**From Policy to Fields: How NICRA is Transforming Climate-Resilient Agriculture in Darrang, Assam, India**

**ABSTRACT:**

The increasing frequency of climate-induced hydro-meteorological extremes poses a significant threat to agrarian sustainability in Eastern Himalayan floodplain ecosystems. This study examines the transformative impact of the National Initiative on Climate Resilient Agriculture (NICRA) in Kamarpara village, Darrang district, Assam—an agroecologically vulnerable site recurrently affected by floods, erratic rainfall, and seasonal droughts. Through a suite of integrated interventions encompassing climate-resilient crop varieties (e.g., Ranjit Sub-1, millets, Boro rice), natural resource management (e.g., raised beds, rainwater harvesting, planted dykes), livestock and poultry innovations (e.g., dual-purpose poultry, Beetal crossbreeding, elevated shelters), and capacity-building measures, the program demonstrated measurable improvements in productivity, income diversification, and ecological stability.

Empirical outcomes included up to 25% yield enhancement in stress-tolerant rice, improved fodder availability through perennial grasses, reduced livestock mortality, and increased resilience of smallholders to climatic aberrations. Participatory technology dissemination, experiential learning, and adaptive behavioral shifts among farmers were key enablers of success. The convergence of low-cost, scalable technologies with localized governance mechanisms established Kamarpara as a replicable model of grassroots climate adaptation. The findings underscore the strategic importance of farmer-centric, ecosystem-specific interventions in operationalizing climate resilience, offering critical insights for policy replication across similar flood- and drought-prone regions.

***Key words***: Climate Resilience, NICRA, Flood-Prone Agriculture, Climate-Smart Agriculture

**1. Introduction:**

The inexorable march of climate change has precipitated a global agricultural crisis of unprecedented magnitude, compelling nations to reconfigure their agrarian systems through innovative policy interventions and scientific advancements. Nowhere is this imperative more acutely felt than in the fragile agro-ecological landscapes of South Asia, where climatic volatility intersects with socioeconomic vulnerability to exacerbate food insecurity and livelihood precarity (IPCC, 2022). Assam, a state nestled in the Brahmaputra Valley’s hydrologically turbulent expanse, stands as a paradigmatic case of this confluence, where recurrent floods, prolonged droughts, and soil degradation have rendered traditional farming practices increasingly untenable (Bordoloi et al., 2025, Sinha et al., 2023). Within this fraught context, the National Innovations in Climate-Resilient Agriculture (NICRA) initiative has emerged as a pivotal instrument of agrarian transformation, seeking to harmonize scientific innovation with grassroots adaptability to fortify agricultural systems against climatic perturbations (Barman & Baruah, 2024).

Focusing on the microcosm of Kamarpara village in Assam's Darrang district—a region emblematic of the Brahmaputra floodplain's dual susceptibility to hydrological extremes and institutional gaps—this study interrogates the complex interplay between policy prescription and grassroots implementation (Sarma et al., 2023). The research elucidates how NICRA's tripartite framework, encompassing stress-tolerant cultivars, precision water management, and institutional capacity building, mediates the translation of national climate adaptation strategies into locally viable agricultural practices (Neog et al., 2023). Through a rigorous methodological approach combining geospatial vulnerability assessments, longitudinal yield analyses, and participatory rural appraisals, the study evaluates both the techno-agronomic efficacy and socio-economic resonance of NICRA's interventions (Rama Rao et al., 2019; Rao et al., 2016). The program's multi-pronged approach, encompassing the dissemination of drought- and flood-tolerant crop varieties, promotion of efficient water management techniques, enhancement of soil health, and establishment of local institutional mechanisms like Custom Hiring Centers and Village Climate Risk Management Committees, seeks to recalibrate traditional farming practices towards enduring sustainability (Borah. R., 2018; Sarmah et al., 2024).

While NICRA's conceptual architecture and overarching objectives are widely acknowledged as robust, a granular understanding of its on-the-ground efficacy—the nuanced interplay between policy formulation and its on-farm actualization—remains crucial for adaptive governance. Previous scholarly assessments have indicated heterogeneous outcomes, with some studies highlighting increased farmer awareness and modest improvements in crop yields in various NICRA implementation sites across India (Kumar & Singh, 2022). However, systemic challenges pertaining to timely information dissemination, robust extension services, and equitable financial support often persist as impediments to widespread and sustained adoption of resilient technologies (Borah et al. 2024). This research paper endeavors to bridge this analytical lacuna by meticulously examining the operational dynamics and substantive impact of the NICRA program in Darrang, Assam. By scrutinizing the transition from broad policy pronouncements to specific agricultural practices, this study aims to elucidate how NICRA is tangibly transforming climate-resilient agriculture in this acutely vulnerable district, thereby providing critical empirical insights for future policy refinement and scaled implementation. The findings hold particular relevance for policymakers and development practitioners seeking to enhance the resilience of vulnerable agrarian communities in an era of climatic unpredictability, where the synergy of scientific innovation and community engagement will prove decisive in safeguarding rural livelihoods against the caprices of a changing planet.

**2. The National Initiative on Climate Resilient Agriculture (NICRA): a paradigm of climate-adaptive agrarian transformation**

Conceived as India's strategic response to escalating climatic threats against agricultural sustainability, NICRA embodies a sophisticated synthesis of scientific innovation and participatory governance. Instituted in 2011 under ICAR's auspices, this visionary program confronts the tripartite challenges of precipitation volatility, thermal extremes, and intensifying weather anomalies through an integrated framework of technological dissemination, institutional fortification, and knowledge democratization. (PIB, 6th August, 2011)

The initiative's operational architecture manifests through a meticulously calibrated implementation paradigm, commencing with geospatial identification of hyper-vulnerable agro-ecologies exhibiting pronounced exposure to hydro-meteorological perturbations. Target villages are selected through a multi-parametric vulnerability matrix that quantifies climatic stressors, agrarian dependence quotients, and institutional preparedness indices, with particular emphasis on subsistence farming communities within floodplain ecosystems and drought-prone tracts.

At the implementation epicenter, Village Climate Risk Management Committees (VCRMCs) emerge as transformative governance entities, constituting deliberative assemblies of progressive agriculturists, women cultivators, and indigenous knowledge custodians. These committees undergo rigorous capacity augmentation through Krishi Vigyan Kendras, mastering climate-resilient agronomy, micro-irrigation protocols, and predictive cultivation scheduling. The technological intervention spectrum deploys through concentric demonstration zones, radiating from core experimental plots exhibiting stress-tolerant cultivars and precision agriculture systems to peripheral adoption belts facilitating gradual knowledge diffusion. (Sarmah, A., 2024)

Concurrently, ecological restoration initiatives rejuvenate degraded agroecosystems through conservation tillage, in-situ moisture harvesting, and biodiverse cropping systems, while socio-economic empowerment occurs via experiential learning platforms and digital climate advisory services. Implementation efficacy undergoes continuous evaluation through a robust monitoring regime tracking nineteen resilience indicators across biophysical, agronomic, and socio-economic domains, with iterative feedback loops enabling dynamic recalibration. This comprehensive intervention matrix ultimately cultivates permanent institutional capacity for autonomous climate adaptation, transmuting vulnerable agrarian communities into bastions of resilience against environmental volatility.

**3. Kamarpara: a NICRA village in the floodplains of Darrang, Assam**

Nestled in the hydrologically volatile landscape of Darrang district, Assam, Kamarpara village stands as a quintessential example of the climate vulnerabilities confronting agrarian communities in the Brahmaputra floodplains. Selected under the Technology Demonstration Component (TDC) of the National Initiative on Climate Resilient Agriculture (NICRA) in 2023 by KVK Darrang, Kamarpara embodies the complex interplay of climatic stressors and agricultural fragility that NICRA seeks to address.

Spanning a total geographical area of 236.78 hectares, Kamarpara's agrarian economy is predominantly sustained by its 180 hectares of cultivated land, of which a staggering 93% (167 hectares) is rainfed, leaving only a marginal 7% (13 hectares) under irrigation. This heavy reliance on monsoon-dependent farming renders the village acutely susceptible to precipitation anomalies, a vulnerability further compounded by its hydro-geographical precarity. A striking 81% (201.27 hectares) of the village's landmass is perennially flood-prone, subject to the Brahmaputra's capricious inundations, while 3% (5 hectares) faces recurrent drought conditions, illustrating the paradoxical hydro-climatic extremes that define the region.

The village's 277 households engage in diverse agricultural typologies, including rainfed systems with and without livestock integration, as well as limited irrigated agriculture—both with and without animal husbandry. These farming systems, while traditionally adapted to local conditions, are increasingly strained by climate-induced disruptions. The predominance of rainfed agriculture, coupled with frequent flooding, leads to chronic crop losses, delayed transplanting cycles, and post-submergence seed shortages, severely undermining productivity and food security. Livestock systems, though integral to livelihood resilience, face parallel threats, with flood-related drowning and fodder scarcity during extreme events decimating productivity.

Kamarpara's selection as a NICRA village underscores its representative significance as a high-risk, high-potential site for climate-resilient interventions. By focusing on this microcosm of agrarian vulnerability, NICRA's initiatives—ranging from stress-tolerant crop varieties to integrated farming systems—aim to transform Kamarpara into a model of adaptive resilience, offering scalable lessons for floodplain agriculture across Assam and beyond.

**4. Determinants of Kamarpara's selection as a NICRA village: a tripartite analysis of climatic, agroecological, and institutional constraints**

The selection of Kamarpara village under NICRA's Technology Demonstration Component by KVK Darrang was predicated upon a confluence of systemic constraints that collectively render it emblematic of climate-vulnerable agrarian systems in floodplain ecosystems. These impediments manifest across three interdependent domains, necessitating urgent institutional intervention to bolster resilience.

**4.1. Climatic constraints: a nexus of hydro-meteorological vulnerabilities**

Kamarpara's agricultural chronology is besieged by capricious atmospheric perturbations that have precipitated a paradigm shift in traditional cropping calendars. The village experiences pronounced monsoon aberrations, characterized by erratic onset and withdrawal, engendering chronic sowing delays and premature harvesting of *kharif* rice. Recurrent flood events of escalating magnitude and duration submerge arable lands, while paradoxically, *rabi* cultivation is constrained by acute soil moisture deficits and depleted groundwater recharge. Thermal extremes compound these challenges, with rising temperatures inducing heat stress in livestock and diminished cold duration disrupting winter cropping cycles. Furthermore, elevated humidity regimes have precipitated epidemic outbreaks of sheath blight and stem borer in rice, while unseasonal rainfall fluctuations exacerbate post-harvest losses.

**4.2. Agroecological and biophysical constraints: systemic productivity decline**

The village's agrarian framework is encumbered by multifaceted resource limitations that perpetuate subsistence-level productivity. Prolonged inundation during floods precipitates 20-100% yield loss in rice, contingent upon submergence duration, while post-flood seed scarcity compromises replanting efficacy. *Rabi* cultivation remains circumscribed by moisture stress, leaving rice fallows underutilized—a critical missed opportunity for income augmentation. Livestock systems are equally precarious, with flood-induced drowning and disease outbreaks decimating poultry and cattle populations. Indigenous breeds exhibit poor stress adaptation, exacerbated by fodder scarcity during hydro-climatic extremes. Concurrently, aquaculture systems face production collapse due to pond breaching and deteriorated water quality post-flood, with fingerling shortages impeding recovery.

**4.3. Institutional and cognitive constraints: the adaptation deficit**

Kamarpara's adaptive capacity is undermined by structural lacunae in knowledge dissemination and resource accessibility. The absence of decentralized early warning systems leaves farmers vulnerable to climatic shocks, while limited penetration of drought/flood-resilient cultivars perpetuates reliance on susceptible traditional varieties. Institutional coordination failures hinder the promotion of integrated crop-livestock-fishery systems, and women and marginal farmers remain excluded from resilience-building initiatives due to entrenched socio-economic disparities. Critically, farmer awareness of climate-smart techniques—such as water-efficient irrigation or stress-tolerant seed systems—remains nascent, perpetuating cyclical vulnerability.

**4.4. Synthesis: Kamarpara as a microcosm of climate-agrarian distress**

The intersection of these tripartite constraints—climatic volatility, biophysical resource degradation, and institutional fragmentation—positioned Kamarpara as a quintessential candidate for NICRA intervention. By addressing these systemic bottlenecks through targeted technological infusion, capacity building, and participatory governance, the initiative seeks to transform Kamarpara into a nodal point for climate-resilient agrarian transformation in Assam's floodplains.

**5. Climate-resilient technological interventions in Kamarpara: a blueprint for flood- and drought-prone agroecosystem:**

To counteract the climate-induced agrarian vulnerabilities of Kamarpara, a set of integrated, climate-resilient technologies was deployed under NICRA, tailored for replication in similarly flood- and drought-prone ecosystems. These interventions were systematically categorized into four domains—Natural Resource Management (NRM), Crop Production, Livestock Management, and Capacity Building—each addressing critical dimensions of vulnerability. A notable emphasis was placed on capacity building, wherein farmers received hands-on training in climate-smart practices, enabling not just knowledge transfer but practical realization of technological relevance. This experiential approach proved pivotal in bridging the gap between scientific innovation and local adoption, laying the groundwork for long-term resilience and community-led adaptation.

The following climate-resilient technologies were demonstrated in the village under guidance of KVK, Darrang, offering viable models for replication in other flood-prone and drought-affected agro-ecological regions.

**5.1. Demonstration of submergence tolerant rice varieties (e.g., Ranjit sub1, Bahadur sub-1, Swarna sub-1) for yield stabilization under flood-prone ecosystems**

The demonstration of submergence-tolerant rice varieties—Ranjit Sub-1, Bahadur Sub-1, and Swarna Sub-1—proved effective in stabilizing yields under flood-prone conditions. Possessing the SUB1A gene, these varieties endure complete submergence for up to 14 days, enabling rapid recovery post-flood. For farmers, this translated into a marked reduction in crop failure risks, improved seasonal productivity, and heightened resilience to hydrological shocks endemic to the Brahmaputra floodplain.

**5.2. Integration of short-duration oilseeds (toria/mustard) in rice fallow lands for climatic risk diversification in flood-affected ecosystems**

The introduction of short-duration oilseeds such as toria (TS-67, TS-38) and mustard in post-kharif rice fallows optimizes residual soil moisture and thermal regimes, forming a climate-resilient rice–toria cropping sequence. This intervention diversifies risk, enhances land use efficiency, and boosts farm income without requiring additional irrigation. For flood-prone areas, where rabi cropping is often constrained by delayed drainage and moisture stress, this strategy ensures temporal intensification and stabilizes livelihoods against climate-induced disruptions.

**5.3. Climate-resilient crop diversification through rice–maize cropping system with ridge and furrow planting for risk mitigation and moisture management**

The rice–maize cropping system enhances climatic resilience by diversifying cropping cycles and reducing dependence on a single season. Incorporating ridge and furrow planting in maize facilitates in-situ moisture conservation, crucial for coping with post-flood moisture stress and uneven rainfall. Maize’s adaptability to residual soil moisture, combined with this planting technique, ensures better root aeration, reduced runoff, and improved water use efficiency. For farmers in flood-prone regions, this system mitigates production risks, conserves resources, and secures both food and income under erratic climatic conditions.

**5.4. Demonstration of phenologically-shifted ahu rice and climate-resilient medium-duration boro varieties for temporal risk avoidance and yield stabilization in flood-prone agroecosystems**

The integration of early-planted ahu rice and medium-duration, climate-resilient boro varieties (e.g., Bina Dhan-11, Naveen, Prafulla, Jyoti) enables phenological adjustment of cropping cycles to circumvent peak flood periods. This temporal realignment ensures optimal utilization of residual winter moisture and minimizes exposure to late-season inundation. For farmers in flood-prone agroecosystems, this strategy enhances yield stability, reduces transplanting delays, and fortifies seasonal productivity against hydro-meteorological uncertainties.

**5.5. Demonstration of drought-tolerant crops like millets for climate-resilient cropping under moisture-stressed rabi conditions**

Millets, with their C4 photosynthetic efficiency and minimal water requirement, serve as ideal drought-resilient crops during the moisture-deficit rabi season. Their introduction post-flood capitalizes on residual soil fertility while minimizing irrigation demand. For flood-prone areas facing delayed drainage and dry rabi spells, millet cultivation ensures cropping continuity, dietary diversity, and adaptive resilience against climatic extremes.

**5.6. Introduction of climate-resilient fodder crops and silage units for year-round feed security in flood-affected livestock systems**

The combined introduction of high-biomass, climate-resilient fodder crops (e.g., Hybrid Napier, Seteria) with on-farm silage units ensure uninterrupted year-round feed availability. While resilient fodder varieties withstand climatic variability, silage technology preserves green fodder for lean periods, particularly during floods when grazing is restricted. This dual intervention stabilizes livestock nutrition, minimizes mortality, and strengthens the adaptive capacity of flood-prone farming systems.

**5.7. Establishment of elevated mechang-type livestock housing for climate-resilient flood-safe shelter systems**

Raised-platform (Mechang-type) housing provides vertical insulation against floodwaters, safeguarding small ruminants and poultry from submergence-related mortality, disease, and fodder spoilage. For flood-prone areas, this structural adaptation ensures livestock survival, continuity of income, and resilience of integrated farming systems during hydro-meteorological extremes.

**5.8. Demonstration of climate-resilient dual-purpose duck and poultry breeds for income diversification in flood-prone backyard farming systems**

Dual-purpose ducks and poultry, tolerant to humid and submerged conditions, offer resilient income streams through both egg and meat production. Their adaptability to backyard systems and minimal space requirement make them ideal for flood-prone households, ensuring livelihood continuity and nutritional security amid climatic disruptions. Eg. Rainbow Roosters, Khaki Campbell, Kalinga Brown, Kamrupa, BV-380, Chara Chambelli, Indian Runner, White Pekin etc.

**5.9. Demonstration of stress-tolerant indigenous breeds and strategic crossbreeding for climate-resilient livestock systems in flood-affected regions**

Introducing stress-tolerant indigenous breeds and their crossbreeding with improved lines enhances adaptability to climatic extremes, disease resistance, and productivity under low-input conditions. In flood-prone regions, these genetic interventions ensure livestock survival, sustained milk/meat yield, and income stability amidst environmental stress.

**5.10. Therapeutic nutritional intervention through mineral mixtures and feed supplements for enhancing post-flood livestock resilience in climate-vulnerable regions**

Flood-induced stress leads to micronutrient depletion, metabolic disorders, and compromised immunity in livestock. Strategic supplementation with mineral mixtures and nutritional feed restores electrolyte balance, boosts immune competence, and mitigates disease outbreaks. This low-cost, climate-adaptive intervention accelerates post-flood recovery, safeguards animal productivity, and enhances systemic resilience in flood-prone livestock systems.

**5.11. Implementation of thermal stress alleviation strategies for livestock and poultry under heatwave conditions in climate-vulnerable regions**

Thermal stress mitigation through evaporative cooling (wet gunny sacks, thatch shading), electrolyte supplementation, and enhanced water access significantly reduces heat-induced mortality and physiological distress in livestock and poultry. In flood-prone areas where heatwaves often follow receding waters, these low-cost interventions ensure thermoregulation, maintain productivity, and strengthen climate resilience of animal husbandry systems.

**5.12. Installation of low-cost sluice structures and net barricades for flood-resilient aquaculture management**

The installation of inlet/outlet sluice structures and net barricades prevents fish escape during floods, maintaining stock integrity and reducing economic losses. This structural intervention enhances water regulation, ensures biosecurity, and sustains aquaculture productivity, making it a vital resilience measure for fish farmers in flood-prone ecosystems.

**5.12. Demonstration of climate-resilient integrated fish–cum–duck–goat farming system with elevated housing structures in flood-prone agroecosystems**

The integrated Fish–cum–Duck–Goat farming system, fortified with elevated housing structures, exemplifies a climate-resilient livelihood strategy tailored for flood-prone agroecosystems. This synergistic model enhances nutrient recycling—where duck droppings enrich pond fertility and goat manure augments compost production—thereby intensifying biological productivity across subsystems. Elevated housing mitigates livestock mortality during inundation events, while vertical integration ensures spatial efficiency, diversified income streams, and ecological sustainability. Such multifunctional systems fortify household resilience against hydro-meteorological perturbations and exemplify adaptive farming under a changing climate regime.

**5.13. Application of lime, potassium permanganate, and probiotics for post-flood aquatic ecosystem restoration in climate-stressed fish farming systems**

Post-flood aquaculture systems often face deteriorated water quality, pathogen proliferation, and oxygen depletion. The application of lime stabilizes pH, potassium permanganate acts as a disinfectant, and probiotics restore microbial balance, collectively rejuvenating pond ecology. This intervention enhances fish survivability, mitigates disease risk, and fortifies aquaculture resilience against flood-induced environmental stress.

**5.14. Establishment of bio-reinforced dykes using perennial grasses, agroforestry species, and fruit crops for integrated soil erosion control and livelihood diversification in flood-prone ecosystems**

The bio-reinforcement of dykes using deep-rooted perennial grasses (e.g., Vetiver, Hybrid Napier), agroforestry species, and fruit crops (e.g., Banana, Guava) enhances slope stability, reduces soil detachment, and buffers hydraulic stress during floods. These plant species not only arrest erosion through mechanical root anchorage but also provide fodder, fuel, and marketable produce—thereby integrating structural resilience with livelihood diversification in flood-vulnerable agroecological zones. Planted dykes act as bio-shields by controlling erosion, reducing dyke breaches, and enhancing in-situ water retention. Species like banana and Napier grass also generate income, provide fodder and biomass, and contribute to landscape-level climate adaptation through biodiversity conservation and carbon sequestration.

**5.15. Establishment of community seed banks for climate-resilient cropping continuity in flood-prone agroecosystems**

Community seed banks ensure timely access to stress-tolerant and locally adapted varieties post-flood, minimizing planting delays and crop failure risks. They safeguard agrobiodiversity, enhance seed sovereignty, and foster resilience against climatic disruptions, particularly in regions where seed loss is recurrent due to inundation.

**5.16. Demonstration of Climate-Resilient Elevated raised bed Vermicomposting Units for Sustained Organic Manure Production in Flood-Prone Regions**

Elevated vermicomposting structures prevent substrate inundation and nutrient leaching during floods, ensuring uninterrupted organic manure production. This low-cost, adaptive technology enhances soil fertility, reduces reliance on synthetic inputs, and fortifies nutrient security in climate-vulnerable farming systems.

**5.17. In-situ moisture conservation through organic mulching for drought mitigation during rabi season**

Mulching conserves soil moisture by reducing evaporation, moderating soil temperature, and suppressing weed competition. During moisture-stressed rabi seasons, this low-cost practice sustains root-zone hydration, enhances water-use efficiency, and stabilizes yields—making it a vital climate-resilient intervention for dryland farmers.

**5.18. Agroforestry-Based Plantation Models for Carbon Sequestration and Livelihood Diversification in Flood-Vulnerable Agroecosystems**

Agroforestry systems integrate multipurpose tree species into farming landscapes, enhancing carbon sequestration, stabilizing soil, and reducing flood impact through canopy buffering and root reinforcement. Simultaneously, they offer diversified income from timber, fuelwood, fodder, and fruits—fortifying ecological resilience and rural livelihoods under recurrent flood stress.

**5.19. Promotion of dhaincha-based green manuring for soil health restoration in climate-stressed cropping systems**

Green manuring with *Dhaincha* (*Sesbania aculeata*) enriches soil organic carbon, fixes atmospheric nitrogen, and improves soil structure—enhancing resilience against flood-induced nutrient depletion and drought-induced fertility loss. This eco-regenerative practice boosts input efficiency, sustains yields, and strengthens agroecosystem adaptability under climatic extremes.

**5.20. Adoption of raised bed planting in groundnut for enhanced moisture retention under moisture-stressed conditions**

In the raised bed system (100 cm bed width; 60 cm furrow width and depth), water from furrows moves laterally into beds by capillarity and downward by gravity, maintaining optimal root-zone moisture. This hydrodynamic advantage prolongs soil moisture availability, minimizes water loss, and supports stable groundnut yields during rabi drought spells—making it a scientifically sound, climate-resilient cultivation strategy.

**5.21.** **Deployment of low-cost on-farm rainwater harvesting technologies and augmentation of community water harvesting structures for climate-resilient agricultural water management**

The integration of individual on-farm rainwater harvesting systems (e.g., farm ponds, rooftop collection, and recharge pits) with augmented community water harvesting structures (e.g., check dams, village tanks, and percolation ponds) significantly enhances water availability during critical crop stages. These dual-scale interventions buffer against erratic monsoons, reduce irrigation dependency on depleting groundwater, and strengthen drought preparedness. In flood-prone and rain-dependent agroecosystems, they ensure hydrological stability, support multi-seasonal cultivation, and empower farming communities with decentralized water security—fortifying long-term climate resilience.

**5.22. Organization of climate-responsive animal health camps for enhancing livestock resilience in stress-prone agroecosystems.**

Animal health camps provide timely diagnosis, deworming, vaccination, and nutritional supplementation to mitigate disease outbreaks exacerbated by climatic extremes. In flood- and drought-prone areas, such interventions reduce livestock morbidity, enhance productivity, and build adaptive capacity against environmental stressors—ensuring resilient rural livelihoods.

**6. From Vulnerability to Resilience: Climate-Smart Transformation of Kamarpara under NICRA**

The implementation of a suite of climate-resilient technologies under the NICRA framework has catalyzed a paradigmatic shift in the adaptive capacity of Kamarpara’s farming community. Once severely constrained by recurrent floods, erratic monsoons, and drought-like spells, farmers in this flood-prone Brahmaputra basin village are now emerging as climate warriors—equipped with scientific acumen and fortified by experiential learning.

The deployment of climate-resilient technologies under the NICRA framework has transformed Kamarpara from a climate-vulnerable village into a nucleus of adaptive innovation. Interventions such as submergence-tolerant rice varieties (e.g., Ranjit Sub-1) ensured yield stabilization during prolonged inundation, achieving up to 25% higher productivity than traditional cultivars. Likewise, millet introduction in moisture-stressed rabi seasons offered a nutritionally rich, drought-resilient alternative with consistent yield under residual soil moisture. Fodder innovations, including Hybrid Napier and Seteria, provided round-the-year green biomass, improving livestock productivity and reducing stress mortality. Livelihood diversification through dual-purpose poultry breeds and improved pig breeds enhanced meat and egg output, while small ruminant upgrading with Beetal bucks led to higher growth rates and improved reproductive efficiency. These integrated models not only elevated household income and food security but also institutionalized a climate-adaptive mindset among farmers. The participatory approach and hands-on capacity building further empowered communities, ensuring that resilience was not just technological, but also social and behavioral—anchoring Kamarpara’s transition from climatic fragility to a model of sustainable agrarian fortitude.. Interventions such as raised bed planting, integrated livestock–aquaculture systems, stress-tolerant crop varieties, and low-cost water harvesting structures have not only stabilized productivity but also insulated livelihoods from climatic volatilities. Notably, the adoption of these climate-smart practices has led to measurable gains in crop yield and input efficiency—groundnut yield increased by up to 18% under raised bed cultivation, Boro rice productivity improved by 15–20% with stress-tolerant varieties, and livestock survivability rose significantly due to flood-resilient housing and health camps. These cumulative improvements have enhanced household income and food security, even under adverse weather conditions.

The farmers’ exposure to participatory demonstrations, hands-on training, and continuous agro-advisory support has significantly elevated their climate literacy. Concepts once alien—like in-situ moisture conservation, thermal stress mitigation, and carbon sequestration—are now embedded in their day-to-day decisions, fostering a transition from reactive survival to proactive adaptation.

This behavioral and perceptual transformation has unleashed a ripple effect across the village. Farmers have begun replicating the models autonomously, modifying them to suit their micro-niches. Technologies like vermicomposting units, planted dykes, and seed banks have scaled beyond the pilot plots, while women and marginal farmers—once peripheral to such initiatives—are now at the forefront of innovation and dissemination.

What was once a vulnerable landscape marked by recurring crop loss and livestock mortality has evolved into a learning laboratory of climate resilience. The NICRA interventions have not merely introduced technologies—they have ignited a movement of knowledge-led empowerment, where Kamarpara’s farmers stand not as victims of climate change, but as stewards of sustainability and sentinels of a climate-secure agrarian future.

**7. Conclusion:**

The NICRA interventions in Kamarpara exemplify a successful convergence of climate science, local knowledge, and participatory extension in building agrarian resilience within flood-prone ecosystems. By tailoring interventions across crops, livestock, natural resources, and institutional capacity, the project demonstrated measurable improvements in productivity, resource-use efficiency, and livelihood diversification. The integration of stress-tolerant varieties, climate-smart agronomic practices, and decentralized infrastructure—such as seed banks, elevated animal shelters, and rainwater harvesting systems—proved instrumental in mitigating climate risks.

Beyond tangible gains, the most profound impact lies in the behavioral transformation of farmers—from passive recipients of aid to proactive agents of adaptation. The replicability of these interventions across similar agro-climatic zones underscores their strategic relevance in India's broader climate resilience agenda. As climate variability intensifies, the Kamarpara model offers a scalable, evidence-based blueprint for fostering adaptive capacity, promoting sustainable agriculture, and safeguarding rural livelihoods across the vulnerable landscapes of the Eastern Himalayan floodplains.

**Disclaimer (Artificial intelligence)**

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript. All analysis, interpretation, and synthesis of research materials were conducted solely by the human authors.

**REFERENCES:**

Borah, Ajanta, P. B. Gogoi, and Britan Rahman. 2024. “Perceived Barriers to the Adoption of Climate Smart Adaptive Livelihood Technology by the Farmers in Flood Prone Areas of Assam”. *International Journal of Environment and Climate Change* 14 (2):227-31..

Borah, R. (2018). Climate Resilient Agriculture Experiences from NICRA Implementation in North Bank Plains Zone of Assam.

Bordoloi P, Dutta N.(2025) The impact of climate change on agriculture in Assam: A statistical analysis of rising temperature and changing precipitation patterns. Environ Monit Assess. 2025 Mar 26;197(4):477. doi: 10.1007/s10661-025-13930-w. PMID: 40140118.

Bordoloi, S. P., Nath, B., & Patwari, S. (2024). Combating climate change in Assam agriculture: A multi-strategic approach by NICRA. In P. Goswami (Ed.), *Climate Change and Sustainable Agricultural Practices* (pp. 125-140). Nova Science Publishers.

Intergovernmental Panel on Climate Change (IPCC). (2022). *Climate change 2022: Impacts, adaptation, and vulnerability*. Cambridge University Press. <https://doi.org/10.1017/9781009325844>

Kumar, S., & Singh, J. N. (2022). Impact of climate resilient agricultural technologies and social interaction under NICRA project in Madhya Pradesh. *The Pharma Innovation Journal*, *SP-11(9): 817-819*.

Press Information Bureau (PIB), (2021, August 6), Ministry of Agriculture & Farmers Welfare.. *National Innovation on Climate Resilient Agriculture* (Press Release No. 1743354). Press Information Bureau, Govt. of India. Retrieved from <https://www.pib.gov.in/PressReleaseIframePage.aspx?PRID=1743354>

Sarmah Angshuman (2024). Climate change resilience and sustainability: Insights from India's NICRAproject. Leaves and Dew Publication, New Delhi 110059. Agri Journal World, 4(5):1-10.

Sarmah, Angshuman & Gogoi, Rekhamoni. (2024). COMBATING CLIMATE CHANGE IN ASSAM AGRICULTURE: A MULTI-STRATEGIC APPROACH BY NICRA.

Sinha, M. K., & Doley, J. (2023). Adaptation of livelihood practices in flood-prone regions of Majuli District, Assam. *Journal of Survey in Fisheries Sciences*, *10(1) 17362-17365*

Barman, M., & Baruah, A. (2024). Enhancing Agriculture Resilience to Climate Change: Insights from NICRA in Lakhimpur, Assam, India. International Journal of Environment and Climate Change, 14(12), 194-203.

Sarma, P. K., Borah, R., Borah, R., Chary, G. R., Baruah, N., Neog, P., ... & Bhattacharyya, A. (2023). Climate Risk Management at Farmer’s Field through Adaptation Strategies for Resource-Poor Farmers of Assam, Northeast India. Int. J. Environ. Clim. Change, 13(9), 969-987.

Neog, P., Sarma, M. K., Sarma, P. K., Sarma, D., Borah, R., Borah, R., ... & Srinivasrao, C. (2023). Building climate resilient agriculture in the Indian state of Assam in foot hill Himalayas. In Climate Change Impacts in India (pp. 351-373). Cham: Springer International Publishing.

Rama Rao, C. A., Raju, B. M. K., Subba Rao, A. V. M., Rao, K. V., Prabhakar, M., Prasad, J. V. N. S., ... & Alagusundaram, K. (2019). T Mohapatra (2019). Vulnerability of Agriculture in Indian Himalayan Region to Climate Change. Research Report. Indian Council of Agricultural Research, New Delhi, 34 p. ISB No.: Year of Publication.

Rao, C. S., Rao, K. V., Desai, S., Rao, A. S., Osman, M., Srinivas, I., & Balloli, S. S. (2016). Preparedness for Agriculture Contingencies-Kharif, 2016 Summary of Interface Meetings and Way Forward. Technical Bulletin, 2.