



Weather-Based Advisory Services for Climate-Resilient Smallholder Farming in India: A Review of the Gramin Krishi Mausam Sewa (GKMS) Framework

DR Vaghasiya¹, JB Gajera^{2*}, UB Parmar³ and PK Chovatia⁴

¹Assistant Professor, Agrometeorology Cell, Department of Agronomy, College of Agriculture, Junagadh Agricultural University, Junagadh (Gujarat), India

²Research Associate (GKMS), (AMFU-IMD), Agrometeorology Cell, Department of Agronomy, College of Agriculture, Junagadh Agricultural University, Junagadh (Gujarat), India

³Agromet Observer (GKMS), (AMFU-IMD), Agrometeorology Cell, Department of Agronomy, College of Agriculture, Junagadh Agricultural University, Junagadh (Gujarat), India

⁴Professor and Head, Department of Agronomy, College of Agriculture, Junagadh Agricultural University, Junagadh (Gujarat), India

***Corresponding Author:** JB Gajera, Research Associate (GKMS), (AMFU-IMD), Agrometeorology Cell, Department of Agronomy, College of Agriculture, Junagadh Agricultural University, Junagadh (Gujarat), India.

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Abstract

Indian agriculture, dominated by smallholder farmers and highly dependent on monsoon rainfall, is increasingly exposed to climate variability and extreme weather events. The Gramin Krishi Mausam Sewa (GKMS) programme was established to translate weather forecasts into actionable farm advisories and thereby reduce climate-related risks in agriculture. This review synthesizes evidence from programme reports, peer-reviewed studies, and documented case experiences to assess the institutional evolution, operational framework, digital innovations, and field-level impacts of GKMS in India. The review indicates that the use of weather-based advisories under GKMS has contributed to yield improvements of about 10–15 percent in major crops, reduction in weather-induced losses by approximately 15–25 percent, and improved efficiency of water and fertilizer use by 15–20 percent in several regions. Digital dissemination platforms, particularly mobile-based advisory services, have substantially expanded outreach and timeliness of information delivery. Case evidence from semi-arid regions demonstrates improved decision-making in sowing, irrigation scheduling, and pest management, leading to enhanced farm resilience. Despite these gains, challenges remain in the form of digital access gaps, uneven forecast accuracy in complex terrains, and limitations in last-mile communication. The review concludes that strengthening hyper-local forecasting, improving institutional coordination, and enhancing inclusion of small and marginal farmers are critical for maximizing the effectiveness of GKMS as a national climate service for agriculture.

Keywords: Gramin Krishi Mausam Sewa; Agrometeorological Advisories; Climate-Smart Agriculture; Meghdoot App; Smallholder Resilience and Digital Agriculture Tools; Indian Farming

Introduction

The symbiosis between agriculture and meteorology in India is as ancient as the Indus Valley Civilization, yet contemporary climate exigencies demand unprecedented precision. With 45% of the workforce ensconced in agriculture and the sector underpinning national food security, smallholders—managing an average of 1-2 hectares—confront a precarious equilibrium.

Indian agriculture remains highly sensitive to weather and climate variability due to the dominance of rainfed farming systems and the prevalence of smallholder farmers. Irregular monsoon rainfall, prolonged dry spells, heat stress, and extreme weather events increasingly disrupt crop calendars, input management, and harvest operations, leading to substantial production and income instability. Climate change projections indicate further intensification of such risks, making climate-responsive decision support systems an essential component of agricultural sustainability and food security [1,5]. Climate projections further indicate a rise in the frequency and intensity of extreme events, reinforcing the need for adaptive, information-driven farming strategies [6].

Rainfed cultivation, dominant across 60% of arable expanse, amplifies susceptibility to monsoonal vicissitudes: delays precipitate sowing shortfalls, excesses engender floods and deficits spawn droughts, culminating in ₹1.5 lakh crore in yearly economic attrition. The Intergovernmental Panel on Climate Change [5] prognosticates a 20% augmentation in extreme events by 2030, underscoring the imperative for adaptive paradigms that transmute weather data into actionable agrarian stratagems.

Agrometeorological advisory services aim to bridge the gap between meteorological science and farm management by converting weather forecasts into practical, location-specific guidance for farmers. In India, the Gramin Krishi Mausam Sewa (GKMS) programme serves as the primary institutional mechanism for delivering such advisories. By integrating numerical weather prediction outputs with agronomic expertise, GKMS supports farm-level decisions related to sowing, irrigation, nutrient application, pest and disease management, and harvesting operations.

Although the Gramin Krishi Mausam Sewa (GKMS) programme has been operational for more than a decade and several region-specific studies have reported its benefits, the available literature

remains fragmented and uneven. Most existing studies focus on isolated districts or individual components of the programme such as SMS advisories, farmer perception, or short-term impacts on specific crops. There is a lack of a comprehensive synthesis that integrates the institutional evolution of GKMS, its operational framework, recent digital innovations, and consolidated evidence on its agronomic, economic, and resilience outcomes across diverse agro-climatic regions of India.

Furthermore, limited attention has been given to systematically examining implementation challenges such as forecast uncertainty at finer spatial scales, digital access constraints among small and marginal farmers, and institutional coordination across meteorological, agricultural, and extension agencies. This gap restricts the ability to draw generalized conclusions about the overall effectiveness, scalability, and policy relevance of GKMS as a national climate service for agriculture.

The Gramin Krishi Mausam Sewa (GKMS)—“Village Agricultural Weather Service”—epitomizes this exigency, inaugurated in 2007 as Integrated Agromet Advisory Services (IAAS) under IMD’s aegis within MoES. Rechristened in 2012, GKMS operationalizes the National Action Plan on Climate Change (NAPCC, 2008) by amalgamating IMD’s numerical weather prediction (NWP) prowess with ICAR’s agronomic acumen and SAUs’ regional insights. As of December 2025, it encompasses 130 Agro-Met Field Units (AMFUs) spanning 127 agro-climatic zones, augmented by 199 District Agro-Met Units (DAMUs) at Krishi Vigyan Kendras (KVKs) and hyperlocalized Panchayat-tier services via the Ministry of Panchayati Raj. This framework not only furnishes 5-day district/block forecasts for rainfall, temperature, humidity, wind and cloud cover but also curates biweekly advisories (Tuesdays/Fridays) tailored to 50+ crops and livestock, disseminated through a hybrid matrix: 70% digital (SMS to 43 million, Meghdoot app to 4.16 million), 20% broadcast (Doordarshan Kisan, All India Radio) and 10% grassroots (5,700 WhatsApp groups across 57,000 villages; [4]).

Empirical validations abound: ICAR pilots (2025) evince 10-15% yield accretions, while a Punjab survey (n = 122; [12]) registers 77% high-impact perceptions and a 74% effectiveness index. Regionally, Gujarat’s integration yields 72% operational adoption, with case studies documenting 175% income surges [15]. Yet, disparities persist—30% of smallholders remain

digitally estranged, particularly in undulating terrains where forecast fidelity wanes (root mean square error [RMSE] ~2K for land surface temperature; [14]). This review, synthesizing archival documents, 2025 PIB dispatches and contemporaneous web-sourced intelligence, chronicles GKMS's ontogeny, dissects its mechanics, appraises ramifications and prognosticates trajectories. By bridging esoteric meteorology with quotidian husbandry, GKMS heralds a resilient agrarian epoch, aligning with Sustainable Development Goal 2 (Zero Hunger) and NAPCC's Sustainable Habitat Mission.

At the regional level, the effectiveness of the Gramin Krishi Mausam Sewa depends on Agro-Meteorological Field Units that translate national forecasts into locally relevant farm advisories. The Agro-Meteorological Field Unit (AMFU) at Junagadh Agricultural University represents a key institutional link in this process for the South Saurashtra agro-climatic zone of Gujarat. By integrating India Meteorological Department forecasts with region-specific knowledge of crops, soils and management practices, AMFU-Junagadh supports location-specific advisory services for rainfed and irrigated farming systems. Its role highlights how scientific weather information is operationalized at the field level to support smallholder decision-making under semi-arid and climate-variable conditions.

Objectives of the study

- Synthesize the historical development and institutional framework of the Gramin Krishi Mausam Sewa (GKMS) programme in India.
- Examine the operational mechanisms of GKMS, including advisory generation, dissemination pathways, and recent digital innovations.
- Consolidate and assess available evidence on the impacts of GKMS on crop productivity, resource-use efficiency, and reduction of weather-related risks for smallholder farmers.
- Identify key implementation challenges, limitations, and future directions for strengthening weather-based advisory services to support climate-resilient agriculture in India.

Historical evolution and policy foundations

The foundations of agricultural meteorology in India date back to the early twentieth century, with the establishment of observational networks and crop-weather studies under IMD.

Post-independence investments in numerical weather prediction and coordinated agrometeorological research strengthened the scientific base for operational advisory services [7]. The launch of Integrated Agromet Advisory Services in 2007 marked a transition from experimental efforts to a national program aligned with the National Action Plan on Climate Change.

In 2012, the service was formally renamed Gramin Krishi Mausam Sewa, accompanied by the expansion of Agro-Met Field Units (AMFUs) across agro-climatic zones. Subsequent integration with initiatives such as the National Innovations in Climate Resilient Agriculture enhanced the relevance of advisories for droughts, floods and heat stress [2,8]. From 2019 onwards, digitalization accelerated through the Meghdoot mobile application, satellite-based products and the establishment of District Agro-Met Units at Krishi Vigyan Kendras, enabling block- and sub-district-level advisories [3,9].

By 2025, GKMS had expanded to cover all states and agro-climatic regions, delivering forecasts and advisories through multiple channels including SMS, mobile applications, radio, television and community networks [1]. This progression reflects a shift from district-scale forecasting to increasingly granular, user-oriented climate services.

Antecedents: From colonial observatories to post-independence precursors (1932-2006)

IMD's Agricultural Meteorology Division, inaugurated in Pune in 1932 amid Bengal Famine recriminations, pioneered crop-weather correlations through rudimentary observatories. Post-1947, the 1988 NCMRWF under DST galvanized NWP models, furnishing 3-10 day prognostications that presaged GKMS [2]. The 1990s All India Coordinated Research Project on Agrometeorology (AICRPAM) under ICAR augmented this with pest-disease-weather linkages, laying empirical bedrock.

Inception and consolidation (2007-2018)

IAAS's 2007 debut, buoyed by NAPCC, piloted advisories in 100 districts, mitigating 2009 monsoon deficits via SMS prototypes [1]. The 2012 GKMS rebranding institutionalized 130 AMFUs, engendering biweekly vernacular bulletins for 22 million recipients [4]. This era synchronized with the National Innovations in Climate Resilient Agriculture (NICRA, 2011), embedding GKMS in drought/flood contingencies.

Digital and hyperlocal ascendancy (2019-2025)

The 2019 Meghdoot app, co-developed with ICRISAT and IITM, catalyzed ubiquity, amassing 3.75 million downloads by 2024 and facilitating offline agro-tips in 13 languages [18]. ISRO’s VEDAS portal (2019) infused satellite-derived indices—Normalized Difference Vegetation Index (NDVI, 90% accuracy), Potential Evapotranspiration (PET, 91%), Surface Dryness Index (SDI, 90%), Land Surface Temperature (LST, RMSE 2K) and Soil Surface Moisture (SSM, 90%)—elevating block-scale fidelity [14]. The 2021 DAMU proliferation at 199 KVKs (e.g., Odisha/West Bengal phases) extended sub-district purview, while 2025’s Mission Mausam (₹1,000 crore) inaugurates AI for 1-2 km resolutions and MoPR’s e-Gramswaraj/Meri Panchayat integrations blanket all Gram Panchayats [10]. [6] corroborates: Block-level forecasts and AI augur 14 crore coverage by 2030.

Operational Framework: Synergizing Data, prediction and dissemination

GKMS operates through a structured workflow that links data generation, forecast modeling, advisory formulation and dissemination. Meteorological inputs are derived from surface observatories, automatic weather stations, Doppler radars and satellite platforms, which feed numerical weather prediction models operated by IMD and allied institutions [1,7]. These models generate short- and medium-range forecasts for key parameters such as rainfall, temperature, humidity, wind and cloud cover.

Advisory preparation is carried out by multidisciplinary teams at AMFUs and DAMUs, involving agrometeorologists, agronomists, plant protection specialists and extension personnel. Forecasts are interpreted in relation to crop stage, soil conditions and prevailing risks and translated into practical recommendations for farmers. Advisories are typically issued twice a week and updated during extreme events.

Dissemination relies on a mixed communication strategy. Digital modes, particularly SMS and mobile applications, now account for the majority of outreach, complemented by mass media and interpersonal extension activities. Feedback from farmers and field staff is incorporated to refine advisories and improve clarity and relevance [4,10].

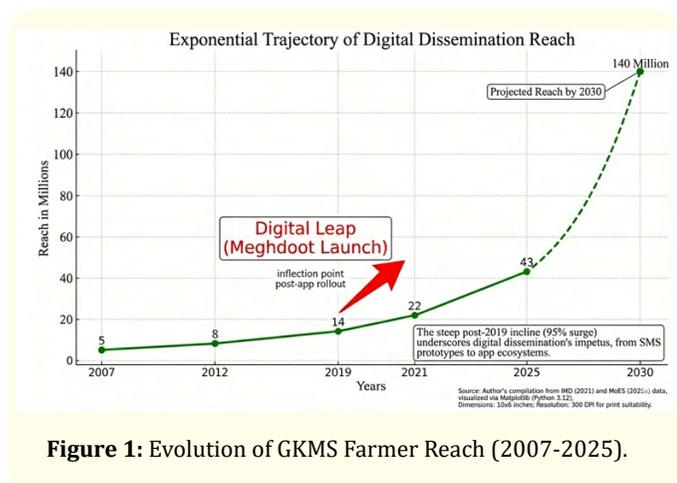


Figure 1: Evolution of GKMS Farmer Reach (2007-2025).

Timeline	Milestone	Coverage Expansion	Policy/Tech Enabler	Reach Milestone (Millions)
1932	IMD Agromet Division Est.	National observatories	Pre-NAPCC foundational monitoring	N/A
2007	IAAS Launch	100 districts; Initial SMS pilots	NAPCC Sustainable Agriculture Mission	5
2012	GKMS Rebrand; 130 AMFUs	127 agro-climatic zones	ICAR-AICRPAM; NICRA integration	8
2019	Meghdoot App; VEDAS Satellites	Block-level advisories; 3.75M downloads by 2024	Digital India; ISRO collaborations	14
2021	199 DAMUs at KVKs	Sub-district bulletins (e.g., Odisha Phase-I)	KVK network; COVID-accelerated rollout	22
2025	Panchayat Forecasts; AI Pilots	All Gram Panchayats; 1-2 km resolutions	Mission Mausam (₹1,000 Cr); MoPR e-Gramswaraj	43 (projected 140 by 2030)

Table 1: GKMS Evolutionary Milestones (Compiled from [2,6,10]).

Data assimilation and predictive modeling

NWFC harnesses 1,019 AWS, Doppler radars and INSAT satellites for granular inputs, powering NWP models that yield 5-day district/block forecasts (rainfall probability, max/min temperatures, relative humidity, wind vectors; [10]. Weekly meteorological subdivision outlooks and 3-hourly nowcasts mitigate acute perils like hailstorms. Sub-seasonal (2-4 week) extensions, piloted in 2025 via IITM’s Earth System Model, facilitate contingent crop shifts [2]. Satellite adjuncts—NDVI for vegetative vigor, PET for evaporative demands—afford 90-91% precision, with SSM delineating irrigation thresholds (10% variance [14].

Agrometeorological basis of GKMS

The agrometeorological basis of the Gramin Krishi Mausam Sewa rests on the systematic interpretation of weather parameters in relation to crop growth, soil conditions and farm management practices. Forecasts of rainfall, temperature, humidity, wind speed and cloud cover generated by the India Meteorological Department are analyzed by Agro-Meteorological Field Units to assess their implications for crop phenology, evapotranspiration, pest and disease dynamics and operational timing. At AMFU-Junagadh, this analysis is contextualized for the semi-arid South Saurashtra region by integrating local cropping systems, soil moisture regimes and seasonal risk patterns. Such region-specific agrometeorological interpretation enables GKMS to convert meteorological forecasts into actionable advisories that support timely, climate-responsive decision-making at the farm level.

Agrometeorology forms the scientific foundation of the Gramin Krishi Mausam Sewa (GKMS) programme. Weather parameters generated by the India Meteorological Department, including rainfall, temperature, humidity, wind speed and solar radiation, are interpreted in relation to crop growth stages, soil conditions and management practices to develop location-specific advisories. The response of crops to these parameters is non-linear and crop-specific, with each variable influencing physiological processes such as germination, photosynthesis, evapotranspiration and pest-disease dynamics.

Figure 2 illustrates the relationship between mean air temperature and relative crop growth rate, demonstrating the existence of an optimum temperature range beyond which crop

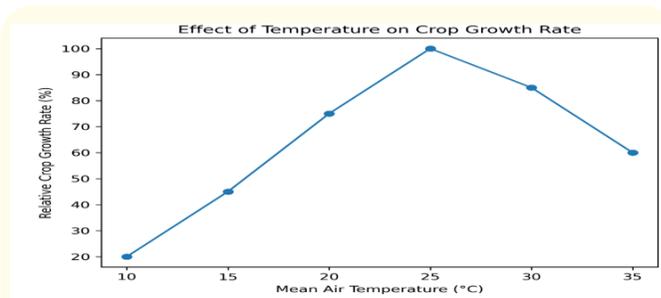


Figure 2: Effect of Temperature on Crop Growth Rate.

performance declines due to heat stress. Such relationships guide GKMS advisories related to sowing windows, varietal selection and heat stress management.

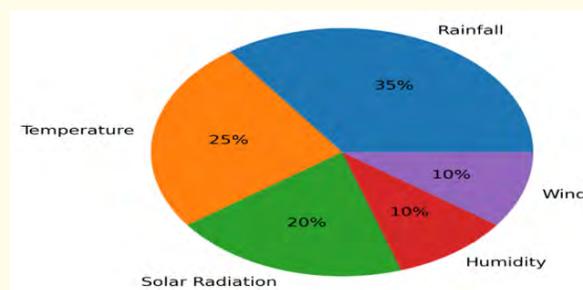


Figure 3: Contribution of Weather Variables to Crop Yield Variability.

Weather-induced yield variability is influenced by multiple atmospheric factors acting simultaneously. As shown in Figure 3, rainfall and temperature contribute the largest share of yield variability, followed by solar radiation, humidity and wind. This relative contribution explains the prioritization of rainfall- and temperature-based advisories within GKMS, particularly in rainfed and semi-arid regions.

Advisory curation: From forecast to farm imperative

AMFUs/DAMUs orchestrate biweekly conclaves, melding forecasts with domain expertise (agronomy, pathology) and crop phenology data. Bulletins encapsulate 10-day historical synopses, 5-day prognostications and prescriptive counsel—e.g., “Defer pesticide application amid 40 km/h winds; inoculate chickpeas against powdery mildew if humidity >65%” [4]. Tailored for 50+

staples (rice, groundnut) and allied sectors (poultry heat stress), they espouse CSA: micro-irrigation per Per Drop More Crop, resilient hybrids via NICRA.

Dissemination dynamics and feedback loops

Dissemination under the GKMS framework relies on a multi-channel communication strategy supported by strong regional institutions such as the Agro-Meteorological Field Unit (AMFU) at Junagadh Agricultural University. AMFU-Junagadh plays a central role in ensuring timely circulation of agromet advisories through SMS services, digital platforms, print media and extension networks linked with KVKs and line departments across South Saurashtra. Feedback from farmers, field extension staff and crop observations is systematically incorporated during advisory preparation, allowing refinement of recommendations based on ground-level responses and emerging risks. This continuous two-way flow of information strengthens advisory relevance, improves farmer confidence and reinforces the adaptive capacity of GKMS at the regional scale.

A tripartite matrix ensures ubiquity: Digital (70%; SMS/IVRS to 43 million, Meghdoot’s 4.16 million users with offline vernacular audio [18]; Broadcast (20%; DD Kisan, AIR, print via PPPs with

Reliance/IFFCO); Community (10%; KVK fairs, 5,700 WhatsApp cohorts in 57,000 villages). Impact-Based Forecasts (IBFs) for agriculture, 2025’s innovation, append remedial directives during cyclones (e.g., “Anchor livestock; elevate stores”). AgroDSS portals harvest feedback, refining iteratively—e.g., 51% understandability critiques spurred jargon mitigation [12].

Digital innovations: Meghdoot and the expanding agri-tech constellation

The Meghdoot mobile application has become a central pillar of GKMS delivery. Designed to provide location-specific forecasts and advisories in multiple languages, the app supports both text and audio formats to accommodate varying literacy levels. Evaluations indicate that Meghdoot users are more likely to adjust sowing dates, irrigation schedules and plant protection measures in response to weather information [3,9].

Satellite-derived products, including vegetation indices and soil moisture indicators, further enhance spatial resolution and early warning capability. Integration with broader digital agriculture initiatives, such as farmer databases and decision support platforms, has enabled more targeted advisories and improved convergence with insurance and risk management schemes [7,11].

Parameter	High (%)	Medium (%)	Low (%)	Effectiveness Index (%)	Key Insight
Timeliness/Need	62	29	9	74	Timely alerts avert 19% irrigation waste (Punjab, n = 122)
Understandability	31	51	18	68	Vernacular boosts +15%; Jargon critiques addressed
Applicability	29	43	28	65	10-15% yield via sowing tweaks
Overall Impact	77	18	5	77	175% income in Gujarat cases
National Avg.	50	35	15	71	15-25% extremes mitigation

Table 2: Advisory Effectiveness Metrics (Source: [12]).

Meghdoot: Genesis, features and 2025 augmentations

Conceived in 2019 amid Digital India, Meghdoot—IMD/ICAR/IITM/ICRISAT’s progeny—aggregates AMFUs’ bulletins for bespoke access: Post-registration (mobile/location), users procure 5-day forecasts, biweekly advisories (e.g., “Vaccinate poultry if humidity spikes”) and nowcasts in 13 tongues, replete with infographics and 30-second videos. Offline caching and voice-over

narration democratize for 70% low-literacy cohorts. By November 2025, 4.16 million registrations (10% YoY growth) evince 25% behavioral pivots during monsoons, per mKisan analytics—e.g., 38 million adjusted plantings amid 15% deficits.

Synergistic agri-tech ecosystem

DAM’s AgriStack (2024; 10 crore Farmer IDs) furnishes GKMS with geospatial soil/crop registries, enabling precision alerts.

Complements include Kisan Suvidha (50 million users; scheme/pricing nexus), FarmerChat (Digital Green; 3 million AI queries for pests), Plantix (15 million; photo-diagnostics slashing 20-30% pesticides), DeHaat (1.8 million; market linkages) and Farmonaut (NDVI *via* satellites). Krishi Decision Support System (Krishi-DSS, 2024) amalgamates GKMS with reservoir data for drought prognostication (Global AgTech Initiative, 2025). IndiaAI Mission (₹10,372 crore) funds pest predictive analytics, with 2025 pilots yielding 50x scaling for Farmer Producer Organizations (FPOs).

Regional Impacts: Gujarat as exemplar of localized resilience

Gujarat’s semi-arid expanse (60% rainfed; 600-875 mm annual precipitation) epitomizes GKMS’s adaptive prowess, where cyclones and salinity imperil 42% workforce-dependent livelihoods.

Gujarat provides a clear illustration of how localized implementation of the GKMS framework strengthens climate

resilience in semi-arid farming systems. Characterized by high rainfall variability, frequent dry spells and increasing incidence of heat stress and cyclonic events, the state has benefited from region-specific agrometeorological advisories that support timely farm decisions. The integration of AMFUs and extension networks has enabled effective translation of weather forecasts into actionable guidance on sowing, irrigation scheduling, pest management and contingency planning. Gujarat provides a useful illustration of GKMS performance under semi-arid and climatically variable conditions. Studies from North Gujarat and Saurashtra report high levels of awareness and adoption of advisories, particularly for irrigation scheduling and pest management [12,13]. Empirical assessments show yield improvements of around 10–15% in major crops and significant reductions in input use and weather-related losses.

Innovation	Core Functionality	2025 User Base (Millions)	GKMS Synergy
Meghdoot	Forecasts/advisories; Offline multilingual	4.16	Direct bulletin aggregator; 25% monsoon shifts
AgriStack	Farmer/crop registries; Soil maps	100	Targeted hyperlocal alerts; Scheme transparency
FarmerChat	Voice AI for pests/climate	0.35	3M queries; FPO scaling x50
Plantix	Image-based disease ID	15	20-30% input reductions; CSA alignment
Krishi-DSS	Drought/flood mapping	Nationwide	Reservoir integration; Evidence-based policies

Table 3: Digital Agri-Tech Innovations (Source: [3,18]).

The synthesis of programme reports and empirical studies indicated measurable improvements in farm management outcomes associated with the adoption of GKMS advisories. Across multiple agro-climatic regions, reported yield gains in major crops ranged between 10 and 15 percent. Reductions in weather-related production losses were documented in the range of 15 to 25 percent, particularly during episodes of unseasonal rainfall, droughts, and heat stress.

Evidence from field-level assessments showed improved efficiency in the use of irrigation water and fertilizers, with reported reductions in input use of approximately 15 to 20 percent where

advisories were consistently followed. Adoption of sowing window advisories was associated with more timely planting operations, while pest and disease advisories were linked with reduced crop damage in several case study regions.

Digital dissemination platforms expanded the outreach of GKMS, with mobile-based advisories enabling more frequent and timely access to weather and management information during critical crop growth stages. Regional studies from semi-arid and rainfed zones reported higher utilization of advisories for irrigation scheduling and plant protection decisions compared to other management operations.

Quantifiable outcomes and case narratives

Case studies document notable income gains where farmers diversified crops or adjusted management based on GKMS advisories. During recent cyclonic and unseasonal rainfall events, impact-based forecasts helped reduce crop and livestock losses through timely protective actions [1,13]. These findings underscore the value of localized, trusted climate information in enhancing farm resilience.

Empirical Evidence: Metrics of transformation

Productivity and resilience metrics

ICAR’s 2025 district pilots affirm 10-15% yield uplifts across staples, with Punjab’s SMS cohort (n = 122) evincing 62%

timeliness/need fulfillment, 77% overarching impact and 74% index [12]. CSA corollaries: 15-20% input efficiencies, 12% livestock deprecation curtailments [1]. NICRA synergies double drought yields via hybrids.

The documented improvements in crop productivity and reductions in weather-related losses highlight the potential of weather-based advisory services as a practical climate adaptation tool for smallholder agriculture. Similar benefits have been reported in earlier national and international studies on climate information services, suggesting that timely, localized weather information can significantly enhance farm-level decision-making and risk management.

Metric	2021 Baseline (%)	2025 Enhanced (%)	Delta (%)	Illustrative Outcome
Irrigation Recalibration	73	78	+5	19% water savings in North Gujarat
Spraying Modulation	65	70	+5	20-30% pesticide economization
Yield Accretion (Groundnut)	10	15	+5	+57 quintals/ha in Jamnagar cases
Income Escalation	Variable	+175 (case)	N/A	₹2.74L to ₹7.57L via diversification
Loss Mitigation (Cyclones)	15	25	+10	₹500Cr statewide averted (2025)

Table 4: Gujarat GKMS Metrics Evolution (Source: [13,15,17]).

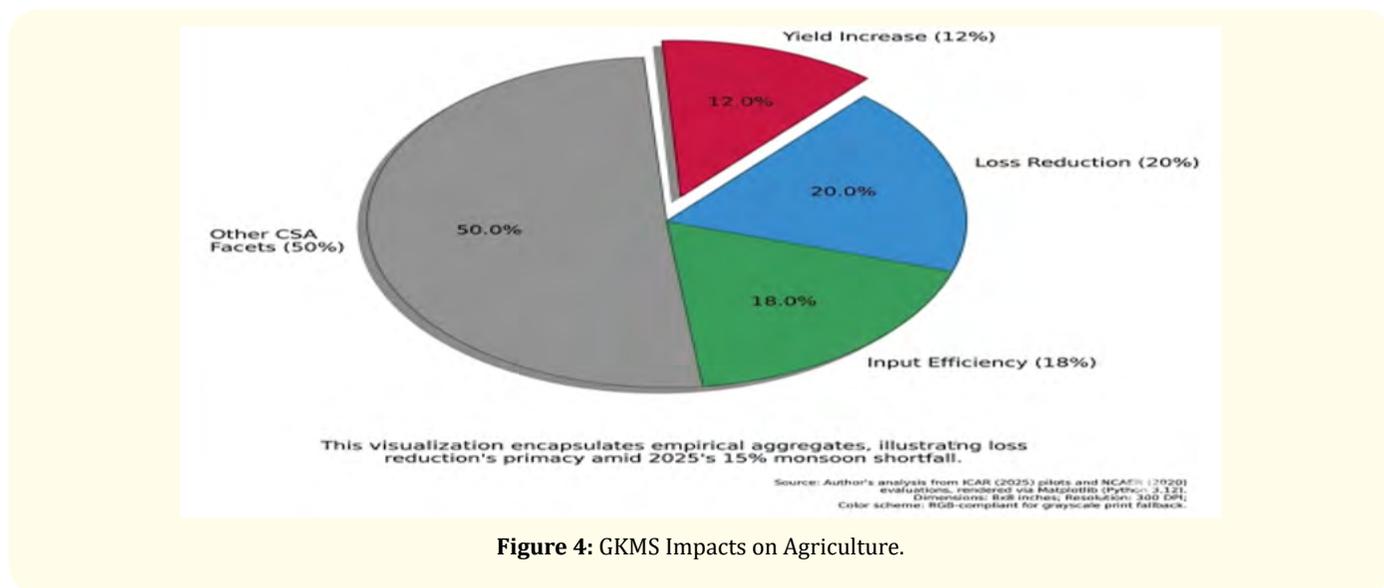


Figure 4: GKMS Impacts on Agriculture.

The greater utilization of advisories for irrigation scheduling and pest management reflects the high sensitivity of these operations to short-term weather variability. This pattern is consistent with findings from extension research indicating that farmers are more likely to adopt advisories when the perceived risk of incorrect timing is high.

The expansion of digital dissemination platforms appears to have strengthened the timeliness and reach of advisories, although uneven access to smartphones and mobile connectivity continues to constrain benefits among small and marginal farmers. In addition, forecast uncertainty at finer spatial scales may limit farmer confidence in some regions. Addressing these constraints

through improved observational networks, hyper-local forecasting, and complementary community-based dissemination mechanisms is essential for enhancing the overall effectiveness and equity of GKMS.

Economic and socio-ecological ramifications

[13] quantifies ₹50,000 crore returns per ₹1,000 crore infusion, with ₹13,331 crore rainfed accruals. 2024 floods: ₹500 crore salvaged via IBFs [16]. Odisha KVKs (2025): 60% cyclone losses thwarted, 20% women-led adoption premium [4]. Utilization study (IJCMA, Nov 2025; n = 200 North India): 80% apply for planning, 68% for contingencies.

Category	Quantitative Evidence	Contextual Illustration	Source
Yield Enhancement	10-15% (avg.)	Groundnut +57 q/ha (Gujarat)	[15]
Loss Mitigation	15-25% (extremes)	₹500Cr floods (2024 national)	[10,16]
Effectiveness Index	74% (high)	77% impact (Punjab SMS)	[12]
Income Accretion	+₹12,500/HH (BPL)	+175% (Jamnagar case)	[7,13]
Resource Efficiency	15-20% (water/fertilizer)	19% irrigation savings	[1,6]

Table 5: Empirical Impact Spectrum.

Challenges: Impediments to universal efficacy

Accessibility and equity gaps

Despite demonstrable benefits, GKMS faces persistent challenges. Digital exclusion remains a concern for farmers without access to smartphones or reliable connectivity. Forecast accuracy can be constrained in regions with complex terrain and sparse observational networks. Institutional coordination across agencies and states also requires continuous strengthening [1,17].

Predictive and operational hurdles

Microclimate variances erode fidelity in Aravallis/Himalayas; coordination interstices among IMD/ICAR/states occasion delays [10]. Awareness deficits: 2025 KVK surveys register 15% non-utilization in interiors.

Future Directions: Charting a hyper-resilient horizon

Future priorities include expanding hyperlocal forecasting using artificial intelligence, improving last-mile communication through community institutions and integrating advisories more closely

with insurance, credit and market systems. Addressing gender and social inclusion will be essential to ensure equitable benefits from climate services.

Conclusion

The Gramin Krishi Mausam Sewa framework represents a significant institutional effort to translate meteorological science into practical, farm-level decision support for smallholder agriculture in India. The evidence synthesized in this review indicates that weather-based advisories, when delivered in a timely and locally relevant manner, can support improved planning of sowing operations, irrigation scheduling, nutrient management, and pest and disease control. As such, GKMS functions not only as an information service but also as a risk management tool that strengthens the adaptive capacity of farming systems under increasing climate variability.

From a practical perspective, the findings underscore the importance of strengthening last-mile delivery mechanisms so that advisories reach farmers in usable formats and at decision-

critical times. Enhancing coordination between meteorological agencies, agricultural research institutions, and extension systems can further improve the relevance and credibility of advisories. Integration of GKMS with complementary services such as crop insurance, contingency planning, and market advisory platforms can increase its utility for farm households and improve uptake of climate-responsive practices.

At the policy level, the GKMS experience offers valuable lessons for the design of national climate service programmes in agriculture. Continued investment in hyper-local forecasting capacity, digital inclusion, and institutional convergence will be essential to sustain and scale the benefits of weather-based advisory services. Strengthening these components can help position GKMS as a core element of climate-resilient agricultural development in India.

Bibliography

1. Amith G., *et al.* "Agromet advisory services for climate smart agriculture". *Journal of Experimental Agriculture International* 44.4 (2022): Article 30810.
2. Chattopadhyay N. "Advances in application of sub-seasonal weather forecast in Indian agriculture". *Journal of Agrometeorology* 25.1 (2023): 41-51.
3. Global AgTech Initiative. "India's AI-driven farm revolution: Are we ready to lead or lag?" (2025).
4. India Meteorological Department. "GKMS newsletter: January 2021" (2021).
5. Intergovernmental Panel on Climate Change. "Climate change 2022: Impacts, adaptation and vulnerability". Cambridge University Press (2022).
6. Jaankaar Bharat. "Gramin Krishi Mausam Sewa (GKMS): Weather services for Indian farmers". (2025).
7. Just Agriculture. "Success story: Improvement in income through agro advisory services" (2024).
8. Lakshmi M S., *et al.* "Implementation of GKMS for climate smart agriculture in rural areas". *Vigyan Varta* 6.4 (2025): 219-221.
9. Manjusha K., *et al.* "Exposure, perception and advantages about weather based agro-advisory services". *International Journal of Current Microbiology and Applied Sciences* 8.5 (2019): 1234-1245.
10. Ministry of Earth Sciences. "Parliament question: Initiatives to strengthen climate forecasting" (2025a).
11. Ministry of Earth Sciences. "Support to farmers to enhance sustainability of agriculture".
12. Mohapatra L and Sharma P. "Effectiveness of the SMS advisory service under Gramin Krishi Mausam Sewa (GKMS)". *International Journal of Farm Sciences* 10.3-4 (2020): 12-17.
13. National Council of Applied Economic Research. "Economic impact of weather forecast-based advisories". MoES Report (2020).
14. Nigam R., *et al.* "Satellite agromet products and their adaptation for advisory services to Indian farming community". *Journal of Agrometeorology* 25.2 (2023): 52-62.
15. Patel HK and Patel M M. "Impact assessment of agro advisory services in North Gujarat region". *ResearchGate* (2022).
16. Press Information Bureau. "Support to farmers to enhance sustainability of agriculture" (2025a).
17. Press Information Bureau. "Parliament question: Initiatives to strengthen climate forecasting" (2025b).
18. Press Information Bureau. "Parliament question: Unpredictable weather patterns" (2025c).