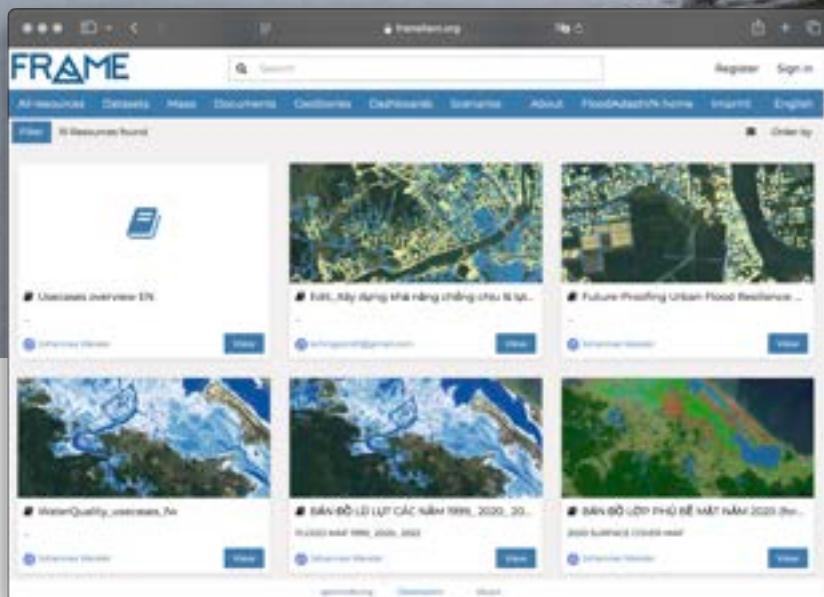


FloodAdaptVN

Flood Risk Information System for Adaptation Measures and Evaluation in Central Vietnam – (FRAME) – GeoNode Facilitation

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Background photo: Vietnam (photo credit: DLR).
FRAME online platform landing page (Retrieved from framefavn.org).



The Flood Risk Information System for Adaptation Measures and Evaluation (FRAME) is an online tool developed for Thừa Thiên Huế province in Central Vietnam, aimed at helping local decision-makers plan for floods more effectively. It's part of the Integrating Ecosystem-based Approaches into Flood Risk Management for Adaptive and Sustainable Urban Development in Central Viet Nam (FloodAdaptVN) project, designed to address the growing challenges of climate change and flooding. FRAME provides easy access to data on land use, urban assets, and flood scenarios, including the costs of different adaptation measures. The tool evaluates measures for reducing and adapting to flood risk, emphasising their effectiveness in impact mitigation, cost-efficiency, and sustainability, and serves as decision support tool. It uses GeoNode technology, making it easy to deploy and customise for other regions if needed. This paper explains how FRAME works, its key features, and its potential benefits for flood risk management. This is the first of a series of publications revolving around the functionalities of FRAME and focus here is set on technical necessities and orchestration aspects within GeoNode, to support the requirements defined within FloodAdaptVN.

Deutsch

Das Hochwasserrisikokennzeichnungssystem für Anpassungsmaßnahmen und Bewertung (FRAME) ist ein Online-Tool, das für die Provinz Thừa Thiên Huế in Zentralvietnam entwickelt wurde, um lokale Entscheidungsträger bei der effektiveren Planung von Hochwasserschutzmaßnahmen zu unterstützen. Es ist Teil des Projekts „Integration ökosystembasierter Ansätze in das Hochwasserrisikomanagement für eine adaptive und nachhaltige Stadtentwicklung in Zentralvietnam (FloodAdaptVN)“, dass sich mit den wachsenden Herausforderungen des Klimawandels und der Hochwassergefahr befasst. FRAME bietet einfachen Zugang zu Daten über Landnutzung, städtische Vermögenswerte und Hochwasserszenarien, einschließlich der Kosten verschiedener Anpassungsmaßnahmen. Das Tool bewertet Maßnahmen zur Verringerung und Anpassung an Hochwasserrisiken unter Berücksichtigung ihrer Wirksamkeit bei der

Schadensminderung, ihrer Kosteneffizienz und ihrer Nachhaltigkeit und dient als Entscheidungshilfe. Es nutzt die GeoNode-Technologie, wodurch es bei Bedarf leicht in anderen Regionen eingesetzt und angepasst werden kann. In diesem Beitrag werden die Funktionsweise von FRAME, seine wichtigsten Merkmale und seine potenziellen Vorteile für das Hochwasserrisikomanagement erläutert. Dies war die erste einer Reihe von Veröffentlichungen zu den Funktionen von FRAME, wobei der Schwerpunkt auf den technischen Anforderungen und den Koordinationsaspekten innerhalb von GeoNode lag, um die im Rahmen von FloodAdaptVN definierten Anforderungen zu erfüllen.

Tiếng Việt

Hệ thống Thông tin Nguy cơ Lũ lụt cho các Biện pháp Thích ứng và Đánh giá (FRAME) là một công cụ trực tuyến được phát triển cho tỉnh Thừa Thiên Huế ở miền Trung Việt Nam, nhằm mục đích giúp các nhà quyết định địa phương lên kế hoạch đối phó với lũ lụt một cách hiệu quả hơn. Đây là một phần của dự án Tích hợp Các Phương pháp Tiếp cận Dựa trên Hệ sinh thái vào Quản lý Rủi ro Lũ lụt cho Sự phát triển Đô thị Thích ứng và Bền vững ở miền Trung Việt Nam (FloodAdaptVN), được thiết kế để giải quyết những thách thức ngày càng tăng của biến đổi khí hậu và lũ lụt. FRAME cung cấp quyền truy cập dễ dàng vào dữ liệu về sử dụng đất, tài sản đô thị và các kịch bản lũ lụt, bao gồm cả chi phí của các biện pháp thích ứng khác nhau. Công cụ này đánh giá các biện pháp giảm thiểu và thích ứng với rủi ro lũ lụt, nhấn mạnh vào hiệu quả của chúng trong việc giảm thiểu tác động, hiệu quả chi phí và tính bền vững, và phục vụ như một công cụ hỗ trợ quyết định. Nó sử dụng công nghệ GeoNode, làm cho việc triển khai và tùy chỉnh cho các khu vực khác nếu cần trở nên dễ dàng. Bài báo này giải thích cách FRAME hoạt động, các tính năng chính của nó và lợi ích tiềm năng của nó đối với quản lý rủi ro lũ lụt. Đây là bài đầu tiên trong một loạt các bài công bố xoay quanh các chức năng của FRAME và tập trung vào các nhu cầu kỹ thuật và khía cạnh điều phối trong GeoNode, để hỗ trợ các yêu cầu được định nghĩa trong FloodAdaptVN.

(Automated translation)

Introduction

Flood Risk Information System for Adaptation Measures and Evaluation in Central Vietnam (FRAME) is an online tool designed for decision-makers in Thừa Thiên Huế province to assist in climate-resilient planning against flood risks, potentially extendable to other areas. Developed within the Integrating Ecosystem-based Approaches into Flood Risk Management for Adaptive and Sustainable Urban Development in Central Viet Nam (FloodAdaptVN) project, it addresses the increased frequency and impact of disasters due to climate change. FRAME provides spatial insights on land use, urban assets, and environmental effects of flood scenarios, including cost estimations for adaptation strategies. It emphasises ecosystem-based disaster risk reduction (EcoDRR) and adaptation (EbA) measures, offering a strategic approach to flood adaptation planning and integrating ecosystem services to mitigate vulnerabilities. The tool facilitates interdisciplinary assessments, targeting

Vietnamese local administration in Thừa Thiên Huế for effective planning. It features a secure, web-based data infrastructure with access to data, maps, statistics, and visualisations for flood impact assessment. FRAME incorporates research insights, foundational maps, remote sensing data, and information on current and projected flood hazards, infrastructure, and land use. It empowers stakeholders by allowing system ownership, personal data integration, and customisation to meet specific needs. FRAME is based on GeoNode and can be deployed as Docker, enhancing its ease of transfer and adaptability for use by other organisations or regions. A Docker container is a all-in-one software package that includes the application, libraries, and dependencies needed to run it anywhere. Figure 1 provides a conceptual overview of the system and the different features it offers within the context of FloodAdaptVN. Within this paper we provide details on the technical workings of FRAME and highlight GeoNode context and features.

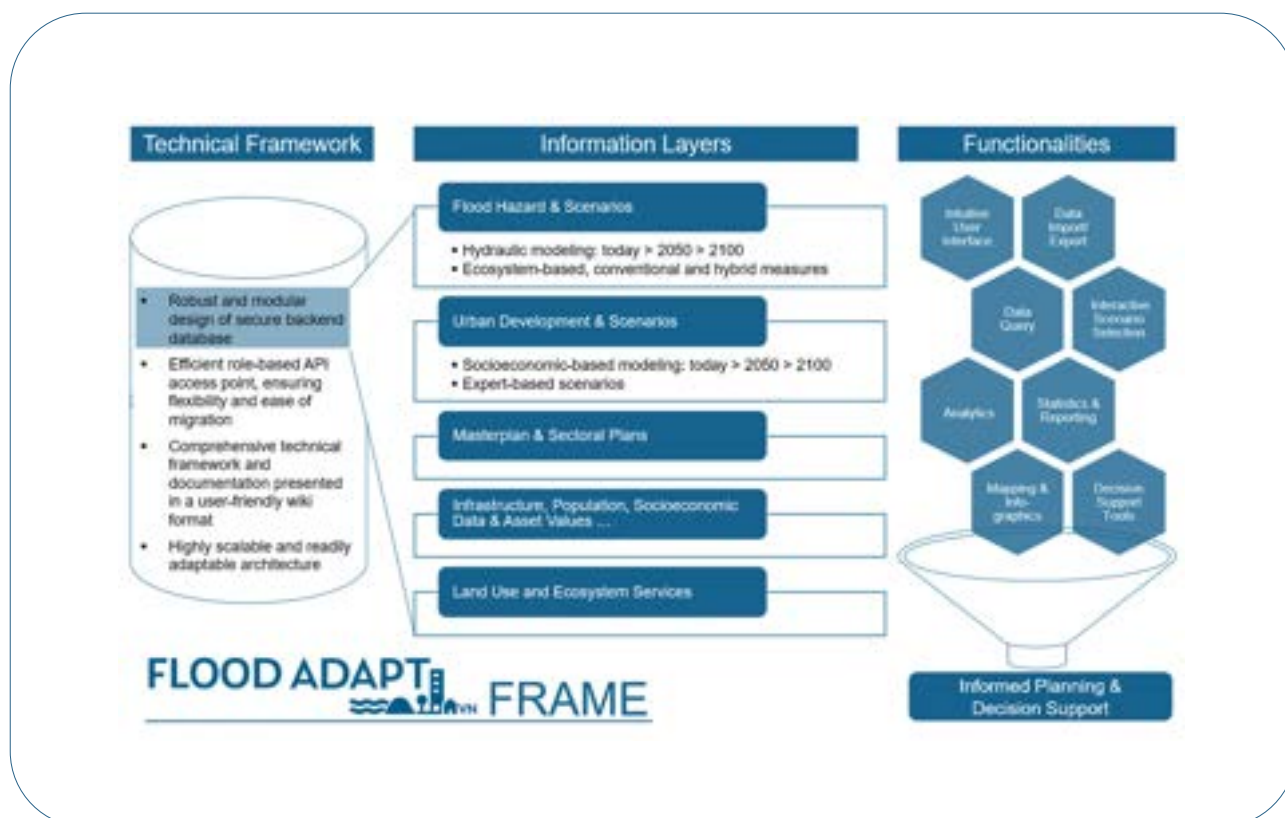


Fig. 1: Conceptual overview of FRAME.



Unlike proprietary GIS solutions (e.g., ESRI's ArcGIS), open-source platforms like GeoNode offer transparency, cost-effectiveness, and community-driven support. They provide flexibility for users with diverse technical backgrounds, enabling local agencies or NGOs to tailor the system to specific flood risk challenges without steep licensing costs.

Implementation of FRAME using GeoNode

GeoNode was chosen as a solution to facilitate FRAME. GeoNode orchestrates components interaction to provide a web-based comprehensive geospatial content management system. Django offers the web framework, facilitating rapid development and serving as the backbone for user interfaces and functions interaction logic. GeoServer handles spatial data, enabling map rendering and data downloading. GeoExplorer supports map composition and publishing. PostgreSQL/PostGIS stores and manages spatial data, while pycsw implements metadata catalogue services. Geospatial Python Libraries gsconfig and OWSLib, integrate GeoNode with GeoServer's configuration and OGC services (GeoSolutions, n.d). Django Pluggables extend GeoNode's functionality, jQuery enhances UI interactivity, and Bootstrap ensures consistent styling across browsers. Each component plays a crucial role in the GeoNode ecosystem, supporting data management, user interaction, and system functionality for flood management (Cristofori et al., 2015). Within the following subsections relevant aspects of FRAME and GeoNode are presented.

Functionalities and Features

GeoNode provides a wide range of functionalities for geospatial data management and analysis. Users can upload and download geospatial data in formats such as Shapefiles, GeoTIFFs, GeoJSON, Keyhole Markup Language (KML), or comma-separated values file (CSV). The platform includes built-in search capabilities based on keywords, categories, regions, and filters, while detailed metadata entry enables consistent cataloguing. Visualisation and editing are possible through an integrated map composer (GeoExplorer) or external GIS tools including QGIS and GeoTools. Data sharing

among user groups or the public fosters collaboration, and OGC-compliant services plus a Django-based architecture allow for easy integration with external applications.

Compared to commercial solutions such as ArcGIS Online, GeoNode's open-source design emphasises cost-effectiveness, transparency, and adaptability. Organisations can tailor the software to specific project requirements without incurring high licensing fees, making it accessible to both technical specialists and non-expert stakeholders. The open and modular design also supports rapid updates through community-driven enhancements (GeoSolutions, 2024).

Architecture and Design

GeoNode relies on several key components that work together. GeoServer is a Java-based server for sharing and editing geospatial data through Open Geospatial Consortium (OGC) standards including Web Map Service WMS, Web Feature Service WFS, Web Coverage Service WCS, and Web Map Tile Service WMTS. It integrates with OpenLayers for map rendering and GeoTools for spatial data handling. Django, a Python-based web framework, manages user authentication, data uploads, and interactions between GeoServer, metadata services such as pycsw or GeoNetwork, and the database. FRAME uses PostgreSQL with the PostGIS extension for efficient spatial storage and querying. Web front-ends (OpenLayers or Leaflet) offer interactive map displays, layer controls, and data exploration. Integration with desktop GIS tools ensures interoperability.

By using Docker, these components are containerised, simplifying installation and updates. The hosting environment, with open ports such as 80 and 443, ensures both internal and external accessibility. Let's Encrypt can handle SSL certificates for secure traffic. The FRAME system can thus operate as a robust decision-support tool for flood risk management, combining technical flexibility with user-friendly access.

The client side of GeoNode includes web browsers or applications that access GeoNode's functionalities

through its web interface or APIs. It supports a wide array of tools and libraries for geospatial data display and interaction, including OpenLayers, Leaflet, Mapbox, and integration with external GIS software, facilitating a versatile and user-friendly experience for accessing and simple manipulating geospatial data (vectors). Each of these components plays a pivotal role in the overall functionality and user experience of GeoNode, illustrating the platform's comprehensive approach to geospatial data management and analysis. For a deeper understanding of GeoServer's capabilities and standards, see the GeoServer User Manual and documentation on OGC API (Green, 2021; Corti et al., 2019).

GeoServer

- Java-based engine for serving and editing geospatial data under OGC standards (WMS, WFS, WCS, WMTS).
- Integrates with OpenLayers and the GeoTools library for robust map rendering and spatial data handling.

Django

- Python-based web framework orchestrating user authentication, data workflows, and communication with GeoServer and metadata services.
- Maintains a unified interface to link databases, geospatial services, and the client-facing application.

Database (PostgreSQL/PostGIS)

- Ensures reliable storage of spatial data and supports advanced querying, improving performance in multi-user environments.
- Scales effectively for large datasets, vital for extensive flood maps and asset registries.

Metadata Management (pycsw or GeoNetwork)

- Facilitates cataloguing and compliance with ISO 19115 standards, enabling efficient data discovery.
- Ensures traceability and standardisation across various datasets.

Client Interface

- Web-based front end using libraries such as OpenLayers or Leaflet for interactive maps, layer toggling, and data exploration.
- Compatible with external GIS clients, so users can view or edit data in desktop tools.

Docker Deployment

- Containers wrap each component (GeoServer, Django, etc.) to streamline installation, updates, and scalability.
- Requires open ports (80 for HTTP, 443 for HTTPS) and SSL (Secure Sockets Layer) certificate integration (e.g., Let's Encrypt) for secure external access.

Data Models and Formats

Geonode employs a variety of data models and formats for the storage and exchange of geospatial data and metadata. A data layer represents geospatial features or rasters and contains attributes including name, type, geometry, and value. A data store acts as a repository for one or more data layers and can be a file, folder, database, or web service, characterised by parameters such as name, type, location, and connection. Each layer or workspace has a URI (Uniform Resource Identifier) that provides a standardised address for data retrieval. Workspaces serve as namespaces to group data stores, featuring properties name, prefix, and URI, and are utilised to organise data according to project, domain, or owner. Styles define the visual appearance of data layers on maps through elements: symbol, colour, size, label, and filter, and are adaptable to other formats SLD, CSS, or YSLD. Maps integrate data layers and styles on a canvas, including classic GIS components such as base map, zoom level, centre, extent, and legend, with storage options in formats such as JSON, XML, or WMC. Lastly, metadata describes the various elements of GeoNode, including data layers, stores, workspaces, styles, and maps, with fields covering title, abstract, keywords, licence, owner, date, and spatial extent, and can be formatted in ISO 19115 standards, Dublin Core, and FGDC. GeoNode is built upon several key components, each offering unique



functionalities and enabling integration with external services and clients (Green, 2021; Corti et al., 2019).

Security, Authentication, and Relevance for Stakeholders

Within FRAME, the security and authentication mechanisms ensure that different user groups—ranging from local authorities to non-technical stakeholders—can access only the relevant data and functionalities. This safeguards sensitive information (e.g., infrastructure plans) while allowing broader project teams and the public to view general flood risk data.

GeoNode handles FRAME security and authentication mechanisms to safeguard and manage access to its resources, including data layers, data stores, workspaces, styles, maps, and metadata. The core elements of GeoNode's security framework encompass users, groups, permissions, policies, authentication, and authorisation. Users, defined by attributes such as username and password, can assume roles ranging from administrator to staff. Groups bring together users with shared interests, equipped with attributes of name and members, and roles such as manager or editor that can be freely configured. Permissions specify the actions users or groups can perform on resources, articulated through parameters of resource type and action. Policies aggregate permissions under conditions related to resource ownership or user roles. Authentication verifies user identities through a password and if necessary tokens, while authorisation determines access rights, relying on Django permissions and GeoServer security to grant or restrict resource usage (GeoSolutions, 2024; Corti et al., 2019).

Features Integrated into FRAME

The FRAME tool enhances decision-making across several domains by offering research-backed insights and evidence-based recommendations for the stakeholders of FloodAdaptVN. In decision support, it aids planning units and institutions with data for infrastructure and urban planning, focusing on adapting to and predicting future socio-economic and urban vulnerabilities to extreme

events. For flood scenarios, FRAME provides detailed spatial analyses of flood extents and inundation depths, assessing current hazards, future changes due to climate and economic factors, and the effectiveness of adaptation measures. This approach enriches flood risk management and assessment strategies. In urban development, FRAME facilitates informed land use and development strategies through cost-benefit analyses, ensuring resilient infrastructure against future challenges. It also enables comparative analysis of adaptation options, weighing ecosystem-based approaches against conventional engineering solutions, highlighting long-term socio-economic impacts. Furthermore, FRAME conducts thorough analyses of agricultural and ecosystem impacts, focusing on the financial aspects of land use changes. Similarly, its infrastructure impact analysis covers a wide range of assets, supporting various sector-specific assessments of healthcare accessibility and flood risk for tourism. Through these applications, FRAME significantly contributes to strategic planning and risk management in a changing environmental and socio-economic landscape. Table 1 outlines the applications we have or are currently realising for FRAME using GeoNode technologies. By clearly defining roles and permissions, FRAME helps maintain data integrity and fosters collaboration among diverse stakeholders, ensuring reliable and secure access.

Figure 2 comprises two facets (A and B) illustrating dynamic aggregation in FRAME's flood damage test use case. Facet A demonstrates on-the-fly spatial aggregation, where right-hand tables automatically update according to the current zoom level, reflecting ward- or district-level summaries. Facet B shows individual buildings, with corresponding aggregation also sensitive to map scaling. These multi-layered, zoom-dependent widgets allow stakeholders to seamlessly transition from broad overviews (e.g., total damage per district) to granular building-level estimates. This flexible design, exemplified by the flood damage scenario, highlights FRAME's capacity for real-time data aggregation and interactive exploration across multiple spatial scales.

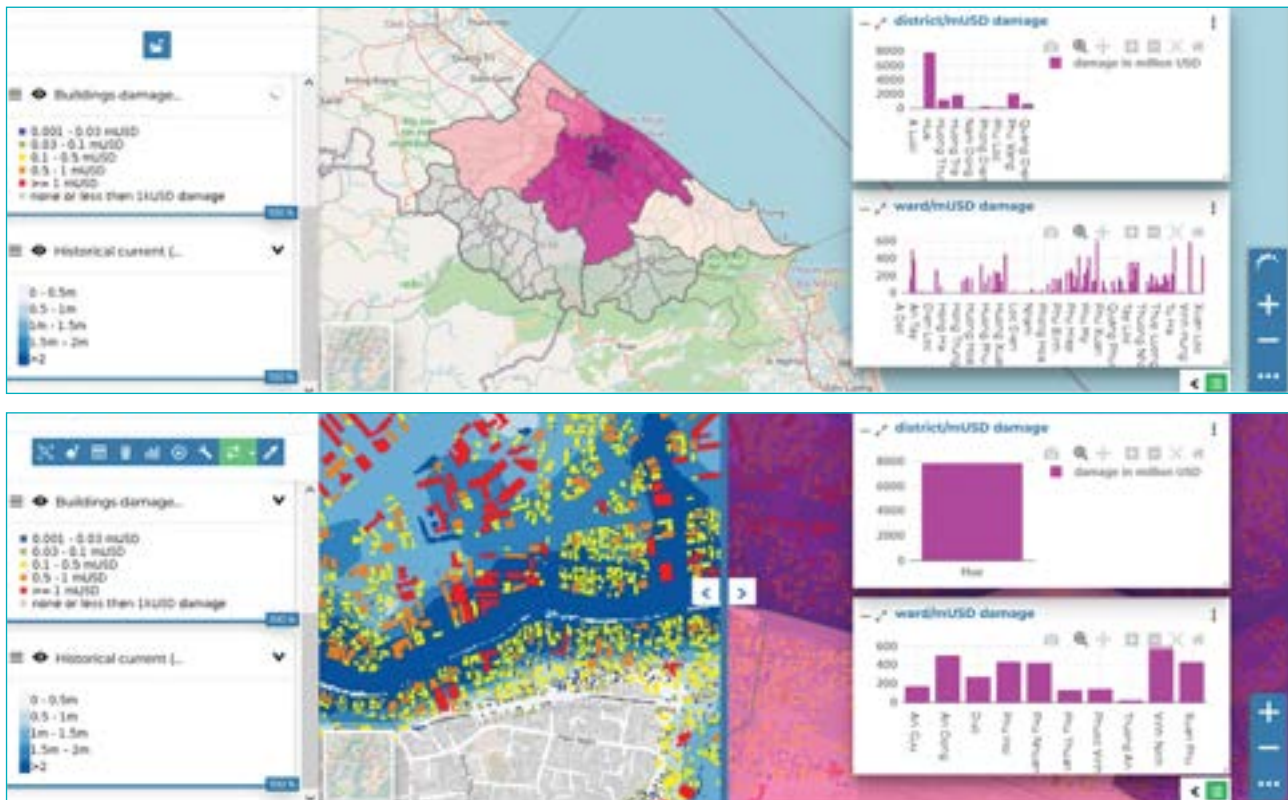


Fig.2 Example of GeoNode feature use for FRAME. On the fly data aggregation via widgets (top) and individual buildings and flood impact analysis (bottom).

These interactive maps and charts underscore FRAME's capacity as a user-friendly WebGIS:

- **Layer Swapping and Swiping:** Users can compare various scenarios (e.g., historic flood vs. future flood) or layer combinations by simply dragging the swipe bar.
- **Granular vs. Aggregated Insights:** Building-level data illuminates specific assets at risk, while aggregated ward or district damage totals inform broader-scale adaptation strategies.
- **Automatic Chart Updates:** As users zoom in or switch layers, the bar charts recalculate accordingly, ensuring real-time, scenario-based analytics.



FRAME goes beyond flood risk. By containerizing GeoNode, it unites data for housing, transport, or environment, all in one flexible ecosystem."