on already fragile food systems. Among Wayanad's Paniyan and Kattunayakan communities, chronic nutritional deficiencies are widespread, with 40.3% of individuals underweight and children showing some of the worst birth-weight outcomes in the district. Adivasi women suffer higher rates of chronic undernourishment (32%) compared to non-tribal women (23%), and the erosion of traditional agroforestry systems, combined with erratic rainfall and rising temperatures, is narrowing dietary options and reducing adaptive capacity. Yet, community-led initiatives—such as tuber conservation plots managed by women in Wayanad—are reclaiming nutrition and livelihoods by reviving climate-resilient crops like yam and tapioca that survive when others fail (Vipindas, 2025; Vipindas and Joseph, 2026). For tribal and indigenous communities, the stakes are even higher. The Cholanaikkans of Nilambur, Asia's last cave dwellers, face nutritional scarcity, wildlife conflict and erosion of traditional ecological knowledge as climate change and deforestation reshape their forests (Shaji, 2025). In Wayanad, Paniyan women are conserving climate-resilient tubers (yam, tapioca) to strengthen food security and livelihoods, recognising these crops' ability to survive when others fail. Millet cultivation among Attappadi's tribal farmers is similarly being revitalised as a climate-resilient, nutritionally superior strategy for food and livelihood security.

The triple challenge: An integrated response

Kerala's triple challenge - climate change, food insecurity and livelihood vulnerability - demands an integrated, cross-sectoral response that moves beyond siloed interventions. Strengthening local food systems requires reviving paddy and wetlands, promoting climate-resilient crops such as millets and tubers and shortening supply chains to reduce dependence on external imports. Protecting and diversifying livelihoods entails scaling up climate-resilient agriculture, sustainable fisheries governance, aquaculture-nutrition linkages and bioresource-based microenterprises for women and coastal communities. Equity and health must be embedded in adaptation planning by addressing gendered nutrition gaps, providing mental health support post-disasters and targeting assistance to tribal and marginalised groups facing disproportionate climate risks. Climate finance and innovation through mechanisms like KERA, climate insurance, AI-powered weather advisories and blue economy investments can

align mitigation, adaptation and livelihood goals while building long-term resilience. Only by integrating ecological restoration, social protection and inclusive governance can Kerala transform this triple challenge into an opportunity for climate-resilient, food-secure, and livelihood-rich development in the 21st century (Ritu and Mercykutty, 2025; The Hindu, 2026). The interlinkages among climate change, food security, and livelihoods in Kerala demand integrated, cross-sectoral responses. Siloed interventions focusing only on crop yields, fish landings or disaster relief will be insufficient. Instead, policies must:

- **Strengthen local food systems** by reviving paddy and wetlands, promoting climate-resilient crops (millets, tubers), and shortening supply chains to reduce dependence on external imports
- **Protect and diversify livelihoods** through climate-resilient agriculture, sustainable fisheries governance, aquaculture-nutrition link, and bioresource-based microenterprises for women and coastal communities
- **Embed equity and health** by addressing gendered nutrition gaps, mental health support post-disasters and targeted assistance for tribal and marginalised groups facing disproportionate climate risks
- **Scale up climate finance and innovation** via mechanisms like KERA, climate insurance, digital advisories and blue economy investments that align mitigation, adaptation, and livelihood goals.

CONCLUSION

Kerala's experience demonstrates that climate change, food security and livelihoods are not separate challenges but closely interconnected dimensions of a single socio-ecological crisis. Rising temperatures, changing monsoon patterns, floods, droughts, landslides, coastal erosion and marine ecological changes are already affecting agricultural productivity, fisheries, household incomes, nutrition, public health and social wellbeing. The decline of paddy cultivation and the state's growing dependence on rice imports reveal the fragility of Kerala's food system, while the instability of marine fisheries threatens both coastal livelihoods and an important source of affordable protein. These pressures are intensified by land-use change, wetland loss, inadequate water management, ecological degradation, and development practices that increase exposure to climate hazards. The burden of this crisis is not distributed equally. Small and marginal farmers, agricultural labourers, fisher households, women, children, tribal communities and landless families possess fewer assets and weaker safety nets to recover from climate-related shocks. For women, food insecurity is linked not only to inadequate dietary intake but also to unpaid care work, occupational exposure, income loss, and limited access to land, credit, technology and

decision-making. Among tribal communities, the erosion of traditional food systems and ecological knowledge further narrows the range of available nutritional and livelihood options. The hidden consequences including child undernutrition, declining dietary diversity, psychological distress, displacement and cultural erosion must therefore be treated as central components of climate vulnerability rather than secondary effects.

Kerala's existing institutional capacity, decentralised governance traditions, social development achievements, and emerging climate policies provide a strong foundation for transformative action. However, programmes such as the State Action Plan on Climate Change, KERA, biodiversity strategies, paddy revival initiatives, and fisheries reforms must be implemented through coordinated and locally responsive mechanisms. Climate adaptation should be integrated with agricultural planning, nutrition programmes, public health systems, disaster management, coastal regulation, social protection and rural employment policies. An equitable response must place affected communities at the centre of decision-making. Women farmers, fisherwomen, tribal institutions, local self-governments, community organisations, and indigenous knowledge holders should participate meaningfully in planning, implementation and monitoring. Climate finance must reach vulnerable households and local institutions rather than remain concentrated in large infrastructure projects. With integrated policies, community participation, scientific innovation and social justice at their core, Kerala can transform its triple challenge into an opportunity to develop a food-secure, climate-resilient and sustainable model for other tropical regions facing similar pressures.

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