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Design and Development of Climateviz: A Climate Data Visualization Tool

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Abstract
Climate change is one of the most pressing issues of our time, affecting various aspects of life on Earth. Understanding climate data and trends is crucial for policymakers, researchers, and the general public. This project focuses on the development of ClimateViz, a cross-platform mobile application designed to provide users with comprehensive access to climate data, visualizations, and reporting tools. The app integrates APIs like OpenWeatherMap and large data sources like the World Bank Climate Database, ensuring real-time and historical data availability. It also includes an interactive map, custom report generation, and current news, making it a robust tool for climate data analysis and awareness.

Keywords: Climate Visualization Tool, Climate Change, Informed Decision Making, Climate Awareness, Data Visualization and Insights

1. Introduction and Background

According to the Intergovernmental Panel on Climate Change (IPCC, 2021) [5], climate change refers to the long-term warming of the planet, which is primarily caused by the increasing levels of greenhouse gases in the Earth's atmosphere. These gases, such as carbon dioxide and methane, trap heat from the sun, leading to a rise in global temperatures. Climate change is having far- reaching consequences, including melting of polar ice caps, sea-level rise, and altered ecosystems, which in turn affect human settlements, agriculture, and biodiversity.

The IPCC (2021) [5] reports that the past decade was the warmest on record, with the global average surface temperature having risen by 1.1°C since the late 19th century.

Climate visualization is an essential tool for understanding and communicating climate change trends. According to NASA (2020) [9], climate visualization involves the use of graphical representations, such as charts, graphs, and maps, to illustrate climate data and trends.

This enables researchers, policymakers, and the general public to better comprehend the complexities of climate change, identify patterns, and anticipate future changes.

Climate visualization can also facilitate the development of effective climate mitigation and adaptation strategies.

The National Oceanic and Atmospheric Administration (NOAA, 2022) [10] reports that the current rate of global warming is unprecedented in the past 1,000 years. The consequences of climate change are widespread, with rising sea levels, more frequent natural disasters, and altered ecosystems affecting human populations worldwide. According to the United Nations (2020) [11], climate change could displace up to 143 million people by 2050, with the majority being from sub-Saharan Africa, South Asia, and Latin America.

The importance of addressing climate change cannot be overstated. As emphasized by the IPCC (2021) [5], limiting global warming to 1.5°C above pre-industrial levels requires immediate and drastic reductions in greenhouse gas emissions.

This can be achieved through a transition to renewable energy sources, increased energy efficiency, and the development of carbon capture and storage technologies. Climate visualization and trend analysis play critical roles in informing climate policy and decision-making, enabling us to mitigate the worst impacts of climate change and create a more sustainable future.

Moreover, climate change has significant implications for global food security. The Food and Agriculture Organization (FAO, 2020) [2] reports that climate change is projected to lead to crop yield declines, changes in growing seasons, and increased frequency of extreme weather events, which can result in food shortages and price increases.

Climate-smart agriculture practices, such as agroforestry and conservation agriculture, can help mitigate these impacts and promote sustainable agricultural development.

In addition, climate change is having devastating effects on global biodiversity. The Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES, 2019) [6] reports that up to 1 million species are facing extinction due to human activities, including climate change. Climate change is altering ecosystems, disrupting species interactions, and reducing biodiversity, which can have cascading effects on ecosystem services and human well-being.

The role of climate visualization in communicating climate change risks and trends cannot be overstated. According to the American Meteorological Society (AMS, 2020) [1], climate visualization can facilitate public understanding and engagement with climate change issues, enabling individuals to make informed decisions about their own lives and communities.

Climate visualization can also support climate change research and decision- making, enabling scientists and policymakers to identify areas of high climate risk and develop effective adaptation and mitigation strategies.

In summary, Climate change is a pressing global issue that requires immediate attention and action. Climate visualization and trend analysis are critical tools for understanding and communicating climate change risks and trends, enabling us to develop effective climate mitigation and adaptation strategies. By working together to address climate change, we can create a more sustainable future for all.

1.1 Motivation and Significance of the Study

The motivation for this study arises from the growing urgency to understand and address climate change through effective data integration and visualization. With increasing global temperatures, erratic weather patterns, and the subsequent impacts on public health, agriculture, and the environment, there is a critical need to consolidate diverse climate data sources into an accessible platform.

By harnessing climate visualization technologies and making climate data more accessible, we can empower the public and policymakers to make informed decisions. This initiative will help combat climate change, support sustainable agriculture, and promote personal health and well-being.

1.2 Scope of the Study

This project includes designing and developing a climate data integration and visualization platform, addressing data accessibility and usability considerations. Pilot testing with policymakers, researchers, and the general public who will provide feedback to refine the platform's design for effectiveness and informed decision-making.

1.3 Problem Statement

The lack of integrated and accessible climate data hinders effective analysis, visualization, and prediction.

Most climate and weather sources only offer current weather data and a limited prediction of up to seven days. Historical and Projected data only exists in complex formats like GRIB, Net-CDF and CSV or platforms which require specialized skills and knowledge to use and understand. This research aims to fill these gaps by designing and developing a web-based climate data integration and visualization platform that is both comprehensive and easy to use.

1.4 Aim of Study

The aim is to develop a comprehensive climate visualization system that aggregates, analyzes, and clearly presents past, current, and projected future climate data from diverse sources. This system will translate complex datasets into intuitive visual formats, making climate trends, risks, and projections accessible and understandable. By bridging the critical knowledge gap between scientific data and public understanding, it will empower policymakers, researchers, communities, and businesses to make informed, data- driven decisions. The outcomes have the potential to enhance climate literacy, support proactive planning and adaptation.

1.5 Specific Objectives

1. Design a platform integrating climate data from diverse sources.
2. Develop data visualization tools for trend analysis, anomaly detection, and future predictions.
3. Provide actionable insights for policymakers and the general public.

1.6 Research Questions

1. What are the key features and performance metrics of climate data integration and visualization methods, and how do data quality, scalability, and user experience affect them?
2. How can a web-based platform be built to seamlessly integrate and display climate data from diverse sources, and clearly communicate actionable insights?
3. What do testing and evaluation results reveal about the accuracy, reliability, and usability of a climate data visualization platform, and how can these findings improve climate mitigation and adaptation strategies?

1.7 Operational Definitions of Concept

The aim is to create a web-based system for climate data visualization. This system includes a dashboard for current weather, an analytics page for past and future data, and a news feed for climate news and alerts. It would bridge the knowledge gap between complex climate information and public understanding.

In this study, climate data refers specifically to the information that ClimateViz collects, processes, and displays through its system architecture. Within the system, this data becomes the core input driving maps, charts, insights, and analytics.

Data visualization describes how ClimateViz transforms raw datasets into interactive outputs, such as temperature and rainfall map layers, regional time-series graphs, and scenario comparisons.

In the context of this system, climate awareness refers to the increase in user understanding that occurs when ClimateViz delivers simplified insights, contextual explanations, and climate-related news. awareness is measured through the user's ability to recognize local risks, understand changes over time, and interpret the implications of projected climate patterns.

Here, informed decision-making refers to the practical actions users can take after interacting with ClimateViz's analytical modules and insight panels.

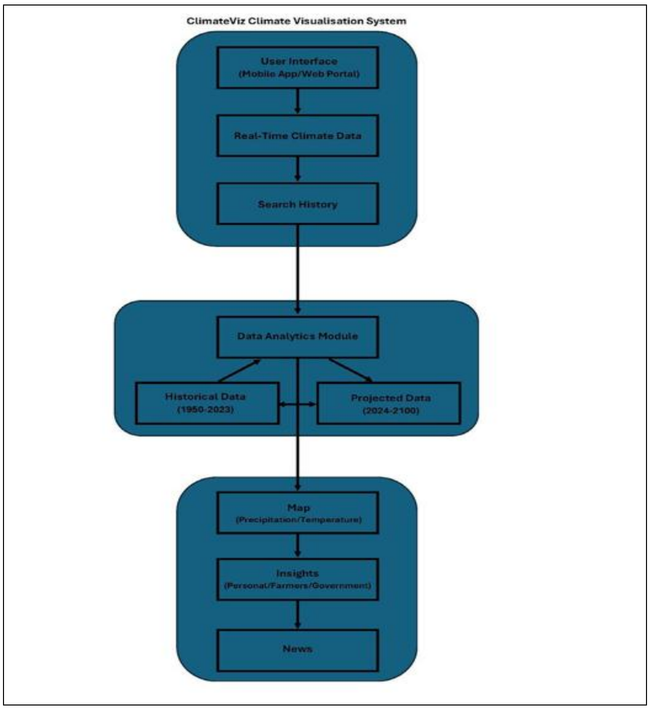

Fig 1: Operational Definitions of Concept

1. Definition of Terms

Climate Data refers to a broad range of information related to climate change, including temperature records, precipitation patterns, sea level rise, and extreme weather events.

Data Visualization is the process of creating graphical representations of climate data to facilitate understanding, analysis, and communication of complex climate information.

Climate awareness refers to the state of being informed and knowledgeable about climate change, its causes, consequences, and potential solutions, enabling individuals and communities to make informed decisions.

Informed Decision-making is the process of making choices and taking actions based on accurate, reliable, and accessible climate data and information, supporting effective climate adaptation, mitigation, and resilience strategies.

2. Literature Review

2.1 Overview

This study focuses on two key areas: integrating climate data and visualizing climate trends. Wu *et al.* (2022) [12] developed a knowledge graph platform that unifies diverse data sources into one organized database, making it easier to analyze trends and detect anomalies. Meanwhile, the Copernicus Interactive Climate Atlas (Copernicus Climate Change Service [C3S], 2025) [3] provides a comprehensive, web-based environment for exploring historical and projected climate data through maps, time-series, and scenario comparisons. Together, these approaches improve climate-data accessibility and communication, though challenges remain in representing local variations and turning large, integrated datasets into clear, actionable insights for effective climate decision-making.

2.2 Review of the Literature

Wu *et al.* (2022) [12] developed link Climate, a knowledge graph platform for climate data.

Their system integrates varied sources from satellite observations to ground station measurements into a unified, query-able database.

By using web-standard technologies to link disparate datasets, the platform addresses the problem of scattered climate data.

This approach facilitates comprehensive analysis (e.g. combining satellite and model outputs) by standardizing data descriptions. Wu *et al.* report that their platform simplifies access to climate information and supports tasks like trend identification and anomaly detection. Such work demonstrates the value of advanced data engineering in climate analysis, but the system primarily targets researchers and requires familiarity with graph query languages, limiting its use for lay audiences.

The Copernicus Interactive Climate Atlas, a tool that allows users to explore historical climate change and future projections, was recently updated (Copernicus Climate Change Service [C3S], 2025) [3]. This platform synthesizes major climate records from weather stations, satellite-based reconstructions, and global and regional climate models. It provides functionalities for viewing maps, time-series graphs, annual-cycle charts, and stripe-style visuals, and includes options to compare different future emission scenarios. The newest version adds more climate indicators and clearer displays of uncertainty to help users understand the confidence level of scientific projections.

The importance of actionable insights in climate data tools is emphasized by major reports and frameworks. The IPCC's Fifth Assessment Report (2013) [4] highlights that climate information must be communicated clearly to support policy and adaptation (IPCC, 2013) [4]. Similarly, Maier *et al.* (2016) [8] discuss "actionable knowledge" for climate adaptation, advocating for co-produced tools that meet user needs (e.g. water managers, farmers. In practice, this means combining scientific data with decision-relevant indicators. For instance, some platforms overlay climate data with socio-economic layers to identify vulnerable regions. In the realm of climate visualization software, several desktop and web- based tools exist. The Grid Analysis and Display System (GrADS) and Ferret are classic applications for scientists to visualize model outputs.

They support multi-dimensional climate and weather data (latitude, longitude, time, etc.) and offer plots like contours, vectors, and station maps. While powerful, these tools have steep learning curves and are not designed for casual users or mobile devices. More modern efforts include web dashboards for climate metrics. For example, several research projects (e.g. AgMIP and regional climate dashboards) have developed prototype web apps combining maps and charts. However, many such systems remain limited in scope (e.g. fixed data sources or regions) or focus on one aspect (e.g. agricultural impacts) rather than a general public tool. Another relevant area is climate news and information aggregation. Websites like the UNDP Zambia climate portal and NASA climate news feeds provide up-to-date articles on climate issues.

In conclusion, the literature shows that climate data visualization has progressed through three key approaches: semantic integration platforms that unify diverse datasets; minimalist graphics that distill global trends into clear visuals; and interactive dashboards that combine maps, charts, and news for user exploration.

Traditional scientific tools still offer deep analysis but require specialist skills.

Together, these advances have improved data accessibility, visual clarity, and engagement, underscoring the value of integrating multiple techniques for effective decision support.

2.3 Related Works

1. Link Climate: Semantic Web for Climate Data Integration

Link Climate, developed by Wu *et al.* (2022) [12], demonstrates how the Semantic Web can unite a wide array of climate data into a single, richly interconnected resource. The Semantic Web extends the traditional web by adding meaning—or semantics—to data, enabling computers to understand relationships much like humans do. In practice, Link Climate ingests satellite measurements of surface temperature and rainfall (for example, data products from NASA), outputs from sophisticated climate models (such as those used in global climate simulations), and direct observations from tens of thousands of weather stations around the globe. Each of these diverse inputs is converted into a simple "triple"—a three-part statement such as "Station 123 records Measurement 456."

Behind these triples sits an ontology, which acts like a shared dictionary and instruction manual at the same time. The ontology ensures that terms like "air_temperature" and "temp" refer to the same concept, that temperature units are automatically converted (for instance, Fahrenheit to Celsius), and that highly detailed daily readings can be rolled up into meaningful monthly or yearly averages without losing important metadata such as measurement accuracy or source information. Because all of the data obey the same structure and naming rules, users can pose complex, cross-cutting questions—such as "List every weather station in Zambia where average annual rainfall fell by more than 10 percent between 2000 and 2020"—and receive accurate results in under a second, despite the fact that the underlying database contains more than fourteen million linked facts.

Users interact with this graph via SPARQL, a query language that resembles SQL (Structured Query Language) but is designed specifically for graph-structured data. A typical SPARQL query might look like this:

```
SELECT ?station ?year
?rainfall WHERE {
?station ex:locatedIn
ex:Zambia .
?station ex:hasAnnualRainfall
?r .
FILTER(?year >= 2000 && ?year
<= 2020 && ?r < 0.9 *
?baselineValue)
}
```

This query asks the system to find all stations in Zambia where the rainfall value (?r) dipped to below 90 percent of a baseline. Because Link Climate's "triplestore" holds millions of triples, the platform uses optimized indexes and logical shortcuts (inference rules) to answer these kinds of questions almost instantly. Its modular architecture also means new data— a fresh set of CMIP6 climate projections, or a high-resolution urban-climate simulation of a major city—can be plugged in without rewriting the entire system.

Researchers can browse the data graph visually, too, clicking on any node (a station, a region, or a variable) to reveal all its linked measurements, metadata, and relationships. This semantic layer makes it easy to discover, for example, which nearby stations share similar rainfall trends or to trace a model's projection back to the raw data it was trained on.

However, this power comes at a cost: crafting SPARQL queries requires specialized training, and the built-in web interface offers only basic tables or simple chart previews. Although a "Beginner's Guide" and sample queries are provided, most policymakers, journalists, and interested members of the public lack the technical background to write their own. As a result, while Link Climate shines as a researcher-oriented backend, it underscores the need for more intuitive system that translate its deep, semantic structures into everyday insights for a broader audience.

2. Copernicus Interactive Climate Atlas (C3S Atlas) v2: A Data-Rich, Regional Explorer

The Copernicus Interactive Climate Atlas began as a public, web-based evolution of the IPCC Interactive Atlas and was first released in February 2024; a major update (v2) of both the dataset and viewer was published on 7 May 2025, introducing new data and viewer features.

The Atlas brings together several trusted climate datasets into one unified, downloadable collection. These include station-based observations such as E-OBS, which compiles real measurements from thousands of weather stations across Europe, as well as reanalysis products like ERA5 and ERA5-Land, which blend observations with atmospheric models — computer simulations of how the atmosphere behaves — to recreate past climate conditions even in places where measurements are sparse. The Atlas also incorporates global and regional climate-model projections from CMIP5/CMIP6 and CORDEX, which simulate how climate may change in the future, with CORDEX providing higher-resolution detail for specific regions.

Using this combined dataset, the Atlas allows users to view maps, regional time- series, annual-cycle graphs, and stripe-style summaries, and to compare future scenarios based on specific years or global-warming levels.

Despite these strengths, the Atlas remains a specialist tool: it exposes tens of variables and configurable model ensembles, and its many options and scientific settings demand expertise to interpret correctly. As a result, while indispensable for research and policy analysis, it is less suited to rapid, public- facing summaries or simple, real-time dashboards. For applications that prioritize clarity and speed (for example rapid policy briefings, stakeholder outreach or classroom use), a lighter, focused system such as ClimateViz can be a practical complement: by surfacing a curated set of key metrics with straightforward scenario switching and compact dashboards, ClimateViz preserves scientific rigor while delivering the quick, communicable insights that the Atlas's depth sometimes obscures.

3. Risk Finder & World Bank Climate Portal: Localized Impact Dashboards

Climate Central's Risk Finder and the World Bank's Climate Change Knowledge Portal (CCKP) illustrate how interactive web dashboards can translate complex climate science into practical, place-based insights for non-technical users.

Risk Finder allows anyone to enter a U.S. ZIP code or coastal city name and instantly view detailed flood-risk maps under both current conditions and future sea-level rise scenarios. It combines high-resolution LiDAR elevation models, created by sending laser pulses from aircraft to map the ground with centimeter accuracy, with historical tide-gauge records from the National Oceanic and Atmospheric Administration (NOAA).

Over this base layer, it overlays demographic data (population density, median home values) to calculate, for example, how many people and how much property would be inundated under a 1-meter, 2-meter, or higher sea-level rise. A simple slider control adjusts the scenario, and the map and summary statistics update in real time. This fine-grained, location-focused approach makes coastal vulnerability tangible for homeowners, city planners, and real-estate professionals.

However, because Risk Finder concentrates exclusively on coastal flooding, it does not address other major climate risks such as heatwaves, droughts, or shifting precipitation.

By contrast, the Climate Change Knowledge Portal offers a global-scale view of dozens of climate indicators at both country and river-basin levels. Users select any region worldwide and explore interactive charts of historical data (back to 1950) alongside future projections under different greenhouse-gas scenarios—known as Representative Concentration Pathways (RCPs). Metrics include average monthly and annual temperature, total seasonal rainfall, and the frequency of extreme drought or heavy-rainfall events.

The portal also computes composite vulnerability indices, such as agricultural stress, water scarcity, and urban heat exposure, by blending climate data with socioeconomic models. Yet the portal's interface, filled with nested menus, technical terminology, and dense graphs, can overwhelm general audiences and lacks real-time weather feeds or a built-in news section.

Together, these systems illustrate the range of current approaches to climate communication. Each contributes in its own way to making climate information more accessible and meaningful for different audiences.

2.4 Personal Critique of Literature Review

The body of work surveyed in this review represents a remarkably rich collection of innovations that together chart the evolution of climate data integration and presentation. The World Bank's Climate Change Knowledge Portal remains a reliable, widely used resource, offering long historical records and well-documented future projections. While its datasets are robust and carefully maintained, the portal's structure is relatively traditional, prioritizing stability and breadth over newer forms of interactivity or analytical depth.

By contrast, the Copernicus Interactive Climate Atlas merits particular commendation for its scientific richness and technical rigor. Its integration of observational datasets, reanalyses, and global and regional climate-model ensembles into a unified, FAIR (Findable, Accessible, Interoperable, and Reusable)- compliant framework represents one of the most comprehensive regional-analysis systems currently available. The Atlas's emphasis on uncertainty assessment, ensemble robustness, and multi-scenario comparisons positions it as a leading reference tool for advanced research and policy evaluation.

Equally notable is Link Climate, which leverages Semantic Web technologies to merge satellite records, climate-model outputs, and in-situ observations into a knowledge graph that can be read by a machine. By enforcing a shared ontology that harmonizes variable names, units, and temporal resolutions, it demonstrates how highly heterogeneous datasets can be transformed into an interoperable and instantly searchable system. Its near-instant SPARQL query performance, despite operating on millions of linked data triples, exemplifies a level of technical optimization and architectural design rarely seen even in specialized climate-data infrastructures.

Climate Central's Risk Finder then translates these insights into actionable, place-based intelligence, overlaying high-resolution LiDAR elevation models, tidal records, and demographic data to map flood risk at the ZIP-code level. Its intuitive slider for future sea-level scenarios and clear exposure metrics have proven invaluable to homeowners, insurers, and city officials seeking concrete guidance.

Taken together, these works showcase a remarkable blend of data breadth, technical rigor, and creative design. They confirm that climate information can be both scientifically robust and broadly accessible, a dual imperative that the ClimateViz project wholeheartedly embraces and extends.

However, even this impressive literature leaves important gaps. First, real-time weather data and long-term archives are rarely unified in a single interface; ClimateViz will stream up-to-the-minute forecasts alongside World Bank historical time series. Second, while many tools excel at explaining the "what" of climate change, they offer limited "what to do" guidance.

Finally, the literature often illustrates a trade-off between technical depth (as in Link Climate and the Atlas) and visual simplicity, but seldom both in a single package. ClimateViz aims to bridge this divide by combining the semantic robustness of advanced back-end integration with an intuitive, mobile-friendly front end design—serving researchers, policymakers, and the general public with equal clarity and impact.

2.5 Gaps in the literature

Despite the impressive progress documented above, key gaps remain in how climate data are brought together and made useful for a wide audience. First, many existing platforms still rely on a patchwork of complex file formats—such as NetCDF, GRIB, or highly specialized CSV schemas. Even when powerful back-end systems like Link Climate can reconcile these differences behind the scenes, the raw data can be difficult for non-technical users to access or understand. Without clear, uniform metadata and simple import tools, getting data into a single, easy-to-use system remains a barrier for students, local officials, and journalists.

While the Copernicus Interactive Climate Atlas does offer a unified, web-based interface, it has its own usability limitations: its interface can feel overwhelming due to the large number of variables and model- settings available. As the user guide notes, the selection panel includes many dimensions (dataset, variable/index, time period, projection type), which can be confusing to navigate.

Moreover, its scenario tools (e.g., selecting warming levels, ensemble members) require technical familiarity with climate- model ensembles, reducing accessibility for less experienced users. Some of the planned mobile-friendly functionality is not fully optimized: the user guide explicitly lists "the mobile version of the application requires improvement." (Copernicus Climate Change Service [C3S], 2025) [3].

These constraints limit its accessibility for educators, community groups, and decision-makers who need rapid interpretation rather than deep analytical control.

Finally, there is a notable lack of actionable insights embedded directly within these platforms. A user might be able to see that temperatures are rising or that flood risk zones are expanding, but few systems go further to suggest what to do next— whether that means planting a different crop, reinforcing a seawall, or updating building codes. Interactive, user-friendly guidance—tailored to specific regions, time frames, and stakeholder needs— remains rare. Closing these gaps would not only strengthen the scientific foundations of climate data tools but also vastly increase their practical value for everyday decision-makers and the public at large.

3. Resesearch Methodology

3.1 Overview

This chapter details the methodology employed in the study, outlining the research design, data collection methods, and analytical techniques used to address the research objectives.

It explains the rationale behind the chosen approaches, describing how the climate data integration and visualization platform was developed, tested, and evaluated. The chapter also covers the system design aspects, including software architecture and data models, ensuring that the methods adopted provide reliable and valid findings.

3.2 Research Design

The study's research design utilizes an experimental mixed-methods approach, combining both qualitative and quantitative methods to gain a comprehensive understanding of the Climate Visualization System. This approach is particularly effective for examining user engagement and evaluating system effectiveness, as it allows the integration of insights from multiple data sources (Creswell & Plano Clark, 2017) [13]. The experimental component involves testing system features, usability elements, and performance under controlled conditions to determine how specific design changes influence user experience and system outcomes.

The quantitative aspect involves gathering numerical data concerning climate conditions, user interaction metrics, and system performance indicators. Surveys are used to collect information from users about their experiences and satisfaction levels with the system.

The qualitative aspect includes interviews and open-ended survey questions, offering more in-depth understanding of user perceptions, implementation challenges, and improvement recommendations. This valuable data provides a deeper insight into user experiences, complementing the quantitative results (Patton, 2015) [14].

3.3 Baseline Study

The baseline for this study on the design and development of ClimateViz was established through a comprehensive evaluation of the primary channels through which ordinary citizens obtain climate information (e.g., news, public dashboards, and mobile apps). Data were collected via live APIs (such as OpenWeatherMap), RSS news feeds, and the World Bank Climate Database, and were supplemented with recent authoritative assessments and observations (for example, the IPCC Sixth Assessment Report and global monitoring datasets). Each observed trend and reported insight is grounded in peer- reviewed climate research and expert reports on environmental impacts. The assessment identified recurring shortcomings in current practice: fragmentation between real-time weather and long-term records, limited local and short-term detail in many public visuals, technically complex systems, and a scarcity of clear, actionable guidance tailored to everyday users. This baseline therefore provides a critical reference point for identifying specific areas for improvement and for aligning ClimateViz's features with the needs of citizens, farmers, and decision- makers.

3.4 Data Collection

Information about the topic under study was collected using various methods, including observation, and administering questionnaires. The data collection process for this study utilized both qualitative and quantitative techniques to gain a complete understanding of user experiences and system performance. Structured surveys and questionnaires were used to collect quantitative data on user preferences and satisfaction levels. Usability evaluations with a small group of users were carried out to assess the interface and functionality of the climate visualization system, with feedback informing ongoing improvements.

3.5 Research Approach

In the context of a Climate Visualization System where technology integration, user feedback, and adaptability are crucial, Agile methodology may be more suitable due to its iterative approach, continuous user involvement, and responsiveness to changing needs.

Why agile?

Agile's focus on functionality, collaboration, and incremental value delivery aligns well with the dynamic nature of a Climate Visualization systems that require ongoing adjustments and enhancements based on new data and user feedback.

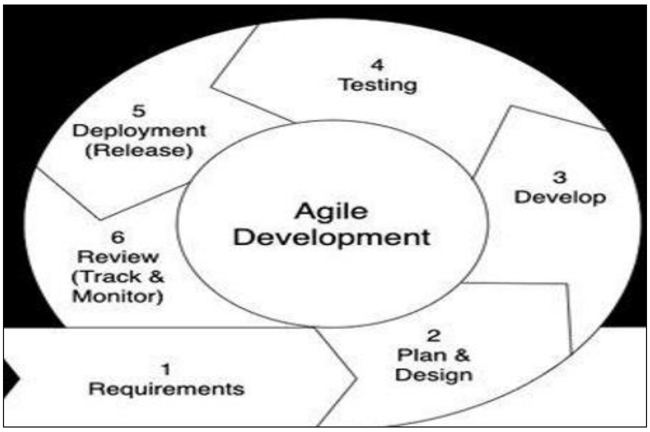

Fig 2: Agile Methodology

Requirements: Throughout the initial stage, every requirement of the project is gathered and documented.

Stakeholders, including clients and end-users, provide input on their system expectations.

Planning is essential for defining clear and achievable goals for the platform. This involves understanding desired outcomes such as enhancing data clarity, supporting informed climate decisions, or improving accessibility of complex climate information. Planning provides a strategic road map, ensures efficient use of development resources, allows for adaptation to evolving user or scientific needs, fosters team collaboration, and establishes a foundation for continuous improvement. By emphasizing structured planning, teams can maximize the benefits of Agile methodologies and deliver value- driven outcomes that empower users with actionable climate insights.

Design: is critical for translating user needs and scientific requirements into functional, intuitive, and impactful visualizations. It plays a central role in envisioning how data analytics, interactive dashboards, and dynamic mapping tools can be integrated effectively to communicate complex climate data. A well-designed Climate Visualization solution ensures optimal usability, scalability across different datasets and user groups, and interoperability with diverse data sources, aligning with the dynamic and urgent nature of climate science and policy- making.

Development is the crucial phase that transforms strategic plans and user-centered designs into a functional, reliable platform. In the context of ClimateViz, development focuses on building the software architecture, data processing functions, and interactive visualization technologies that make complex climate information accessible. Agile development methodologies are essential, as they allow for iterative and incremental progress.

Testing: plays a critical role in ensuring the quality, functionality, and reliability of systems and technologies. By integrating testing throughout the Agile development process, teams can identify and address potential issues early, minimizing risks and enhancing overall product performance.

Testing also facilitates continuous feedback and iteration, allowing for rapid adaptation to evolving requirements and market dynamics.

Deployment follows the Agile principle of releasing functional increments at regular intervals. Rather than a single, monolithic launch, the platform evolves through a series of managed updates, each delivering new value. A release might introduce a new set of regional climate indicators, the ability to download datasets, or newer projected climate data. This approach allows stakeholders to interact with tangible progress, provide immediate feedback, and see the platform grow in capability.

Review: This phase is the cornerstone of continuous improvement for a climate visualization system. Following each development iteration and deployment, structured reviews gather critical feedback from all stakeholders. This includes assessing the technical performance of the system, and evaluating usability with end- users to ensure clarity and impact. These regular checkpoints allow the team to verify that the platform aligns with its core goals of enhancing understanding and supporting decision-making. This cycle of build, deploy, and review ensures the system remains a dynamic, trusted tool that continuously evolves to meet the urgent needs of the community.

3.6 Technologies to be used

The ClimateViz platform will integrate a range of web and data technologies to collect, harmonize, and present climate information in near real-time. The system will combine live APIs (e.g., OpenWeather) for current and short-range forecasts with historical and projected data stored in an SQL database sourced from the World Bank Climate Database. A lightweight JavaScript front end, using Chart.js for interactive charts and Leaflet.js for maps, will provide the user interface and interactive components, enabling the dynamic exploration of climate trends and scenario comparisons.

3.7 System Data Model Design

The system data model design outlines how data is organized, stored, and managed within the application.

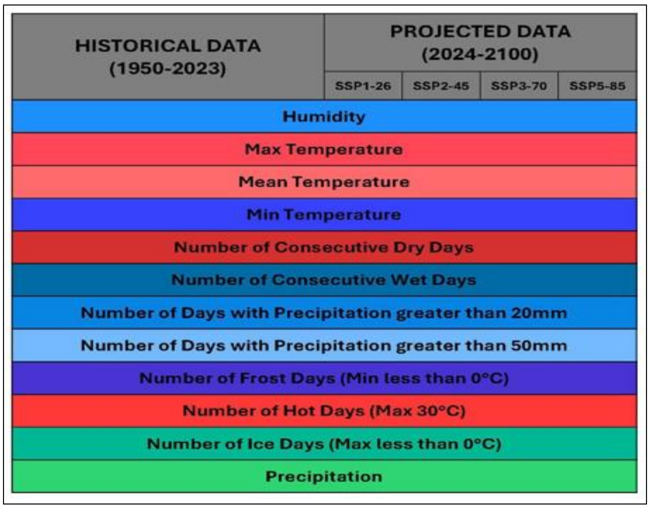

Fig 3: System Data Model Design

The climate data for the above metrics (12 for historical data and 48 for projected data) for over 3000 regions is stored and organized on a database.

3.8 User Interface Design

The implementation of the Climate Visualization System involves integrating various libraries and data sources to create a functional system for visualizing climate data and providing insights. Below are images of the main interface.

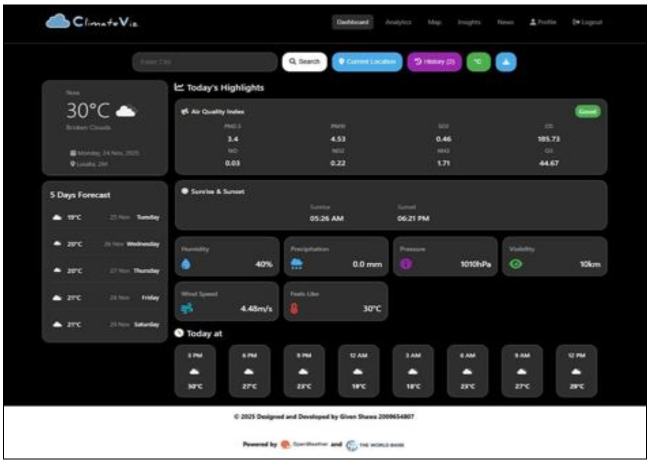

Fig 4: Dashboard

Here, users can get access to current weather, hourly forecast, and a 5 day forecast with detailed descriptions for any location.

Fig 5: Analytics

Analytics allows users to view climate data for 12 metrics, such as humidity and precipitation from 1950-2100 under different emission scenarios for over 3000 global regions.

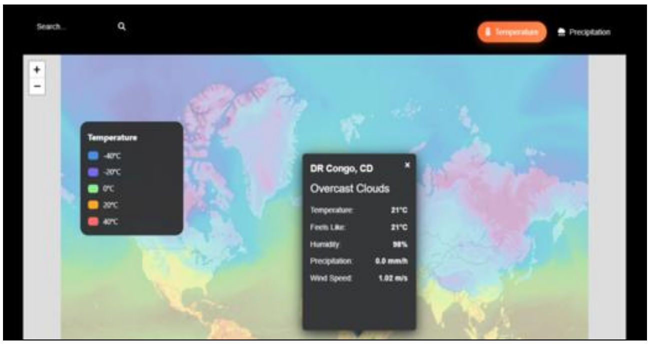

Fig 6: Map

A global map is drawn with layers to visualize temperature and precipitation.

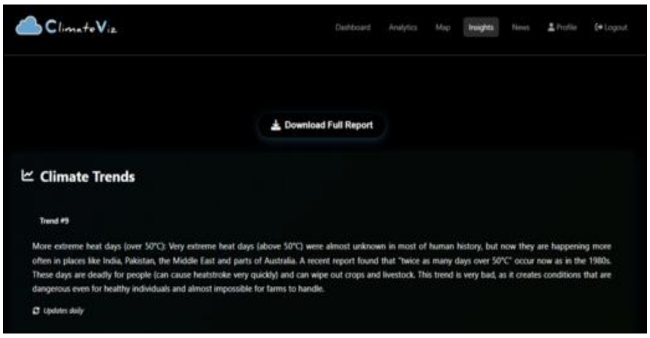

Fig 7: Insights

This page provides climate trends, current insights based on the weather, and long-term insights. The full report is downloadable.

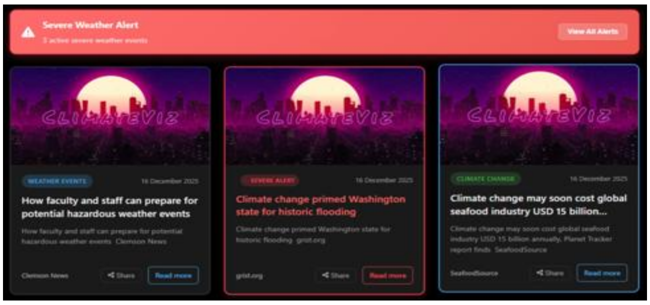

Fig 8: News

Users can access current news and alerts pertaining to weather and climate with. Articles can be filtered by region or category and have multiple sharing options.

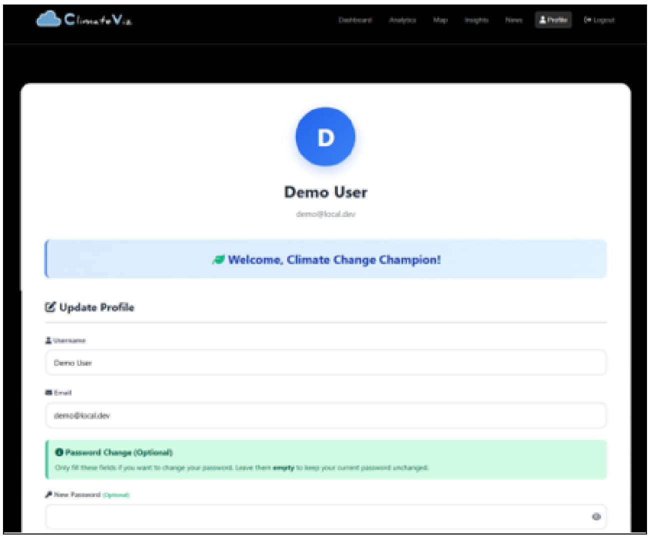

Fig 9: Profile

The profile page allows users to change their details, such as username and password.
Users can also delete their profile and send a direct email to the system developer.

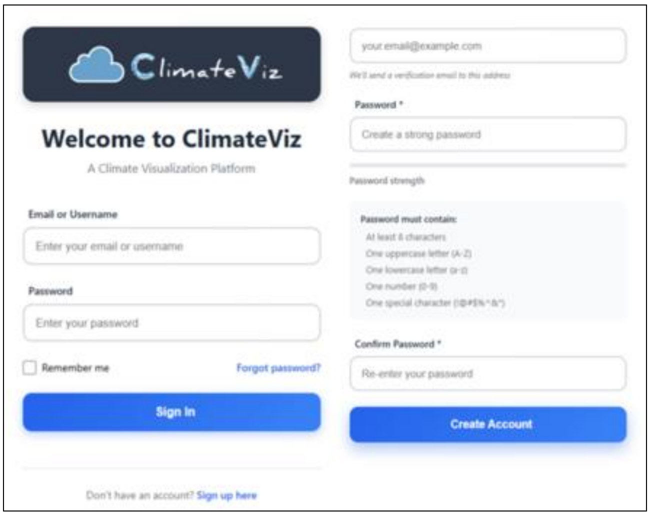

Fig 10: Login/Signup

A modern login/signup page protected by reCaptcha and includes email verification and password validation.

4. Conclusion

In conclusion, the ClimateViz System represents a significant and transformative advancement in climate visualization technology. By strategically leveraging diverse, authoritative data sources and rigorously applying user-centered design principles, the platform transcends traditional static reporting. It translates complex, multidimensional climate information into intuitive, interactive, and actionable insights.

This synthesis of near real-time data, historical context, and future projections within a single, cohesive interface fundamentally enhances public and professional understanding of climatic patterns, vulnerabilities, and trends. More than just an analytical tool, ClimateViz is designed to foster informed dialogue, support evidence-based decision-making, and promote proactive, responsible climate change management among consumers, educators, communities, and policymakers. Ultimately, by making critical climate data more accessible and comprehensible, the system empowers a broader audience to engage with one of the most pressing challenges of our time, bridging the gap between scientific knowledge and tangible action.

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