Flooding and Vulnerable Communities: Working Toward Proper Preparation and Protection via RS and GIS Developments

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Abstract

Floods have been deemed the most frequent form of natural disaster worldwide. In alignment with target #5 of SDG #1, it is recommended that the United Nations Office for Disaster Risk Reduction, specifically in their Regional Office for Asia and the Pacific, work to facilitate the sharing of satellite imaging and remote sensing advancements between more developed and less developed countries, particularly aimed toward supporting the vulnerable regions of Southern and Eastern Asia in flood risk projection efforts.

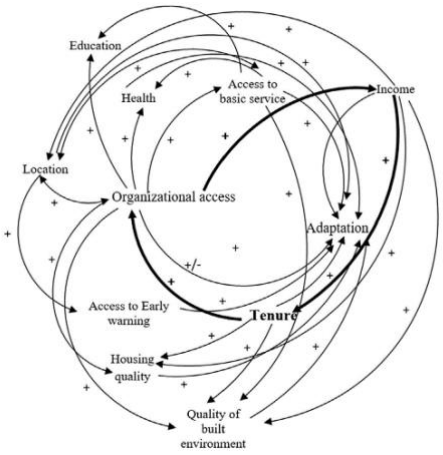
This brief explores the steps that can be taken within the science-policy-society interface (in accordance with Track 2) to get ahead of the curve in protecting those who are at the highest risk of experiencing a flood. Means to achieve proper preparation and protection will primarily revolve around the facilitating of knowledge sharing between specified nations, predominantly in the realm of geospatial knowledge related to recent remote sensing and geographic information systems' technological developments.

In accordance with SDG #1 target #5, it is recommended that the United Nations Office for Disaster Risk Reduction (UNDRR) prompts their Regional Office for Asia and the Pacific to facilitate knowledge sharing in the arena of satellite imaging and remote sensing advancements. This communication should be focused between more developed and less developed countries, specifically targeted toward supporting the vulnerable regions of Southern and Eastern Asia in projecting flood risk.

For decades, the matter of how to best prepare and protect communities from flooding has been contested. The fifth target of the first SDG encompasses building the resilience of vulnerable communities through reducing their exposure to extreme climate-related events. This idea of building resilience can be split into three subphases: preparation and protection as they are relevant (1) before, (2) during, and (3) after a flood occurs. This discussion will primarily focus on the '<u>before</u>' subphase of flooding.

Figure 1 outlines how to most effectively facilitate adaptation to flooding in low-income settlements within developing countries. The organization of this figure is pertinent to this discussion in that it allows for the visualization of relationships among factors present *before* a flood occurs, and how those factors ultimately affect the ability of a community to adapt to a flood.

Figure1.



Data source: Haque et al. via *The Geographic Journal*

Some of the factors in this diagram may be more difficult for the government to influence, such as the preexisting location of a flood victim, for example; however, there are others that the government may have *all* the control over, such as the factor that this discussion will prioritize: <u>access to early warning</u>. With new remote sensing and satellite imaging techniques emerging just in this past year, there are new routes to propose in the realm of policy, specifically in regard to how advancements are shared from more developed to less developed nations to allow countries to be warned of their flood susceptibility *sooner*. Therefore, in alignment with Track 2, this discussion will predominantly explore how to mesh the science-policy-society interface to ultimately assist two of today's most vulnerable regions: Southern and Eastern Asia.

The Need

It is first necessary to identify why the regions of Southern and Eastern Asia, in particular, could benefit from new imaging and sensing technologies in predicting flood occurrences. Statistics reveal that flooding is notably prominent in Southern and Eastern Asia, as well as that the most high-impact flood events (where 'impact' is represented by flood displacement as a function of the number of fatalities in a given world region, grouped by unique flood event) most often occur in Asia.

Looking more specifically into the region of Southern Asia, one can refer to the example of Bihar: the most flood-affected state in all of India, in which roughly 17.2% of the land is flooded each year. With incredibly low levels of elevation, this region is no stranger to the overwhelming social and economic consequences initiated by flood occurrences. As poverty is both the subject of SDG #1 *and* happens to be commonly cited as one of—if not—the most indicative factors impacting disaster vulnerability, it becomes necessary to investigate the steps that can be taken toward achieving some form of social equity in flood protection and preparation for vulnerable communities.

The Opportunity for Advancement

Continuing with the example of the Bihar district, a study released in December of 2023 tested the use of various imaging and sensing technologies in conducting detailed flood susceptibility analyses of the region. By investigating factors such as slope angle, curvature, and drainage density within a given plain through using a Google Earth Engine platform as well as Sentinel-1 data, the researchers were able to perform in-depth analyses of the flood susceptibility of different regions within Bihar. The fact that data from imaging technologies was effectively used to produce tangible results in the past year implies that there is room for these technologies as a solution in this field.

Additionally, this same study raises the point that there is an information deficiency in this space and, therefore, that the application of geographic information system (GIS) and remote sensing (RS) technologies may prove a valuable aspect of the investigation of this topic in the future, particularly due to their exceptional accuracy and rapidity. This claim highlights two non-negotiable features of technology as a means to measure flood susceptibility and hence to assist in predicting flood occurrences in a given area: (1) the technology must be accurate, and (2) the technology must be fast, as to aid in preparing and protecting these communities as quickly as possible.

Solutions in the Wrong Place at the Right Time

Recent investigation of the breadth and depth of spatial technology research conducted in various countries worldwide reveals stand-out leaders in the space. Data shows that China, Australia, and Italy have led in GIS and RS knowledge accumulation in recent years. However, it is necessary to note that five of the ten current leading countries are located in Europe, with Asia next in line with three leading countries. However, it has also been found that the median rate of displacement in Europe due to flooding is less than *5*% of the median rates seen in other continents. This begs the question: If this knowledge is spread across far-ranging regions, but one region is especially threatened and one is especially not, *why not share the knowledge in a way that helps those who are most vulnerable?*

Facilitating Knowledge Sharing

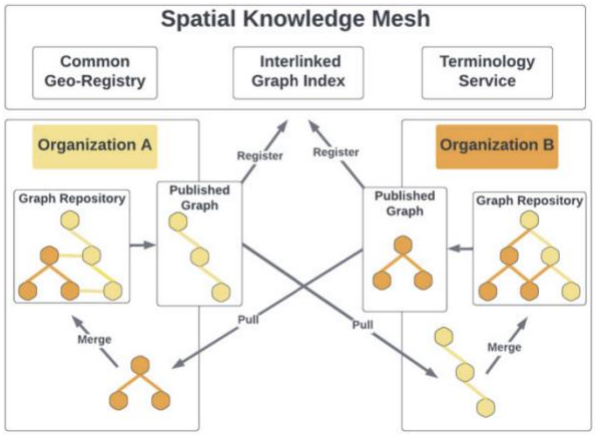
In thinking about making the move from data-centric architectures to knowledge-sharing architectures, one route in the context of this discussion is through a Geospatial Knowledge Infrastructure (GKI). This infrastructure is further made up of spatial knowledge graphs (SKGs) as well as the broader spatial knowledge mesh (SKM) approach, the latter of which is perhaps more relevant to this discussion. The SKM is particularly useful here as it serves to outline the concept of 'distributed domain-oriented ownership.' This translates into the idea that each organization or entity involved in the knowledge sharing process still *owns* their respective information, but that they would publish said information in a format that is compatible with the broader ecosystem—or in this case—in a format that might be useful to vulnerable communities in managing flood risk. See Figure 2 (see below) for a visual representation of how an SKM might function between two entities.

It is necessary to note that although this is only one idea for the facilitation of knowledge sharing among entities, this particular approach is currently part of an open-source project seeing adoption with various United States federal agencies, suggesting that it might be a rather viable method for achieving effective communication.

In this vein, the idea of facilitating knowledge sharing among entities can start with the recommendation of a single technique such as utilizing the SKM approach, but then allowing room for adaptation and modification by

the participating parties throughout the knowledge sharing process.

Figure2.



Data source: McEachen and Lewis via the *International Society for Photogrammetry and Remote Sensing*

Security Considerations

Perhaps one of the most prominent arguments for recent propositions relating to the sharing of imaging technology surrounds the issue of data privacy and security. In this regard, one of the main limitations of the recommendations in this discussion may be the fine line that must be walked in order to share new imaging developments without threatening the national security of any of the countries involved in the conversation. In other words: *How can it be ensured that countries are productively sharing new technological advancements in a safe and secure way?*

Therefore, an improvement to this recommendation could include the idea of 'guided conservations.' This would entail the UN providing certain parameters for the conversations between countries on these sensitive topics; for example, the UN might recommend that a detailed report of new developments be shared by one country to another, *but* under the condition that there are no explicit images included of any actual data collected in that country. That is, no confidential information specific to the country itself would be shared, but rather the report would detail strictly science-and-technology-related developments.

Policy Recommendations / Conclusions

By considering the following recommendations, the UN can work to build the resilience of communities from floods by circulating information about flood susceptibility *sooner*, supporting SDG Target 1.5, in order to move toward proper protection and preparation for those are who most vulnerable.

1) ***Facilitate guided conversation between leading countries in RS + GIS knowledge and countries in Southern and Eastern Asia:*** The Regional Office for Asia and the Pacific under the UNDRR should work to facilitate conversation among leading countries in this space, such as the three primary examples of China, Australia, and Italy, and countries in Southern/Eastern Asia such as India and Bangladesh, where poverty overlaps heavily with flood vulnerability. These conversations are recommended to be guided—i.e., to have certain given parameters related to avoiding sharing direct images or data from specific countries, but rather sharing solely scientific and technological developments—as to best protect the national security of all parties involved.

2) ***Advocate for the use of SKMs in GK sharing:*** The UNDRR should advocate for the utilization of the spatial knowledge mesh approach in geospatial knowledge sharing in order to provide a framework for how information can effectively be shared between two nations. This is a more direct recommendation for the improvement of the current science-policy interface methods in this space in accordance with Track 2.

3) ***Encourage the overall implementation of RS + GIS technologies in flood susceptibility measurements for countries in Southern and Eastern Asia:*** By encouraging the use of these notably accurate and rapid technologies (the technologies that would presumably be discussed with other countries according to the previous recommendations), flood-prone countries can develop a better system for understanding risk at different points of time in space. This would aid in eliciting access to early information for civilians residing in these countries, ultimately working to limit the gap of flood impact (e.g., rates of displacement, which further contribute to regional poverty levels) between the regions of Southern/Eastern Asia and other regions around the world.

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