URBAN DEVELOPMENT DIRECTORATE (UDD)

Ministry of Housing and Public Works

Government of the People's Republic of Bangladesh

82, Segunbagicha, Dhaka-1000

Preparation of Development Plan for Meherpur Zilla

Report on the Assessment of Flood Inundation Zones Under Different Return Period Scenarios

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Table of Content

1. Introduction

Flooding is a recurrent natural hazard in Bangladesh that causes significant damage to life, property and livelihoods. Meherpur District situated in the northwestern part of the country and relatively elevated compared to many other districts. However, this district is vulnerable to moderate to extreme flood events due to its proximity to several rivers and khals such as the Bhairab, Ichamati, Kazla, and Mathabhanga as well as its low-lying terrain in many areas. With increasing pressure from population growth, land-use change, and climatic variability, it is important to assess the spatial extent and severity of flooding in project area. This report focuses on the assessment of flood inundation zones in project area by using hydrological and geospatial techniques to generate flood scenarios for various return period events which will be serve as an important decision-making tool for spatial planning team and respective authorities of this project to support disaster risk reduction and long-term climate resilience regional, structural, urban and rural planning.

2. Objectives

The objective of this report is to assess flood inundation zones in project associated area by using maximum flood levels for various return periods and high-resolution DEM data with a focus on classifying and mapping flood inundation zones based on inundation depths for each return period event.

3. Methodology

Inundation mapping approach adopted in this study is based on the spatial association between elevation and maximum flood levels. Historical flood level records from four gauging stations: SW32, SW205, SW206, and SW208. were selected due to their hydrological relevance to the project area. Annual maximum water levels were processed in HEC-SSP software using different probability distribution functions (PDFs) including Pearson Type III, Log-Pearson Type III, Generalized Extreme Value (GEV), Normal and Log-Normal for flood frequency analysis. After the frequency analysis, water levels for each return period were interpolated using Inverse Distance Weighted (IDW) spatial analysis techniques. This interpolation methods allowed for the creation of continuous water surface elevation layers over the entire project area. These surfaces represented hypothetical flood water elevations under each return period scenario.

To determine the flood inundation area, a high-resolution DEM prepared from field survey data was used. Flood inundation scenarios corresponding to 1.01, 2, 5, 10, 25, 50, and 100-year return periods were generated by subtracting interpolated flood water surface elevations from the DEM elevations. Positive depth values indicated areas of potential inundation or flooding while negative or zero values indicated non-flooding areas.

4. Flood inundation Analysis

The spatial extent and severity of flooding in Project area were analyzed under seven return period scenarios: 1.01, 2, 5, 10, 25, 50, and 100 years. The results indicate a progressive increase in both inundated area and flood depth with increasing return periods. In the case of the 1.01, 2,5-year return scenario, flooding was limited primarily to some low-lying areas adjacent to water bodies and river channels. However, long term return periods scenario like 10, 25, 50, 100 years, floodwaters extended significantly into inland areas including depression lands, agricultural fields and settlements etc.

The 1.01-year return period flood inundation map of the project area is shown in Figure 4.1. The 1.01 -year return period flood is considered as very usual or normal flood for the project area which is occurred every year where major inundation area are riverbanks and some depression land with shallow depths between

0.01 to 6.13 meters. An approximately 15.27 km² of land across the project area will be inundated in 1.01 -year return period flood.

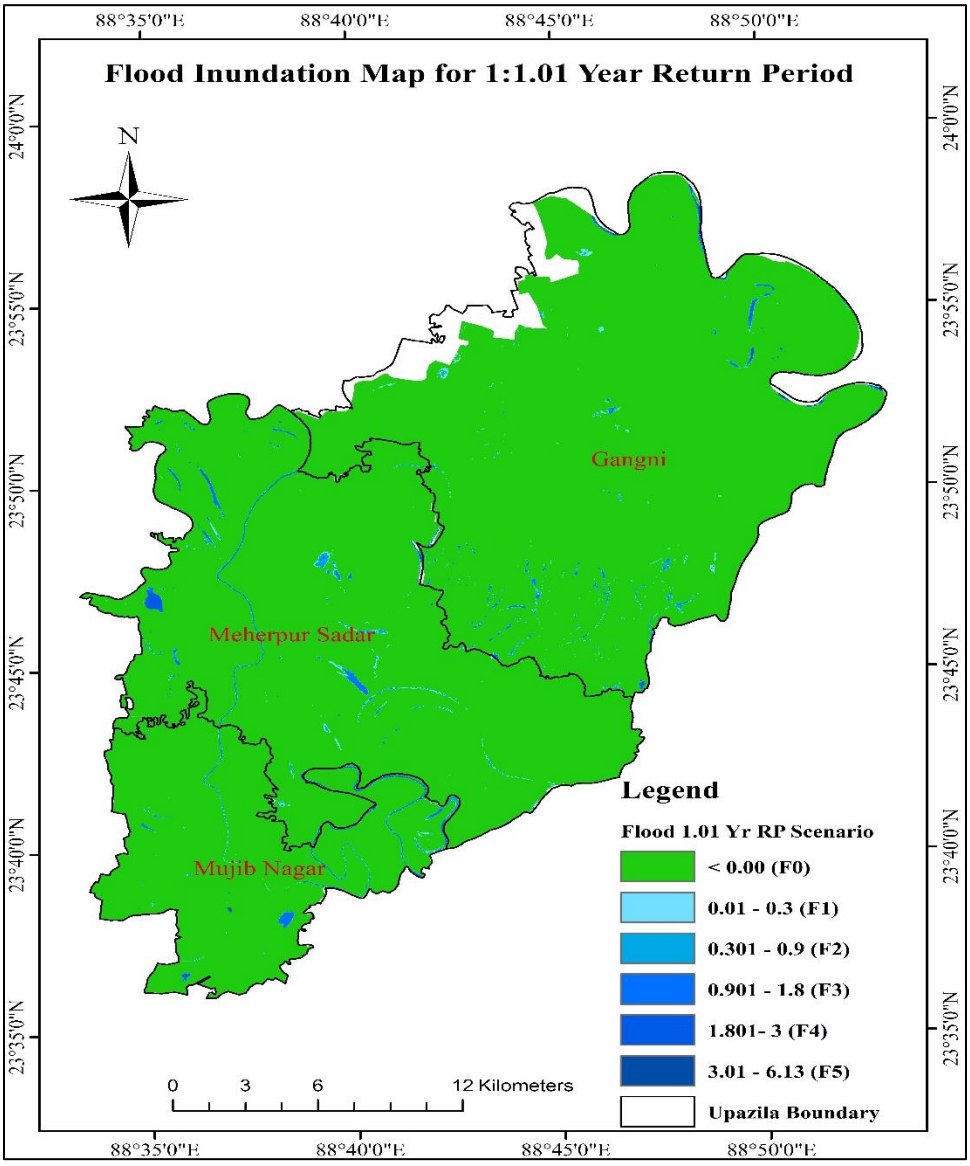

Figure 4.1: Flood Inundation Map over the project area for 1.01-year return period

Under the 2-year return period event, the flood extent increased significantly to around 73.38 km² which means that additional 58.10 km² of land will be inundated in comparison to 1.01-year return period. The inundation area is mainly in Meherpur Sadar and Gangni Upazila. Water depths ranged from 0.01 to 7.89 meters, where higher depths were found in some river sections and wetland areas. The flood inundation map under 2-year return period for the project area is shown in Figure 4.2.

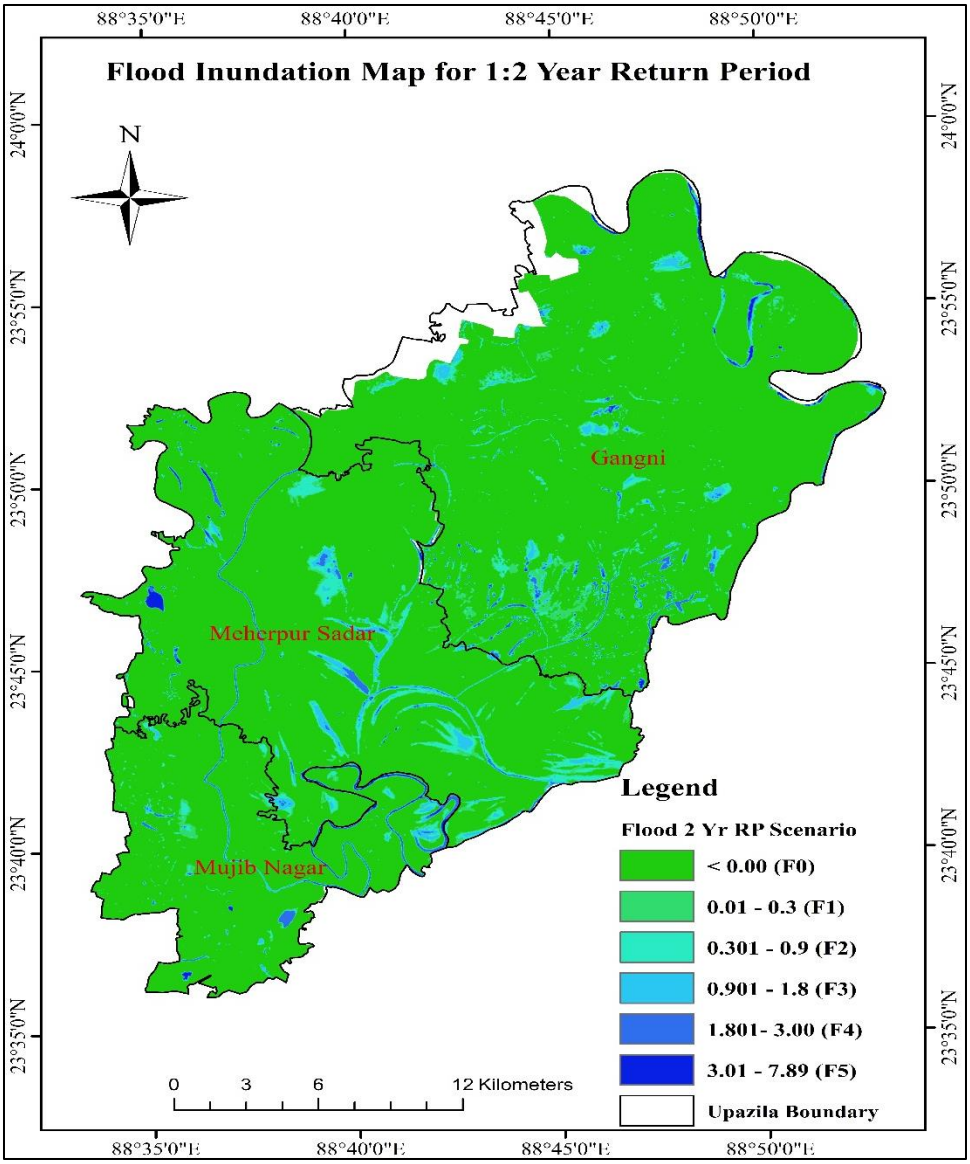

Figure 4.2: Flood Inundation Map over the project area for 2-year return period

The 5-year return period flood scenario will affect approximately 141.15 km² of the district which means that additional 67.77 km² of land will be inundated in comparison to 2- year return period. This scenario marked the extended impacts of beginning flood scenario, especially in agricultural areas of all Upazilas. Depths ranged from 0.01 to 8.59 meters across many parts of the project area, particularly in low-lying depressions and major river sections. The 5-year flood inundation map of the project area under 5-year return period is represented in Figure 4.3.

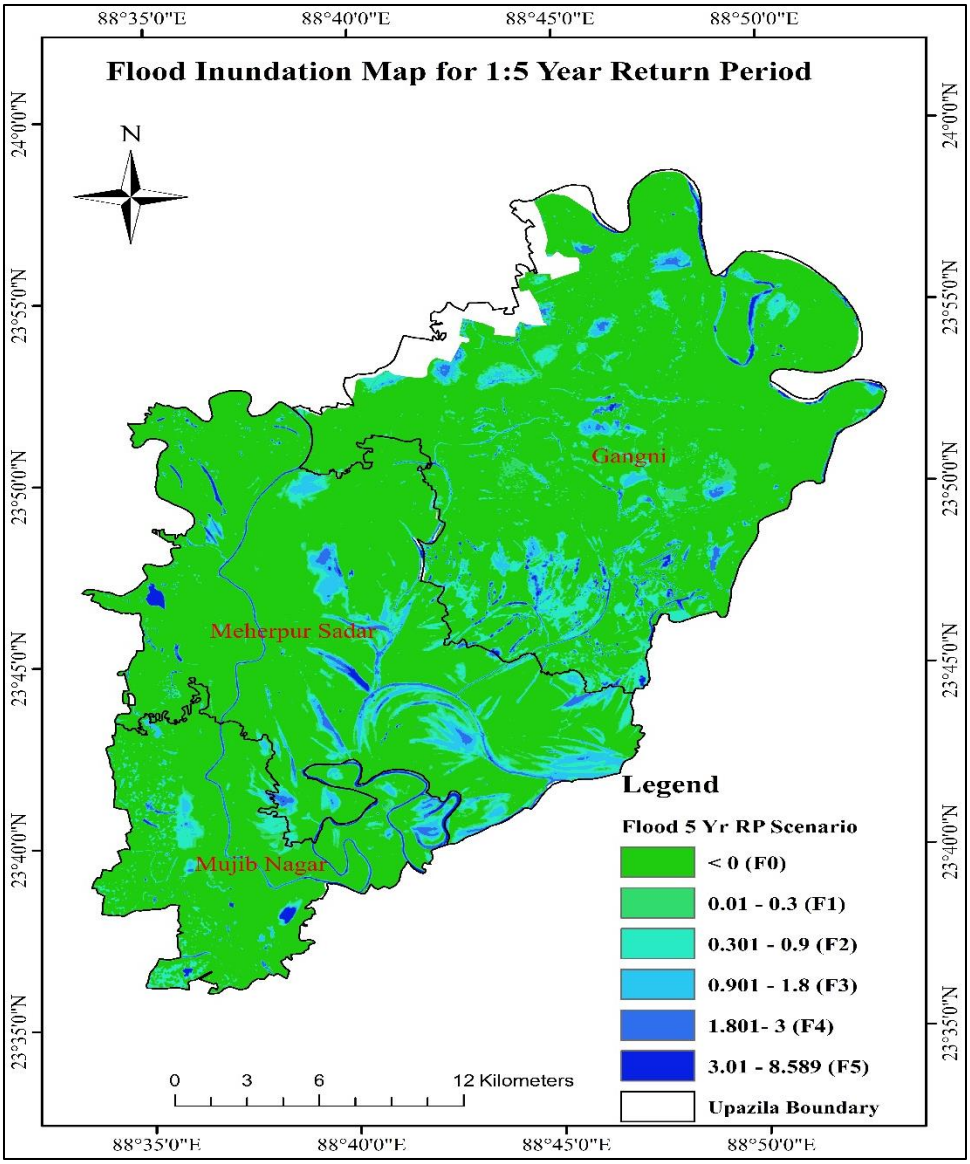

Figure 4.3: Flood Inundation Map over the project area for 5-year return period

In the 10-year return period flood, the inundated area expanded to about 198.88 km². Affected regions mainly included low depression area and agriculture land. A total of 74.50 km^2, 90.80 km^2 and 33.35 km^2 land of Meherpur Sadar, Gangi and Majub Nagor Upazila will be inundated. The inundation depth varied between 0.01 and 8.98 meters, with maximum depths found in low-lying depressions, wetlands, and main river channels. The flood inundation map under 10-year return period for the project area is shown in Figure 4.4.

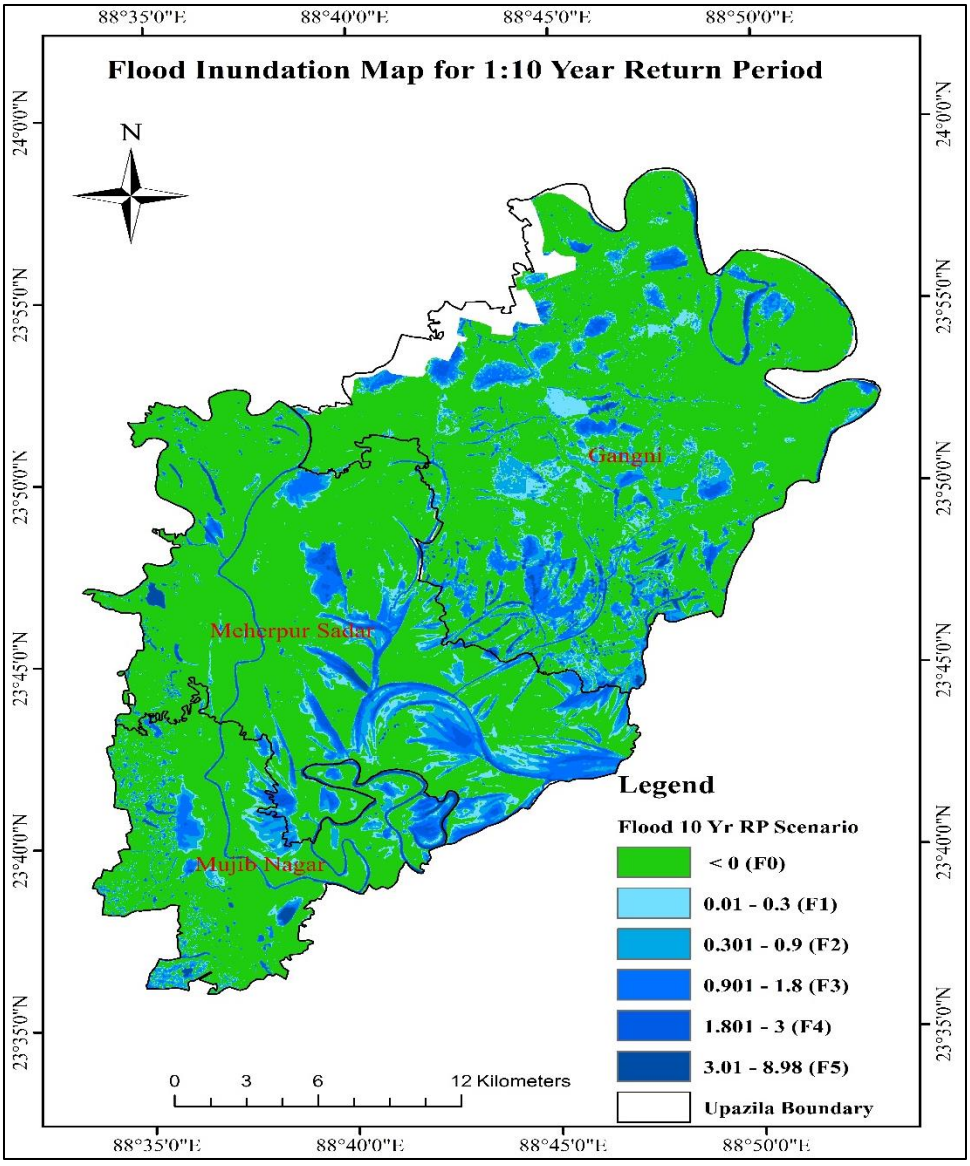

Figure 4.4: Flood Inundation Map over the project area for 10-year return period

The 25-year flood inundation map of the Meherpur District is shown in Figure 4.5. The flood affected area is estimated 264.31 km² which means that additional 65.43 km² of land will be inundated in comparison to 10-year return period. Total area of 122.30 km^2, 96.75 km^2 and 45.25 km^2 will be inundated in Meherpur Sadar, Gangi and Majub Nagor Upazila respectively. Inundation reached to settlements and agricultural lands, posing serious concerns for displacement, crop failure and damage to critical infrastructure. Depths exceeded to 9.35 meters in several locations near river confluences and low land depressions.

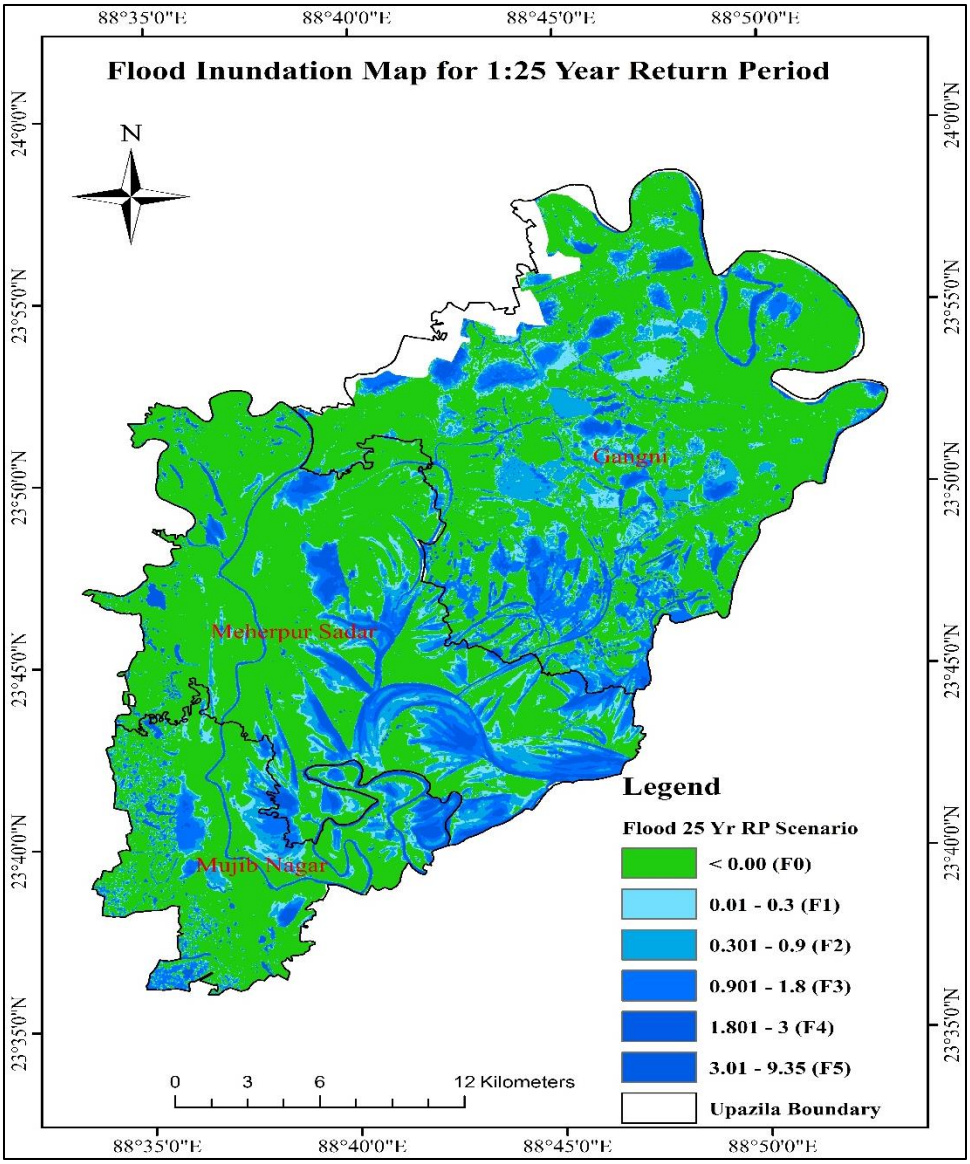

Figure 4.5: Flood Inundation Map over the project area for 25-year return period

For a flood of 50-year return period, 376.58 km² of the area under Meherpur district will be inundated, which means that additional 109.27 km² of land will be inundated in comparison to 25-year return period. The water depths increased notably, reaching more elevated zones that are normally safe during lower return period floods. Low-lying residential areas, agricultural lands and transportation networks are highly vulnerable under this flood scenario. A total of 137.10 km^2, 176.65 km^2 and 62.85 km^2 of land in Meherpur Sadar, Gangi and Majub Nagor Upazila are expected to be inundated during this return period. The flood inundation map under 50-year return period for the project area is shown in Figure 4.6.

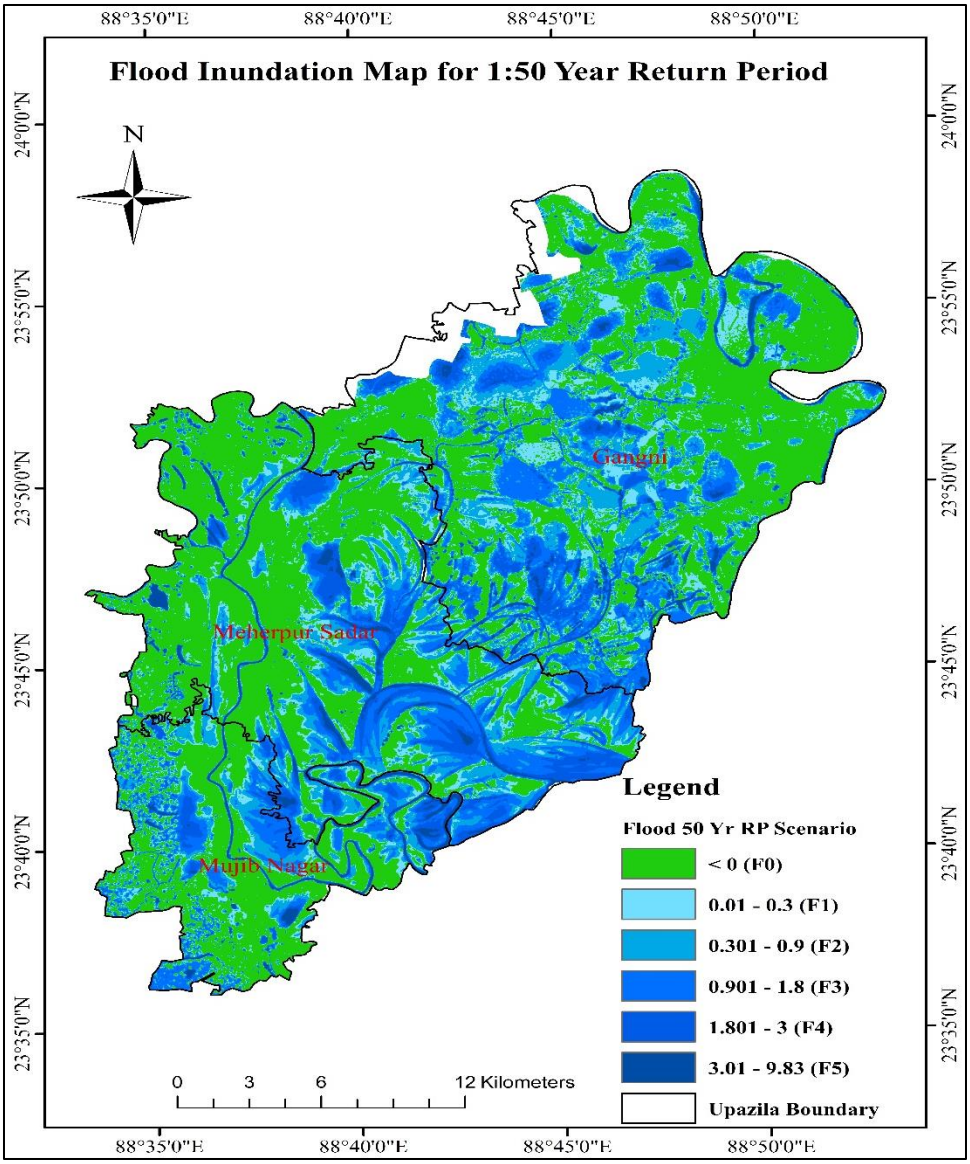

Figure 4.6: Flood Inundation Map over the project area for 50-year return period

The 100-year return period flood represents an extreme scenario in which inundation increases to approximately 390.75 km² across Meherpur District, indicating an additional 17.15 km² of land inundated compared to the 50-year return period. A total of 155.35 km^2, 166.45 km^2 and 68.95 km^2 of land in Meherpur Sadar, Gangi and Majub Nagor upazila will be inundated. This included extensive portions of cropland, settlements, public facilities, and portions of the transportation network. In several places, the inundation depth surpassed 3 meters, with serious implications for emergency response, infrastructure design, and long-term climate resilience planning. The flood inundation map under 100-year return period for the project area is shown in Figure 4.7

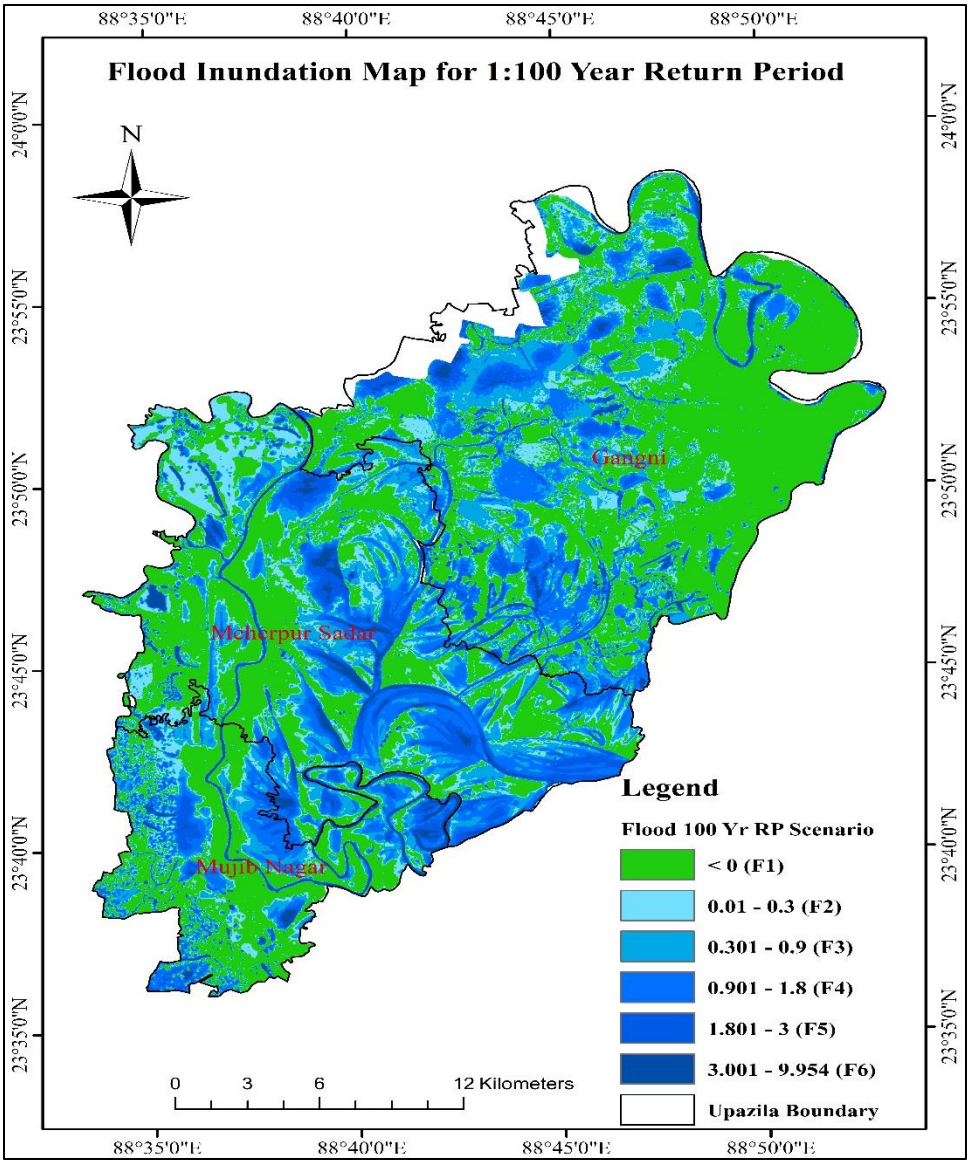

Figure 4.7: Flood Inundation Map over the project area for 100-year return period

Table 4.1 presents a summary of flood-inundated areas under different depth ranges and return period scenarios for all upazilas

Table 4.1: Flood Inundated area and depth over the project area for different return periods

Return Period (Years)	Upazila	Flood Depth Range (m)	Estimated Inundated Area (km²)
	Meherpur Sadar	Less than 0.00	255.44
		0.01~0.3	1.68
		0.301~0.9	1.97
		0.901~1.8	2.01
		1.801~3.0	0.83
		Above 3.0	-

1.01	Gangni	Less than 0.00	319.86
		0.01~0.3	1.56
		0.301~0.9	1.739
		0.901~1.8	1.188
		1.801~3.0	0.441
		Above 3.0	0.172
	Mujib Nagor	Less than 0.00	112.41
		0.01~0.3	0.67
		0.301~0.9	1.35
		0.901~1.8	1.33
		1.801~3.0	0.26
		Above 3.0	0.024
2	Meherpur Sadar	Less than 0.00	230.15
		0.01~0.3	8.07
		0.301~0.9	12.01
		0.901~1.8	7.46
		1.801~3.0	3.34
		Above 3.0	0.90
	Gangni	Less than 0.00	294.83
		0.01~0.3	10.12
		0.301~0.9	9.11
		0.901~1.8	6.58
		1.801~3.0	3.27
		Above 3.0	1.02
	Mujib Nagor	Less than 0.00	104.62
		0.01~0.3	2.83
		0.301~0.9	2.77
		0.901~1.8	2.39
		1.801~3.0	2.69
		Above 3.0	0.74
5	Meherpur Sadar	Less than 0.00	206.53
		0.01~0.3	12.14
		0.301~0.9	18.56
		0.901~1.8	15.85
		1.801~3.0	6.52
		Above 3.0	2.33
	Gangni	Less than 0.00	263.00
		0.01~0.3	16.51
		0.301~0.9	24.33
		0.901~1.8	12.66
		1.801~3.0	6.07
		Above 3.0	2.37
	Mujib Nagor	Less than 0.00	92.30
		0.01~0.3	5.95
		0.301~0.9	8.62
		0.901~1.8	4.05
		1.801~3.0	2.80
		Above 3.0	2.31
	Meherpur Sadar	Less than 0.00	187.46
		0.01~0.3	15.51
		0.301~0.9	23.45
		0.901~1.8	22.04
		1.801~3.0	10.08

10		Above 3.0	3.38
	Gangni	Less than 0.00	234.17
		0.01~0.3	23.95
		0.301~0.9	32.06
		0.901~1.8	22.66
		1.801~3.0	8.63
		Above 3.0	3.47
	Mujib Nagor	Less than 0.00	82.47
		0.01~0.3	7.80
		0.301~0.9	11.76
		0.901~1.8	7.60
		1.801~3.0	3.25
		Above 3.0	3.16
25	Meherpur Sadar	Less than 0.00	165.20
		0.01~0.3	18.59
		0.301~0.9	29.52
		0.901~1.8	27.83
		1.801~3.0	15.67
		Above 3.0	5.11
	Gangni	Less than 0.00	202.65
		0.01~0.3	28.60
		0.301~0.9	43.79
		0.901~1.8	33.01
		1.801~3.0	11.86
		Above 3.0	5.03
	Mujib Nagor	Less than 0.00	70.8
		0.01~0.3	9.71
		0.301~0.9	14.86
		0.901~1.8	12.54
		1.801~3.0	4.08
		Above 3.0	4.02
50	Meherpur Sadar	Less than 0.00	124.88
		0.01~0.3	24.77
		0.301~0.9	39.82
		0.901~1.8	38.31
		1.801~3.0	24.82
		Above 3.0	9.33
	Gangni	Less than 0.00	148.31
		0.01~0.3	37.90
		0.301~0.9	57.63
		0.901~1.8	50.55
		1.801~3.0	22.55
		Above 3.0	8.01
	Mujib Nagor	Less than 0.00	53.21
		0.01~0.3	11.09
		0.301~0.9	19.44
		0.901~1.8	19.23
		1.801~3.0	7.86
		Above 3.0	5.21
	Meherpur Sadar	Less than 0.00	95.52
		0.01~0.3	38.72
		0.301~0.9	47.87
		0.901~1.8	43.35

100		1.801~3.0	25.31
		Above 3.0	11.15
	Gangni	Less than 0.00	169.60
		0.01~0.3	33.13
		0.301~0.9	53.67
		0.901~1.8	42.68
		1.801~3.0	19.21
		Above 3.0	6.65
	Mujib Nagor	Less than 0.00	47.12
		0.01~0.3	12.63
		0.301~0.9	20.51
		0.901~1.8	20.52
		1.801~3.0	9.74
		Above 3.0	5.52

These findings indicate that almost 54% of Meherpur District could be affected by severe flooding during a 100-year flood event which suggest the critical need for integrated flood risk management.

5. Conclusion and Recommendations

This study demonstrates a comprehensive approach to flood risk assessment by integrating statistical analysis of flood level data and geospatial techniques. The resulting flood inundation maps for seven different return periods provide valuable insights into the varying nature of flood hazards in project area. Despite its relatively high elevation, localized flood risks persist in specific low-lying zones. Even under the extreme 100-year return period scenario only about 54% of the district is projected to be inundated. The flood-prone areas identified especially in agricultural lands, wetlands and settlements near riverbanks and depression zones should require strong attention. So, it is recommended that urban expansion and critical infrastructure planning should be carried out with special attention in high-depth identified zones under the 10-year and higher return period scenarios. Furthermore, the development of local land-use zoning and floodplain regulation based on these return period flood maps could enhance the resilience of the project area against both frequent and extreme flood events under changing climate conditions.