CAPSTONE PROJECT CONCEPT NOTE AND IMPLEMENTATION PLAN

PROJECT TITLE: AI-POWERED CLIMATE RISK PREDICTION AND EARLY WARNING SYSTEM FOR AFRICA

TEAM MEMBERS

1) Roosevelt Williams

A. CONCEPT NOTE

1. PROJECT OVERVIEW

Climate change poses significant risks to Africa, with extreme weather events such as floods, droughts, and heatwaves threatening lives, livelihoods, and ecosystems. Many African countries lack robust early warning systems due to data scarcity, limited infrastructure, and inadequate technology. This project proposes an AI-powered climate risk prediction and early warning system to enhance resilience and disaster preparedness. The system aligns with the UN Sustainable Development Goals (SDGs 13: Climate Action, 11: Sustainable Cities and Communities, and 2: Zero Hunger). By integrating artificial intelligence with regional climate data, the system will provide localized, accurate, and timely risk forecasts to support governments, communities, and NGOs in decision-making.

2. OBJECTIVES

- Develop a machine learning–based model for predicting climate risks such as droughts, floods, and heatwaves in Africa.
- Design an early warning system that delivers real-time alerts tailored for vulnerable communities.
- Integrate multi-source climate data (satellite, weather stations, socio-economic datasets) to improve prediction accuracy.
- Enhance community preparedness and resilience through data-driven policy recommendations and awareness tools.

3. BACKGROUND

Africa contributes the least to global greenhouse gas emissions but suffers disproportionately from climate impacts. Existing warning systems are often fragmented, inaccessible, or dependent on global models that lack local relevance. AI has the potential to bridge these gaps by integrating diverse datasets, identifying hidden patterns, and generating context-aware forecasts. Previous initiatives have attempted climate monitoring, but few have deployed scalable, community-focused AI-driven early warning systems specifically tailored to Africa's unique vulnerabilities.

4. METHODOLOGY

The project will use a combination of supervised learning (regression, classification) for event prediction, and time-series forecasting (LSTM, Prophet) for climate trend analysis. Ensemble methods (Random Forest, Gradient Boosting) will be used for event probability estimation. The early warning system will incorporate real-time APIs from weather agencies, geospatial analysis using GIS tools, and a dashboard with AI-driven predictive analytics.

5. ARCHITECTURE DESIGN DIAGRAM

- Data Ingestion Layer: Satellite data, weather APIs, socio-economic datasets.
- Preprocessing Module: Data cleaning, normalization, feature engineering.
- AI/ML Models: Time-series forecasting, classification, anomaly detection.
- Decision Engine: Risk scoring and threshold-based alerts.
- User Interface: Dashboard, mobile notifications, and SMS-based alerts.

6. DATA SOURCES

Data will be collected from NASA Earth Observation, Copernicus Climate Data, African Meteorological Agencies, FAO datasets, and World Bank socio-economic indicators. Preprocessing steps will include missing value imputation, temporal alignment, and geospatial feature extraction to ensure data consistency and accuracy.

7. LITERATURE REVIEW

Studies indicate that AI enhances climate prediction accuracy by capturing nonlinear interactions among climatic variables. Research on AI-driven early warning systems (e.g., in Asia and Europe) shows improved disaster preparedness. However, gaps remain in African contexts, where data scarcity and localization challenges hinder reliability. This project builds on existing work by integrating multi-source data with community-centered risk forecasting to create a scalable, Africa-specific solution.

B. IMPLEMENTATION PLAN

I. TECHNOLOGY STACK

- Programming Languages: Python, R
- Libraries/Frameworks: TensorFlow, PyTorch, Scikit-learn, Prophet, Pandas, NumPy, GDAL (for GIS)
- Database: PostgreSQL with PostGIS extension
- Visualization & Dashboard: Power BI / Dash / Streamlit

- APIs: OpenWeather, Copernicus Climate Data Store
- Deployment: AWS / Azure / Google Cloud, with SMS/USSD integration for rural communities

II. TIMELINE

- Week 1–2: Data collection and preprocessing
- Week 3–4: Model selection and baseline training
- Week 5–6: Model optimization and evaluation
- Week 7: System integration (dashboard, alert system)
- Week 8: Deployment and pilot testing
- Week 9: Final evaluation and documentation

III. MILESTONES

- Completion of data preprocessing and exploratory analysis
- Baseline model achieving target accuracy
- Deployment of functional early warning dashboard
- Successful pilot testing with at least one African regional dataset

IV. CHALLENGES AND MITIGATIONS

- Data scarcity → Use data augmentation and satellite-based proxies.
- Model bias → Continuous retraining with local datasets and community validation.
- Technical constraints in rural areas → Provide SMS/USSD alerts in addition to internet dashboards.

V. ETHICAL CONSIDERATIONS

- Data Privacy: Ensure compliance with GDPR and local data protection regulations.
- Bias Mitigation: Avoid models that disadvantage vulnerable groups by including socio-economic diversity in training data.
- Community Impact: Design alerts to be culturally sensitive, actionable, and non-alarming.

VI. REFERENCES

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