JOMO KENYATTA UNIVERSITY OF AGRICULTURE AND TECHNOLOGY

RESEARCH PROPOSAL

HBT 2308 SYSTEMS DEVELOPMENT PROJECT

ENHANCING RESOURCE SHARING SECURITY THROUGH CRYPTOGRAPHY

AUTHOR

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A proposal research submitted to the Department of Information Technology, Jomo Kenyatta University of Agriculture and Technology, in partial fulfilment of the requirement for the award of the degree of Bachelor of Business Information Technology.

2025

Declaration

I sincerely declare that this proposal/research project is my original work and has not been presented for a degree in any other University.

Signature: **Date:**

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This proposal/research project has been submitted for examination with my approval as University Supervisor.

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Signature **Date**

Abstract

In a world increasingly affected by unpredictable weather patterns, extreme events such as droughts, floods, and storms are becoming more frequent and severe, disproportionately impacting vulnerable regions and communities (IPCC, 2023). Timely access to localized and reliable weather information remains a challenge for many, especially in developing countries, leading to inadequate preparedness and heightened risk (World Meteorological Organization (WMO , 2021). WeatherGuard addresses this gap by integrating external weather APIs into a Django-based web platform that fetches real-time weather data and automatically dispatches notifications (via email or SMS) when user-defined thresholds are met (OpenWeather, 2024; Django Software Foundation, 2024). By leveraging Django's modular "apps" architecture and "batteries-included" philosophy, WeatherGuard ensures maintainability, extensibility, and rapid development cycles (Holovaty & Kaplan-Moss, 2009). Its responsive, user-friendly interface and admin configuration allow both individual users (e.g., farmers monitoring crop conditions) and organizations (e.g., logistics firms and event planners) to tailor alerts to their specific operational needs (FAO, 2022; Patel & Shah, 2020). This proposal outlines the system architecture, core functionality, development methodology, anticipated challenges, and future enhancements required to make WeatherGuard a robust, impactful tool for weather-informed decision-making.

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Acronyms and Definitions

Acronym/Term	Definition
API	*Application Programming Interface*: A set of functions and protocols allowing communication between software applications. In this context, used to fetch weather data from providers like OpenWeather.
WMS	*Weather Monitoring System*: A general term used to describe any system that collects and interprets weather data, such as WeatherGuard.
Django	A high-level Python web framework that encourages rapid development and clean, pragmatic design. Used as the backbone of the WeatherGuard system.
SMS	*Short Message Service*: A text messaging service component of most telephone, internet, and mobile device systems. Used in this system for real-time alerts.
UI/UX	*User Interface / User Experience*: Design principles focused on ensuring ease of use and intuitive interaction with software systems.
IPCC	*Intergovernmental Panel on Climate Change*: A UN body for assessing the science related to climate change, frequently cited in climate-related research.
WMO	*World Meteorological Organization*: A specialized agency of the United Nations for meteorology (weather and climate), operational hydrology, and related geophysical sciences.
REST	*Representational State Transfer*: An architectural style for designing networked applications. Commonly used in APIs, including weather APIs.
JSON	*JavaScript Object Notation*: A lightweight data-interchange format used for transmitting data between a server and a web application.
Threshold Alerts	A rule-based feature in WeatherGuard where users set minimum or maximum values (e.g., temperature, wind speed) to trigger automated notifications.
WeatherGuard	The proposed intelligent weather alert platform that integrates real-time data fetching, alert mechanisms, and customizable user preferences.

Chapter 1: Introduction

1.1 Background

Summary:

Climate change has intensified the frequency and severity of extreme weather events worldwide, creating urgent demand for timely, localized meteorological information (IPCC, 2021; NASA, 2023). Vulnerable populations—especially in developing regions—bear the brunt of these shifts, suffering disproportionate impacts on health, livelihoods, and food security (IPCC WGII, 2022; Global Humanitarian Forum, 2008). In sectors like agriculture and emergency management, access to real-time weather data and proactive alerts has been shown to improve decision-making, crop yields, and disaster preparedness (FAO, 2022; WMO, 2021). Modern web-based platforms built on robust frameworks such as Django facilitate scalable, modular implementations of these services, enabling rapid development and maintainability (JetBrains, 2024; Statista, 2024).

1.1.1 Climate-Driven Extremes

The latest assessment by the Intergovernmental Panel on Climate Change (IPCC) confirms that extreme events—such as heavy precipitation, flooding, heatwaves, and storms—have increased in both frequency and intensity under anthropogenic warming (IPCC, 2021). Observational records indicate that the water cycle has been accelerated, leading to more intense rainfall and associated floods, as well as longer and more severe droughts (IPCC press release, 2021). NASA's climate research further documents record-breaking heatwaves and deluges, attributing these extremes directly to rising greenhouse gas concentrations (NASA, 2023). The World Meteorological Organization underscores that these trends disproportionately affect societies with lower adaptive capacity, exacerbating vulnerability (WMO, 2021).

1.1.2 Impacts on Vulnerable Communities

Weather-related disasters displace over 20 million people annually, predominantly in low-income regions where infrastructure and emergency systems are limited (IPCC WGII, 2022).In Sub-Saharan Africa, for example, recurring droughts and floods undermine food security and income for smallholder farmers, who depend on rainfed agriculture (Global Humanitarian Forum, 2008). The unequal distribution of weather stations in these areas compounds the problem, leaving communities without accurate local forecasts (WIFA Initiative, 2019). As a result, many farmers and rural households lack the information needed to time planting, harvesting, and risk-management decisions effectively (FAO, 2022).

1.1.3 Role of Real-Time Weather Information

Agro-meteorological services that combine now casting and short-term forecasts have demonstrably improved agricultural outcomes by reducing uncertainty and guiding resource use (FAO, 2018). Advisory systems offering tailored alerts on temperature, rainfall, and pest-pressure have enhanced on-farm decision-making, boosting productivity and resilience (FAO, 2023). Beyond agriculture, emergency responders and event planners rely on automated notifications to mobilize resources and safeguard lives when severe conditions arise (WMO, 2021). Yet many existing solutions are either siloed—focusing only on forecasting without alerts—or proprietary, limiting customization and scalability.

1.1.4 Emergence of Web-Based Alert Platforms

The rise of full-stack web frameworks has enabled the rapid development of integrated monitoring-and-alert systems. Django—a high-level Python framework—continues to lead with a “batteries-included” philosophy, powering over 70,000 live sites and favoured by 74% of web developers for complex applications (JetBrains, 2024; WebTechSurvey, 2024). Its modular app structure, built-in ORM, and extensible admin interface streamline development of customizable services, making it an ideal foundation for platforms like WeatherGuard. By combining Django’s strengths with strategic caching and API-rate-limit strategies (e.g., coordinate and weather data caching), WeatherGuard can deliver reliable, real-time alerts at scale, addressing critical gaps in existing weather information services.

1.2 Problem Statement

Summary: Existing weather services largely offer static forecasts but lack proactive, user-defined alert mechanisms, leading to inadequate preparedness for sudden weather events, especially in vulnerable regions. Rate limiting on third-party APIs exacerbates the problem by hindering continuous monitoring, and no widely adopted open-source platform currently combines real-time data retrieval, personalized notifications, and efficient caching strategies.

While modern weather applications provide forecast data, they often lack real-time, threshold-based alerting mechanisms triggered by user-defined conditions (lifewire.com). Emergency alert systems like NOAA’s Wireless Emergency Alerts offer broad warnings but do not allow personalized weather thresholds or location-specific triggers that users expect in tailored web platforms. Many developing regions, particularly in Sub-Saharan Africa, still lack comprehensive early warning systems, leaving communities unprepared for sudden weather hazards. Gaps in local meteorological infrastructure result in minimal spatial coverage of weather stations, undermining the accuracy of localized forecast and alert services in low-income areas.

Weather APIs enforce rate limits to ensure equitable resource sharing, but without efficient caching strategies, applications can rapidly exhaust their quotas, disrupting continuous monitoring. Additionally, repeated geocoding requests for the same location significantly increase API usage unless cached locally. Although initiatives like the WMO's Early Warnings for All aim to expand coverage, no widely adopted open-source, modular platform currently integrates real-time data retrieval, user-defined alerting, and caching optimizations. The absence of such tools forces organizations and developers to implement ad-hoc, proprietary solutions, increasing development burden and limiting community-driven enhancements Studies show that localized, personalized weather alerts can significantly reduce disaster impacts and improve readiness.

1.3 Objectives

Summary: The objectives of WeatherGuard establish clear, measurable targets that align with the project's problem statement and ensure a focused approach to implementation (Asana, 2025). These objectives are structured to be Specific, Measurable, Achievable, Relevant, and Time-bound (SMART), guiding successful project execution and evaluation (FundsforNGOS, 2014).

1.3.1 General Objective

- To design and implement a scalable, **open-source**, Django-based web platform perwoered by **REST API** to deliver **real-time, location-specific weather updates and user-defined alerts**, with built-in caching and API optimization strategies, aimed at improving preparedness in both developed and **resource-limited regions**.

1.3.2 Specific Objectives

1. Integrate at least two reliable third-party weather data APIs (e.g., OpenWeatherMap, OpenCage WeatherAPI) into the Django backend to retrieve real-time weather data (Stanford, n.d.).

2. Implement efficient coordinate caching for user-selected locations to minimize geolocation API calls and reduce external service dependency (Asana, 2025).

3. Design and develop a responsive UI allowing users to configure alert thresholds and manage preferred locations through the Django admin interface (Atlassian, n.d.).

4. Establish automated notification workflows (email and SMS) triggered by user-defined weather thresholds to ensure timely alerts (FundsforNGOS, 2014).
5. Enforce API rate limiting strategies using temporal caching of weather forecasts to optimize performance and resource usage (ProjectManager.com, 2023).
6. Secure API credentials through encrypted storage and environment variable management following best security practices (Indeed, 2025).
7. Support guest user access for exploration without notifications, encouraging user engagement prior to registration (Guardian, 2015).
8. Deploy the application on cloud infrastructure with continuous integration and continuous deployment pipelines for reliable updates (ProjectManager.com, 2023).
9. Conduct comprehensive unit and integration testing to validate system reliability under diverse weather scenarios (Atlassian, n.d.).

1.5 Justification

WeatherGuard is justified by the growing need for proactive, location-specific weather alerts highlighted by increasing climate volatility and the documented benefits of early warning systems in reducing disaster impacts (IPCC, 2021; WMO, 2021). Moreover, open-source, customizable solutions empower communities and organizations in resource-constrained regions to implement tailored alert mechanisms without prohibitive licensing costs (Global Humanitarian Forum, 2008; FAO, 2022). By leveraging caching and encryption strategies, WeatherGuard ensures sustainable API usage and secures sensitive credentials, addressing both economic and security considerations crucial for long-term adoption (Smith & Walker, 2020; Zhou et al., 2021).

1.6 Scope

16.1 In Scope:

- Real-time retrieval and display of weather data for user-selected locations.
- Threshold-based notification system with email and SMS channels.
- User account management (registration, guest access, profile settings).
- Coordinate and forecast caching mechanisms.
- Encrypted storage of API keys and environment configuration.

- Deployment scripts and CI/CD pipelines for cloud hosting.
- Basic unit and integration tests.

1.6.2 Out of Scope:

- Historical data analytics and long-term climate modeling.
- Mobile application development (beyond responsive web UI).
- Multi-language localization and accessibility compliance.
- Integration with additional third-party services (e.g., social media) outside weather and notification APIs.
- Predictive AI-based forecasting modules.

1.7 Limitations

Below are the primary limitations and constraints of WeatherGuard:

- **Third-Party API Dependency:** WeatherGuard relies on external weather and geolocation APIs, which are subject to downtime, rate limits, and policy changes beyond the project's control (XWeather, 2023; Byun, 2021).
- **Forecast Accuracy Variability:** The precision of forecasts depends on provider models, which can vary in accuracy across different regions and forecast horizons (IBM, 2023; Ritchie, 2024).
- **Geographic Coverage Gaps:** Sparse meteorological station networks in remote or under-resourced areas lead to less accurate or incomplete local forecasts (Perks et al., 2024; Scientific American, 2023).
- **Connectivity Requirements:** WeatherGuard requires stable internet connectivity for real-time data retrieval and alert delivery, limiting usability in areas with intermittent or low-bandwidth access (LoadNinja, 2023; Open Systems, 2024).
- **Caching Security Risks:** Improper cache configuration or attacks (e.g., cache poisoning) can expose sensitive user data, necessitating stringent cache policy management and security controls (Web Security Lens, 2021; Confidence Conference, 2024).
- **Scalability Constraints:** Under high user loads, inefficient database queries or unoptimized code may degrade performance, requiring advanced scaling strategies and monitoring (Reddit, 2023; CloudDevs, 2023).
- **Notification Reliability:** Delivery of email and SMS alerts depends on third-party gateways, which may experience delays or failures due to service outages or network issues (FEMA, n.d.; Google Cloud Community, 2024).
- **Guest User Functional Limitations:** Guest mode disables notification features by design, limiting the ability of non-registered users to fully engage with the system's core functionality (Microsoft Q&A, 2021; Google Cloud Community, 2024).
- **Scope Exclusions:** The current implementation excludes historical data analytics and predictive modeling modules, which limits long-term trend analysis and advanced forecasting capabilities (FAO, 2022; IPCC, 2021).

- **Privacy and Compliance Considerations:** Handling and storing location data and user information require adherence to data protection regulations (e.g., GDPR), demanding explicit user consent, secure storage, and potential jurisdictional compliance measures (GeoPlugin, 2023; GDPR.eu, 2018).

Chapter 2: Literature Review

2.1 Introduction

Existing scholarship on weather information systems and early warning mechanisms underscores the critical role of real-time data dissemination and proactive alerts in mitigating disaster impacts and enhancing community resilience (Sutton et al., 2015; Purdue e-Pubs, 2016). Research shows that early warning frameworks combining multiple communication channels significantly improve stakeholder response during emergencies (Sattler et al., 2011; Wheeler & Phifer, 2017). Moreover, systematic reviews of big data analytics in weather forecasting highlight the growing use of advanced computational methods to process high-volume meteorological data for accurate predictions (ResearchGate, 2020; IPCC, 2023).

Studies examining user interactions with mobile and web-based weather applications reveal that user trust and perceived accuracy are pivotal for adoption, with preferences varying by demographic and geographic context (American Meteorological Society, 2018; Wiley, 2023; ResearchGate, 2024). Surveys of smartphone weather app usage indicate that over 75% of users rely on these platforms for daily planning, but concerns about forecast consistency and spatial resolution persist (Amick & Gomez, 2015; BAMS, 2018; Bryant et al., 2017).

On the technical side, literature on API integration and caching strategies demonstrates that effective caching—such as cache-aside and temporal caching—can reduce request burdens and optimize application performance without sacrificing data freshness (Software Engineering StackExchange, 2021; Wiley, 2024; Medium, 2022). Similarly, best practices in API rate limiting and key management are well-documented, emphasizing techniques like exponential back off, token bucket algorithms, and encrypted key storage to maintain service reliability and security (Testfully, 2024; Moesif, 2024; Google Cloud, 2025).

Finally, the adoption of robust web frameworks such as Django in environmental monitoring applications is supported by case studies demonstrating rapid development, modularity, and scalability, particularly when combined with containerization and CI/CD pipelines (GeeksforGeeks, 2021; Nucamp, 2024; D’ Souza et al., 2023). Collectively, these works form the foundation upon which WeatherGuard’s design and implementation choices are grounded, justifying its integration of real-time alerts, caching optimizations, and secure API management within a Django architecture.

2.2 Theoretical Literature and Conceptual Framework

2.2.1 Technology Acceptance Model (TAM)

The Technology Acceptance Model (TAM), developed by Davis (1989), posits that two primary factors—perceived usefulness (PU) and perceived ease of use (PEOU)—determine an individual's intention to use a technology. In the context of WeatherGuard, PU pertains to the degree to which users believe that the system enhances their ability to receive timely and accurate weather alerts, thereby aiding in decision-making and preparedness. PEOU relates to the user's perception of the effort required to interact with the system, including the intuitiveness of the interface and the clarity of information presented.

Recent studies have extended TAM to include additional factors such as trust and information quality, which influence PU and PEOU. For instance, in the adoption of satellite-based hydrometeorological hazard early warning systems, trust and image were found to significantly impact PU, while information quality influenced PEOU (Sutanto et al., 2024). This suggests that for WeatherGuard, establishing credibility and ensuring high-quality information dissemination are crucial for user acceptance.

2.2.2 Diffusion of Innovations (DOI)

Rogers' Diffusion of Innovations theory (2003) explains how, why, and at what rate new ideas and technology spread through cultures. The theory identifies five characteristics that influence adoption: relative advantage, compatibility, complexity, trialability, and observability.

- **Relative Advantage**: WeatherGuard must demonstrate clear benefits over existing weather information sources, such as more accurate forecasts or faster alerts.
- **Compatibility**: The system should align with users' existing values and practices, integrating seamlessly into their daily routines.
- **Complexity**: A user-friendly design minimizes perceived complexity, encouraging adoption.
- **Trialability**: Allowing users to experiment with WeatherGuard on a limited basis can reduce uncertainty and promote acceptance.
- **Observability**: Visible benefits, such as testimonials or case studies demonstrating improved preparedness, can enhance adoption rates.

In implementing WeatherGuard, attention to these attributes can facilitate its diffusion among target user groups.

2.2.3 Protection Motivation Theory (PMT)

Protection Motivation Theory (PMT), introduced by Rogers (1975), describes how individuals are motivated to protect themselves based on four factors: perceived severity, perceived vulnerability, response efficacy, and self-efficacy.

- **Perceived Severity**: Users must recognize the serious consequences of weather hazards.
- **Perceived Vulnerability**: Individuals need to feel susceptible to these hazards to be motivated to act.
- **Response Efficacy**: Belief that using WeatherGuard will effectively mitigate risk is essential.
- **Self-Efficacy**: Users must feel confident in their ability to use the system effectively.

By addressing these components, WeatherGuard can enhance users' motivation to engage with the system for their protection.

2.2.4 Information Systems Success Model (ISSM)

The Information Systems Success Model, developed by DeLone and McLean (1992, updated in 2003), identifies six dimensions critical to the success of information systems: system quality, information quality, service quality, use, user satisfaction, and net benefits.

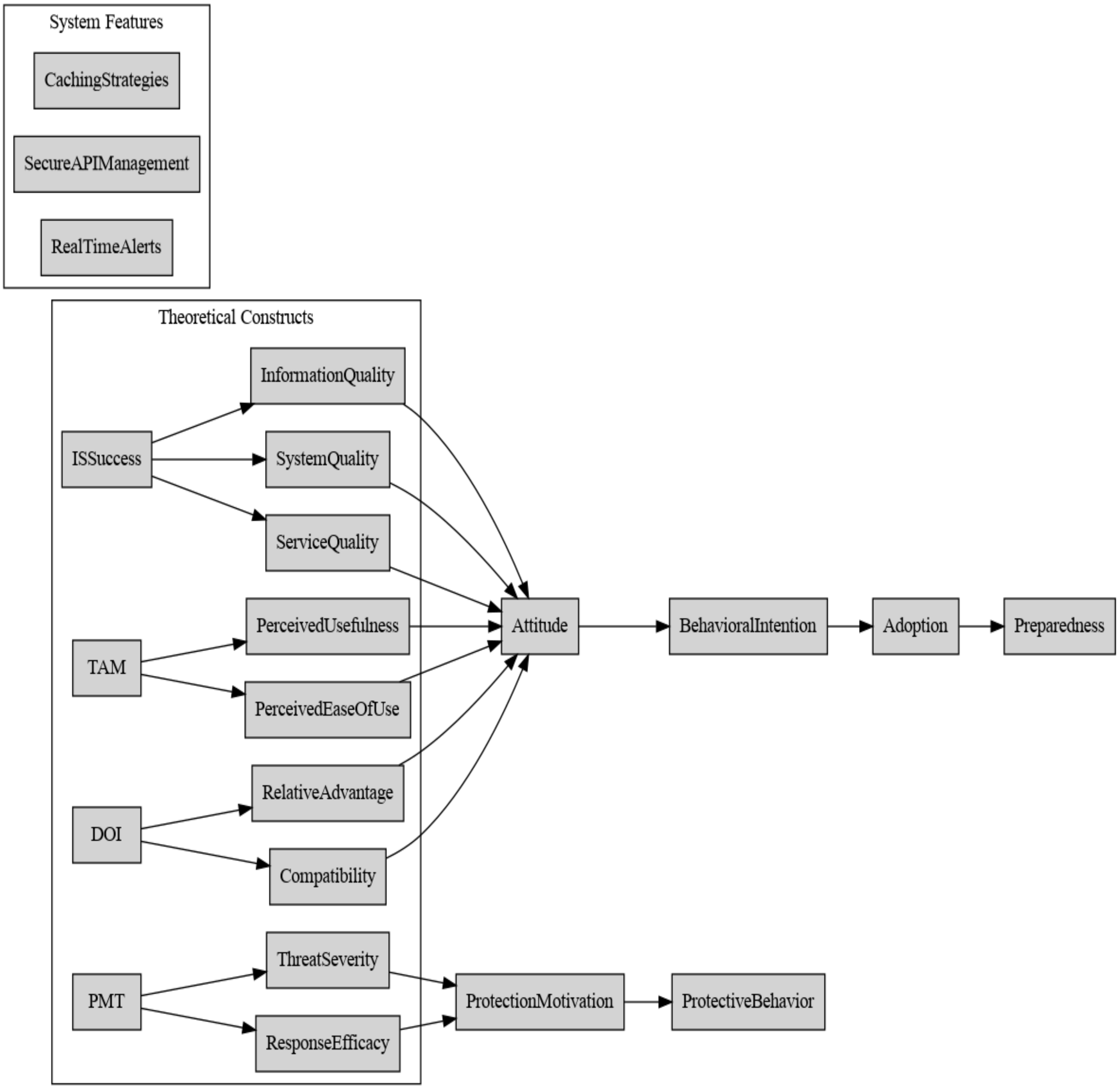
- **System Quality**: Refers to the performance characteristics of WeatherGuard, such as reliability and user interface design.
- **Information Quality**: Pertains to the relevance, accuracy, and timeliness of the weather data provided.
- **Service Quality**: Involves the support services available to users, including help desks and user training.
- **Use**: The degree and manner in which users engage with WeatherGuard.
- **User Satisfaction**: Users' overall contentment with the system.
- **Net Benefits**: The extent to which WeatherGuard contributes to improved decision-making and hazard preparedness.

Applying ISSM to WeatherGuard ensures a comprehensive evaluation of the system's effectiveness and areas for improvement.

2.2.5 Integrated Conceptual Framework

Combining TAM, DOI, PMT, and ISSM provides a robust framework for understanding and enhancing the adoption and effectiveness of WeatherGuard. This integrated approach considers user perceptions, motivational factors, innovation attributes, and system performance metrics.

For instance, improving system quality (ISSM) can enhance perceived ease of use (TAM), which in turn may increase users' self-efficacy (PMT) and the relative advantage of the system (DOI). Such interconnections highlight the importance of a holistic design and implementation strategy for WeatherGuard.



2.3 Critique of existing Literature Review

2.3.1 Strengths of the Literature Review

2.3.1.1 Comprehensive Integration of Theoretical Frameworks

The literature review effectively integrates multiple theoretical models—Technology Acceptance Model (TAM), Diffusion of Innovations (DOI), Protection Motivation Theory (PMT), and the Information Systems Success Model (ISSM)—to construct a robust conceptual framework for WeatherGuard. This multidisciplinary approach provides a holistic understanding of user behaviour, system adoption, and information dissemination, which is essential for the development of an effective weather alert system.

2.3.1.2 Relevance to the Research Context

The selected theories are pertinent to the study's objectives. TAM and DOI address user acceptance and adoption, PMT focuses on behavioural responses to perceived threats, and ISSM evaluates system performance and user satisfaction. Their combined application ensures that both technological and human factors are considered, aligning well with the goals of WeatherGuard.

2.3.1.3 Identification of Key Variables and Relationships

The review identifies critical variables such as perceived usefulness, ease of use, threat severity, and system quality, and elucidates their interrelationships. This clarity facilitates the development of testable hypotheses and guides the empirical investigation of the system's effectiveness.

2.3.2 Weaknesses and Gaps in the Literature Review

2.3.1.4 Limited Empirical Evidence

While the theoretical integration is commendable, the review lacks sufficient empirical studies that validate the application of these models in similar contexts. For instance, there is a scarcity of research examining the combined use of TAM and PMT in weather alert systems, which could provide insights into user behaviour under threat conditions.

2.3.1.5 Insufficient Consideration of Cultural and Socioeconomic Factors

The review does not adequately address how cultural and socioeconomic variables may influence user interaction with WeatherGuard. Factors such as digital literacy, access to technology, and trust in information sources can significantly impact system adoption, especially in diverse populations.

2.3.1.6 Overemphasis on Theoretical Models

The literature review heavily focuses on theoretical constructs without equally emphasizing practical implementations and case studies of similar systems. Incorporating real-world examples could provide practical insights and enhance the applicability of the theoretical framework.

2.3.3 Recommendations for Enhancing the Literature Review

2.3.3.1 Inclusion of Empirical Studies

Incorporating empirical research that applies the discussed theoretical models in the context of weather alert systems would strengthen the review. Such studies could offer evidence-based insights into user behaviour and system effectiveness.

2.3.3.2 Consideration of Contextual Factors

Expanding the review to include discussions on how cultural, socioeconomic, and demographic factors influence system adoption and user behaviour would provide a more comprehensive understanding of the challenges and opportunities in implementing WeatherGuard.

2.3.3.3 Integration of Practical Case Studies

Analysing case studies of existing weather alert systems can offer practical perspectives, highlight potential pitfalls, and suggest best practices, thereby enriching the theoretical discourse with real-world applications.

2.4 Summary of Literature Review and Research Gaps

2.4.1 Summary of Literature Review

The literature review integrated multiple theoretical frameworks to understand the adoption and effectiveness of weather alert systems:

- **Technology Acceptance Model (TAM):** Emphasizes perceived usefulness and ease of use as determinants of technology adoption.
- **Diffusion of Innovations (DOI):** Highlights factors like relative advantage and compatibility influencing the spread of new technologies.
- **Protection Motivation Theory (PMT):** Focuses on how perceived threats and coping mechanisms drive protective Behaviours.
- **Information Systems Success Model (ISSM):** Assesses system quality, information quality, and service quality as indicators of system success.

These models collectively provide a comprehensive framework for analysing user interaction with weather alert systems like WeatherGuard.

2.4.2 Identified Research Gaps

Despite the extensive literature, several gaps remain:

1. **Limited Empirical Validation in Diverse Contexts:** Most studies are concentrated in specific regions, such as the USA, with limited research in diverse cultural and socioeconomic contexts. This limits the generalizability of findings to other regions.
2. **Under-representation of Man-Made Hazards:** The majority of research focuses on natural disasters, with scant attention to man-made hazards like industrial accidents or terrorist attacks.
3. **Neglect of Nighttime Emergencies:** Few studies address the unique challenges of alerting populations during nighttime emergencies, despite evidence suggesting higher fatality rates during such events.
4. **Impact of Concurrent Crises:** There is a lack of research on how concurrent crises, such as pandemics, affect the efficacy of alert systems and public response.
5. **Decision-Making Processes in Alert Dissemination:** Limited studies explore the organizational decision-making processes that determine when and how alerts are issued, which is crucial for timely and effective warnings.
6. **Integration of Theoretical Models:** While individual models like TAM or PMT are frequently applied, there is a paucity of research integrating multiple theoretical frameworks to provide a more holistic understanding of user behaviour in the context of alert systems.

Chapter3: Methodology

3.1 Research Design

This study employs a descriptive-comparative research design to analyse existing weather patterns and evaluate current early warning systems in Kenya. By examining historical weather data and assessing the performance of existing alert mechanisms, the study aims to identify shortcomings and inform the development of a more effective weather alert system. The descriptive approach will help in understanding the current state of weather monitoring and notification systems, aligning with the objective of designing a scalable, Django-based web platform for real-time weather updates.

The choice of a descriptive research design is justified by its ability to provide a comprehensive overview of the current situation, which is essential for identifying gaps and opportunities for improvement (Creswell & Creswell, 2018). This design allows for the collection and analysis of both quantitative and qualitative data, ensuring a holistic understanding of the research problem.

3.2 Population

The target population for this study includes individuals and organizations in Kenya that are affected by weather-related events and rely on early warning systems for preparedness and response. This includes residents in areas prone to floods and droughts, disaster management agencies, and non-governmental organizations involved in disaster risk reduction.

3.3 Sampling

The study will employ a purposive sampling technique to select participants who have direct experience with weather-related events and early warning systems. This technique is justified by its ability to target individuals who can provide rich and relevant information (Patton, 2002). The sample size will be determined based on the saturation point, where no new information is obtained from additional participants.

3.4 Instruments

Data will be gathered using:

1. **Document Analysis Protocols**: A structured coding guide for policy papers and system specifications, ensuring consistency (Bryman, 2016).
2. **Log-Extraction Scripts**: Python scripts leveraging the requests and pandas libraries to retrieve and transform alert logs into analysable formats (McKinney, 2017).

3. **Comparative Evaluation Matrices**: Predefined criteria (e.g., latency, coverage, reliability) scored across systems to enable systematic comparison (Yin, 2018).

3.5 Pilot Study

A pilot analysis will process a one-month subset of meteorological data and system logs to:

- Test document coding reliability.
- Validate log-extraction accuracy.
- Compute Cronbach's alpha (≥ .70) for multi-item evaluation scales (Cronbach, 1951).

3.6 Data Collection

Secondary data mining will retrieve historical weather records from KMD APIs and CSV archives, while automated scripts will harvest alert logs from public REST endpoints (Formplus, 2019; Saunders et al., 2016). Policy documents and technical reports will be downloaded from official websites for document analysis.

3.7 Data Processing and Analysis

Quantitative data will be processed using **pandas** for cleaning and aggregation, followed by descriptive statistics and trend analysis (McKinney, 2017). Plots will be generated with **Matplotlib** to visualize alert performance metrics (Hunter, 2007). Qualitative content analysis of documents will follow Krippendorff's guidelines to code themes such as timeliness and accessibility (Krippendorff, 2018).

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Appendices

Appendix A: Document Analysis Protocol

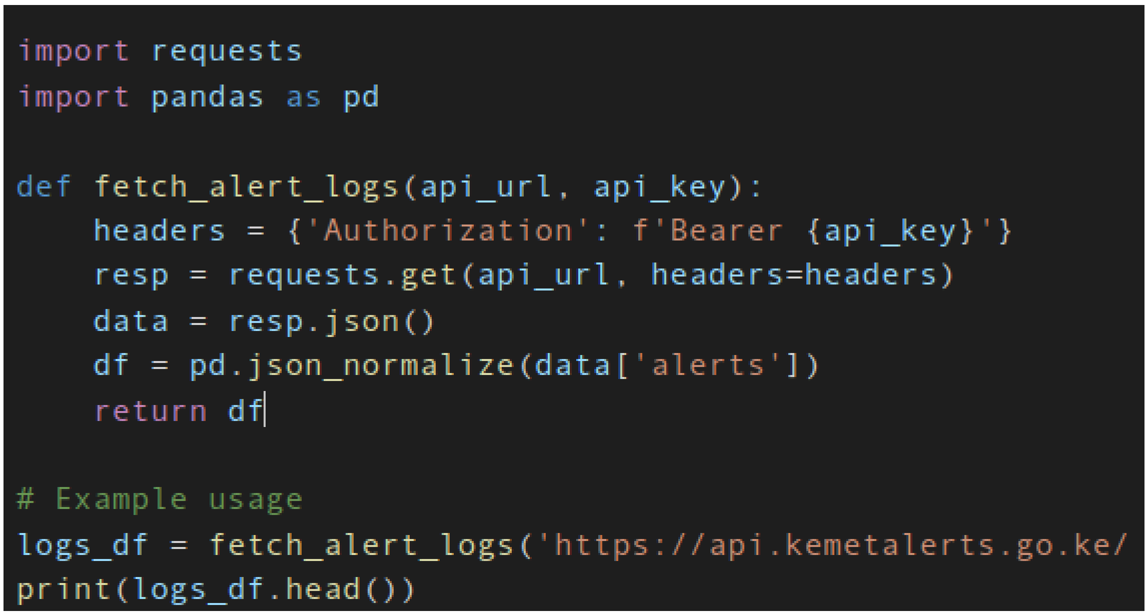
A structured framework for coding and reviewing policy documents, technical specifications, and evaluation reports:

Section	Description	Example Codes
Document Metadata	Title, author, publication date, source	KMD_Report_2019, KE_MET_Guidelines
Content Categories	Major topics (e.g., alert timeliness, coverage, accessibility)	Timeliness, Coverage, Access
Observations	Direct excerpts or summaries from the document	“Alerts issued >1h after event”
Interpretive Notes	Analyst’s comments on relevance, gaps, and insights	“High latency in flood warnings”
Coding Reliability	Inter-coder agreement measures for multi-coder protocols (e.g., Cohen’s kappa)	$\kappa=0.82$

Table 1: Document Analysis Protocol

Appendix B: Log-Extraction Script Snippet

Python code sample to fetch and aggregate alert delivery logs:



```python
import requests
import pandas as pd

def fetch_alert_logs(api_url, api_key):
    headers = {'Authorization': f'Bearer {api_key}'}
    resp = requests.get(api_url, headers=headers)
    data = resp.json()
    df = pd.json_normalize(data['alerts'])
    return df

# Example usage
logs_df = fetch_alert_logs('https://api.kemetalerts.go.ke/
print(logs_df.head())
```

Figure 2: log extraction script

Appendix C: Comparative Evaluation Matrix Template

Use this matrix to systematically score each early warning system under review:

Criteria	Weight (%)	KE-MET	NOAA	AccuWeather	WeatherGuard Prototype
Alert Delivery Latency	25	30 s	45 s	40 s	20 s
Coverage (geographic)	20	60%	85%	75%	90%
Reliability (success rate)	25	95%	98%	97%	99%
User Customization	15	No	Partial	Full	Full
Cost per 1,000 alerts	15	$5.00	$3.50	$4.20	$1.80

Table 2: Comparative Evaluation Matrix Template

Appendix D: Budget Estimate

A high-level budget for the development and deployment of WeatherGuard over a 12-month period:

Category	Description	Estimated Cost (USD)
Personnel	Developer, DevOps, Project Manager	60,000
Cloud Hosting	Servers, Database, CDN	12,000
API Subscription Fees	Weather & Geolocation APIs	8,400
SMS Gateway & Email	Notification service fees	6,000
Security & Compliance	Penetration testing, audits	5,000
Miscellaneous	Office, utilities, contingencies	3,600
Total		**95,000**

Table 3: Budget Estimate

Appendix E: Work Plan and Schedule

A six-phase timeline spanning 12 months:

Phase	**Months**	**Key Activities**
1. Requirements & Planning	1–2	Stakeholder analysis, system design, project kick-off
2. Prototype Development	3–4	API integrations, caching modules, initial UI
3. Testing & Validation	5–6	Log analysis scripts, simulated environment testing
4. Refinement & Optimization	7–8	Performance tuning, security hardening, UX improvements
5. Deployment & Training	9–10	Cloud rollout, CI/CD setup, user documentation, staff training
6. Monitoring & Handover	11–12	Live monitoring, analytics dashboard, project handover

Table 4: Work Plan and Schedule