Power of GIS Mapping: ATLAS Flood Maps 2022

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Abstract

In this paper, we are introducing an efficient method based on the GIS technology, to design data immediate and analysis-ready mapping from open GIS and remote sensing data, vector and raster data into a single visualization to facilitate fast and flexible mapping, also referred to as ATLAS maps. The Google Earth Engine approach is used to pre-process the satellite data, while ArcGIS software is to integrate all the data layers. Since the ArcGIS software is included as a default dependency in GIS and remote sensing data, the proposed method provides a cross-platform and single-technology solution for handling flood mapping. For now, we conducted flood analysis using the latest open data for Pakistan and Nigeria countries, then elaborated on the advantages of each data for flood mapping with respect to inundated areas, rainfall analysis, and affected populations, health, and education facilities. Given a wide range of tasks that can benefit from the method, future work will extend the methodology to heterogeneous geodata (vector and raster) to support seamless and make it automatic interfaces.

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Category Short Paper

1 Introduction

Urban flooding is a serious issue in many cities across the world. They cause significant losses in terms of lives, possessions, buildings, and means of subsistence [2]. In 2022, Pakistan and Nigeria experienced severe flooding in various regions due to their topography and monsoon season, resulting in loss of life, property, and infrastructure. The use of Geographic Information Systems (GIS) and remote sensing techniques can be a valuable tool in mapping and analyzing the extent and impact of the flood. Also, social media and crowdsourcing applications have enabled real-time data collection from citizens in flood-prone areas. This data on integration can create situational awareness maps and inform emergency response efforts. Then this information can be used to model flood scenarios and assess the potential impact on communities and infrastructures. But when comes to integrating or fusing all data layers, it makes managing and monitoring floods very challenging. Therefore, in every flood-prone area, a thorough assessment of floods is crucial. In order to analyze flood inundation, this work shows a logical framework based on Sentinel-1 Synthetic Aperture

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Radar (SAR) data, which is then integrated with GIS data to produce flood ATLAS maps. A collection of different maps of the Earth or a particular area of the Earth is called an ATLAS. The maps in ATLAS display geographical characteristics, local topography, and political boundaries. Additionally, they provide information on a region's social, religious, and economic statistics [1]. The availability of open data and open-source GIS software has made flood ATLAS mapping more accessible to researchers, policymakers, and citizens. This has enabled the development of community-based flood management strategies and increased public participation in disaster risk reduction. By providing a comprehensive visualization of the flood impact, the ATLAS maps can also help to raise awareness among the public about the severity of the flood and the need for action to mitigate its effects [4]. This study first creates ATLAS flood maps of various factors in each province of Pakistan, including population, inundated areas, and rainfall analysis. In addition, it includes an ATLAS map of the torrents of Dera Ghazi (DG) Khan, depicting the water flow patterns in the region. DG Khan is a district located in the southern part of Punjab province, Pakistan, and is known for its rugged terrain and arid climate. The district is prone to flash floods, which can cause significant damage to the local communities, agriculture, and infrastructures in Punjab province. It includes a post-flood analysis showing inundated areas and affected populations, schools, and hospitals for each state of Nigeria. In the following, there is more detail of data and methodology in Section 2. The ATLAS maps for the flood-2022 are shown in Section 3 following the conclusion in Section 4.

2 Framework

Following Figure 1, a methodology for creating the ATLAS maps of flood disasters using remote sensing and openly available GIS data is shown. The main step in the process is to collect the necessary primary and secondary data. Primary data consists of Sentinel images downloaded from GEE, which provides free access to a wide range of remote sensing data. The data are obtained for August and October 2022, which is typically the peak monsoon season in Pakistan [3] and Nigeria, respectively.

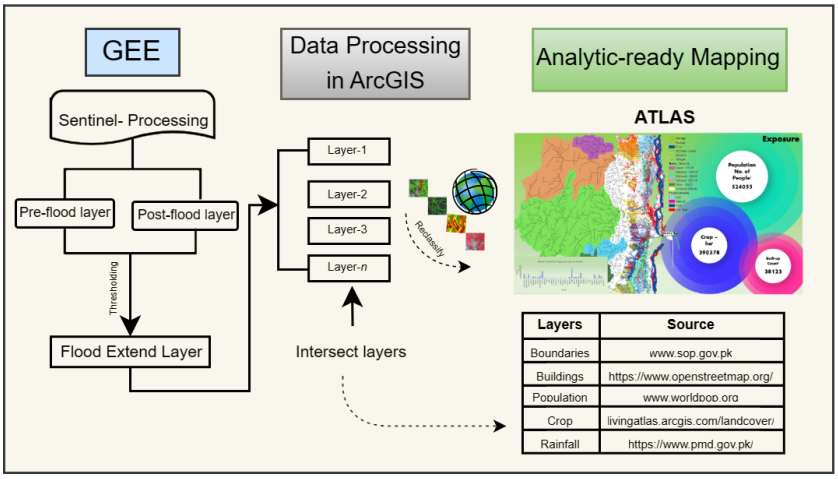

Figure 1 Framework for ATLAS Mapping.

The secondary data and modeling outputs from different data sources (Figure 1) are used to compile geospatial maps. Data used in the maps are also showing the importance of open data for flood mapping in emergencies.

The methodology's most crucial step is identifying the flooded areas by processing Sentinel-1 SAR data. The JavaScript programming language, which is directly integrated into the GEE interface, is deployed in this part. In addition to image processing, analysis of images, result visualizing, and result exporting, it covers command declaration tasks for importing image data to the platform. Pixel values from pre- and post-flood imagery have been obtained and compared for this investigation. A difference makes it easier to distinguish between pixels that represent areas that are flooded during the flood season and those that represent permanent water bodies like rivers and wetlands. The following describes the GEE flood mapping and inundated area computation methodology: the Sentinel-1 data package and study area boundary have been imported to GEE in the first step. In the next step, the time frame and sensor parameters were specified for this study. For Pakistan, the base period selected for flooding area comparison is from the 6th to the 27th of August, while for Nigeria is from the 13th of October to the 24th of October. By setting periods, the selection covers the specific season of the selected area. The " descending" pass direction and polarization " VV" of the sensor are the specified parameters. When the pixels that represented the flooded area were correctly identified, the extent of the flood was calculated. The key comparison is the variation between the photographs taken before and after the flood. The flood extent mask is made once the predetermined threshold has been applied, and the flood result has been improved. ArcGIS has been used to display the flood extent area data that was obtained from GEE. It is a desktop GIS tool that is cross-platform for browsing, editing, and analyzing geographic data.

Once the flood inundation layer is created, it is used to calculate the impact of the flood on populations, schools, and hospitals. This is done by overlaying the flood inundation layer with other openly available data sources. The impact analysis is carried out using ArcGIS software, which enabled the calculation of the affected population, schools, hospitals, and rainfall analysis.

The final step in the process is to create ATLAS maps that visualize the flood inundation and its impact. This is done using ArcGIS software and involved selecting an appropriate symbology and colors for the map and adding labels and legends. The ATLAS maps are designed to be visually appealing and easy to interpret with clear information. In conclusion, the methodology for creating the ATLAS maps of flood disasters in Pakistan and Nigeria involved collecting remote sensing and open source data, processing and analyzing the data using ArcGIS software, and finally visualizing the extent of the flood inundation and its impacts. This methodology can create similar ATLAS maps for other regions or different types of natural disasters.

3 ATLAS Maps

The following ATLAS maps give an overview of all the situations showing population, inundated area, and rainfall analysis. Starting from Pakistan, the situation in four provinces has been shown (from Figure 2 to Figure 6) with DG Khan torrent response in Figure 3, showing the situation of water levels/pressures on different water streams, rivers, and nullahs. Figure 7 glance into the overall status of Nigeria in terms of inundated areas, affected population, schools, and hospitals.

4 Conclusion

This flood ATLAS summarizes the findings of the post-flood assessment that took place in Pakistan and Nigeria in 2022. The 2022 floods in Pakistan, affected about 5 million people in total and an area of about 55,058 km^2 has been inundated. We also made an ATLAS map

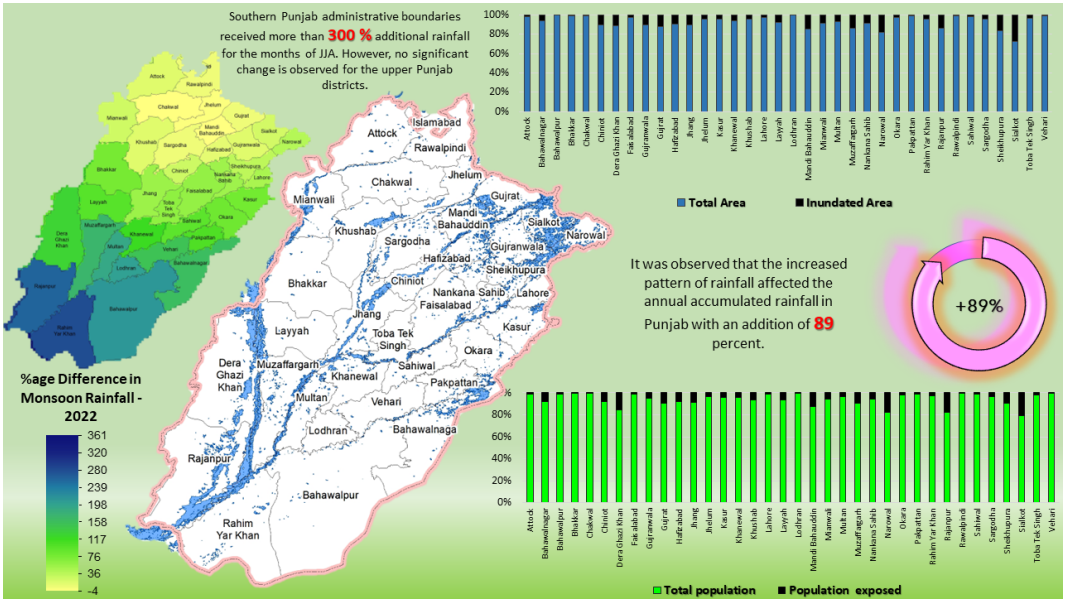

Figure 2 ATLAS Map for Punjab Province.

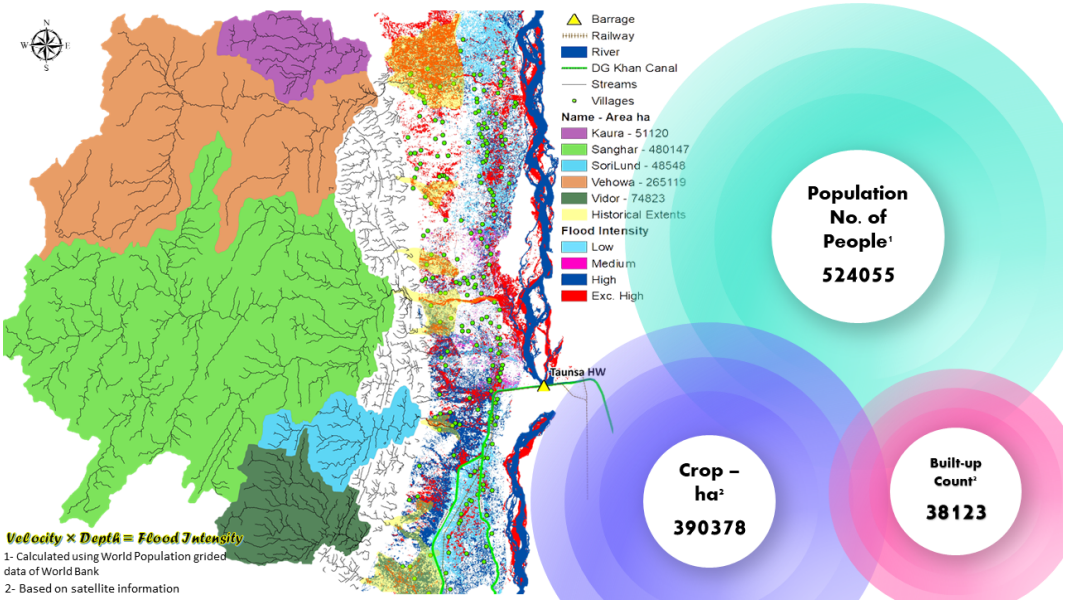

Figure 3 ATLAS Map DG Khan Torrent's Response.

of Nigeria's 2022 floods showing the affected population, flood extent, schools, and health facilities in each state. Future damage assessments of urban areas as well as the delineation and designation of existing floodplain boundaries, can all be updated by these maps.

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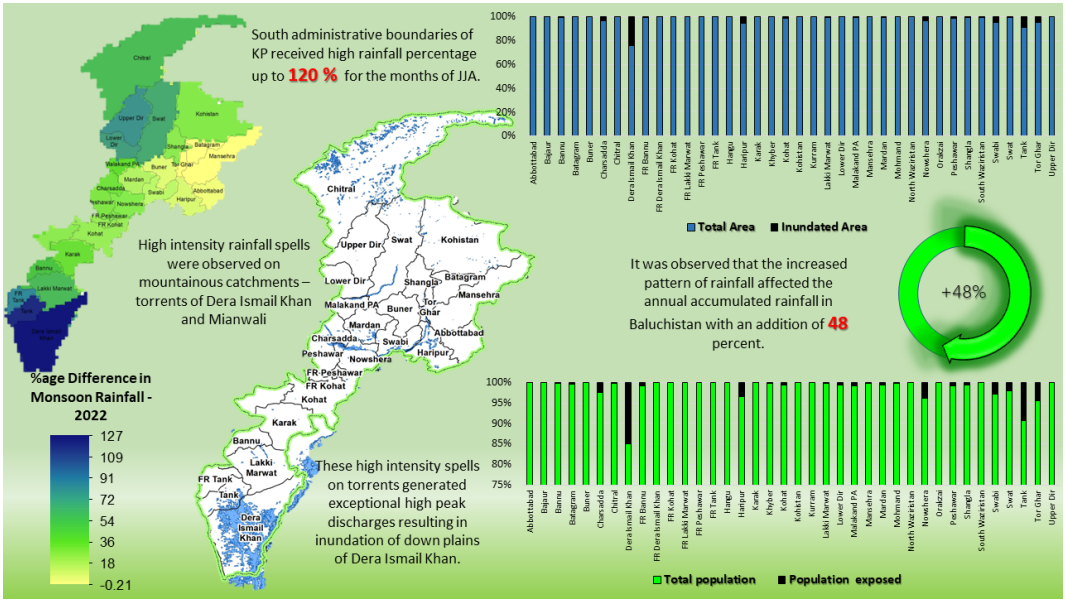

Figure 4 ATLAS Map for KPK Province.

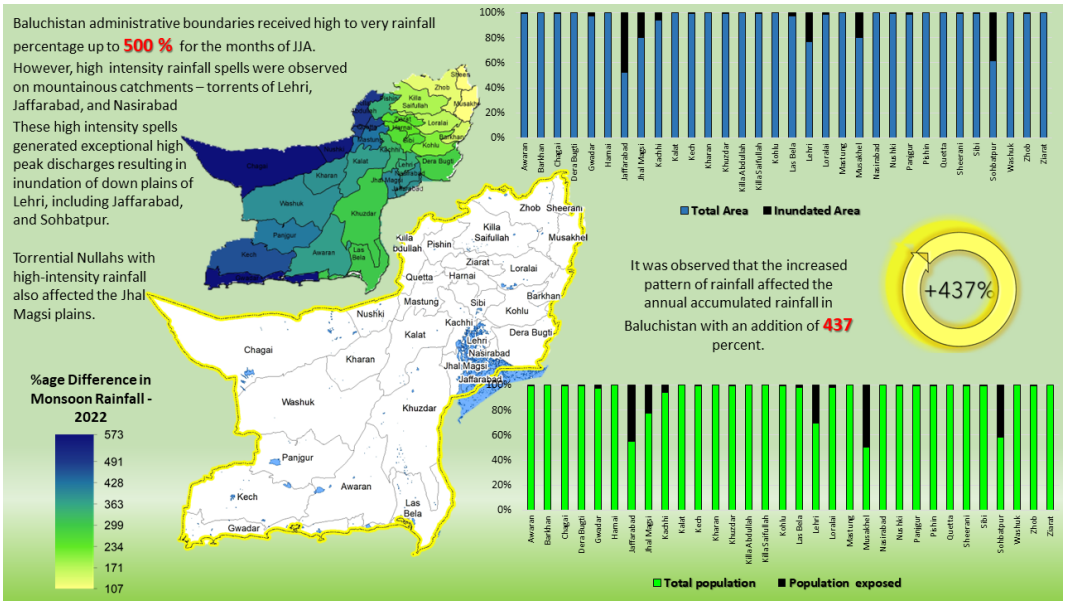

Figure 5 ATLAS Map for Baluchistan Province.

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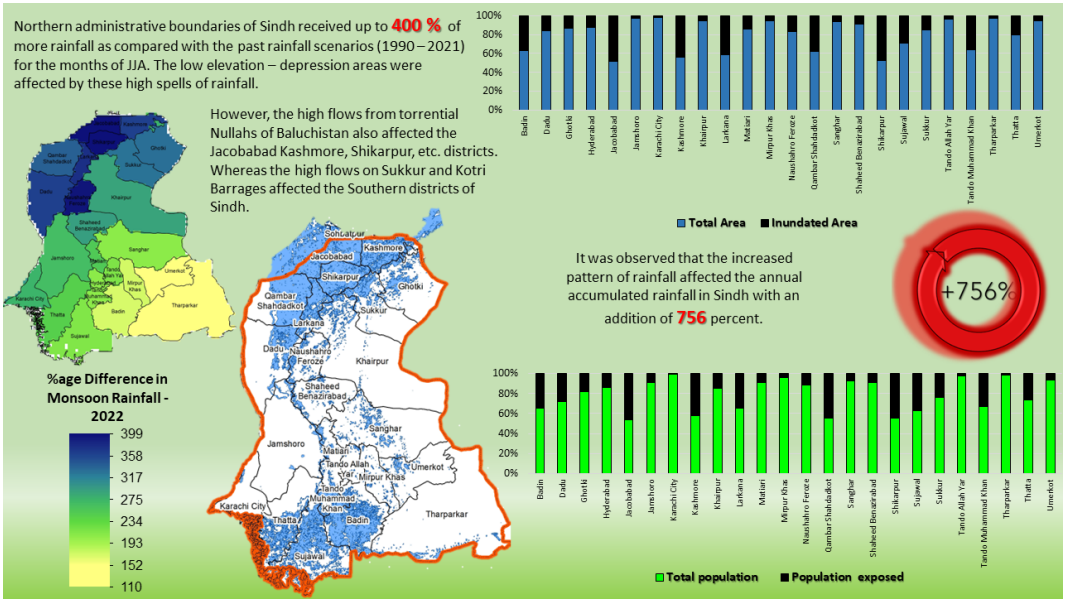

Figure 6 ATLAS Map for Sindh Province.

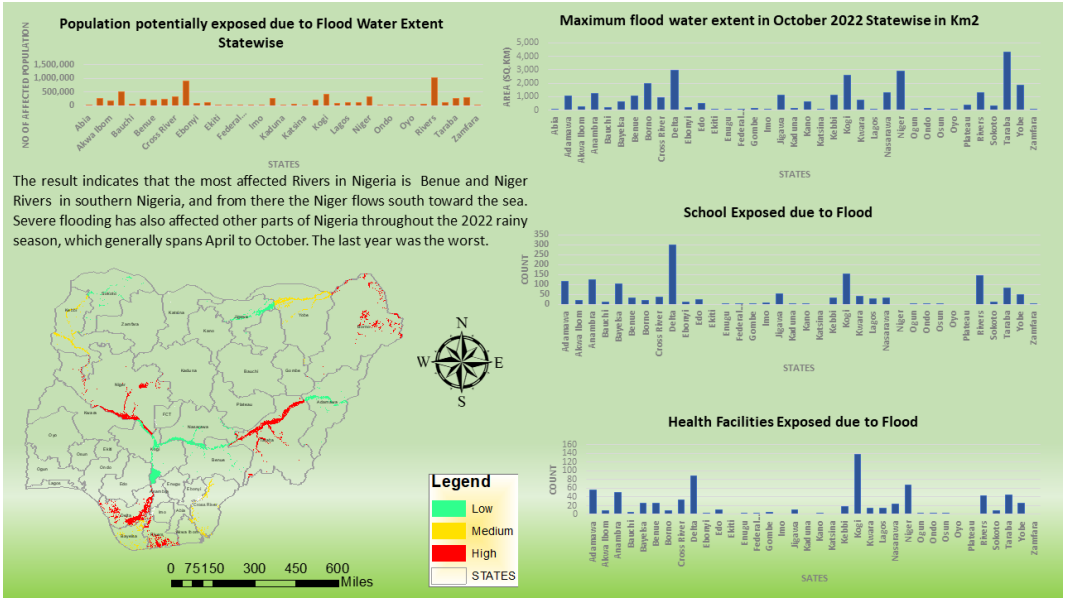

Figure 7 ATLAS Map for Nigeria.