GIS case studies

Amazon Rainforest – Brazil (PRODES & ARPA Program)

- **Topic:** *Rainforest Deforestation Monitoring & Sustainable Biome Management*
- **GIS System: PRODES (Projeto de Monitoramento do Desflorestamento na Amazônia Legal por Satélite)**
- **Organization:** Developed by **INPE (National Institute for Space Research)**, Brazil
- **Launch Year: 1988 (modernized annually)**
- **Technology:** Uses **Landsat satellite imagery** (30m resolution), integrated with **GIS databases** to monitor forest cover annually.
- **Supplementary Program: ARPA (Amazon Region Protected Areas Program)** launched in **2002** by the **Brazilian Ministry of Environment**, supported by **World Bank, WWF, and GEF**.
- **How it's used:**
  - Tracks yearly forest loss in Legal Amazon using geospatial change detection.
  - Helps identify illegal logging areas and prioritize law enforcement.
  - Supports conservation zoning for ARPA's 60+ million hectares of protected areas.
- **Example:**
  - In **2021**, PRODES detected a sharp increase in deforestation near Pará state, enabling immediate legal and military intervention.
- **Why it's useful:**
  - Enables **real-time forest protection** and long-term planning.
  - Supports international climate goals by preserving carbon sinks.
  - Integrates with **DETER** (real-time alert system) for faster action.

Danube River Basin – Europe (EU Water Framework Directive)

- **Topic:** *Transboundary River Conservation via EU Water Policy*
- **GIS System: WISE (Water Information System for Europe)** integrated with **DanubeGIS** by the **ICPDR (International Commission for the Protection of the Danube River)**
- **Organizations Involved:** EU Commission (DG Environment), ICPDR, European Environment Agency (EEA)
- **Launch Year: 2000 (WFD adoption), DanubeGIS active since 2006**
- **Technology:** Combines **hydrology models**, **water quality sensors**, and **georeferenced datasets**.
- **How it's used:**
  - Creates **River Basin Management Plans (RBMPs)** for 19 nations.
  - Allows real-time coordination on nutrient pollution, biodiversity conservation, and flood risk.
- **Example:**
  - **RBMP 2015–2021** reduced nutrient runoff in the Danube Delta by 25% through coordinated wastewater management across borders.
- **Why it's useful:**
  - Enables shared data access for 83 million people.
  - Supports **EU Sustainable Development Goals** and biodiversity frameworks.
  - Vital for managing **climate change impacts on water resources**.

Merapi Volcano Monitoring – Indonesia (Post-2010 Upgrades)

- **Topic:** *Volcano Risk Prediction and Evacuation*
- **GIS System: MAGMA Indonesia (Multiplatform Application for Geohazard Mitigation and Assessment)** by **PVMBG (Centre for Volcanology and Geological Hazard Mitigation)**
- **Organization: PVMBG**, under the Indonesian Ministry of Energy and Mineral Resources
- **Launch Year: 2010 (revamped post-eruption)**

- **Technology:** Combines **GIS mapping**, **seismic data**, **thermal imagery**, and **topographic models**.
- **How it’s used:**
  - Helps define exclusion zones and evacuation corridors.
  - Issues real-time alerts via MAGMA web and mobile platform.
- **Example:**
  - In **2018**, pre-eruption GIS data predicted dome collapse; alerts enabled evacuation of thousands with **zero casualties**.
- **Why it's useful:**
  - Saves lives in high-density volcanic regions.
  - Integrates with **drone surveillance** and field volcanologist observations.
  - Offers **multilingual data access** to local governments.

Hazus – USA (FEMA’s Risk Analysis Program)

- **Topic:** *Nationwide Risk Simulation for Earthquakes, Floods, Hurricanes*
- **GIS System: Hazus-MH (Hazards United States – Multi-Hazard)**
- **Organization:** Developed by **FEMA** and **NIBS (National Institute of Building Sciences)**
- **Launch Year: 1997** (updated regularly with FEMA’s Risk MAP program)
- **Technology:** ArcGIS-based software modeling tool using census data, infrastructure layers, and hazard simulations.
- **How it’s used:**
  - Models building damage, casualties, economic loss for disaster planning.
  - Informs emergency planning, insurance models, and mitigation strategies.
- **Example:**
  - Used during **Hurricane Harvey (2017)** to project infrastructure losses in Houston, guiding FEMA aid allocation.
- **Why it's useful:**

- Customizable for local governments.
- Visual risk assessments help **justify pre-disaster mitigation funding**.
- Supports **urban resilience planning**.

Singapore’s Population Density GIS System

- **Topic:** *Urban Infrastructure Planning and Optimization*
- **GIS System: URA SPACE (Singapore Urban Redevelopment Authority Spatial Data Platform)**
- **Organization: Urban Redevelopment Authority (URA), Singapore**
- **Launch Year: 2016**
- **Technology:** Public-facing **interactive 3D GIS platform** with layers on zoning, land use, population, housing, amenities.
- **How it’s used:**
  - Tracks real-time population density, transportation use, and housing needs.
  - Informs public housing development and MRT line expansions.
- **Example:**
  - Helped optimize the **North-East Line MRT stations** by evaluating ridership and population density.
- **Why it's useful:**
  - Prevents urban sprawl and overcrowding.
  - Balances green space with high-density development.
  - Supports **Smart Nation Singapore** policy goals.

Global Migration Trend Mapping – IOM & UNHCR Dashboards

- **Topic:** *Climate and Conflict-Driven Human Migration*
- **GIS System:**
  - **Migration Data Portal GIS Dashboard** by **International Organization for Migration (IOM)**

    - **UNHCR Operational Data Portal** (GIS-based refugee mapping) by the **United Nations High Commissioner for Refugees**
- **Launch Years:**
    - IOM Portal: **2017**
    - UNHCR Portal: continuously developed since **2011 Syrian refugee crisis**
- **Technology:**
    - Combines **ArcGIS Online**, **Esri StoryMaps**, real-time geospatial data, demographic models, and border monitoring datasets.
- **How it's used:**
    - Maps origin-destination flows, conflict zones, migration corridors.
    - Tracks refugee settlement locations, services, and emerging hotspots.
- **Example:**
    - **Rohingya crisis (2017–2022):** GIS dashboards tracked the migration of over 900,000 refugees from Myanmar to Cox's Bazar, Bangladesh, enabling efficient humanitarian logistics and aid delivery.
- **Why it's useful:**
    - Informs **international agencies on resource allocation**.
    - Helps predict secondary migration due to climate change.
    - Supports **real-time coordination across borders**.

PHIVOLCS Volcano Monitoring – Philippines

- **Topic:** *Real-Time Volcanic Risk Monitoring and Alert System*
- **GIS System:**
    - **Volcano Monitoring and Alert System (VMAS)** by **PHIVOLCS (Philippine Institute of Volcanology and Seismology)**
- **Launch Year:** Continuous upgrades post **Mount Pinatubo (1991)**, system formally integrated in **2004**.
- **Technology:**
    - Seismic sensors, GPS stations, thermal cameras, satellite (MODIS, ASTER), and automated **GIS alert mapping systems**.

- **How it’s used:**
  - Issues eruption alerts for 24 active volcanoes.
  - Defines hazard zones (lava, pyroclastic flow, lahars) and notifies LGUs (local government units).
- **Example:**
  - During the **Taal Volcano eruption in January 2020**, PHIVOLCS used real-time GIS data to raise Alert Level 4 and evacuate ~300,000 residents.
- **Why it's useful:**
  - **Minimizes casualties** during eruptions.
  - Data used in land-use planning and resettlement.
  - Integrates with **NDRRMC disaster response system**.

ShakeAlert – USA (California, Oregon, Washington)

- **Topic:** *Earthquake Early Warning (EEW) for Population Centers*
- **GIS System:**
  - **ShakeAlert** EEW System
  - Developed by the **USGS (U.S. Geological Survey)** with partners: Cal OES, Berkeley Seismology Lab, and University of Washington
- **Launch Year:** Pilot in **2011**, public mobile alerts active since **October 2022**
- **Technology:**
  - Network of 1,600+ **seismometers**, real-time **GPS sensors**, and **GIS-based alert visualization** platforms
- **How it’s used:**
  - Sends alerts via **cell phones, trains, and industrial machinery** within seconds of detecting a quake.
  - Visualizes predicted shaking intensity zones.
- **Example:**
  - On **June 28, 2021**, ShakeAlert warned parts of Oregon and Washington ~5 seconds before a magnitude 5.9 quake.

- **Why it's useful:**
  - Automates **brake systems on trains**, stops elevators, and warns schools.
  - Gives people precious seconds to **"Drop, Cover, and Hold On"**.
  - Part of **USGS Advanced National Seismic System (ANSS)**.

DART System – Global Ocean Tsunami Network

- **Topic:** *Tsunami Detection and Ocean Monitoring*
- **GIS System:**
  - **DART (Deep-ocean Assessment and Reporting of Tsunamis)**
  - Managed by **NOAA (National Oceanic and Atmospheric Administration), USA**
- **Launch Year:** First deployed in **2001**, global expansion post **2004 Indian Ocean tsunami**
- **Technology:**
  - Ocean-floor **pressure sensors + surface buoys**, transmit data via satellites to NOAA centers.
  - Feeds into **Tsunami GIS models** that map wave propagation and impact zones.
- **How it's used:**
  - Tracks pressure anomalies to detect tsunami wave formation.
  - Sends alerts to countries within **minutes** of deep-sea disturbance.
- **Example:**
  - During the **2011 Japan Tōhoku tsunami**, DART data helped issue Pacific-wide warnings hours before impact in Hawaii and California.
- **Why it's useful:**
  - Vital for **early evacuation of coastal areas**.
  - Prevents **thousands of deaths** in multi-country impact zones.
  - Integrated into the **UNESCO Intergovernmental Oceanographic Commission** warning system.

Indonesia PVMBG + Merapi GIS Mapping

- **Topic:** *Volcanic Exclusion Zone Enforcement and Risk Planning*
- **GIS System:**
  - **SIG-MERAPI** (Sistem Informasi Geospasial Merapi)
  - Developed by **PVMBG** in collaboration with **ITB (Bandung Institute of Technology)**
- **Launch Year: 2012**, as a GIS upgrade following 2010 Merapi disaster
- **Technology:**
  - Incorporates **DEM (Digital Elevation Models)**, eruption history, lahar flow paths, settlement data, and satellite maps.
- **How it's used:**
  - Designs **dynamic exclusion zones** that shift with activity levels.
  - GIS maps distributed to local authorities and disaster managers.
- **Example:**
  - Used in **2013 and 2021** Merapi activity spikes to enforce no-go zones and redirect tourism.
- **Why it's useful:**
  - Provides **tailored evacuation planning** for each new event.
  - Protects vulnerable slope settlements.
  - Boosts **resilience of volcanic communities** with risk-informed development.

Pacific Tsunami Warning Center (PTWC)

- **Topic:** *Tsunami Detection & Coastal Alert System*
- **GIS System:**
  - **PTWC Tsunami Warning System** integrated with **Tsunami Travel Time (TTT) Maps**
  - Operated by **NOAA's National Weather Service**, under the **Pacific Tsunami Warning and Mitigation System (PTWS)**

- **Launch Year:** Established **1949**, GIS-enhanced modules added after **2004 Indian Ocean tsunami**
- **Technology:**
  - Integrates data from **DART buoys**, **tide gauges**, **seismometers**, and **GIS models** to simulate tsunami wave propagation in real time.
- **How it’s used:**
  - Issues alerts to Pacific nations with estimated arrival times, affected areas, and recommended evacuations.
  - Visual GIS maps show wave direction, speed, and coastal impact zones.
- **Example:**
  - In **March 2011**, the system alerted Hawaii, Alaska, and U.S. West Coast after the Japan Tōhoku earthquake, helping authorities issue accurate evacuation orders.
- **Why it's useful:**
  - Coordinates multi-nation responses.
  - Reduces **disaster impact on islands and coastal megacities**.
  - Acts as **global warning hub** for tsunami-prone regions.

Japan Earthquake Early Warning System (EEWS)

- **Topic:** *Seismic Risk Alert for Densely Populated Areas*
- **GIS System:**
  - **Kyoshin Network (K-NET)** and **Hi-net**, managed by the **Japan Meteorological Agency (JMA)** and **NIED (National Research Institute for Earth Science and Disaster Resilience)**
- **Launch Year:** Pilot in **2007**, expanded nationwide by **2009**
- **Technology:**
  - Over 1,000 seismic sensors, real-time telemetry, and GIS platforms integrated into **mobile alert systems, television, and rail networks**.
- **How it’s used:**

    - Sends alerts seconds before P-waves (fastest seismic waves) arrive, giving time to brace.
- **Example:**
    - In the **2011 Tōhoku earthquake**, the system issued alerts **12 seconds** before tremors reached Tokyo, enabling train stoppage and school sheltering.
- **Why it's useful:**
    - Saves lives through **automated safety actions**.
    - Pioneered **public-access earthquake warning tech**.
    - Serves as a global model for EEWS systems.

Urban Heat Mapping – Los Angeles, USA

- **Topic:** *Heat Risk Management & Urban Planning*
- **GIS System:**
    - **Urban Heat Vulnerability Mapping Tool** by **NOAA Climate Program Office**, **CAPA Strategies**, and **LADWP**
- **Launch Year:** Initial LA campaigns started in **2015**, expanded in **2021** with city-wide analysis
- **Technology:**
    - Thermal satellite imagery (e.g. Landsat 8), air temperature sensors, **land-use overlays**, and census data.
- **How it’s used:**
    - Maps urban “heat islands” based on surface temps and built environment.
    - Guides placement of **cool roofs, reflective pavements, and tree canopy expansion**.
- **Example:**
    - Data used in **South LA and Boyle Heights** to launch cooling interventions and mitigate temperature disparities.
- **Why it's useful:**

- Addresses **climate justice**, since hottest areas often overlap with low-income communities.
- Reduces **heat-related illnesses**.
- Informs zoning and urban greenery efforts.

NASA GIS for Climate Change

- **Topic:** *Long-Term Global Environmental Monitoring*
- **GIS System:**
  - **NASA Earth Observing System Data and Information System (EOSDIS)**
  - Main platform: **Worldview**, developed by **NASA's Earth Science Data Systems (ESDS) Program**
- **Launch Year:** EOSDIS active since **1994**, Worldview viewer released in **2012**
- **Technology:**
  - Integrates data from **MODIS, OCO-2, ICESat, Landsat**, and **Sentinel missions** into a public GIS interface.
- **How it's used:**
  - Tracks changes in **glacier mass, CO_2, methane levels, wildfires, and sea-level rise**.
  - Supports climate modeling used by **IPCC reports** and national policies.
- **Example:**
  - Used to monitor **Greenland and Antarctic ice sheet retreat**, which contributed to global sea-level models used by the **UN Paris Agreement (2015)**.
- **Why it's useful:**
  - Enables **scientific transparency**.
  - Visualizes decades of change for global audiences.
  - Powers **climate action plans and mitigation strategies**.

FEMA Disaster Response GIS – USA

- **Topic:** *Post-Disaster Planning and Emergency Logistics*
- **GIS System:**
  - **FEMA GeoPlatform**, part of the **Risk MAP (Mapping, Assessment, and Planning) initiative**
- **Launch Year:** Developed post-Hurricane Katrina, expanded into **GeoPlatform in 2014**
- **Technology:**
  - Real-time integration of **storm tracks, floodplain models, evacuation zones**, and **damage assessments** with Esri-based tools.
- **How it's used:**
  - Supports FEMA regional offices during hurricanes, wildfires, and floods.
  - Guides search & rescue, logistics deployment, and funding requests.
- **Example:**
  - During **Hurricane Ian (2022)**, GIS systems tracked rising flood levels in Florida to reroute rescue boats and FEMA supply chains.
- **Why it's useful:**
  - Improves **response efficiency**.
  - Reduces time to assess **FEMA assistance eligibility**.
  - Supports **mitigation planning and zoning changes**.

WWF GIS for Wildlife Migration – Africa

- **Topic:** *Endangered Species Monitoring and Anti-Poaching Strategies*
- **GIS System:**
  - **WWF Wildlife Tracker**, integrated with **SMART (Spatial Monitoring and Reporting Tool)**, co-developed by **WWF, Wildlife Conservation Society, and Esri**
- **Launch Year:** SMART released in **2013**, migration tracking projects ongoing since mid-2000s
- **Technology:**
  - **GPS collars**, real-time GIS mapping, and ranger patrol planning tools.

- **How it’s used:**
  - Tracks elephants, rhinos, lions across **Kenya, Namibia, Botswana, and Zambia**.
  - Helps define corridors and detect poaching risk areas.
- **Example:**
  - In the **Kavango-Zambezi Transfrontier Conservation Area (KAZA)**, GIS helped reduce elephant poaching by guiding rangers and mapping safe zones.
- **Why it's useful:**
  - Prevents **human-wildlife conflict**.
  - Protects **biodiversity hotspots**.
  - Enhances collaboration across **country borders**.

Precision Agriculture – India and USA

- **Topic:** *Smart Farming, Water Conservation, and Yield Optimization*
- **GIS System:**
  - India: **KISAN Platform (Krishi Integrated Spatial Analysis Network)** by **ISRO** and **ICAR**
  - USA: **AgriGIS** and **Climate FieldView** by **Monsanto/Bayer**
- **Launch Year:**
  - India: Active since **2015**, USA: Commercial use since **2013**
- **Technology:**
  - Satellite NDVI imaging, **drones**, soil sensors, yield prediction algorithms, mobile apps with **farm-scale GIS interfaces**.
- **How it’s used:**
  - Guides **irrigation schedules, pesticide use, and seed placement** based on land variability.
  - Tracks water stress, rainfall, and growth zones.
- **Example:**

    - In **Maharashtra, India**, GIS-based advisory services helped farmers increase wheat yields by **up to 40%** through zone-based fertilization.
- **Why it's useful:**
    - Reduces **water and chemical waste**.
    - Increases **climate resilience**.
    - Supports **food security** in both developed and developing economies

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Copernicus Programme – European Union

- **Topic:** *Earth Observation for Environmental, Security, and Climate Monitoring*
- **GIS System:**
    - **Copernicus Earth Observation Programme** powered by **Sentinel Satellites**, coordinated by the **European Commission** and operated by **ESA (European Space Agency)**.
- **Launch Year:** Officially launched in **2014**; satellite launches began with **Sentinel-1A in April 2014**
- **Technology:**
    - A suite of **Sentinel satellites** (1–6), offering **radar and optical imagery**, thermal sensors, ocean salinity, and atmospheric data.
    - Data distributed via **Copernicus Open Access Hub**, integrated into **GIS tools** across sectors.
- **How it’s used:**
    - Monitors **climate change**, **air quality**, **urban sprawl**, **flood risk**, **wildfires**, **agriculture health**, and **coastal erosion**.
    - Supports **INSPIRE-compliant GIS layers** for EU countries.
- **Example:**
    - During the **2021 wildfires in Greece and Turkey**, Sentinel-2 imagery enabled near-real-time fire boundary detection and coordination of firefighting efforts.
- **Why it's useful:**

- Covers **global data, updated every 5–10 days** at high resolution.
- Enables **policy compliance** with EU environmental laws (e.g. Natura 2000).
- Data is **open-access**, supporting NGOs, researchers, and even developing nations.

Global Forest Watch – Worldwide (WRI)

- **Topic:** *Forest Change Detection and Environmental Policy Enforcement*
- **GIS System:**
  - **Global Forest Watch (GFW)** platform by the **World Resources Institute (WRI)**
  - Powered by **Google Earth Engine**, **UMD (University of Maryland)** forest monitoring models, and **satellite imagery** (Landsat, MODIS, Sentinel).
- **Launch Year:** Officially launched in **2014** (built on prior FORMA and GLAD alerts)
- **Technology:**
  - Integrates **deforestation alerts**, **carbon emissions estimates**, **biodiversity overlays**, and **fire risk mapping** into a real-time GIS dashboard.
  - Users can download shapefiles or use the **interactive web-based viewer**.
- **How it’s used:**
  - Monitors illegal logging, fires, and agricultural encroachment.
  - Used by governments, companies, and activists to **track deforestation trends**.
- **Example:**
  - In **Peru’s Madre de Dios region**, GFW data helped expose **illegal gold mining** clearing rainforest, leading to national park protection expansions.
- **Why it's useful:**

- Offers **weekly updates on tree cover loss**, even in remote tropical forests.
- Helps enforce **zero-deforestation supply chains** (e.g., cocoa, palm oil).
- Supports **Indigenous rights groups** in monitoring ancestral land use.
