Geospatial Technology for Effective Disaster Risk Reduction: Best practices in capacity building

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Abstract

Geospatial technology, including remote sensing, Geographic Information Systems (GIS), and Global Navigation Satellite Systems (GNSS), is identified as a key component in disaster management. It enables hazard, risk, and vulnerability mapping, aiding in the development of effective evacuation plans and resource allocation strategies. Moreover, it facilitates the evaluation of the Sustainable Development Goals (SDGs) and can contribute to improving accountability. While geospatial technology has seen rapid development primarily in developed countries, there's a growing need to expand its adoption globally, particularly in developing and vulnerable regions. Capacity building initiatives are highlighted as crucial in achieving this goal, emphasizing the importance of education, training, and infrastructure development. India is a leading example in the application of geospatial technology for disaster risk reduction, with significant integration into various phases of disaster management. The government's commitment and leadership, along with extensive training programs facilitated by institutions like Indian Space Research Organization, have been instrumental in promoting the widespread use of geospatial technology. Furthermore, India's efforts extend beyond its borders, with capacity building initiatives targeted towards the Asia-Pacific region through the Centre for Space Science and Technology Education in Asia and the Pacific (CSSTEAP). These initiatives aim to equip officials with the necessary skills to apply geospatial technology in disaster management within their respective countries. The paper underscores the importance of integrating geospatial technology into DRR strategies to build resilient communities and minimize the impact of disasters. It emphasizes the need for concerted efforts in capacity building to meet the growing demand for skilled professionals and promote evidence-based decision-making in disaster management.

1. Introduction

Disasters, whether natural or human-induced, pose significant threats to humanity, impacting lives, property, and infrastructure. In 2023 alone the Emergency Events Database (EM-DAT) recorded a total of 399 disasters related to natural hazards and these events resulted in 86,473 fatalities and affected 93.1 million people and a total economic losses of US$ 202.7 billion (EMDAT, 2023). As reported by Thomas et. al., faster population growth, large scale urbanization, industrialization, hazardous occupation, etc. cause large number of high-density populations live in high risk areas, and these eventually may also be responsible for the increase in natural disasters. The increasing frequency and intensity of these events, driven by factors such as climate change, urbanization, and environmental degradation, necessitate a shift towards more proactive and robust disaster risk reduction (DRR) strategies (UNDRR report 2020). In this evolving landscape, geospatial technology has emerged as one of the most powerful tools for enhancing preparedness, response, and recovery efforts. Capacity building initiatives are essential in fostering resilient communities that can better withstand and recover from disasters. By investing in education, training, and infrastructure development, societies can reduce vulnerability and improve their ability to adapt to a changing climate and environment. Integrating geospatial technology into these capacity building initiatives can significantly enhance resilience against disasters. This paper explores the manifold benefits of geospatial technology and how capacity building can amplify its application in DRR. Disasters are becoming more frequent and severe due to several interrelated factors. Climate change is leading to more extreme weather events, such as hurricanes, floods, and droughts. Urbanization, especially in developing countries, often leads to unplanned and vulnerable settlements. Environmental degradation, such as deforestation and loss of wetlands, reduces natural buffers against disasters. These elements combine to create a landscape where disasters can have devastating impacts on communities.

Geospatial technology, which includes tools such as Geographic Information Systems (GIS), remote sensing, and satellite imagery, offers significant advantages in DRR: Geospatial technology enables the mapping of hazard-prone areas, allowing for better planning and zoning. For example, floodplain mapping can inform infrastructure development, ensuring that buildings and critical facilities are situated in safer locations. During a disaster, real-time geospatial data can provide crucial information for emergency responders. Satellite imagery and drones can assess damage and identify accessible routes, ensuring that aid reaches affected areas promptly. Post-disaster, geospatial tools can aid in damage assessment and resource allocation. By comparing pre- and post-disaster imagery, authorities can accurately gauge the extent of destruction and prioritize rebuilding efforts.

To prepare a community for effective response during any disaster, the capacity building of the community is of most importance that involves developing the skills, knowledge, and resources necessary to effectively manage and mitigate disaster risks (Mansourian et. al.). Providing education and training in geospatial technologies ensures that local authorities and emergency responders can effectively utilize these tools. Workshops, certification programs, and academic courses can build a skilled workforce capable of leveraging geospatial data. Simultaneously, there is a need to investing in infrastructure, such as satellite ground stations and GIS laboratories, provides the necessary technical support for geospatial applications. Access to high-quality data and advanced analytical tools is critical for effective DRR. Involving communities in capacity building initiatives ensures that local knowledge and needs are integrated into DRR strategies. Community-based mapping and participatory GIS can enhance local resilience by empowering residents with the tools to monitor and respond to risks.

The most important part of the exercise is integrating geospatial technology into capacity building initiatives that can fortify resilience against disasters in several ways: Training local authorities in geospatial analysis promotes data-driven decision making, leading to more effective and targeted DRR measures. Accurate risk assessments and predictive modeling can inform resource allocation and emergency planning. Geospatial technology facilitates collaboration between different sectors, such as urban planning, environmental management, and public health. A holistic approach to DRR can address the multifaceted nature of disaster risks. Incorporating geospatial technology into capacity building supports sustainable development goals. By ensuring that development projects consider disaster risks, communities can build more resilient infrastructure and reduce long-term vulnerability.

2. The geospatial technology ecosystem

The geospatial technology ecosystem, encompassing remote sensing, Geographic Information Systems (GIS), and Global Navigation Satellite System (GNSS), has been advancing at a remarkable pace and enabling more comprehensive and site specific databases that are available on geoportals and mobile applications (Uniyal, et. al.). Both governments and industries are instrumental in driving these changes. While the majority of technological development is concentrated in developed nations, several developing countries such as India, South Africa, Brazil, and the Philippines are also emerging as leaders in this domain. However, to fully realize the potential of geospatial technology, it must be disseminated to all countries and integrated into all major sectors, including Disaster Risk Reduction (DRR).

2.1. The growing importance of geospatial technology

Geospatial technology is revolutionizing how we perceive and interact with our environment, providing advanced tools to address some of the world's most critical challenges. Through remote sensing, data about the Earth's surface can be collected without physical contact, offering vital insights into both natural and human-induced phenomena such as deforestation, urban expansion, and environmental degradation. Geographic Information Systems (GIS) allow for the efficient storage, analysis, and visualization of spatial data, enabling better decision-making by revealing complex patterns and relationships. Additionally, Global Navigation Satellite Systems (GNSS), including systems like GPS, provide precise location information essential for navigation and mapping. These technologies collectively support a wide range of applications across various sectors. In agriculture, geospatial technology facilitates precision farming by enabling farmers to monitor soil conditions, weather patterns, and crop health, leading to improved yields and resource management. In urban planning, it plays a key role in the development of smart cities, allowing for the creation of optimized infrastructure and efficient resource distribution. In environmental management, geospatial tools are critical for monitoring climate change, tracking deforestation, and designing conservation strategies. Most importantly, in disaster risk reduction (DRR), geospatial technology is indispensable for hazard, risk, and vulnerability mapping, helping authorities prepare for and respond to natural disasters by enabling accurate models, early warning systems, and efficient resource allocation. By integrating remote sensing, GIS, and GNSS, geospatial technology not only enhances our understanding of the Earth's processes but also provides practical solutions to improve sustainability, build resilient communities, and protect both lives and the environment.

2.2. GIS in disaster risk reduction

GIS-based hazard, risk, and vulnerability mapping allows authorities to develop effective evacuation plans, allocate resources optimally, and mitigate disaster risks, thereby safeguarding lives and property. By overlaying data from various sources, GIS can identify high-risk areas and predict the potential impacts of disasters. This information is invaluable for emergency responders and planners, enabling them to make informed decisions quickly and efficiently. For instance, during a flood, real-time GIS data can help track the movement of water, identify affected areas, and coordinate rescue operations. In the aftermath of an earthquake, GIS can assist in assessing damage, guiding recovery efforts, and rebuilding infrastructure. The ability to visualize and analyze spatial data makes GIS an indispensable tool in DRR.

The ability of GIS to facilitate integration and analysis of data from multiple sources makes GIS a very powerful tool for development of early warning system for all major disasters (Giardino et. al.). The flood early warning, cyclone tracking and forecasting, even weather forecasting, etc. makes extensive use of GIS. Based on thresholds set in GIS environment, automated alerts can be generated and disseminated to relevant authorities and even to the public, providing early warnings of impending disasters. Such adaptation of GIS helps in automatizing the whole process of data collection, analysis, decision making, alert generation, and alert dissemination.

2.3. Evaluating sustainable development goals (SDGs) with geospatial data

Geospatial data plays a vital role in evaluating the status and impact of the 17 Sustainable Development Goals (SDGs), which were established by the United Nations to tackle pressing global challenges such as poverty, inequality, and environmental degradation. By integrating geospatial data into monitoring frameworks for the SDGs, countries can significantly enhance their accountability and transparency, providing a clearer picture of progress and setbacks. For instance, satellite imagery serves as a powerful tool to monitor critical indicators like deforestation rates, track urban expansion, and assess agricultural productivity, offering insights that traditional data sources may overlook. Geographic Information Systems (GIS) further enhance this analysis by mapping access to essential services, including clean water and sanitation, examining the distribution of health services, and evaluating the adequacy of educational infrastructure. This spatial perspective not only facilitates a comprehensive understanding of advancements toward the SDGs but also helps identify specific areas that require increased attention and resource allocation. By leveraging geospatial technology, nations can better align their development strategies with the SDGs, ensuring a more effective response to global challenges and fostering sustainable progress.

2.4. The Need for Advanced Geospatial Technologies

To fully harness the advantages of geospatial technology, it is crucial to incorporate cutting-edge components such as GeoAI, drone technology, and Light Detection and Ranging (LIDAR). GeoAI integrates geospatial data with artificial intelligence, allowing for the discovery of patterns and insights that would be challenging to identify through manual analysis alone. This powerful combination can significantly enhance predictive modeling, optimize resource allocation, and improve decision-making processes across various sectors. Drone technology provides a flexible and cost-effective solution for collecting high-resolution spatial data, capable of reaching remote or hazardous areas that might be difficult for traditional surveying methods. This ability is particularly invaluable during disasters, as drones can deliver real-time information to first responders and decision-makers, enabling timely and informed interventions. Furthermore, LIDAR technology employs laser pulses to measure distances accurately, generating detailed and precise 3D maps of the Earth's surface. This high-resolution data is especially beneficial for applications such as terrain analysis, urban planning, and disaster management, as it allows for a nuanced understanding of landscapes and infrastructure. By integrating these advanced technologies, organizations and governments can elevate their geospatial capabilities, ultimately leading to more effective planning, resource management, and disaster response efforts.

2.5. The Role of Capacity Building and Training

Bridging the gap between technological development and adaptation requires a focused effort to raise awareness among institutions, especially in developing and underprivileged countries, about the transformative potential of geospatial technology. To achieve this, innovative and tailored training programs are essential, designed to meet the needs of various target audiences across different skill levels. These programs should cover a comprehensive range of geospatial applications, from basic to advanced, ensuring that users at all levels can fully harness the capabilities of the technology. For example, local authorities and emergency responders can benefit from specialized training on using Geographic Information Systems (GIS) for disaster management, enabling them to make informed decisions during crises. Academic courses and workshops can introduce students and professionals to cutting-edge technologies like GeoAI and drone applications, expanding their expertise and preparing them for future challenges. Additionally, community-based initiatives can play a vital role in raising awareness about how geospatial data can support sustainable development efforts, empowering local communities to utilize this technology for resource management, environmental conservation, and economic growth. By creating accessible and inclusive training opportunities, we can ensure that geospatial technology becomes a powerful tool for driving positive change in both developed and developing regions alike.

3. The India experience of using geospatial technology in DRR

India has been in the forefront in so far as application of geospatial technology is concerned. The technology has been mainstreamed in the disaster risk reduction activities including risk assessment, mapping, early warning, planning & preparedness, monitoring & evaluation, etc. Geospatial technology has helped India reduce the impact of disasters by making innovative use of the same during all phases of disaster management including the detecting and predicting major disasters, such as floods, cyclones, landslides, thunderstorms, etc. Extensive use of GIS has been made for collection, analysis, and visualization of spatial data, providing invaluable insights into the dynamics of hazards, vulnerabilities, and exposure. The National Database for Emergency Management (NDEM, figure. 1) set up by the Government of India has been providing space based inputs for the entire country to address all natural disasters in all phases. There are several national and regional level geo-portals that provide seamless and near real time data on infrastructure, weather, status monitoring, forecast, impact, etc. An exclusive space based data and service platform called the “North Eastern Spatial Data Repository (NESDR)” has helped in providing improved disaster risk reduction services through the North Eastern Regional node for Disaster Risk Reduction (NER-DRR), an initiative of North Eastern Space Applications Centre (NESAC), for the NE region of India, which is one of the most disaster prone regions in the South Asia.

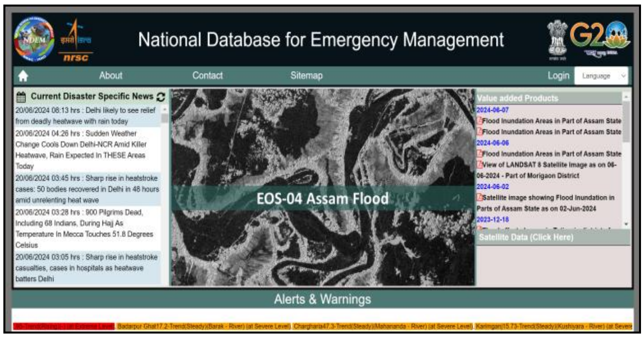

Figure 1: The NDEM portal providing real time data and information on disasters in India

The application of geospatial technology in India increased manifold due to the commitment from the top level leadership, when Hon’ble Prime Minister of the country hosted a national meeting with participation of secretaries from all major departments to prepare a road map for the enhanced and effective utilization of geospatial technology for governance and development. The initiative percolated down to the state level, wherein all states focused on the regional and local problems and tried to prepare a road map for utilizing geospatial technology to address those. Today, all central ministries in government of India and most of the departments at the state level utilizes the space and geospatial technology for planning, executing, and monitoring of projects. This has been possible with a continuous training program for the officials on the geospatial technology. ISRO has taken the lead in arranging short (1-2 weeks), medium (upto 4 weeks), and long term (upto six months) training for different levels of government officials. This has happened along with setting up of GIS laboratories at all ministries with all required infrastructure, collaboration with academics and knowledge sharing.

One of the most efficient ways to impart training and capacity building has been the use of online platform including Massive Open Online Courses (MOOCs) and webinar series. Such online program offers several strengths for training, especially in fields like disaster management where timely and effective knowledge dissemination is critical. The accessibility and cost-effectiveness of online program are the biggest strength. Such courses are scalable in the sense that it can address very large audience in one go and is also repeatable easily. Best experts in the field can be made available for such program that enhances the efficiency and popularity of such program

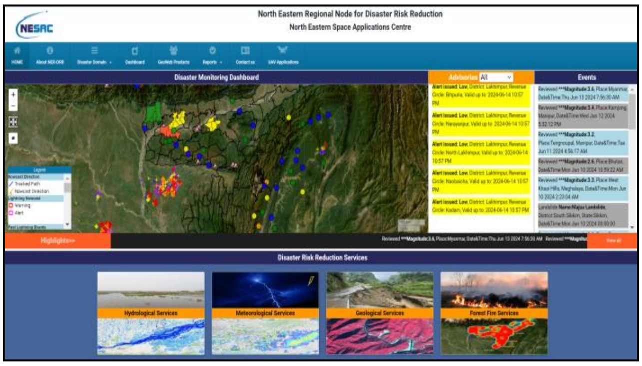

Figure 2: The web-portal of the NER-DRR that provides real time alerts and information on disasters affecting the NE region of India.

3.1. Training and capacity building initiatives at North Eastern Space Applications Centre (NESAC)

The Training and Capacity Building Programme of North Eastern Space Applications Centre was started from its inception. It is initiated not only for the beneficiaries of North Eastern States but also of national level in various fields where space technology inputs has a role to play. Large numbers of outreach and capacity building programme have been organized by NESAC for maximum utilization of geospatial inputs for planning and developmental activities. A number of students from different parts of the country have been carrying out their BTech/MTech/MSc dissertation work in NESAC every year under the supervision of NESAC Scientists and Engineers. NESAC has a separate Training and Outreach facility located in 500m away from the NESAC main campus. It is comprised of Academic Blocks with Lecture Hall cum IT Lab, Smart Digital Class room, Sophisticated Conference room with VC facility, 10 G Network connectivity for internet, Hostel facility for 80 boarders along with the other recreation/multipurpose hall, canteen facility, etc.

Figure 3: Participants of a training program on utilization of geospatial technology in disaster management

In 2022-23 alone, 22 training programs were conducted at NESAC on Basics of Remote Sensing, UAV Remote Sensing and the use of geospatial technology on Agriculture, Forestry, Geosciences, Space and Atmospheric sciences and Satellite communication etc . User specified tailor made courses are also being conducted as and when demand arises from the User Departments. The trainings are provided mostly for two weeks duration, but short training of one week or less are also conducted based on the requirements from the users. Table 1 provides the list of the trainings conducted by NESAC during 2022-23

Table: List of training programs on geospatial technology conducted by NESAC in a year

SN	Name of the training program
1	Training Course for Decision Makers under AMRUT Sub-scheme on formulation of GIS Based Master Plan
2	Applications of geospatial technology for acreage estimation of selected crops and development of a mobile app for planning & monitoring of Crop Cutting Experiment (CCE) in Meghalaya
3	UAV Remote Sensing for Assam Survey & Settlement Training Centre (ASSTC), Guwahati
4	Applications of GIS in Disaster Risk Management
5	UAV Remote Sensing and its Applications for Recorders
6	Applications of GIS in Disaster Risk Management
7	Training on UAV Remote Sensing for Assam Survey & Settlement Training Centre (ASSTC), Guwahati
8	RS & GIS in implementation of watershed development projects
9	Assessment of River Morphological Changes and Coastal Erosion using Remote Sensing
10	Capacity Building under AMRUT Sub-scheme on Formulation of GIS Based Master Plans [Tier-II]
11	Applications of geospatial technology in survey and monitoring of Agriculture in Meghalaya
12	UAV Operation, Data Processing & Applications for ASDMA Officials
13	UAV Remote Sensing & Applications for Staff working in Space Cell of CAPF & IB
14	Applications of GIS in Disaster Risk Management
15	Remote Sensing & GIS in Agriculture and allied Areas
16	UAV RS Technological Advances & its Applications'
17	Remote Sensing & GIS applications in Forestry & Ecology
18	Remote Sensing & GIS Information System in Geosciences.
19	Satellite Meteorology and its Application in Numerical Weather Prediction
20	Basic Course in Remote Sensing and GIS
21	AMRUT Capacity Building Training Programme for Junior Level Officers - Tier 3
22	Satellite Communication Application for Disaster Management (online)

3.2. Training and capacity building for the Asia and the Pacific region

India has also taken lead role towards capacity building for the Asia and the Pacific region as well as for the BIMSTEC (Bay of Bengal Initiative for Multi-Sectoral Technical and Economic Cooperation) countries. The United Nations affiliated Centre for Space Science and Technology Education in Asia and the Pacific (CSSTEAP) located at Dehradun, has been conducting multiple courses every year for capacity building in Asia Pacific countries in the frontier areas of geospatial technology. Under the CSSTEAP, post graduate level courses are offered in the fields of:

- Remote Sensing and Geographic Information System
- Satellite Communications (SATCOM)
- Satellite Meteorology and Global Climate (SATMET)
- Space and Atmospheric Science
- Global Navigation Satellite Systems
- Small Satellite Mission

These courses have been very effective in adopting the state-of-the art geospatial technologies for disaster management in the member countries. The participants get exposure to the best practices on utilization of geospatial technology for DRR through theory as well as hands on sessions. The participants eventually become a master trainer for his/her country.

NEAC has conducted a two weeks training programme on "capacity building on the earth observation applications and research: fundamentals, emerging technological tools and services for BIMSTEC countries professional". Total 24 participants from Bangladesh, Myanmar, Sri Lanka, Thailand, Nepal and Bhutan have attended this two weeks programme organized by NESAC and sponsored by Ministry of External Affairs, BIMSTEC Division, Government of India. The program included lectures, laboratory works, field visits, and project work on topics relevant to the participant country. Several lectures were delivered on utilization of space technology and geospatial technology for disaster risk management in the BIMSTEC countries. More such program is planned in the future.

4. Disaster risk reduction initiatives in NER of India: case study

The NER of India is one of the most disaster prone regions in the world. The region experiences a number of natural hazards with severity varying across spatial and temporal scales. Floods, landslides, cyclones, thunderstorms and river bank erosion are annual events in most parts of the region. Geographical factors like situation, location, underlying geological structures, relief, etc. are primarily responsible for the occurrence of these calamities. To address these disasters and to provide a single window delivery of all major disasters affecting this region, the North Eastern Regional Node for Disaster Risk Reduction (NER-DRR) has been established at NESAC, Shillong. NESAC has been constantly working on preparing space based input preparation disaster risk reduction for the states of NER with special emphasis of flood, landslides, forest fire, thunderstorm, industrial hazards, earthquake precursors, etc. The NER-DRR has proved itself as one of the platform that has helped significantly improve the disaster management in the NE region of India and also enhanced the capacity of the government machinery to respond to any disaster.

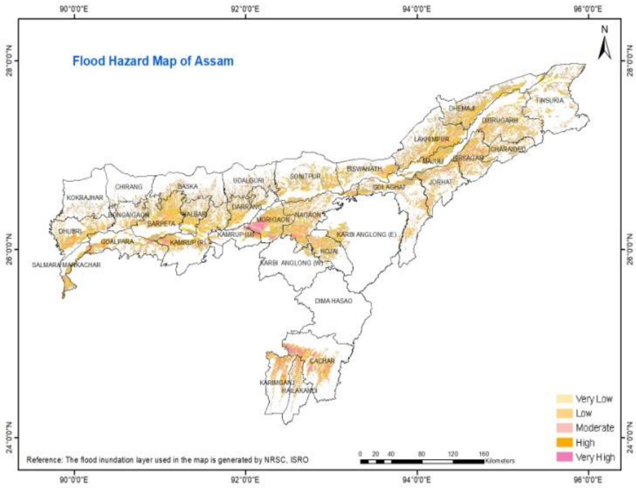

Figure 4: Flood hazard map of Assam

The major objectives of setting up the NER-DRR have been the following:

- Preparation of comprehensive geo-spatial database for different disaster vulnerable areas within the North Eastern region of India and making them available in a central server along with the available database thus meeting the major objectives of disaster preparedness, disaster mitigation, and overall disaster risk reduction.
- Development of support tools (including simulation models) for decision making exclusively for disasters relevant to NER of India using available geospatial data sets in centralized data server.
- Establishing satellite based connectivity through VPN/ Space technology based network with the National and State Emergency operation centers in India and with the district authorizes for faster and more effective dissemination of space enabled services.
- Develop actionable products and services in tune with the requirement of the region in partnership with all stakeholders in the region, and service the region in an operational manner in close collaboration with the stakeholders.
- To ensure most advanced and reliable mode of communication with redundancy and ISRO/NESAC to take initiative to familiarize the potential users on the operation of such instruments.
- Provide training on utilization of geospatial technology in every aspect of DRR including the tailor made training programs for the stakeholders.

The disaster domains covered under the NER-DRR are flood, landslide, earthquake information system, crop damage assessment, forest fire, meteorological services, hazard and vulnerability assessment, epidemiological disasters, industrial hazard, and satellite communication. Early warning services are provided for flood, severe storm, lightning (figure 5), epidemiological disasters, landslide (experimental), etc. Most of the activities of the NER-DRR are done as per the requirement received from the state disaster management authorities (SDMA) in the NE region. The services and alerts generated at NER-DRR

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are directly consumed by the SDMAs. Such direct interaction and continuous feedback has helped developing user friendly and effective products for disaster risk reduction in the NE region of India. All services under NER-DRR make extensive use of the geospatial technology

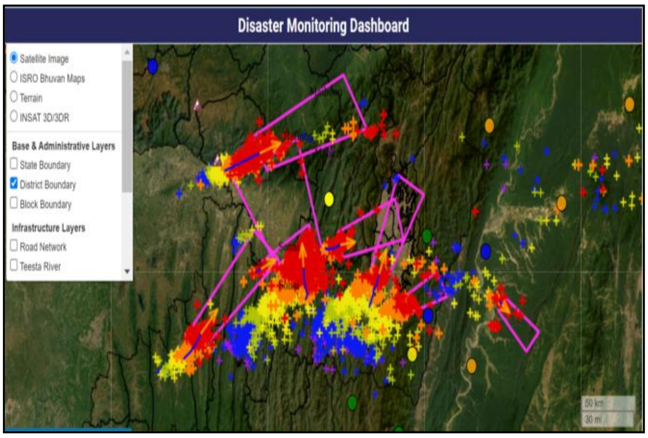

Figure 5: Lightning early warning system as hosted in the NER-DRR portal

5. Challenges in training on geospatial technology

Training in the applications of geospatial technology for disaster risk reduction (DRR) faces several challenges. These challenges could be in the field of technical aspects, educational related, institutional, and socio-economic barriers. A few of the major challenges in this domain are discussed below:

- **Complexity of technology and rapid development:** Geospatial technologies, such as GIS, remote sensing, and LIDAR, are technically complex and require a deep understanding of both software and hardware. Learning these technologies involves mastering a range of tools and techniques, which can be overwhelming for new learners. The field of geospatial technology is evolving rapidly. Keeping training programs up-to-date with the latest advancements, such as GeoAI and drone technologies, requires continuous curriculum updates and access to the latest tools and software. This could pose a serious challenge towards adaptation of this technology for DRR in the developing and primarily economically weaker countries.
- **Data accessibility and quality:** High-quality geospatial data is crucial for effective DRR applications. However, accessing reliable and up-to-date data can be challenging, especially in developing regions. Additionally, data interoperability issues can hinder the integration of datasets from different sources.
- **Lack of specialized training programs:** There is a scarcity of specialized training programs focusing specifically on the use of geospatial technologies for DRR. Existing programs may not adequately cover the nuances and specific applications needed for effective disaster management. Shortage of qualified instructors and limited awareness and understanding of geospatial technology in some of the regions adds more problems.
- **Inadequate Infrastructure and funding constraints:** Many institutions, particularly in developing countries, lack the necessary infrastructure to support geospatial training. This includes hardware, software, and internet connectivity needed to effectively teach and use geospatial technologies. Many institutions struggle with securing adequate funding to support these initiatives
- **Socio-economic barriers:** Training materials and software interfaces are often available only in English or a few major languages, creating a barrier for non-English speakers. This can limit the accessibility of training programs to a broader audience. Cultural resistance to adopting new technologies and poor economy of a country will deter faster adaptation of such technologies in many regions.

To address these challenges, a multi-faceted approach is required focusing on developing comprehensive training programs covering all types of users, enhancing data accessibility preferably free access, investing in infrastructure, enhanced capacity building and awareness, localization of training materials, and encouraging collaboration. A systematic approach towards achieving all the above could be a game changer in the DRR domain.

6. Conclusion

Integrating geospatial technology into Disaster Risk Reduction (DRR) strategies is vital for creating resilient communities, especially as disaster risks continue to escalate globally due to climate change and other factors. By harnessing spatial data and sophisticated analytical tools, stakeholders can improve every stage of the disaster management process—enhancing risk assessment, refining early warning systems, and optimizing both planning and response efforts. These tools allow for more accurate mapping of hazard zones, better resource allocation, and quicker, more informed decision-making during emergencies. However, to unlock the full potential of geospatial technology, substantial efforts in capacity building are required. This includes targeted training programs to equip professionals with the necessary technical skills, ongoing technical support to ensure effective implementation, and fostering collaboration across various sectors to integrate diverse expertise.

Capacity building is not only essential to meet the increasing demand for geospatial professionals but also critical in addressing complex societal challenges such as urbanization, environmental degradation, and public safety. Moreover, it promotes evidence-based decision-making, ensuring that policies and actions are grounded in reliable data. With robust capacity-building initiatives, governments, organizations, and communities can significantly enhance their resilience to disasters, reduce vulnerabilities, and minimize the impact on lives, livelihoods, and infrastructure, ultimately contributing to more sustainable development..

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