Engaging Youth in Flood Risk Management: A Citizen Science Geospatial Initiative in Bangladesh



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Abstract The study shows the significance of the shift in managing disaster impacts from a top-down approach to a more participatory, community-based, data-driven approach. The adoption of citizen science initiatives, armed with the provisions provided by wireless internet and mobile phone technologies, emerges as a promising avenue for generating real-time, community-driven information crucial for effective risk management. The concept of citizen science involves the participation of nonprofessional community members in data collection, interpretation, analysis and finally in the production of hazard and disaster risk maps of local areas. Volunteered Geographic Information (VGI) serves as a broader term encapsulating citizen-based geospatial mapping, fostering participatory engagement through internet platforms. Considering the fact that the vulnerability of people and their assets to disasters varies based on the variations in socio-economic, demographic characteristics of the communities and on the physical characteristics of the land area where they live. It also depends on residual impact conditions (known as cumulative impact conditions).

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The research emphasizes the need for inclusive disaster risk management and planning, where the roles of the local community members are pivotal since they know the challenges better than the external professionals through their personal everyday experiences and actions performed to better build back the impact conditions. The study conducts a risk mapping exercise to facilitate inclusive preparedness and risk management planning in order to minimize the vulnerabilities of at-risk populations. In order to examine the river-induced disaster impacts in a study location (called Harirampur Upazila, Manikganj District) situated in a floodplain of central Bangladesh, the study actively engaged the local youths so that they can inform the impacts situations as they experienced (i.e., using their local knowledge). The study shows how the youths used the geospatial data, methods and technologies to register the information about disaster impacts and how the exercise contributed in transforming them into informed volunteers and change agents towards more effective disaster risk management for their local areas. While local youths emerge as crucial first responders in case of disasters, their potential is hindered by a lack of guidance, knowledge, and orientation with data and methods—this study showed the way how passive recipients of disaster relief items may become effective first responders for their communities. The research employs fieldwork and spatial analysis to develop a risk mapping model applicable in flood and riverbank erosion contexts, emphasizing the methodological steps in easy, generic terms. The resulting risk maps play a vital role in identifying at-risk households, prioritizing service delivery and enhancing project accountability, efficiency and sustainability. This comprehensive study not only contributes to the growing field of citizen science and participatory risk mapping but also provides a replicable model for disaster-prone areas, fostering community resilience through inclusive and informed planning.

Keywords Risk assessment · Participatory · Geospatial mapping · Citizen science · Flood risk

1 Introduction

Natural hazards are becoming more common as a result of climate change, making it more important than ever to reduce risks and create resilience against them [13, 20]. A change from broad-scale, top-down risk and resilience assessments to more participatory, community-based, bottom-up approaches has been noticed [6, 7, 12]. Local stakeholders who are not scientists have arguably always played an important role in risk knowledge management and resilience building [14, 20, 21]. Rapidly evolving information and communication technologies, such as the Internet, cell phones and social media, have already proved their significant potential to increase the multidirectional, decentralized, varied and inclusive nature of knowledge generation [1, 15, 22]. Various citizen science initiatives have lately emerged as a promising direction in the provision of substantial, real-time information for risk management when combined with technologies for robust and low-cost sensor networks (as well

as improving data provision in data-scarce regions) [18, 21]. It can be used to educate and empower communities and stakeholders who would otherwise be left out of more traditional knowledge-generating processes [13, 20].

The participation of nonprofessional scientists in research projects that entail data collecting, interpretation and analysis is often referred to as "citizen science" in the increasing concept of democratizing science [20, 22]. Citizen science is a method that allows non-scientists from a wide range of communities to use local data and expertise to describe a community through various interventions such as monitoring and mapping in a locally intelligible style [6, 7, 12, 18–21]. To co-produce knowledge more effectively and efficiently, it incorporates a wide range of stakeholders and citizens [14, 18]. Citizen science participation in participatory collaborative mapping is becoming more widespread as a method of expanding communities' conceptual common ground and disseminating geographic data [11, 16–18]. Volunteered Geographic Information (VGI) is a term that describes citizen-based geospatial mapping in a broader sense [2, 9, 18]. It is a method of leveraging citizen scientists to create geospatial content with participatory participation through the use of internet platforms [12, 18].

People in disaster-affected areas experience disaster impacts differently depending on their power of resistance and coping capacity [13, 17, 19]. Social and demographic characteristics of a household, cumulative impact conditions, and their location in the contextual physical settings determine the sensitivity of a household to certain kinds of hazards [17, 22]. People with special needs, especially children and old people, suffer the most when hazards strike [3]. The reasons for the vulnerability of these people remain in the fact that the local institutions are less informed about their problems, associated needs, and the locations where they live [10, 13]. In this context, this study carried out a risk mapping exercise so that inclusive planning for building preparedness could be done by taking into account the vulnerabilities of the at-risk people.

Disaster management, including river-induced disasters (e.g., floods, riverbank erosion, strong current and wave conditions), is generally top-down where community involvement in the disaster management cycle (such as pre, during and post-conditions) is poor [21]. The study focuses on developing informed youth leadership and involving them in local-level disaster management, particularly in response to river-induced disasters within a Mauza (the smallest administrative and revenue collection unit) and its surrounding area in Harirampur upazila (upazila means the second administrative tier) of Manikganj district (district means primary administrative division) in Bangladesh. Experience suggests that local youths are the first responders to disasters and help out vulnerable communities in a number of ways. They are energetic, morally remain high, generally interested in Information Communication Technology (ICT), and willing to perform when there is a need [4]. Lack of necessary guidance and knowledge and orientation with data and methods in combination do not allow the local youth to lend their hands in pre-, during, or post-disaster contexts [13, 14]. In this connection, field works and spatial analysis were the main methods used in the exercise and presented in this study. Both conceptual and methodological accounts of how risk mapping could be conceptualized are illustrated

in the article and also indicate how different methods for qualitative and quantitative data collection from the field are carried out connecting with local youths. It is important to note that this model is developed in the contexts of flooding and riverbank erosion and presents the methodological steps in easy, generic terms that could be applied in other disaster-prone areas. It is believed that the risk maps may play useful roles in identifying households that are most at risk by considering their vulnerability and exposure to hazards and also may help to set priorities in delivering necessary services, which, in turn, will make the study more accountable, efficient, and sustainable.

2 Methodology

2.1 Study Area

The research area belongs to Bahadurpur Mouza in Harirampur upazila of Manikganj district in Bangladesh (Fig. 1), which lost most of the land due to riverbank erosion by the Padma River. Besides the riverbank erosion, the inhabited areas have faced flooding during the monsoon season. The people of that area mostly depend on agricultural activities and fishing. The char land (riverbank area) is too fertile where most of the vegetables and cash crops, including nuts, chilies, jute, mustard, wheat, and wheat, are grown.

2.2 Real-Time Kinematic (RTK) Survey

A Global Positioning System (GPS) survey was used to geo-reference and rectify the drone-captured images to complete this research. This study used Real-Time Kinematic (RTK) surveys for 5 centimeters (cm) accuracies of the orthophoto. RTK is a technique that uses carrier-based ranging and provides ranges that are orders of magnitude more precise than those available through code-based positioning. In this study, Kolida K5 Infinity (K5plus+) RTK rover station was used, which was connected with a 3D Benchmark station (GPS 5654) in Fig. 2a. Figure 2b represents 9 ground control points (GCPs) that were collected from the research area.

2.3 Participatory Actions to Collect Low-Altitude Aerial Photographs Using an Unmanned Aerial Vehicle (UAV)

Drone technology has long been seen as a fun pastime, a tool mostly utilized for aerial video and photography [23]. Professional industries around the world are fast

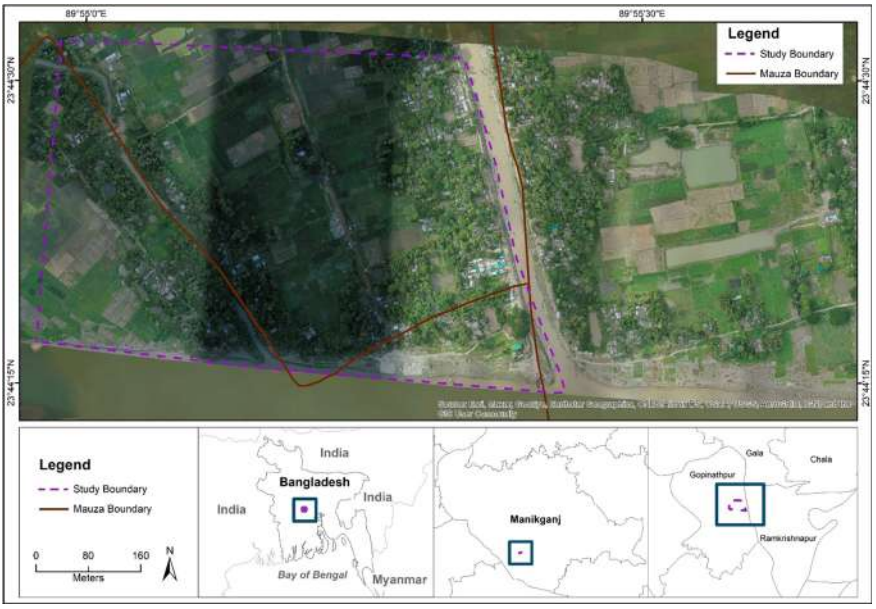


Fig. 1 The study area (Bahadurpur Mauza) and its surroundings area

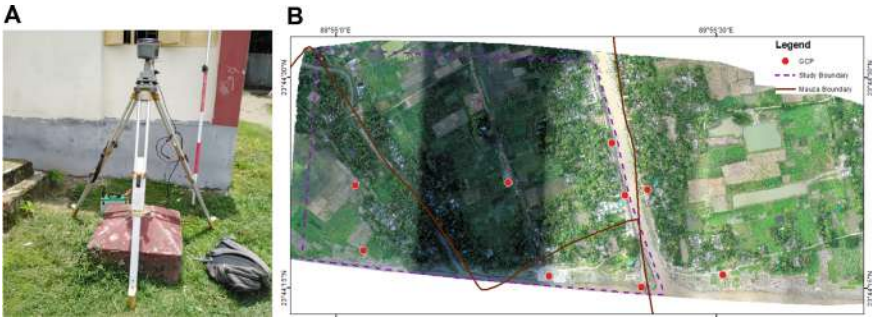


Fig. 2 **a** RTK base station was fixed on 3D Benchmark station (GPS 5654); **b** Ground control point (GCP) distributions of the study area

adopting drone technology to assist in streamlining operations such as mapping, surveying, and inspections, thanks to tremendous advances in UAV hardware and software [5, 23]. Drone technology has quickly proven to be a cost-effective and efficient way to optimize and transform the way professionals conduct mapping and surveying [5]. With the ability to cover large areas of space in a short amount of time, keep workers safe from dangerous or hard-to-reach environments, and acquire highly accurate data at a fraction of the cost of traditional methods, drone technology

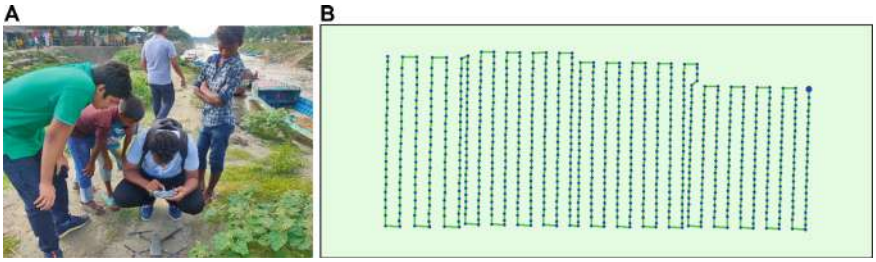


Fig. 3 **a** DJI Mavic 2 Pro using for the aerial survey; **b** Images distribution captured by the drone. Top view of the initial image position. The green line follows the position of the images in time, starting from the large blue dot

has quickly proven to be a cost-effective and efficient way to optimize and transform the way professionals conduct mapping and surveying [5, 23].

For this study, the mini-UAV platform was used, which was called Mavic 2 Pro developed by DJI. It is a completely autonomous, electrically powered rotate-wings drone. It is 350 millimeters (mm) in length (Diagonal Size) with a GNSS receiver and 1375 grams (g) in weight, including four wings. It has so many advantages like more area coverage (8 km^2), high precision, high strong feasibility, higher flight altitude (6000 m), 30-minutes-long flight, easy operator using mobile app, and 5-direction of obstacle sensing, etc. The drone is equipped with a 1-inch CMOS (20 Mega Pixels) sensor with 4096 × 2160-pixels resolution with RGB bands. The photos were taken by auto mode and geo-referenced using the UAV GNSS system (IMU). Figure 3 represents the aircraft that was used in this study.

This study flight was designed in the Pix4dCapture mobile app with 75% forward and 70% side overlapping in one of our study areas. According to our two day data collection process, we have taken 855 images, which are shown in Fig. 4b. The data analysis was done by the Pix4Dmapper (version 4.4.12) software, which was developed at Computer Vision Lab in Switzerland by Pix4D Company using the computer Vision image processing algorithm [8]. Nowadays, it is a very popular commercial software package all over the world. Pix4D was a fully automated workflow. It uses GCP adjustment, bundle block adjustment, 2D Orthomosaic, ray cloud, 3D points cloud generation, filtering, DSM, and DTM generation [8]. Finally, the research team got the 3.5 cm Ground Sample Distance (GSD) Orthophoto, 10 cm resolution DSM, for further analysis.

2.4 Capacity Development of the Youth on Open Access Geospatial Data

This research work was followed a work-based learning approach. The participants were taught the basics of geospatial technology, how to implement it in various

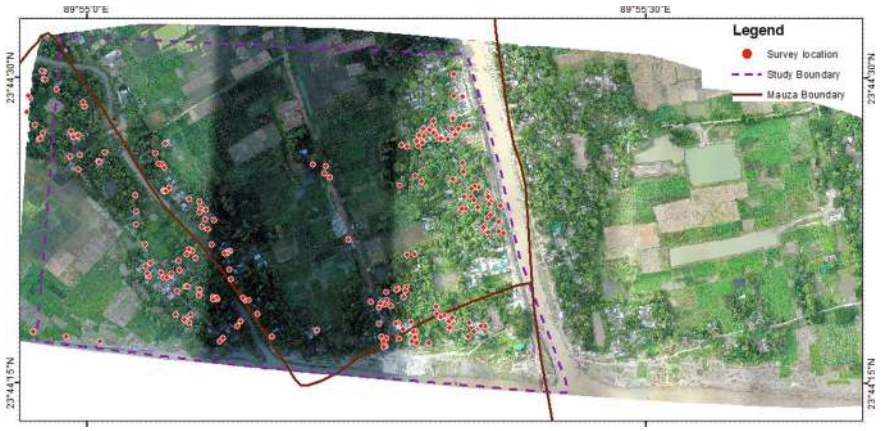


Fig. 4 Distribution of the questionnaire survey locations

humanitarian crises and their own personal skills and portfolio development for the future. In this regard, we have arranged a three-hour introductory workshop on geospatial technologies, basically on OpenStreetMap (OSM). OpenStreetMap is an open-source geospatial data platform used for global mapping, data updates and applications in research, humanitarian efforts and other purposes. The young participants participated in the "Mapathon on Citizen Science for Reduction of Flood Vulnerability in Selected Districts of Bangladesh" workshop to update and develop open geospatial data of that study area and its surroundings. The participant also used and overlayed the orthophoto (generated by UAV data) during the update of the data in the OSM platform.

2.5 Focus Group Discussion (FGD) for Qualitative Data Collection and Field Verification

A focus group discussion (FGD) is a qualitative research approach, mainly Sami-structured interviews used in the social sciences, with a focus on and use in the assessment of developmental programs. In this research, we have conducted several FGDs to understand the real scenario of hazards and disasters in this area. A group of people from different professions from the study area were present to share their experiences and expectations from the local administration.

2.6 Quantitative Data Collection on the Impacts of Flood Risks on Local Crop Production

Only specific research questions are eligible for a questionnaire survey. Its applicability is determined by the types of data required to answer a research topic and the people from whom the researcher wants to obtain data. Questionnaires should not be used to obtain data on sensitive topics like sexual orientation or illegal activity. People rarely discuss behaviors that put them in legal jeopardy. The organized style of the questions, as well as the length and superficiality of the social interaction between researcher and responder, do not foster the intimacy and trust that are necessary for people to divulge potentially harmful habits, attitudes, and characteristics.

Questionnaires that rely on people's ability to effectively express information are generally unproductive when it comes to learning about the past. Memories change throughout time; therefore, answers to the past are sometimes imperfect. Panel studies, in which the same respondents take part in a succession of surveys, are an effective way to learn about prior behaviors and attitudes, yet they are costly and complex to administer. Panel studies have their own set of geographical challenges. Because samples are generally tiny, they provide little information on populations in specific locations in order to save money.

To understand the risk pattern of the study area, we used a mobile device-based questionnaire survey with geospatial attributes (Fig. 4). 210 individual questionnaires were collected from the households of local people engaging local youths.

2.7 Risk Mapping: Concepts and Definitions

Risk mapping is the process of using maps with relevant local elements to show how sensitive a community's households and residents are to dangers. This is accomplished by using various Participatory Vulnerability and Capacity Assessment (PVCA) methodologies to determine risk ratings based on people's vulnerability and level of exposure to specific types of hazards.

In order to create final risk maps, all qualitative and quantitative data layers are managed using geospatial data and techniques in a spatially related system. The exercise of risk mapping captures the vulnerability of individuals resulting from the loss of assets and means of subsistence as well as hazards of all types that occur at different sizes and intensities depending on the season, time of year, topography, and hydro-meteorological contexts.

However, using the risk equation (Risk (R) = Hazard Exposure $\times$ Vulnerability (V)) put forth by Blaikie et al. [3] in their groundbreaking book At Risk: Natural Hazards People's Vulnerability and Disasters, the risk score of a household could be computed once the pattern, characteristics, exposure, sensitivity issues of vulnerability, and hazards have been identified. They maintained that a group of people's vulnerability to a natural hazard and the danger itself determine the risk of a disaster.

It implies that creating risk maps for a community exposed to a particular kind of hazard at a certain moment requires first calculating risks based on the two variables (vulnerability and hazard). Community vulnerability could be assessed using popular community level risk assessment tools like PVCA (Participatory Vulnerability and Capacity Assessment), while the nature of hazards could be described using various tried-and-true techniques for evaluating hazards and disasters. In order to create a risk map, these two score kinds may ultimately aid in establishing a risk score at the household level.

2.8 Methodology for Developing Risk Map

It was previously mentioned that in order to depict distinct risks at the household level on the map with the required institutions and infrastructure, risk mapping must first establish particular ratings for at-risk homes.

Figure 5 indicates the necessary steps for how risk issues should be conceptualized and assessed and related scores could be calculated. The figure mentioned eight major steps to perform that will facilitate the necessary activities, from field data collection to risk map preparation. The model also suggests that a historical disaster context analysis is required prior to the implementation of any DRR project. This assessment will provide the professionals with the necessary guidelines to go through the steps mentioned in the model. Geospatial applications play a major role in developing the risk map and therefore the use of participatory GIS in characterizing local hazards and production of risk map is incorporated in the model and explained in the following sections.

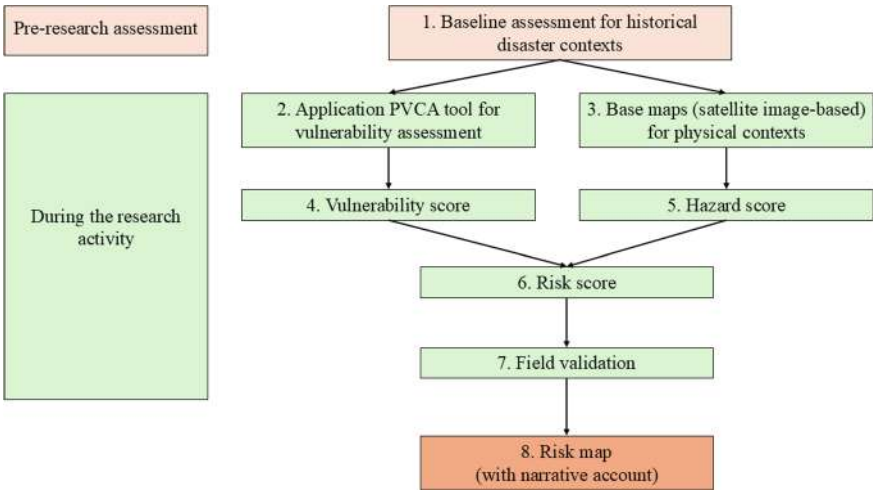


Fig. 5 Methodological steps for developing a risk map

Table 1 Degree of susceptibility of individual households in order to calculate risk score

Community susceptibility to hazards	Degree of fragility	Score
Exposure	1, 2 or 3	3—High; 2—Medium; 1—Low
Sensitivity	1, 2 or 3	3—High; 2—Medium; 1—Low
Vulnerability	1, 2 or 3	4–12 > 8–12 High; 8—Medium < 8 Low
Physical	1, 2 or 3	
Social	1, 2 or 3	
Economic	1, 2 or 3	
Ecological	1, 2 or 3	

Household-level risk calculation
Risk = Exposure × Vulnerability

2.9 PVCA Tool in Assessing Community Vulnerability

Evaluating vulnerability at the local level is one of the main responsibilities in figuring out how vulnerable a community is to particular types of threats. Four categories of vulnerability-physical, social, economic, and ecological-may be employed in catastrophe assessment narratives. Given that the community's levels of vulnerability vary and that several thematic categories of vulnerability must be taken into consideration, particular care must be paid when assigning a score to individual households. A household's exposure, sensitivity, and vulnerability may vary depending on its geographical position in the area and its features. The PVCA tool could be used to ascertain the degree of exposure, sensitivity, and vulnerability for individual households by employing suitable methods (e.g., transact walk, seasonal calendar, Venn diagram, etc.) used in the PVCA. Determining risk scores for individual households will be easy once the scores for subcategories are determined. Table 1 proposes some core values that facilitate the process, which were also used in undertaking this risk mapping exercise.

2.10 Field Validation

Characteristics of hazards occurring in different locations depend on the terrain conditions, local lithology and hydrology, and climatic conditions, and are sometimes determined by local land use patterns. In many cases, households are exposed to multiple hazards at the same time, and these issues have a seasonality dimension as well. Calculating risk scores might be challenging when all these issues are taken into account. In such circumstances commissioning a disaster risk assessment is necessary prior to commencement of the project work at field level. In this exercise, single hazard conditions are considered to make the risk mapping exercise simple and easy for disaster management professionals to grasp. Familiarity of professionals with this easy-to-grasp risk mapping model helped them to take it to use in complicated

conditions and also use it in a variety of contexts. However, field validation has been necessary to get first hand knowledge about disaster impact situations and to receive people's approval on the results (i.e. the risk map). This also facilitated the development of accompanying risk narratives.

2.11 Examining and Measuring the Exposure to Hazards

A deep understanding of local hazards and disaster contexts is important to categorize different households according to their vulnerability and exposure-specific hazards. This may be developed from desk review, examining disaster records from different sources, interviewing and discussing local people during PVCA processes and also using geospatial techniques to know about the impact coverage of past disasters.

3 Result

From the FGD and informal interview, the research team found that the Bahadurpur Mouza and its surroundings lost most of the land due to riverbank erosion. In the last few years, many families in the area have lost their land and are living under the poverty line. Many of them are shifted to urban areas or build their home on the Khas land (unused government land) along the road. Many families had to move their houses 10–12 times because of the riverbank erosion. Besides riverbank erosion, flooding is one of the devastating disasters in this area. During the monsoon season, roads and ghats (A ghat is a place along the bank of a river, canal, or other body of water that is important for daily activities, trade, and transportation, particularly in rural and riverine areas) are inundated under 5–6 feets of water and houses are inundated under 3–4 feets due to flood by excessive rain or flood induced by riverbank erosion and embankment disruption. Sometimes, this condition lasts for one to one and a half months. The inhabitants also use the land created by river erosion as Khas. There is no rent that has to be taken for the land created due to demolition but rent has to be paid for Vita land. There are no specific rules for the settlement of demolished land. All kinds of vegetables and cash crops, including nuts, chilies, jute, mustard, wheat, and wheat, are grown in the char land (river bank area), which was also affected during the disaster.

The poor communication system makes access to the market complex, and farmers are often deprived of fair prices. The condition of primary and secondary education in this area is deplorable. No teacher wants to stay in the Char areas. They live far away from school and have to spend a considerable amount of money on travel expenses. Teachers do not want students to go to school because they do not have enough time. The dropout rate of students from primary and secondary levels is much higher in this area. The local people demanded that if the educated boys and girls living in the char are employed as teachers in the area, the site will be developed, and the boys

and girls of the area will be very interested in education. As a result, the number of students dropping out will be reduced.

The number of child marriages is much higher in this area. Most people in the area are poor, and fishers are fishing in the river day and night, so they can't find out much about the children. As a result, parents are always worried about their children out of fear of embarrassment. About half of the girls got married after primary school. According to the locals, the rate of child marriage is higher among the Hindu community. According to the locals, the expatriates in the area are primarily responsible for this child marriage. Expatriate boys often marry a beautiful 12/14-year-old girl with gold jewellery and money. The girl is 12 years old, but with the help of the local chairman and members, the age of the girls is increased, and their marriage is arranged, said the locals. A few years ago, an electricity line was established in the area, but there was no electricity for most of the day. They have lived in this river area for generations, but today, they are going through the same financial situation as their parents, who lived in the house 30–40 years ago. However, the status and occupation of the children of the families who have somehow got the opportunity to get higher education has changed. The new generation of boys does not want to be in the profession of fathers and grandfathers. There is no work for the people of the area throughout the year. More fish is available in the river during the rainy season, but at other times, due to the lack of fish in the river, many people become unemployed and work as day laborers in the district towns, including Dhaka. Many of them no longer return to the area, living with their families in a residential area in the city. There are hundreds of acres of fallow land in the area.

There are some specific information have collected through the questionnaire survey, which are given below:

As 210 questionnaire surveys were conducted, the age group of the area established the scenario of the age group in the area. Most of the people are middle-aged, whereas the 45–59 age group is the highest in number. However, there are a considerable number of older adults who are vulnerable in terms of disasters. In this scenario, most families reported that there are one or two children or older adults in their family, whereas 17% of the respondents reported they have more than two vulnerable people in their family. 23% of the families have no vulnerable member in their family, as shown in Fig. 6.

The families are relatively small in terms of size. 46% of the families consist of 3–4 members and 42% have more than four. However, 6% of the families consist of 2 or fewer and more than 8. As the respondents suggested, most of them are engaged in agricultural activities and other occupations like day laboring and migrant workers (Fig. 7). Very few of them are involved in government jobs and other businesses.

Most families' yearly income is around 1–1.5 lac; however, there are very few people with an income below 50,000 and some of them have a yearly income higher than 1.5 lac.

Flood Impact in the Area

75% of the respondent agreed that their household had been affected by floods. However, only 25% of the people responded, "No" 72% of the respondents reported

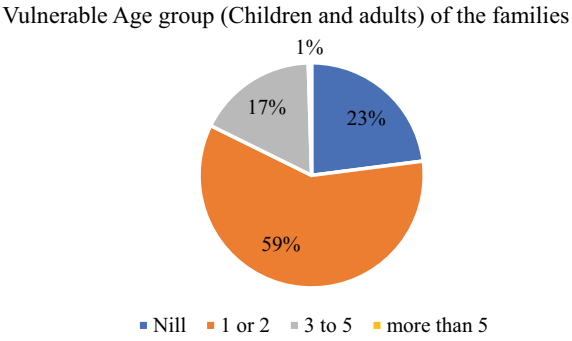


Fig. 6 Vulnerable age group in the study area

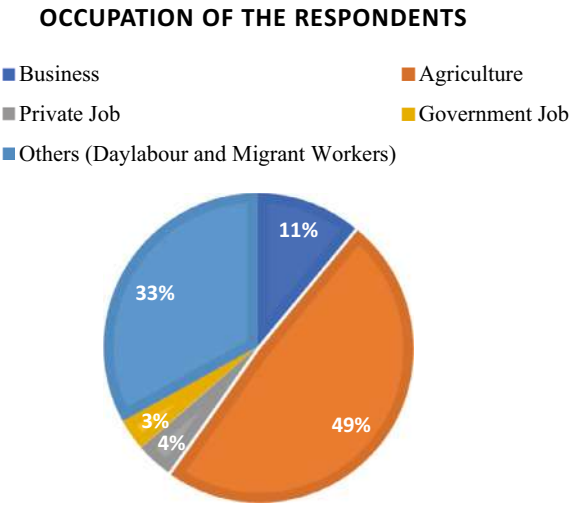


Fig. 7 Occupation of the respondents

that their livelihood had been affected by the flood, and 62% of the families faced food scarcity during the flood period.

3.1 Geospatial Applications for Risk Mapping

Geospatial data gives the opportunity to depict physical and social features in reference to the spatial arrangement of contingent phenomena of the locality. Use of data for different thematic layers (e.g., settlements, infrastructure, institutions, land use, hydrology, disaster-prone areas, etc.), time series satellite images could help to assess the contextual conditions within which household-level vulnerability to hazards generally occurs. This construction of background setting is important to determine the degree of vulnerability and, finally, to calculate the risk score.



Fig. 8 The flood risk map of the Bahadurpur Mouza

Figure 8 represents the risk map of the Bahadurpur Mouza. The deep red color dots represent mostly risk areas/families, light red means medium-risk areas/families, and the Sahara sand color represents low-risk areas/families. The mostly risky area is near the river and alongside the cannel, where don't have any embankment and lowland area. On the other hand, the household positioned in medium low land area are relatively less exposer to river and water, which is indicate medium risk.

3.2 The Significance of Risk Map

Significant reduction of disaster risks depends on the proper assessment of risks so that identified gaps could be addressed by implementing project interventions. Risk assessment provides the necessary understanding of the pattern and characteristics of risks associated with local social, economic, and ecological elements of the surrounding environment. This, in turn, helps to put risk aspects on an intensity scale and finally helps to calculate the vulnerability score. In the similar fashion, deep understanding about the characteristic's local hazards (e.g. propensity, intensity, recurrent interval etc.) may help to know about the types of risks it creates to different people in the community (e.g. old people, women, children, the disabled etc.) and finally help out in ascertaining the score for exposure. Risk score could then be calculated by multiplying these two scores (i.e. vulnerability and exposure) for individual households and based on the risk scoring results households could be categorized as high, medium and low. Simple overlaying of this risk score-based households (as point data) on local physical conditions in association with other infrastructure and facilities will create the risk map. It is important to note that the landform characteristics (morphology and surface terrain) of disaster-prone areas

are dynamic in nature; deformation (e.g. landslides in Chittagong Hill Tracts) and continuous change in the land configuration (e.g. river bank erosion in Bangladesh) are characteristic phenomenon in the areas susceptible to different kinds of hazards. Seasonality issues are also important to take into consideration in these circumstances. The risk map accommodates these factors into account and thus may help professional to implement DRR related research more effectively.

4 Conclusions

This study underscores the transformative potential of involving local youth in disaster risk management (DRM) initiatives through participatory geospatial methods. Local youth, embedded within their communities, possess unique insights into vulnerabilities, hazards, and coping strategies—the knowledge often overlooked by external experts. The results show that their involvement enhances data collection accuracy and fosters community ownership of risk management processes [14, 20]. Findings of the research show when youth are equipped with basic training in geospatial technologies, such as OpenStreetMap (OSM), Global Positioning System (GPS), and open-source satellite imagery, they can become pivotal agents of change, capable of driving localized, evidence-based solutions [12, 17]. It is important to note here, the UN's declaration of "Early Warnings for All" emphasizes the urgency of integrating community-centric approaches in disaster preparedness [22]. Early warning systems that leverage local knowledge, coupled with real-time data from mobile devices, can significantly improve the timeliness and accuracy of alerts, enabling communities to take proactive measures to protect their assets and livelihoods [10, 18]. For instance, mobile-based geospatial applications have already demonstrated their efficacy in flood monitoring and response by integrating real-time citizen inputs with predictive modeling tools [1, 21]. Moreover, this research aligns closely with global frameworks such as the Sendai Framework for Disaster Risk Reduction (SFDRR), the Paris Agreement, and the Sustainable Development Goals (SDGs). These frameworks advocate for inclusive and participatory approaches that bridge scientific expertise and local knowledge, ensuring no one is left behind [13]. By engaging local youth in citizen science initiatives, this study exemplifies how community-led efforts can contribute to achieving these global objectives. Advancements in technologies such as big data analytics, machine learning, and deep learning offer further opportunities to enhance DRM. These tools can analyze large datasets collected through participatory methods, generating actionable insights that were previously unattainable [4, 23]. For example, deep learning algorithms can process satellite imagery to detect changes in land use or water levels, while machine learning models can optimize resource allocation during disasters [5, 18]. While the potential benefits are immense, challenges remain. Local youth often face barriers such as limited access to training, resources, and mentorship, which can hinder their active participation [10, 22]. In this backdrop, the results of this study can help to argue that addressing these gaps requires well

planned actions, sustained investment in capacity-building programs and most importantly the establishment of robust partnerships between local communities, academic institutions, and international organizations [2, 9]. In conclusion it can be said that this study demonstrates that empowering local youth with geospatial technologies and integrating their efforts into broader DRM strategies can yield significant benefits for disaster resilience. By embracing a people-centered, technology-driven approach, we can build more adaptive and inclusive systems that not only mitigate disaster impacts but also foster long-term, community-centric climate resilience.

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