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Flood Risk Assessment of Pursurah Block, Hooghly District, West Bengal

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ABSTRACT

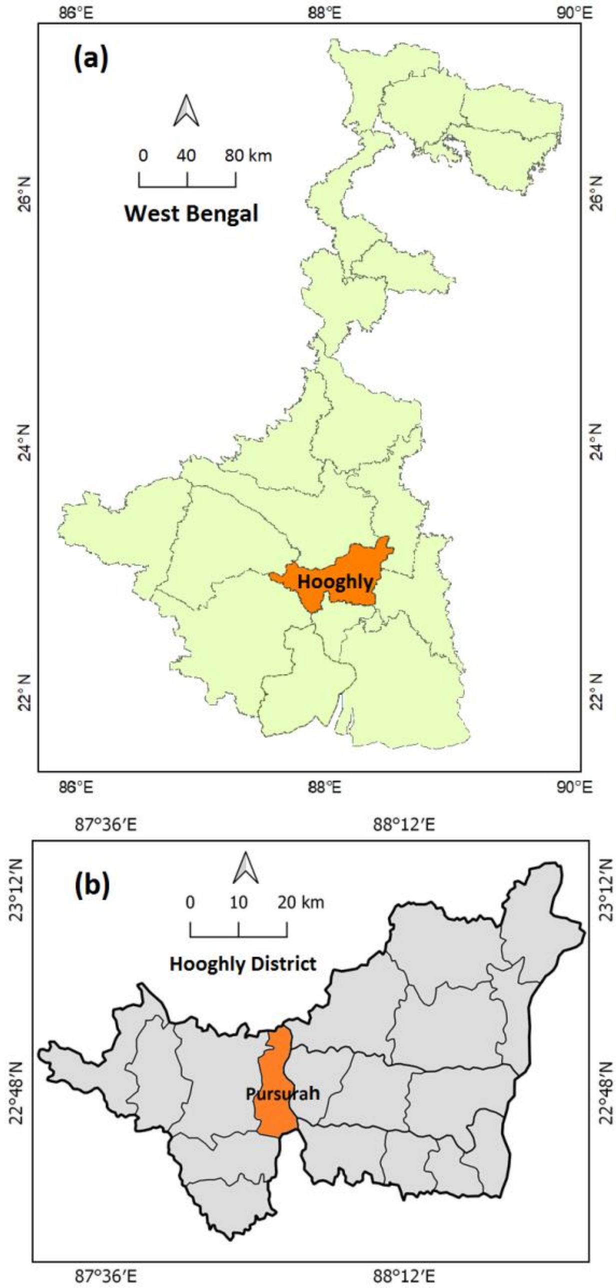
The occurrence of floods in tropical regions during the monsoon period is a very common phenomenon. The study area, Pursurah community development Block of Hooghly district, located in the interfluve region of Damodar and Mundeswari, suffers from floods every year, mainly due to the overflowing of the Damodar and its tributaries. Excessive and sudden water release by D.V.C. from the upper catchment dam of the Damodar instigated the situation and turned it into a more vibrant flooding event, along with various other demographic agents. The most anticipated aftermath of the flood found out here are major economic losses and property damages. The study is embedded in investigating the flood risk tendency of this area in terms of hazard assessment and four vulnerable components, namely, population density, child population (0–6 years), sex ratio, and cultivators and agricultural laborers. The recent progress in flood management systems is also highlighted in brief for a better understanding of future flood prospects in the Pursurah Block region.

Keywords: *Damodar, Flood Hazard, Vulnerability, Risk Assessment, Management.*

Introduction

Flood is an extreme hydrological state that involves overflow of excess water from a water body and inundation of adjacent low-lying areas that extremely hampers the basin ecology and the entire socio-economic structure of human life in the vicinity. Flood in West Bengal is a thought-provoking event. It is estimated that approximately 37,660 sq. km area of West Bengal is under a moderate to severe flood-prone zone (Das et al., 2018; Ghosh and Kar, 2018; Mahata, 2020). More specifically the lower Damodar basin (encompassing some blocks of Bardhaman, Howrah, and Hooghly districts) is one of the most prominent hydrological regimes that gets hit by catastrophic floods every year during monsoon months from June to September (Ghosh and Mistri, 2015; Mahata, 2020). The entire course of the Damodar is shared by two states, i.e., the upper part flows through the Chotonagpur plateau of Bihar, and only one-third of the Damodar is pervaded in Rarh and the deltaic plain of Bengal (Lahiri-Dutt, 2003). Near Chanchai, the river suddenly changes its course to the south, splitting into two rivers named Kanki-Mundeswari and Amta-Damodar channel, which eventually join the Hooghly river at Faulta (Bera and Mistry, 2014). Several paleo-geologic attempts have been made to understand the flood matrix in crucial older plains of Damodar. To describe another captivating phenomenon of Damodar W.W.Hunter (1876) wrote, 'Rainwater rushing off the hills through innumerable channels into the river bed with such great force and suddenness that the water rose to form a gigantic head wave of great breadth and sometimes rising up to 1.5 meters in height. These waves and accompanying flash floods were locally known as *Harka Ban'* (Majumder et al., 2010; Ghosh and Mistri, 2013). Regardless of being a dreadful riverine track, the presence of quaternary floodplain sediments makes the region very fertile which continues to attract human settlement, but it also result in a higher death toll and property losses due to increase in damage levels (Ghosh and Mistri, 2012). In recent times, RS and GIS-based analysis have made hazard studies more convenient and smoother (Majumder et al., 2017; Mitra et al., 2022). Regular monitoring and proper management approaches can save local livelihoods from the devastation of a natural disaster. Therefore, proper analysis of various physical and climatic conditions and the involvement of other man-induced factors will be supportive of flood-control tasks (Mondal, 2016).

Pursurah is a community development block located in Arambagh subdivision of Hooghly district, West Bengal (Fig.1), which experiences such recurrent flooding from two major rivers, Damodar and Mundeswari. Geographically, the study area is located in low depression area of the lower Damodar basin, due to this; the region possesses a very limited capacity to regulate excessive water flow from the upper catchment area of the Damodar River. The population here is largely rural and engaged in agricultural activities as their major occupation. Hence, the livelihood of this region is highly vulnerable to recurrent attacks of water splashes which enhance the risk condition. Therefore the main **objectives** include: a) to identify the flood hazard prone zones, b) to understand vulnerability of the region and c) evaluate the flood risk zones and discuss the effective flood management measures that could be taken into consideration.



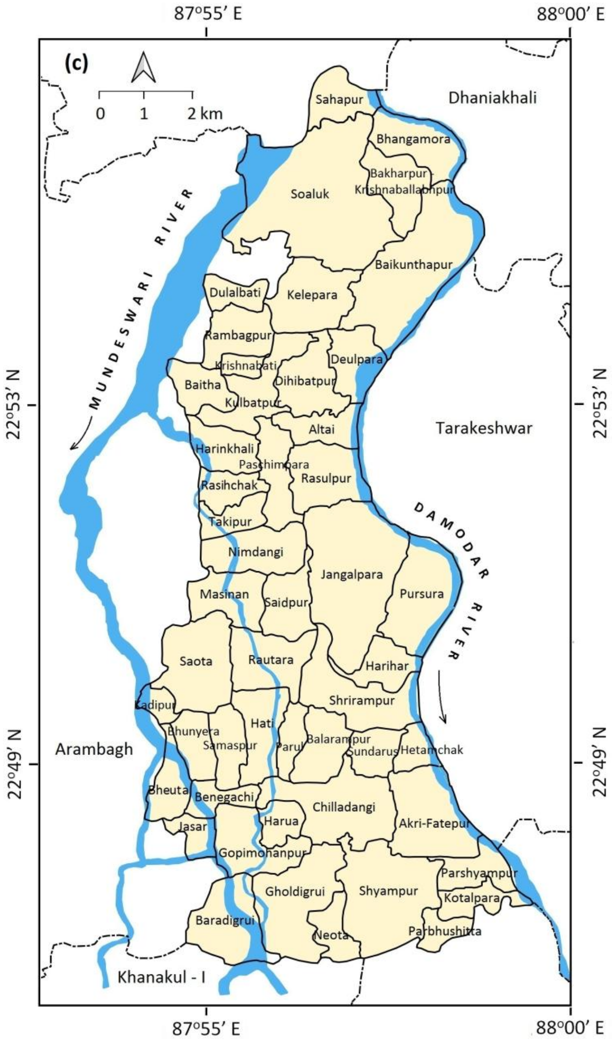


Fig. 1: Location Map (a) Map of West Bengal (b) Map of Hooghly District and (c) Pursurah Block Map

Flood Hazard Condition

Geologically the area is stable but the depression-like structure of this basin is actually filled-up with huge amount of alluvial deposits from the Ganga and its tributaries during the last 150 million years (Das et al., 2018). Various natural and anthropogenic factors can be held responsible for flooding in this region. The natural causes can often be associated with abnormal behavior of monsoon, sinuous pattern of the channels, gentle slope and overflowing nature of the river in the study area (Das, 2019), formation of random depositional lobes along the course, rapid siltation in channel which reduces its carrying capacity, deteriorating condition of natural levees etc. Besides these; human activities such as deforestation, channel modification, dam or reservoir construction, extensive and unscientific practices of cultivation including agricultural encroachment has created a far-reaching impacts on flood intensity over the subsided areas.

Recent years have witnessed such unpredictable consequences, of which flooding conditions for the years 2015, 2018 and 2021 have been observed. In 2015, more than 51 lakh people and over 5 lakh hectares of crops were affected by a massive flood during August in around 222 blocks and 13 districts in south Bengal. The magnitude of flood hit was relatively less in 2018 as compared to 2015. The study area, in 2021 has witnessed two successive devastations during onset of monsoon and its return in the months of June and September respectively.

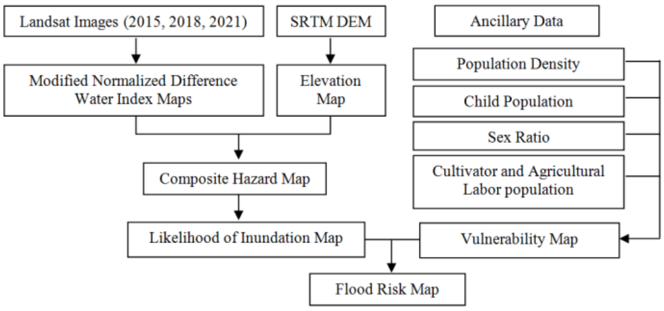


Fig. 2: Conceptual Framework of Map Algebra used for the Study

Either side of Pursurah is affected by the fluvial influences of Mundeswari (west) and Damodar (east). Two gauge stations Champadanga and Harinkhola have been set up on the Damodar and Mundeswari rivers, respectively. The Horinkhola gauge station is reported to have a return period of 2.03 years on a 2175.3 cumec discharge and 49.26% occurrence probability using Gumbel's extreme value (EV-I) method which confirms 50% of flood feasibility every year (Das et al., 2018). In order to pursue an overview of the flood scenario of Pursurah region, a composite flood hazard map (Fig. 3a) has been prepared using SRTM DEM (30m horizontal resolution) and LANDSAT images of post-monsoon timeframe for years 2015, 2018 and 2021. Areas of open water content in satellite images were delineated with Modified Normalised Difference Water Index (MNDWI) where the value ranges from -1 to +1; showing negative values for dry points and positive values for wet counterparts. MNDWI is undoubtedly suitable for highlighting the water logging condition; however a holistic idea of flood hazard is insufficient until the topographic viewpoint is added. Thus with the key purpose of demarcating the relative height variations, SRTM DEM has been used to interpret the relatively safe zones as well as the zones that are likely to get inundated. Henceforth composite flood hazard index was computed, by integrating the outcomes of MNDWI and elevation map, which attempts to manifest the extent of flood water impact.

For the convenience of understanding the extent of the flood hazard and its varying intensities the region has been classified into five zones (Fig. 3a). Accordingly it was observed that villages located in the northern section of Pursurah with elevation between 20 to 30 meters experiences low to very low flooding. Medium-flood-prone areas were sporadically noticed in sections having an altitude of 15 to 20 meters while highly flooded areas with elevation between 10 to 15 meters were located in the middle and southern portion of the area. However extreme southern section of the block with low elevation (5 to 10 meters), comprising of villages namely Chilladanga, Gholdigrui, Neota, Shyampur etc. undergoes maximum inundation. Thus it could be inferred that places prone to flooding are intricately related to lower elevations whereas villages at higher elevation show less susceptibility to inundation.

The composite hazard map has been used to estimate the likelihood that certain areas would be affected by flood. Average inundated areas from past flooding has been computed for each village (Eq. 1), thereby the entire region has been classified into seven categories (Fig. 3b) and indexed from 1 to 7; namely very low (1), moderately low (2), low (3), medium (4), high (5), moderately high (6) and very high (7) hazard condition.

Likelihood of Inundation (%) = (Total Inundated area / Total area) × 100 (Eq. 1)

Sahapur, located at the northern most section and Krishnabati, in the northwestern part, are the only two villages with the lowest propensity of getting flooded, less than 10% of these areas experience inundation. Moderately low (10% - 25%) and low (25% - 40%) flooded area have been observed in seventeen villages. Medium likelihood condition prevails in 28% of the block, where 40% - 60% water logging has been observed and thereby indexed as 4. Ten villages have high prospects of flooding (60% - 80%) whereas only four villages in the south, Parbhurshitta, Koltalpara, Naota, and Chilladangi, have been identified under moderately high-category (80% - 85%) with a hazard index of 6. However, only two villages in the southern most part, Shaympur and Gholdigrui, have been categorized as very high hazard-prone zone with more than 85% of inundated portions, thus denoting that the lower section of Pursurah block comparatively experiences high inundation than that of the upper half. Preparing a synopsis of flooding possibilities is the gateway to carrying forward the vulnerability assessment that clarifies the socio-economic state of this region.

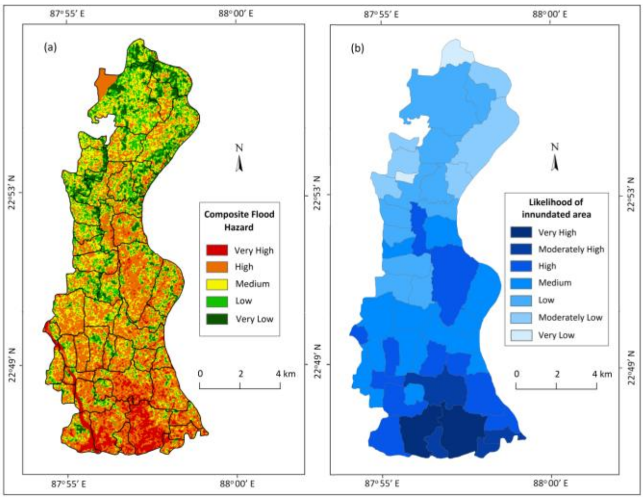


Fig 3: (a) Composite Flood Hazard Map and (b) Likelihood of Inundation Map

Vulnerability Assessment

A community is more susceptible to the effects of risk when it is vulnerable to a set of circumstances and procedures. Thus assessment of flood vulnerability appears to be paramount in the flood hazard impact assessment and management process (Nasiri et al., 2016). According to previous flood history the entire block is vulnerable during heavy monsoon season. Socioeconomic instability in flood-prone areas is a critical aspect that must be carefully considered in risk assessment. Therefore, to calculate the vulnerability index population density, number of children, sex ratio and cultivators and agricultural laborers were used as mandatory social parameters. Population data were collected from *censusindia.gov.in* as the indicators of vulnerability measurement. Areas with fewer inhabitants are less vulnerable to severe damage. Thus population density has been given a weightage of 40%. Similarly, flood events pose greater threat to the viability of women and children, as women are at risk because of family responsibilities and low wages, whereas children (aged 0-6 years) are completely dependent on other age groups (Gayen et al., 2022). So 20% weightage has been assigned to sex ratio and child population each. Agricultural workers and farmers are likewise regarded as being particularly vulnerable because they are dependent on nature and hence assigned weightage of 20% to the cultivators and agricultural laborers combined. Different units have been used to deal with these different socioeconomic parameters. Therefore, the min-max normalization method (Eq. 2) was employed to standardize vulnerability indicators and the approach validates that all variables are on the same scale.

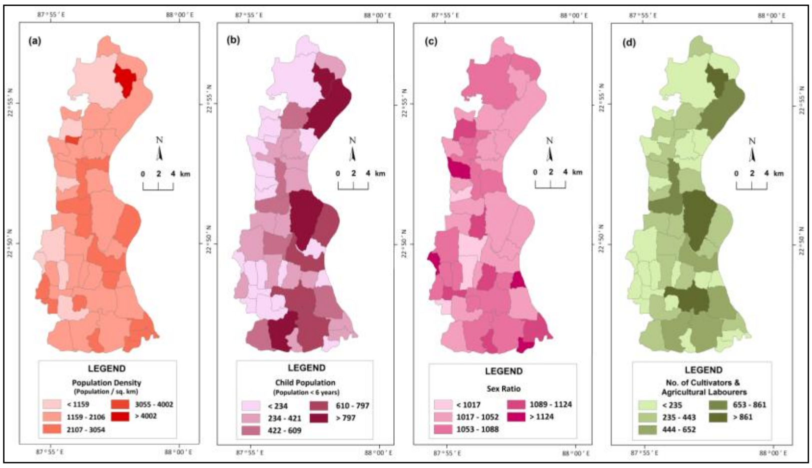


Fig. 4: Vulnerability Indicators: (a) Population Density (b) Child Population (c) Sex Ratio and (d) Cultivators and Agricultural Laborers

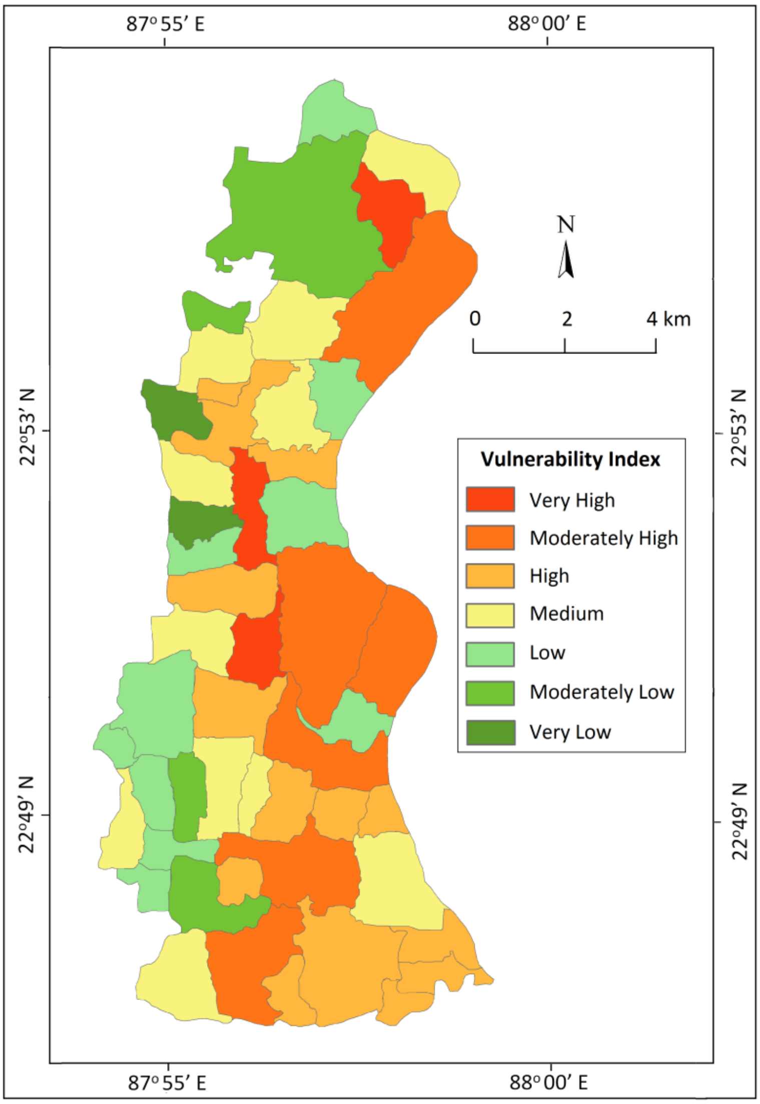


Fig. 5: Vulnerability Map

$$X = (x - x_{min}) / (x_{max} - x_{min}) \quad \text{(Eq. 2)}$$

Where,

x = actual value of the variable

x_{max} = maximum value of the variable

x_{min} = minimum value of the variable

X = Normalised x

Composite Vulnerability Index has been estimated with the assigned weightages of the aforementioned indicators based on their normalized values. Henceforth the entire block has been classified into seven categories (Fig. 5) and indexed from 1 to 7; namely very low (1), moderately low (2), low (3), medium (4), high (5), moderately high (6) and very high (7) vulnerable condition. Extreme cases were seen in Baitha and Rasihchak which project the least vulnerable situation whereas Saidpur, Paschimpara and Bhakharpur – Krishnaballabhpur were the most vulnerable ones. Majority of villages, almost 46% were grouped under very high to highly vulnerable class while 32% were categorized under low to very low vulnerability and only 22% of the block attained a medium score.

Flood Risk Condition

The term "risk" has typically been defined in reference to the goals of various sciences where disaster management techniques were necessary. Although there are several definitions of risk in the literature, the concept of risk in terms of "hazard" and "vulnerability" is the most commonly recognized in flood risk management (Nasiri et al., 2016). According to ISDR, the risk equation is:

Risk = Hazard × Vulnerability (Eq. 3)

Table 1: Flood Risk Index

Vulnerability index (1 to 7)	Hazard index (1 to 7)						
	VL (1)	ML (2)	L (3)	M (4)	H (5)	MH (6)	VH (7)
VL (1)	VL 1×1 = 1	VL 1×2 = 2	ML 1x3 = 3	ML 1x4 = 4	L 1x5 = 5	L 1x6 = 6	L 1x7 = 7
ML (2)	VL 2×1 = 2	ML 2×2 = 4	L 2×3 = 6	L 2×4 = 8	M 2×5 = 10	M 2×6 = 12	M 2×7 = 14
L (3)	ML 3×1 = 3	L 3×2 = 6	L 3×3 = 9	M 3×4 = 12	M 3×5 = 15	H 3×6 = 18	H 3×7 = 21
M (4)	ML 4×1 = 4	L 4×2 = 8	M 4×3 = 12	M 4×4 = 16	H 4×5 = 20	H 4×6 = 24	MH 4×7 = 28
H (5)	L 5×1 = 5	M 5×2 = 10	M 5×3 = 15	H 5×4 = 20	H 5×5 = 25	MH 5×6 = 30	MH 5×7 = 35
MH (6)	L 6×1 = 6	M 6×2 = 12	H 6×3 = 18	H 6×4 = 24	MH 6×5 = 30	MH 6×6 = 36	VH 6×7 = 42
VH (7)	L 7×1 = 7	M 7×2 = 14	H 7×3 = 21	MH 7×4 = 28	MH 7×5 = 35	VH 7×6 = 42	VH 7×7 = 49

where VL = Very Low, ML = Moderately Low, L = Low, M = Medium, H = High, MH = Moderately High and VH = Very High.

Flood risk index had been analyzed for different regions by multiplying hazard index and vulnerability index and there by classified into four categories (Buta et al., 2020) and five categories (Gayen et al., 2022). In this study to delineate the probable risk zones, risk index was determined for each village using the equation (Eq. 3) and thereby the villages were stratified into seven classes for even better understanding with a score range of 1(lowest risk) to 49 (highest risk). The categories thus included were very low (1-2), moderately low (3-4), low (5-9), medium (10-16), high (17-25), moderately high (26-36), and very high (37-49) (Table 1).

Baitha, a hamlet in western Pursurah, has been categorized to be the least risk prone area. This is mainly because all socioeconomic indices (population density, child population, sex ratio, cultivator and agricultural laborer) were observed to be either in very low or low categories. Moreover Baitha has very less exposure to flooding hazard; as a result the village possesses very low risk. Moderately low risk areas include three villages namely Rasihchak, Sahapur, and Dulalbati; where Sahapur has the least propensity to get inundated due to higher elevation and Rasihchak has the least population density and child population making it less susceptible to flood hazard. Village like Krishnabati has a high population density, but moderate topographic elevation making it a low-risk zone. Others villages falling in this category includes Deulpara, Rambagpur, Bhangamora and Soaluk.

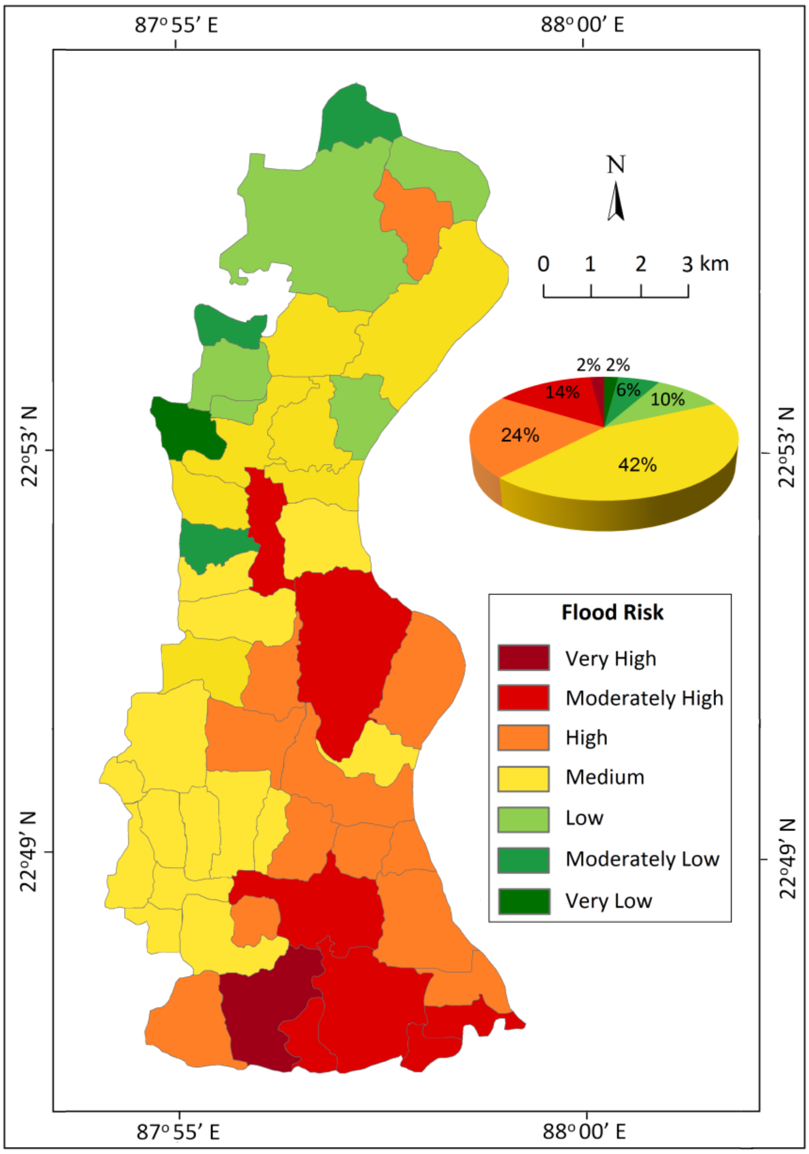


Fig. 6: Food Risk Map

Risk index values ranged from 10 to 16 have been considered as medium risk prone areas and around 21 villages show such values. However, a few villages have been experiencing notable matters of concern. For instance, Samaspur and Gopimohonpur are highly susceptible to hazards because of their medium to low altitude, but their low range of demographic attributes makes them less vulnerable to flood events. Baikunthapur lying in the northeastern part of the block is found to be a moderately low hazardous area, but it has been ranked as a highly vulnerable village due to its very high children concentration and also for being a residence to large number of population having agricultural pursuit. Thus its risk index appears to be in the medium category.

Twelve villages encompasses high risk zone among which Saidpur and Bhakharpur – Krishnaballabhpur have a very high vulnerability score which make the villages risk prone despite having comparatively lower inundation rate. Parbhurshitta, Kotalpara, Neota, Jangalpara, **Paschimpara**, Shyampur and Chilladangi have been demarcated as moderately high-risk zone, experiences high flooding as well as poor resilience. Gholdigrui has been identified as the only village that possesses very high risk and has a risk score of 42. It is highly hazardous due to its low elevation and has a very high child population count and a significant number of agricultural laborers, which causes it to be at a highly vulnerable stage as well. Hence, almost 18 percent of the study area showcases very low to low risk threats; medium risk zone covered 44 percent of the region and 38 percent area possesses high to very high risk (Fig 6).

In order to ensure the reliability of the concluded remarks, primary survey on occupational structure, residential properties, health status, along with other factors, was performed in the identified risk prone areas. More than half of the people were engaged in agricultural pursuits (cultivator or agricultural labor); other professions such as shopkeeper, construction labor, business were also noticeable within the surveyed households. Very low percentages of population were engaged in service sector. Therefore, the occupational structure portrays the area to be an agriculture dominated region. Thus crop damage due to flooding hampers the economic wellbeing of a large portion of the residents. It was observed that people living in kancha houses (23% respondents) were at a higher risk than those living in pakka houses as they experienced partial wrecking or complete destruction of walls due to sudden splash of flood water. Even the total number of rooms in a house assesses the intensity of the impact where multiple living spaces reduce the chances of leaving the house during flood. The minimum days of floodwater stagnation, as reported by 40% of the families, varies from 2 to 4 days in moderate to high risk sections when their primary sheltering places tend to be panchayats, schools and local clubs. During the water logging period the residents even suffered from few water-borne diseases, fever and other infections. Even 45% of the surveyed schools get affected by flood each year. This shows that these risk areas have a significant impact on the population's frailty to flooding.

Flood Management

Incorporation of a proper plan and strategy has always been mandatory to protect and avoid the disastrous effects of the sudden flood on local socio-economic settings. In order to deal with the disaster, adaptation of mitigation plans is insufficient; however, the active participation of the local community adds sustenance to administrative initiatives. As long as the flood surge is beyond complete control, restricting interaction along the river bank should be a concern. Local dwellers tend to prefer practicing agricultural activities and settling down on the verge of the riverbank, which makes their livelihood quite vulnerable (Das et al., 2018). Pursurah has been geologically and geographically vulnerable to flooding. Most of the south and south-eastern villages are highly prone to flood impact. The existing management practices include real time monitoring system that has been set up to track water levels; embankment and flood control structures have been constructed.

According to reports of The Times of India (2022), West Bengal government and Larsen and Toubro Ltd (L&T), one of the country's biggest engineering and infrastructure companies; had signed a deal to manage floods. The project aimed to make a proper plan for protecting the local lifestyle from sudden water splashes during flood time near the lower Damodar sub-basin covering the Howrah and Hooghly districts. The project was entirely based on the conjunction of Mundeswari and the Lower Damodar (Amta) channel, encompassing around 0.335 lakh hectors of cultivable area and the inhabitation of approximately 4.6 lakh people. Accordingly, the state government would be bearing 30% of the cost of the project; however, the World Bank and Asian Infrastructure Investment Bank (AIIB) would also co-finance the project.

However, progress on management system was not quiet adequate and thus other helpful precautions that might be taken into consideration by the local governing body includes dredging of river bed siltation which improves the channel strength and increase water carrying capacity; development of supporting canals or channels to distribute extra flood water; stocking up of most essential stuffs during pre flood stage. Supply of medicine, food, drinking water and safe shelters should be given adequate concentration during flood while providing of monetary compensational support to the affected families; proper documentation of flood event for future reference and demarcation of areas of improvement should be focused post flood event.

Conclusion

The interfluvial location of Pursurah between Mundeswari and Damodar (Amta) channel is a crucial place for successive flooding invasion. The flooding intensity of this region is dependent on various points such as, monsoonal rainfall, untimely water release by DVC and other associated anthropogenic agents. In addition, the variation of elevation throughout the Pursurah region is another factor that accelerates the flooding situation. Apart from this, demographic and socioeconomic components have triggering probability of intensifying the degree of damage at a significant level. With the assistance of flood risk assessment, the multiple correlations among various flood provoking factors have been identified for different villages. Nearly the entire eastern part of Pursurah has been recognised as highly fertile, evidenced by moderate to high concentration of cultivators and agricultural laborers. Therefore maximum economical loss includes damages of crop production and cropping filed. An intensive management system is fairly required to protect the unnecessary damages of agricultural outcomes from frequent flooding. The existing management strategies are to some extend proactive however, joint initiatives taken by state government in association with L&T (expected completion was in July 2022) for resisting the flood magnitude in Pursurah, may successfully alter the flooding scenario and its impact on socioeconomic condition in near future.

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