THE ROLE OF EARLY WARNINGS TOWARDS A CLIMATE RESILIENT AGRICULTURE AND AVIATION INDUSTRY FOR SUSTAINABLE SOCIO-ECONOMIC DEVELOPMENT OF TARABA STATE

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Abstract
This paper critically explores the strategic significance of Early Warning Systems (EWS) in strengthening climate resilience across Taraba State's agricultural and aviation sectors. Anchored in both global paradigms and regional development imperatives, it demonstrates how the timely collection, analysis, and dissemination of climate information empower stakeholders to anticipate and mitigate environmental hazards. The study emphasizes the integration of EWS into policy frameworks, institutional governance, and grassroots practices to transform reactive responses into proactive planning. By evaluating best practices and highlighting innovations under initiatives such as ACReSAL and L-PRES, the paper showcases EWS as a linchpin for sustainable socio-economic development. The findings advocate for multi-level stakeholder engagement, investment in ICT infrastructure, and the localization of climate information services as essential strategies to reduce vulnerability and foster adaptive capacity in Taraba State.
Keywords: Early Warning Systems, Climate Resilient Agriculture and Aviation, Taraba State

Introduction

Climate change poses growing threats to agriculture and aviation, two vital sectors in Taraba State. Extreme weather events such as droughts, floods, and thunderstorms increasingly disrupt food systems and air transport safety. The early warning system (EWS) concept has emerged as a critical component in disaster risk reduction (DRR) and resilience building. Climate change continues to exert profound impacts on socio-economic systems globally, with its effects most pronounced in climate-sensitive sectors such as agriculture and aviation. The Intergovernmental Panel on Climate Change (IPCC, 2021) affirms that intensifying extreme weather events—such as droughts, floods, heatwaves, and storms—are disrupting food production, supply chains, and transport infrastructure, particularly in developing countries.

Globally, early warning systems (EWS) have emerged as a crucial climate adaptation strategy and pillar of disaster risk reduction (UNDRR, 2022). The United Nations' Sendai Framework underscores the role of EWS in reducing mortality and economic losses by enabling timely, people-centered, and actionable information dissemination. In sub-Saharan Africa, evidence from countries like Kenya, Ethiopia, and Ghana demonstrates that functional EWS enhance farmers' resilience, increase preparedness in aviation logistics, and reduce vulnerability in marginalized communities (FAO, 2022).

In West Africa, Nigeria has made strides in developing climate information services through institutions such as the Nigerian Meteorological Agency (NiMet), yet the integration of EWS into critical sectors like agriculture and aviation remains limited and fragmented (NiMet, 2023). Taraba State, situated in Nigeria's northeastern ecological transition zone, is particularly exposed to climatic threats due to its varied topography and reliance on rain-fed agriculture. The recent occurrences of flash floods, prolonged dry spells, and erratic rainfall patterns have amplified the vulnerability of farming households and hindered air travel safety.

Despite the acknowledged benefits of EWS, there is a paucity of localized studies that explore their combined relevance to both agriculture and aviation sectors in a single framework. While research has evaluated EWS in disaster-prone regions or for single hazards, a comprehensive and sector-integrated approach focusing on Taraba State's unique socio-environmental context remains underdeveloped. This study addresses that gap by assessing the role and prospects of early warning systems (EWS) in building climate resilience across both agriculture and aviation, emphasizing their contributions to sustainable socio-economic development in Taraba State.

Conceptual Framework

The conceptual foundation of this study is built upon the global understanding of Early Warning Systems (EWS) as an integrated pillar of Disaster Risk Reduction (DRR). According to the United Nations Office for Disaster Risk Reduction (UNDRR, 2022), an effective EWS is composed of four interlinked components: (1) risk knowledge; (2) monitoring and warning services; (3) dissemination and communication; and (4) response capability. These elements function synergistically to enable at-risk populations to act appropriately and in sufficient time to reduce harm or loss.

Through the lens of DRR, EWS transcends being a reactive tool and instead serves as a proactive resilience-building mechanism. In this model, 'risk knowledge' involves systematic risk assessments that are context-specific and participatory, identifying hazard-prone zones, vulnerabilities, and exposed livelihoods, particularly in agriculture and aviation. 'Monitoring and warning services' hinge on the capacity of institutions like NiMet and the Nigerian Airspace Management Agency (NAMA) to generate and interpret meteorological and environmental data in real time.

The 'dissemination and communication' component is crucial for translating technical forecasts into understandable, actionable messages tailored to end users such as farmers, pastoralists, airport managers, and pilots. This dimension must consider linguistic, technological, and infrastructural barriers common in rural Taraba. Lastly, 'response capability' involves the institutional readiness, policy integration, and community training needed to act upon warnings and mitigate losses effectively.

Figure A illustrates this conceptual framework, contextualized for Taraba State. It highlights the interaction between hazard exposure (e.g., drought, flood, storm), vulnerable systems (rain-fed farming, airport infrastructure), enabling institutions (NiMet, NAMA, TASEPA), and the feedback loop that promotes adaptive decision-making through timely, accurate, and trusted early warnings.

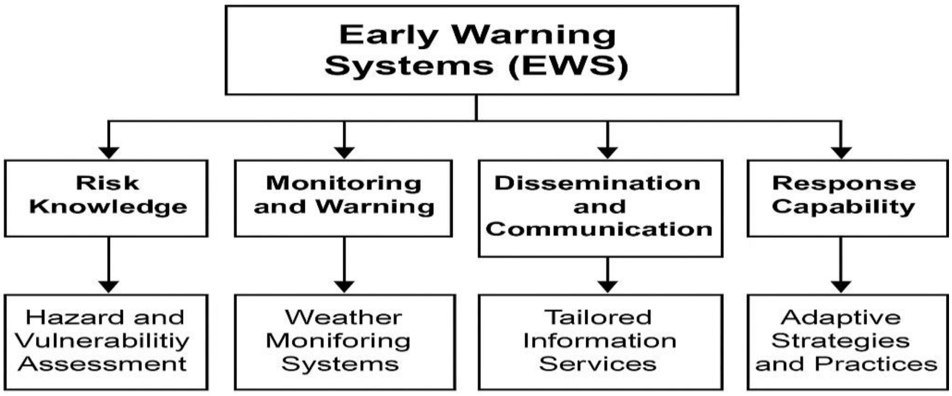


Figure A
Conceptual Framework: Early Warning Systems (EWS) for Agriculture and Aviation

By adopting this EWS-DRR framework, the paper anchors its analysis on how early warnings can serve as a transformative tool to climate-proof agriculture and aviation in Taraba State, thereby contributing to long-term socio-economic resilience.

Climate Profile of Taraba State

Taraba State is geographically located in the northeastern region of Nigeria between latitudes 6°30′ and 9°36′N and longitudes 9°10′ and 11°50′E. It shares boundaries with Bauchi, Gombe, Adamawa, Benue, Nasarawa, and Plateau States, as well as the Republic of Cameroon to the southeast. The state is ecologically diverse, comprising mountainous terrain in the Mambilla Plateau (above 1,800 meters) and lowland savannahs and floodplains across the Benue trough.

Climatically, Taraba falls within the tropical hinterland zone and experiences a distinct wet and dry season typical of the Guinea and Sudan savanna belts. The rainy season spans April to October with peak rainfall between July and September, recording annual precipitation between 1,000 mm in the north and 2,300 mm in the southern uplands (Taraba State Climate Change Policy, 2025).

The dry season extends from November to March and is often dominated by Harmattan winds laden with dust from the Sahara. Temperature regimes range between 20°C in high-altitude areas like the Mambilla Plateau and 38°C and sometime 40°C in the drier lowland regions of the northern zone (Figure 1).

Climate variability has become more evident over the last two decades with noticeable shifts in the onset and cessation of rains, more frequent dry spells within the rainy season, and the occurrence of extreme weather events such as flash floods, heatwaves, and severe windstorms. These conditions negatively impact both agriculture and aviation operations.

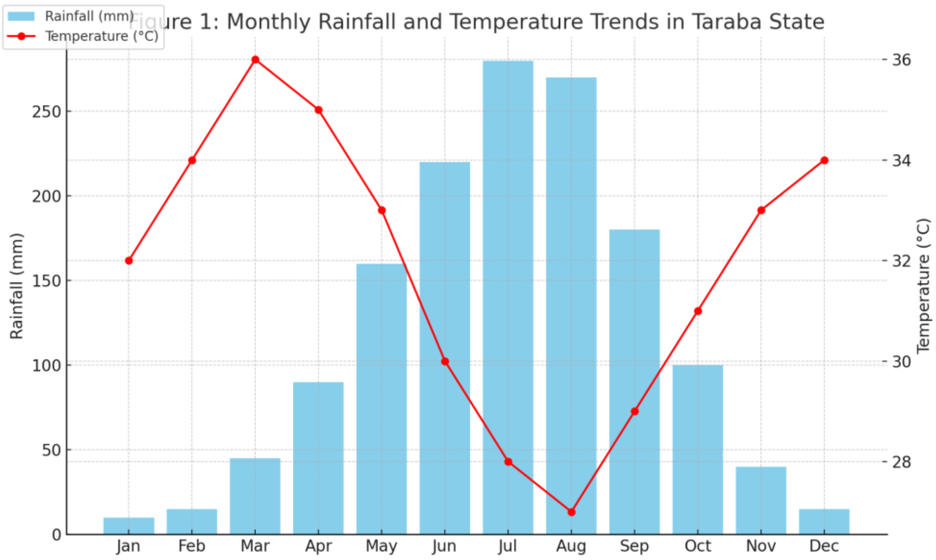


Figure 1: Monthly Rainfall and Temperature Trends in Taraba State

The agricultural sector, which employs over 70% of the state's population, is particularly vulnerable. Climate-induced disruptions such as early cessation of rainfall or flooding of croplands lead to lower yields and food insecurity. Similarly, the aviation industry, especially at Danbaba Danfulani Suntai Airport and emerging facilities like Kashimbila Cargo Airport, faces operational delays due to weather extremes. Runway visibility, safety, and infrastructure resilience are increasingly challenged by changing climate conditions.

In response to these vulnerabilities, the Taraba State Government has adopted a Climate Change Policy Framework that underscores the need for climate-smart planning, including the deployment of early warning systems (EWS). This climate profile thus highlights the urgent necessity of integrated, localized climate monitoring and forecasting services to bolster resilience in high-risk sectors.

Role and Impact of Early Warning Systems in Taraba State

Agrometeorological Forecasting Agrometeorological forecasting integrates climate and weather data with agricultural planning to support farming decisions. In Taraba State, this service is critical for managing risks from delayed onset of rainfall, prolonged dry spells, or unseasonal floods. According to World Meteorological Organization (WMO, 2022), tailored forecasts that include crop calendars, rainfall probabilities, and heatwave alerts can reduce crop failure risks by over 30%. NiMet's Seasonal Climate Prediction (SCP) and Agricultural Advisory Services (AAS) are practical tools currently supporting Nigerian farmers with real-time agrometeorological information (NiMet, 2025).

ICT-based Dissemination Platforms Modern early warning systems leverage information and communication technology (ICT) to reach wide and remote populations. Platforms such as mobile SMS, radio, social media, and voice-enabled tools facilitate timely warning dissemination. Projects like the "Digital Agriculture Nigeria" platform and the FAO-supported "E-Agriculture" initiative show that ICT-based warnings improve decision-making speed and accuracy among smallholder farmers (FAO, 2021; CTA, 2020). In Taraba, integration of localized language messages and visual/audio alerts can bridge literacy barriers and ensure equitable access to warnings.

Community-Based Early Warning Systems (CBEWS) CBEWS enhance grassroots capacity for climate adaptation by incorporating indigenous knowledge with scientific forecasts. These systems rely on participatory mapping of climate hazards, training of local volunteers, and establishment of community response plans. Empirical studies in Uganda and northern Nigeria suggest that community trust and engagement improve EWS credibility and actionability (IFRC, 2021). Taraba's vulnerable communities in flood-prone river valleys and upland agricultural belts can benefit from CBEWS by aligning risk perception with real-time alerts.

Weather Surveillance and Communication for Aviation Weather information is vital for aviation safety, particularly in a state with rugged topography and variable climate like Taraba. NiMet's aviation meteorology services comprising METARs, TAFs, and synoptic charts—are essential for pre-flight planning. Advanced radar systems and satellite-based remote sensing help detect turbulence, wind shear, and fog conditions affecting airports (ICAO, 2022). Communication through the Aeronautical Fixed Telecommunication Network (AFTN) and Automatic Terminal Information Services (ATIS) ensures pilots receive continuous updates.

Airport Emergency Management Airport emergency plans (AEPs) integrate early warnings for rapid response to weather-induced threats. These protocols include contingency drills, emergency shelters, and coordination with disaster agencies. At the Danbaba Suntai Airport and Kashimbila Cargo Airport, developing climate-resilient AEPs is essential given recurrent storms, flooding, and visibility issues. The International Civil Aviation Organization (ICAO, 2021) recommends harmonizing EWS with Standard Operating Procedures (SOPs) and using AI-driven simulation tools for scenario planning.

Capacity Building and Training For both sectors, capacity development is key to EWS effectiveness. Training programs for meteorological officers, extension agents, airport managers, and frontline responders are vital. As UNDP (2022) notes, countries with sustained investment in institutional training exhibit higher early warning uptake and adaptive responses. In Taraba, integrating EWS training into agricultural extension and aviation regulatory frameworks can strengthen human capital for climate resilience.

These six components provide a holistic framework for strengthening early warning systems in Taraba State, ensuring that vulnerable populations and critical infrastructure are better prepared to withstand climate-induced disruptions.

Impact of Climate Change on Agriculture in Taraba State

Crop Failure and Yield Variability: Climate change has intensified the incidence of crop failure and yield variability in Taraba State. Erratic rainfall, early cessation of the wet season, and high temperatures negatively affect critical crops such as maize, yam, sorghum, and rice. According to the Nigerian Meteorological Agency (NiMet, 2023), there has been an observable shift in rainfall onset and cessation by up to two weeks over the past decade. This temporal uncertainty hinders planting decisions, leads to drought stress during key crop growth stages, and contributes to yield declines. Recent data from the International Food Policy Research

Institute (IFPRI, 2022) indicate that climate-induced yield reductions in Nigeria's middle-belt region, including Taraba, could reach up to 25% by 2050 without adequate adaptation.

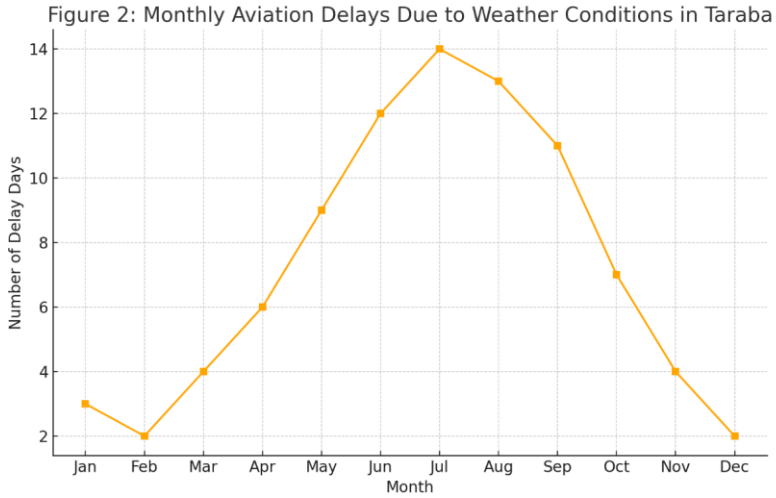
Livestock and Pasture Degradation Pastoral livelihoods in Taraba, particularly in the northern and central LGAs, are increasingly threatened by climate-driven pasture loss and water scarcity. Rising temperatures and prolonged dry spells reduce forage availability, resulting in poor livestock health, lower meat and milk yields, and heightened conflict between herders and farmers due to resource competition. The Food and Agriculture Organization (FAO, 2021) highlights that 70% of pastoralists in semi-arid zones of Nigeria have altered their transhumance routes due to environmental stressors. In addition, climate-sensitive livestock diseases such as contagious bovine pleuropneumonia and helminthiasis are becoming more prevalent, exacerbating livestock mortality and income instability.

Food Insecurity and Rural Livelihoods The compounded effects of crop and livestock disruption significantly heighten food insecurity in Taraba State. Over 70% of the rural population depends on subsistence agriculture, which is highly exposed to climate shocks. The Cadre Harmonisé (CH) Food Security Analysis for Nigeria (2023) reported that over 1.3 million people in the North-East, including parts of Taraba, are projected to experience food crisis levels if current climatic and socio-economic conditions persist. Moreover, climate change aggravates poverty, youth underemployment, and gender-based vulnerabilities, particularly among female-headed households who face limited access to land, credit, and adaptive farming resources (UN Women, 2022).

A good knowledge of these impacts is crucial for designing targeted interventions such as climate-smart agriculture, pasture restoration, and livelihood diversification to safeguard food systems and strengthen resilience in Taraba's agricultural sector.

Impact of Climate Change on the Aviation Sector in Taraba State

Visibility and Flight Delays Climate change has intensified meteorological phenomena that reduce atmospheric visibility and increase the frequency of flight delays and cancellations. In Taraba State, the aviation sector is affected by erratic rainfall patterns, heavy fog during harmattan, thunderstorms, and haze conditions. These factors often lead to poor runway visibility and disrupt flight operations, especially at Danbaba Danfulani Suntai Airport in Jalingo and Kashimbila Agro-Cargo Airport in Takum. According to the International Civil Aviation Organization (ICAO, 2022), low visibility is one of the leading weather-related causes of delays and air traffic disruption in sub-Saharan Africa. NiMet (2025) reports a notable increase in days with critical low visibility (<1000m) in northeastern Nigeria due to extended harmattan and dust outbreaks (Figure 2).



Infrastructure Damage Climate-induced events such as extreme heat, heavy downpours, and flash floods pose serious risks to aviation infrastructure. High temperatures accelerate the degradation of tarmac surfaces, while recurrent flooding damages drainage systems, terminal buildings, and runways. The World Bank (2022) warns that African airports, especially those lacking climate-resilient designs, are increasingly exposed to climate risks. In Taraba, inadequate urban drainage exacerbates surface runoff into airport premises, threatening operational continuity and asset longevity. Reports from Nigeria's Federal Airports Authority (FAAN, 2021) highlight that infrastructure resilience remains a major challenge due to outdated designs and insufficient adaptation investments.

Safety and Operational Risks Changing weather dynamics increase operational risks for pilots, air traffic controllers, and airport management. Intense thunderstorms, turbulence, and wind shear compromise aviation safety, requiring advanced forecasting tools and real-time pilot advisories. According to the Nigerian Airspace Management Agency (NAMA, 2022), there has been a rise in reported mid-air weather-related incidents across Nigeria's domestic routes, particularly in highland and valley regions such as those found in Taraba. Without real-time weather data and effective early warning systems, the risk of accidents during takeoff, landing, and in-flight navigation is elevated. The integration of Doppler radar systems, GPS-enabled surveillance, and trained meteorological personnel is essential to safeguard aviation operations under changing climate conditions. These challenges highlight the urgency of mainstreaming climate adaptation and early warning protocols into airport design, maintenance, and operational planning in Taraba State.

Institutional and Policy Frameworks Supporting EWS

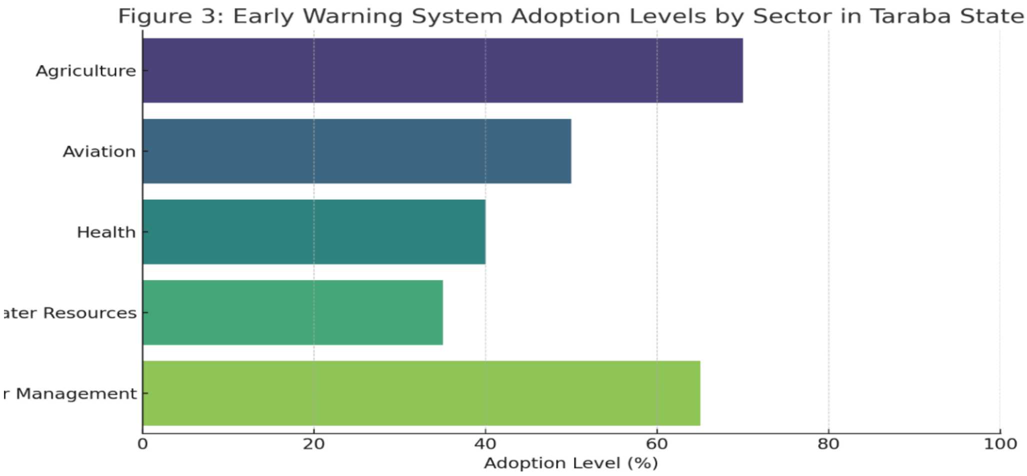
National Policy on Climate Change (NPCC 2021) The NPCC 2021 provides the overarching framework for Nigeria's climate adaptation and mitigation agenda. It emphasizes the integration of early warning systems (EWS) into key socio-economic sectors, particularly agriculture and infrastructure. The policy promotes the use of climate information services and the mainstreaming of disaster risk reduction (DRR) principles into federal and sub-national development plans (Federal Ministry of Environment, 2021). It mandates collaboration with meteorological and hydrological agencies to enhance multi-hazard forecasting and timely response mechanisms.

Taraba State Climate Change Policy 2025 The Taraba State Climate Change Policy (2025) aligns with the NPCC and serves as a tailored strategic document for building local resilience. It outlines sector-specific goals, including the institutionalization of EWS across agriculture, aviation, health, and water resources. The policy supports decentralized planning, gender-inclusive adaptation, and the development of climate risk communication infrastructure at the community level. It also prioritizes the establishment of climate information centers and the use of indigenous knowledge systems alongside modern meteorological tools (Taraba State Government, 2025).

Taraba State Environmental Protection Agency (TASEPA) TASEPA is the state's lead environmental regulatory agency and plays a key role in coordinating climate resilience efforts, including early warning dissemination. However, the agency faces challenges such as inadequate funding, limited technical manpower, and poor inter-agency data sharing. Strengthening TASEPA's institutional capacity and equipping it with geospatial and ICT tools would significantly enhance its ability to serve as an effective node in the EWS architecture. The agency is also critical for implementing climate-smart land use planning and environmental impact assessments (EIA).

Collaboration with Research Institutions Academic and research institutions are central to EWS development through their roles in data analysis, modelling, and community education. Taraba State University, the Nigerian Meteorological Agency (NiMet), and universities like the Federal University Wukari are valuable partners in enhancing the accuracy, localization, and usability of forecasts. Studies by the Centre for Climate Change and Freshwater Resources (2022) advocate for co-designed research involving farmers, aviation stakeholders, and forecasters to improve the effectiveness of warning systems and decision support tools.

Strengthening EWS Uptake through ACReSAL and L-PRES Projects Agro-Climatic Resilience in Semi-Arid Landscapes (ACReSAL) and Livestock Productivity and Resilience Support (L-PRES) projects are critical for scaling up EWS in Taraba State. ACReSAL, funded by the World Bank, focuses on watershed management, agroecological restoration, and climate-smart extension services. It supports the deployment of automatic weather stations and community climate forums. L-PRES addresses pastoral vulnerabilities through disease surveillance, pasture regeneration, and livestock market systems all of which benefit from timely climatic information (World Bank, 2023). Both projects include strong Monitoring, Evaluation, and Learning (MEL) components that can be leveraged for EWS institutionalization and public engagement (Figure 3)



The relatively higher adoption in agriculture and disaster management are due to ACReSAL and L-Pres programs, and lower uptake in sectors like water and health.

Strategic Role of Taraba's Airports in Climate Resilience and Development

Danbaba Danfulani Suntai Airport (Jalingo)

The Danbaba Danfulani Suntai Airport, located approximately 10 km west of Jalingo's central business district, plays a pivotal role in enhancing regional connectivity and economic resilience. With its recent rehabilitation and expansion commissioned in May 2025 by Nigeria's Vice President during the Taraba International Investment Summit (Taravest). The airport has become a central hub for both domestic flights and logistical operations. According to Channels Television (2025), the upgraded facility features improved runway systems and terminal facilities that support safer, more climate-resilient aviation operations.

Strategically, the airport facilitates swift transportation of agricultural produce, supports emergency response activities during climate-related disasters, and boosts tourism to ecologically sensitive areas like the Mambilla Plateau. Improved air access also enhances early warning dissemination through logistical support for meteorological instruments and disaster preparedness supplies. The airport's integration with NiMet's aviation meteorological services, including real-time weather advisories, supports operational efficiency and safety.

Kashimbila Integrated Cargo/Agro-Allied Airport (Takum LGA)

Located in Takum LGA, the Kashimbila Airport is envisioned as an integrated cargo/agro-allied aviation hub. Approved for concession under a Public-Private Partnership arrangement by the Federal Executive Council in February 2025, the airport is part of a broader economic corridor that includes over 3,000 hectares of farmland, livestock ranching zones, and agro-processing facilities (ICRC, 2025).

The airport is strategically positioned to support agricultural exports, facilitate rapid market access for perishable goods, and enable aerial disease surveillance and vaccine delivery systems under the L-PRES project. The cargo functionality further aligns with ACReSAL's objectives by improving resilience in agro-value chains and climate-proofing transportation logistics. As the airport evolves, integrating climate-smart infrastructure and forecasting systems will be essential for operational sustainability. Both airports thus represent more than transportation nodes they are enablers of climate resilience, economic diversification, and early warning system scale-up in Taraba State.

Socio-economic Benefits of Climate-resilient Agriculture and Aviation

Enhanced Productivity and Food Security: Climate-resilient agricultural practices supported by early warning systems and climate-smart technologies can significantly increase productivity and food availability in Taraba State. Accurate seasonal forecasts enable farmers to plan planting schedules, manage irrigation, and reduce losses due to unexpected weather events. According to the International Food Policy Research Institute (IFPRI, 2022), access to agro-climate services in Nigeria has improved crop yields by up to 20% among smallholder farmers. In Taraba, these benefits translate into greater food security, especially in remote and upland communities prone to erratic rainfall and floods.

Improved Trade and Market Access: Taraba's revitalized aviation infrastructure facilitates the swift movement of goods, services, and agricultural produce within and beyond state boundaries. The Kashimbila Cargo/Agro-Allied Airport and Danbaba Danfulani Suntai Airport offer logistics hubs that reduce post-harvest losses and improve time-to-market for perishable goods. This creates new trade corridors linking local producers with regional and international markets. The World Bank (2023) highlights that climate-resilient transport and logistics infrastructure can increase agricultural export revenue by up to 35% in West Africa when paired with robust early warning systems and storage technologies.

Employment and Investment Opportunities Investments in climate-resilient agriculture and aviation sectors stimulate job creation, especially among youth and women. Early warning services require skilled labor in meteorology, ICT, logistics, and agronomy. Airport modernization attracts private sector investment in tourism, agro-processing, and transport. According to the United Nations Development Programme (UNDP, 2023), climate adaptation and green economy transitions could create over 30 million jobs in Africa by 2030, with sub-national innovation hubs like Taraba serving as testing grounds for inclusive economic transformation. Moreover, the public-private partnerships driving projects like L-PRES and ACReSAL provide funding streams and technical capacity to sustain long-term development impacts.

Challenges in Implementing EWS in Taraba State

Despite the growing relevance of early warning systems (EWS) for climate resilience, several structural and systemic challenges hinder their full-scale implementation and sustainability in Taraba State.

Limited Technical Infrastructure Many parts of Taraba State lack adequate meteorological infrastructure such as automated weather stations, Doppler radar, and real-time data relay systems. This constraint impairs the generation and communication of timely, localized forecasts. NiMet (2025) and the World Bank (2022) note that the dearth of meteorological and ICT infrastructure in rural Nigeria creates significant gaps in forecasting accuracy and reach, particularly for smallholder farmers and remote communities.

Low Literacy and Awareness Levels Widespread low literacy, particularly in rural areas, hampers the interpretation and application of forecast messages. Cultural norms, language barriers, and limited public understanding of climate science further reduce trust and responsiveness to EWS. According to UNDP (2023), building public awareness through grassroots sensitization, indigenous knowledge integration, and visual/audio-based alerts is essential for equitable access to warnings.

Inadequate Funding and Political Will The absence of dedicated funding mechanisms and inconsistent political commitment limit the scalability and institutionalization of EWS across sectors. TASEPA and related agencies often operate with insufficient budgets and minimal investment in staff training or equipment upgrades. The Climate Policy Initiative (2022) emphasizes that localized climate financing frameworks are crucial for sub-national EWS effectiveness.

Fragmentation of Data and Institutions Institutional silos and weak inter-agency collaboration create duplication of efforts and gaps in climate data management. There is often poor coordination between meteorological, agricultural, disaster management, and aviation authorities. Establishing integrated platforms for climate data sharing and inter-sectoral planning is necessary to ensure that early warning messages are harmonized, accurate, and actionable. Addressing these challenges requires a multi-stakeholder strategy that combines investments in infrastructure, education, governance reforms, and digital innovation to support the full uptake of early warning systems in Taraba State.

Recommendations

To ensure the successful implementation and institutionalization of Early Warning Systems (EWS) that support climate-resilient agriculture and aviation in Taraba State, the following strategic actions are recommended:

Establish a formal inter-agency platform comprising representatives from NiMet, TASEPA, NEMA, NAMA, the Ministry of Agriculture, and the Ministry of Environment. This body should be tasked with harmonizing data flows, developing joint action plans, and ensuring integrated EWS responses across sectors. A coordinated framework will help reduce duplication and enhance operational efficiency.

Expand the coverage of Community-Based Early Warning Systems (CBEWS) across all Local Government Areas (LGAs), with emphasis on flood-prone and highland farming zones. Incorporate participatory risk mapping, local knowledge, and community training into warning dissemination and response activities. Partnering with civil society organizations and traditional leaders will improve trust and ownership.

Invest in digital infrastructure, such as mobile alert systems, low-bandwidth data dissemination tools, and localized radio programming, to enhance access to climate information. Target underserved rural populations by translating alerts into local languages and developing audio-visual formats for low-literacy users. Collaborate with telecom providers to establish zero-cost climate alert SMS services.

Formulate and adopt a dedicated Early Warning Systems Policy, aligned with the Taraba State Climate Change Policy (2025) and the National Policy on Climate Change (2021). The policy should outline legal mandates, institutional roles, funding mechanisms, and implementation timelines. It should also mandate the integration of EWS into agricultural extension, aviation safety protocols, and disaster risk reduction strategies. These recommendations provide a roadmap for embedding climate foresight and disaster preparedness into the governance, planning, and operational structures of Taraba State, ultimately enhancing resilience and sustainable development outcomes.

Conclusion

Early Warning Systems (EWS) are not merely technical tools but strategic instruments for reducing vulnerability and enhancing climate resilience across Taraba State's vital sectors—particularly agriculture and aviation. As climate variability continues to disrupt food systems, transport logistics, and human livelihoods, the proactive implementation of EWS offers a transformative pathway for anticipating hazards, minimizing losses, and maximizing adaptive capacity.

A robust EWS framework, supported by timely data, effective communication, stakeholder inclusion, and strong institutional coordination, is essential for protecting both people and infrastructure. For agriculture, EWS enhances food security by guiding planting decisions and safeguarding livestock. In aviation, it ensures flight safety, infrastructure protection, and economic continuity during adverse weather events.

The experience of Taraba State shows that projects such as ACReSAL and L-PRES can serve as effective entry points for scaling up EWS if backed by political will, public-private investment, and an enabling policy environment. Moreover, localizing EWS through community-based approaches and ICT innovation will accelerate climate adaptation and build grassroots ownership.

Ultimately, the pathway to sustainable socio-economic development in Taraba hinges on embedding early warning systems within governance, infrastructure, and public awareness frameworks. This not only builds resilience but also empowers the state to transition toward a climate-smart and economically inclusive future.

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