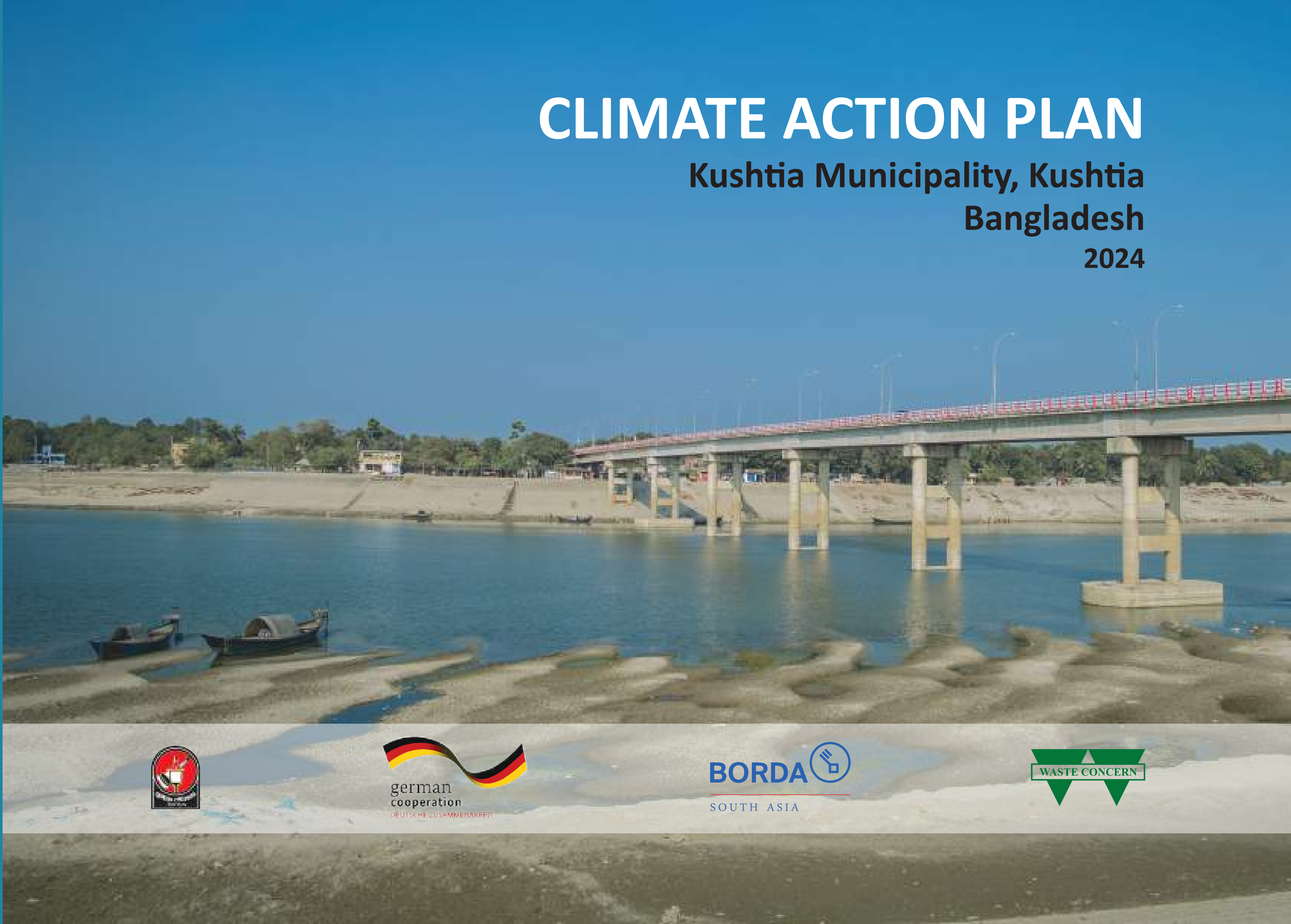
CLIMATE ACTION PLAN

Kushtia Municipality, Kushtia
Bangladesh
2024



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CLIMATE ACTION PLAN
Kushtia Municipality, Kushtia, Bangladesh

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LIST OF ABBREVIATIONS

ADB	Asian Development Bank
BBS	Bangladesh Bureau of Statistics
CAP	Common Agricultural Policy
CAP	Climate Action Plan
CBO	Community-Based Organization
CDC	Community Development Committee
CEO	Chief Executive Officer
CHRS	Center for Hydrometeorology and Remote Sensing
CR	Climate Resilience
CRU	Climatic Research Unit
DMC	Disaster Management Committee
DPHE	Department of Public Health Engineering
DRBP	Dhaka River Basin Project
FSTP	Fecal Sludge Treatment Plant
GDP	Gross Domestic Product
GHG	Greenhouse Gas
HBB	Herring Bone Bond
HIGS	Hazard, Infrastructure, Governance, Socio-Economic
KL	Kiloliter
KM	Kilometer
LGED	Local Government Engineering Department
LIC	Low-Income Community
LIUPCP	Livelihoods Improvement for Urban Poor Communities Project
LST	Land Surface Temperature
MDMC	Municipal Disaster Management Committee
NDC	Nationally Determined Contribution
NGO	Non-Governmental Organization
NUPRP	National Urban Poverty Reduction Program
PDB	Power Development Board
PNO	Paura Nirbahi Officer
RCC	Reinforced Cement Concrete
REB	Rural Electrification Board
SC	Standing Committee
SDG	Sustainable Development Goal
Sq. Km.	Square Kilometer
SWM	Solid Waste Management
TLCC	Town Level Coordination Committee
UDD	Urban Development Directorate
UNDP	United Nations Development Programme
UPSM	Urban Poor Settlement Mapping
USGS	United States Geological Survey
WASH	Water, Sanitation, and Hygiene
WC	Ward Committee
WL	Waterlogging
WVI	Ward Vulnerability Index
WW	Waste Water

GLOSSARY

Adaptation: The process of preparing for and adjusting to the impacts of climate change to withstand its effects. It is a key pillar of climate action, alongside mitigation.

Bottom-up approach: An approach to planning that starts by engaging local residents to understand their needs, demands, and perceptions, ensuring that strategies are inclusive and reflect community priorities.

Canal: Khal or river channel

Carbon Credit: A financial instrument representing a reduction in greenhouse gas emissions. Projects that reduce emissions, like a Material Recovery Facility, can potentially earn carbon credits as part of global circular economy trends.

Climate Action Plan (CAP): A strategic document for municipalities that provides a structured, evidence-based framework for local climate action.

Climate Financing: The mobilization of funds for projects aimed at climate change mitigation and adaptation, such as the development of low-carbon city infrastructure.

Climate Resilience Plan: A strategic plan that outlines actions and interventions to help a community or system prepare for, withstand, and recover from climate-related shocks and stresses. The Climate Action Plan (CAP) serves this function at the municipal level.

Coldwaves: A climatic hazard characterized by unexpected drops in temperature, particularly during winter.

Detail Project Report (DPR): A comprehensive document outlining the plan for a specific project identified within the Climate Action Plan.

Flood Risk: The likelihood of an area being inundated by water, assessed using factors like topography, land elevation, rainfall intensity, and proximity to water bodies.

Floodplains: Low-lying areas of land adjacent to a river that are subject to flooding.

Heatwaves: A climate hazard defined by prolonged periods of extreme heat. In urban areas, their impact is often intensified by the "urban heat island effect."

HIGS Framework: A methodology used for climate vulnerability assessments at the ward level, which analyzes four key dimensions: Hazards, Infrastructure, Governance, and Socio-economic indicators.

IPCC Guidelines 2006: A specific methodology provided by the Intergovernmental Panel on Climate Change (IPCC) for calculating and inventorying greenhouse gas (GHG) emissions.

Kancha/Jhupri: Terms for non-permanent housing structures common in low-income communities. Kancha houses are typically made of materials like mud, bamboo, or thatch, while jhupri refers to a slum shack or hut.

Land Cover Classification: A process that uses satellite imagery to map and analyze how different types of land surfaces (e.g., vegetation, water bodies, built-up areas) change over time.

Land Surface Temperature (LST): The temperature of the ground's surface, which can be measured using satellite data. LST maps are used to identify areas exposed to extreme heat and to understand the effects of urban heat islands.

Littering: The improper disposal of waste in open spaces, drains, or water bodies.

Material Recovery Facility (MRF): A specialized facility designed to receive, sort, and process inorganic and recyclable waste materials for recycling or resale, thereby improving overall waste management efficiency.

Mitigation: A primary component of climate action focused on reducing the impact of climate change to limit the severity of future climate change.

Non-WASH System: Urban infrastructure and services that are not part of the WASH (Water, Sanitation, and Hygiene) sector. This includes critical systems like housing, transportation, and electricity & communication.

Overlay Analysis: A geographic information system (GIS) technique where multiple data maps (e.g., land surface temperature, rainfall, and flood risk) are superimposed on one another to identify "hotspot" areas.

Plastic Credit: A financial instrument, similar to a carbon credit, designed to support projects that manage and reduce plastic waste, aligning with global circular economy goals.

Pourasabha or Pourashava: Local governing body, municipality or municipal corporation of a city or town in Bangladesh

Pre-monsoon: The season immediately preceding the main monsoon rainy season, often referred to as spring.

Rainwater Harvesting: The practice of collecting and storing rainwater for future use, which serves as a key strategy for managing groundwater resources.

Recyclable: Able to be collected, separated, and processed to be used as raw material in the manufacture of a new product

Recycling: The process by which waste materials are transformed into new products in such a manner that the original products may lose their identity

Shared Toilet: A communal toilet facility used by multiple households, often implemented in densely populated low-income communities or slums to improve sanitation and hygiene.

Solid Waste Management: Systematic control of generation, storage, collection, transport, separation, processing, recycling, recovery, and final disposal of solid waste

Stormwater Drainage: The urban infrastructure system, including street gutters and storm drains, is designed to manage runoff from heavy rainfall, prevent water accumulation, and minimize flood risks.

Urbanization: The process of population growth and expansion of cities, often involving the conversion of agricultural land for urban use.

Vulnerability Assessment: A systematic process to identify which geographic areas, communities, or systems are most susceptible to the impacts of climate hazards.

Ward: An administrative and electoral division of a municipality. In the provided documents, vulnerability assessments and climate action planning are conducted at the ward level.

WASH System: An acronym for Water, Sanitation, and Hygiene. It refers to the essential urban services that ensure public and environmental health, including water supply, sanitation and wastewater management, stormwater drainage, and solid waste management.

Vangari dokan (scrap shop) or bhangari: Small shops that buy and sell recyclable waste and old and scrap items.

UNIT CONVERSION

1 ha = 2.471 acres

1 Gg CO_2e = 1,000 tonnes CO_2e

1 kL = 1 m^3 = 1,000 L

1 kWh = 1000 watt-hours (Wh)

EXECUTIVE SUMMARY

The world is facing an escalating climate emergency marked by rising global temperatures, erratic rainfall patterns, intensifying heatwaves, floods, and extreme weather events. Rapid urbanization has increased exposure to climate-induced risks, particularly in developing nations where inadequate infrastructure and institutional capacities exacerbate these risks. Cities, home to over half the global population, are becoming the epicenters of both vulnerability and opportunity for climate action. Against this backdrop, global initiatives such as the Paris Agreement and the Sustainable Development Goals (SDGs) have emphasized the need for local-level resilience and climate-adaptive urban governance. Yet, while frameworks and targets exist globally, localized action, particularly at municipal levels, often remains underdeveloped due to data limitations, resource constraints, and a lack of localized planning instruments.

Bangladesh, one of the most climate-vulnerable nations in the world, faces recurrent challenges from cyclones, floods, heatwaves, waterlogging, and not considering this. While national efforts, such as the National Adaptation Plan (NAP 2023–2050), Nationally Determined Contributions (NDC), Perspective Plan, and Delta Plan 2100, provide comprehensive frameworks, a critical gap persists in translating national commitments into local actions. Municipalities, being the first responders to urban climate impacts, often operate with limited capacity and lack ward-level data to design effective climate responses.

In this context, Kushtia Municipality, a rapidly growing urban center spanning 42.79 square kilometers, faces complex climatic challenges. Located near the Padma River, the city is increasingly exposed to flooding, heat stress, waterlogging, and drainage congestion, with low-income communities (LICs) suffering the most. The Climate Action Plan (CAP) for Kushtia Municipality addresses these challenges through a scientific, data-driven, and participatory approach, integrating both satellite-based environmental assessment and community-based vulnerability analysis.

The CAP for Kushtia was developed through a collaborative process involving the Kushtia Municipal Authority and community stakeholders. The process began with orientation sessions, followed by the collection of secondary and primary data, and GIS-based analyses to identify ward-specific vulnerabilities.

- Secondary Data included land use, hydrological, and climatic datasets from sources such as USGS, CRU, and CHRS.
- Primary Data was gathered through household surveys and focus group discussions, capturing the perceptions and lived experiences of residents, especially from low-income settlements.

This structured process ensured inclusivity and accuracy, aligning local priorities with national climate strategies.

The CAP adopted an advanced GIS and remote-sensing methodology to quantify and map the municipality's climate vulnerability. The satellite analysis focused on four key dimensions:

- Land Cover and Land Use Change (LULC): Satellite imagery from 1992–2023 revealed a sharp decline in vegetation (from 20% to 12%) and water bodies (from 2.53% to 1.28%), alongside a significant increase in built-up areas (from 14.56% to 23.01%). This urban expansion heightened flood and heat risks.
- Land Surface Temperature (LST): Using Landsat data, LST maps identified severe heat concentration zones, "urban heat islands," particularly in wards with dense built-up areas and minimal greenery.
- Rainfall Intensity Mapping: Rainfall variability data were used to pinpoint wards susceptible to flash floods and drainage congestion.
- Flood Risk Mapping: Topography, elevation, and proximity to water bodies were overlaid to identify zones with recurrent flooding.

The overlay analysis combined LST, rainfall, and flood data to generate multi-hazard hotspot maps, identifying wards with compounded climate exposure critical for prioritizing adaptation interventions.

2. HIGS Framework (Hazard, Infrastructure, Governance, Socio-Economic) To complement the physical risk assessment, the HIGS framework was applied to evaluate ward-level vulnerability based on both quantitative and qualitative indicators:

- **Hazard**: Frequency and intensity of cyclones, floods, rainfall, heatwaves, thunderstorms, and cold waves.
- **Infrastructure**: Resilience of WASH (water supply, sanitation, stormwater drainage, and solid waste management) systems and Non-WASH Systems (housing, transportation, and electricity).
- **Governance**: Institutional capacity, planning, accountability, and disaster management readiness.
- **Socio-Economic**: Poverty levels, literacy rates, housing types, and access to basic services.

Each indicator was normalized to a 0–1 scale and combined into a composite HIGS Vulnerability Index. Wards 10, 12, 13, 16, 19, and 21 emerged as high-vulnerability zones, exhibiting multiple stresses, including poor housing, inadequate sanitation, and weak drainage networks. In contrast, Wards 1 and 20 showed lower vulnerability.

The integration of satellite-derived hazard mapping and HIGS-based social data ensured a robust, evidence-based understanding of Kushtia's climate risks.

- Urban heat and localized flooding are emerging as more significant threats than traditional large-scale cyclones in Kushtia.
- Peripheral and LIC-dominated wards lack adequate drainage, water supply, and waste management facilities, exacerbating their vulnerability.
- Absence of ward-level climate data sharing platforms limits proactive decision-making.
- Low-income households in wards 10, 15, and 21 face severe housing and sanitation challenges, increasing exposure to health and livelihood shocks.

Overall, the CAP establishes a scientific basis for municipal adaptation, moving from reactive to anticipatory planning.

The CAP outlines short-term (WASH) and medium-term (non-WASH) interventions, which were primarily suggested by the residents of Kushtia Municipality. Some notable WASH interventions are:

- Ensure universal access to safe piped water, with backups in flood-prone areas.
- Introduce rainwater harvesting and wetland restoration to recharge groundwater.
- Improve sanitation by expanding shared toilets and fecal sludge treatment (FSTP).
- Develop climate-resilient stormwater drainage systems and integrate sustainable urban drainage system (SUDS).
- Establish Material Recovery Facilities (MRFs) and promote waste segregation and recycling.

Unlike conventional master plans, which rarely integrate comprehensive climate considerations, and most Climate Action Plans in Bangladesh, which focus primarily on cyclones and floods, this CAP highlights the growing significance of heatwave preparedness and urban heat management. The study highlights the need to develop ward-level Climate Action Plans, aligning with national regulatory frameworks that now require localized, evidence-based climate resilience planning.

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1.1 Global Context: A Shared Climate Emergency

Climate change has emerged as one of the most pressing global challenges of the 21st century, posing profound threats to ecosystems, economies, and human well-being worldwide. Driven by extensive land-use changes and human-induced greenhouse gas emissions, the Earth's climate system is undergoing unprecedented transformations. These disruptions are manifesting through rising temperatures, shifting rainfall patterns, more frequent and intense extreme weather events, and accelerating sea-level rise, which intensify vulnerabilities and place immense pressure on both natural and human systems. The Intergovernmental Panel on Climate Change (IPCC) has unequivocally stated that global warming has already reached 1.1 °C above pre-industrial levels and is likely to exceed 1.5 °C in the near term unless immediate and sustained reductions in emissions are achieved (IPCC, 2023).

The effects of this warming are already widespread and intensifying, impacting all aspects of the Earth system. The last decade, 2015-2024, was the warmest on record, with 2024 being the hottest year since recordkeeping began in 1880. This rise in temperature is causing more frequent and severe extreme weather events, including intense heatwaves, heavy rainfall, thunderstorms and prolonged droughts. According to the IPCC, with just a 1.1°C of warming so far, approximately 3.3 to 3.6 billion people live in contexts that are highly vulnerable to these impacts, particularly in regions across Africa, South Asia, and Central and South America. Similarly, the planet's oceans have absorbed over 90% of the additional heat, resulting in rising sea levels due to thermal expansion and the melting of ice sheets.

The increasing intensity and frequency of climate extremes have led to severe human and economic losses. Between 2000 and 2019, over 475,000 people died worldwide as a direct consequence of more than 11,000 extreme weather events, with total economic losses exceeding US$2.5 trillion (Germanwatch, 2021). In 2022 alone, weather and climate-related disasters caused an estimated US$313 billion in global economic losses (Munich Re, 2023). These impacts are not evenly distributed: low- and middle-income countries, despite contributing the least to global greenhouse gas emissions, bear a disproportionate share of the damages and are the least equipped to respond.

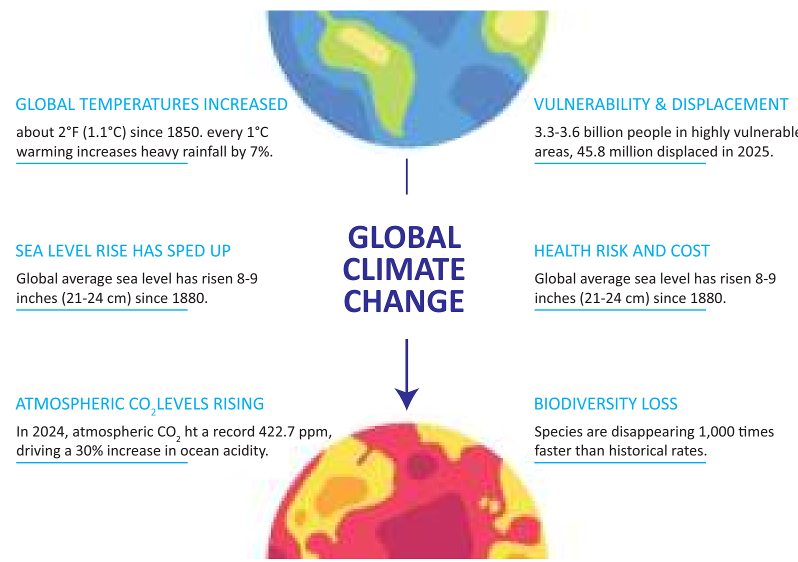


***Figure 1:** Impact of Global Climate Change*

Recognizing the scale and urgency of the crisis, the international community has adopted several frameworks and commitments:

- **Paris Agreement (2015):** Committing countries to limit global temperature rise to well below 2°C, and preferably to 1.5°C.
- **Sendai Framework for Disaster Risk Reduction (2015–2030):** Promoting resilience-building and risk reduction across sectors.
- **Sustainable Development Goals (SDGs, 2015):** Mainstreaming climate action (Goal 13) across all development goals.
- **New Urban Agenda (2016):** Provides a global framework to promote sustainable, inclusive, and resilient urban development aligned with SDG 11.

Mitigation, reducing emissions, and adaptation —preparing societies to withstand impacts —are all critical pillars of global climate action. Urban areas, home to over 56% of the world's population and responsible for more than 70% of global CO_2 emissions, are increasingly recognized as key actors in achieving global targets (UN DESA, 2022; UN-Habitat, 2020). Cities and municipalities have become frontlines for innovative climate solutions, from green infrastructure to renewable energy transitions and resilient urban development.

1.2 National Context: Bangladesh's Rising Climate Risks

Bangladesh, located on the world's largest delta formed by the Ganges-Brahmaputra-Meghna river system, is one of the most climate-vulnerable countries globally. Its low elevation, high population density, and reliance on climate-sensitive sectors such as agriculture and fisheries make it highly susceptible to both slow-onset climate impacts and extreme events. Bangladesh ranked the 7th most affected country globally on the Global Climate Risk Index 2021 for the period 2000–2019 (Germanwatch, 2021).

1.2.1 Observed Impacts and Emerging Threats:

Bangladesh is experiencing an escalation of extreme heat, with the country's maximum temperature increasing by 1.1°C, and the heat index—or "feels like" temperature—rising even more dramatically by 4.5°C (World Bank, 2025). This warming trend has intensified urban heat stress, particularly in urban areas, aggravating health risks and energy demand (Rahman et al., 2022).

Flooding remains the most frequent and damaging hazard. The 2020 monsoon floods, the longest in recent decades, affected 5.4 million people and inundated 37% of the country's area, disrupting livelihoods and infrastructure (UN OCHA, 2020). Moreover, intense rainfall events have increased by 12% since the 1980s, leading to recurrent urban waterlogging in major cities (BMD, 2022).

Similarly, Cyclone Amphan (2020) affected 2.6 million people and resulted in losses exceeding US$130 million, underscoring the increasing severity of coastal disasters (World Bank, 2021).

Salinity intrusion poses another growing threat, as sea-level rise and reduced river flow have increased soil and water salinity in coastal districts, affecting agriculture and safe drinking water for nearly 20 million people (World Bank, 2018).

Climate change is also accelerating rural–urban migration. Every year, hundreds of thousands of people migrate to urban centers due to river erosion, crop failure, and cyclones. By 2050, up to 13.3 million Bangladeshis could become internal climate migrants (World Bank, 2018).

According to the Country Climate and Development Report for Bangladesh by the World Bank

- Average tropical cyclones cost Bangladesh about $1 billion annually.
- By 2050, one-third of agricultural GDP may be lost due to climate variability and extreme events – a devastating figure as the agriculture sector represents around half of employment in the country.
- 13.3 million people may become internal migrants in the next 30 years due to climate impacts on agriculture, water scarcity, and rising sea levels, with higher impacts on women.
- In case of a severe flooding, GDP could fall by as much as 9 percent.
- The costs of environmental degradation and natural disasters are predicted to rise over time, compounded by higher heat, humidity, and health impacts.

Bangladesh will require at least $12.5 billion, approximately 3 percent of its GDP, in the medium term for climate action (World Bank, 2022).

1.2.2 Urban Vulnerabilities:

In 2023, Bangladesh's urban population accounted for 40.47% of the total population, growing at an annual rate of 3.12%, and is projected to reach 50% by 2050, reflecting a rapid pace of urbanization (World Bank, 2024). While urban centers drive economic growth, they are increasingly becoming hotspots of climate risk. Rapid and often unplanned urbanization has heightened exposure to multiple hazards. Urban flooding is becoming more frequent and severe due to intense rainfall events, inadequate drainage systems, and encroachment on natural water bodies (World Bank, 2021). Densely built-up areas with limited vegetation amplify the urban heat island effect, increasing heat stress and energy demand (Dasgupta et al., 2019). Unplanned infrastructure expansion leaves critical services vulnerable to extreme weather, while poor sanitation and stagnant water contribute to growing health risks from vector- and water-borne diseases, such as dengue, cholera, and diarrhea, which are expected to worsen with changing climate patterns (WHO, 2020). These intersecting pressures make urban centers particularly susceptible to climate impacts, threatening lives, livelihoods, and essential urban systems.

1.3 National Strategies and Policy Responses to Climate Change

The Government of Bangladesh has taken proactive steps to address climate change through a comprehensive policy and planning framework, including the following shown in Table 1:

Table 1: Key features of local-level climate action planning in the Regulatory Frameworks of Bangladesh

National Documents	Key features of local-level climate action planning
National Adaptation Plan of Bangladesh (2023-2050)	• Development of climate action plans for urban and peri-urban areas with an investment budget of BDT 4 billion, prioritizing resilience of vulnerable populations, including the urban poor and climate migrants. • Implementation of risk management measures for thunderstorms and lightning in high-risk areas. • Promotion of climate-resilient, inclusive (gender-, age-, and disability-sensitive) WASH technologies and facilities. • Enhancement of urban access to water, sanitation, and hygiene services to reduce exposure to flooding and waterborne diseases during extreme weather events.
Bangladesh's Third Nationally Determined Contribution (NDC 3.0) 2025	• Integration of climate mitigation into city development plans, strengthening local government capacity for low-carbon urban planning, and aligning zoning, building codes, and infrastructure with emission reduction goals. • Implementation of integrated solid waste and fecal sludge management at the city level (establishment of 26 integrated landfills and resource recovery facilities and 6 sewage treatment plants) • Sustainable waste management practices, including source segregation, composting/anaerobic digestion, landfill gas capture, e-waste management; • Workforce training, job creation through repair, reuse, and recycling hubs; and formalization of waste pickers with PPE, contracts, and health coverage.

National Documents	Key features of local-level climate action planning
Bangladesh Delta Plan 2100	• Recognizes urban areas as critical climate hotspots with an investment budget of USD 8 billion, particularly vulnerable to flooding, heat stress, and infrastructure strain due to rapid urbanization and climate change. • Appropriate action plan for removing waterlogging in urban areas • Categorization of wastes into e-waste, hospital wastes and others and separate effective waste management plans. • Community engagement and local knowledge in developing and implementing climate adaptation strategies, ensuring that interventions are context-specific and inclusive. • Strengthening local governance and institutional frameworks to effectively plan, implement, and monitor climate adaptation measures in urban settings.
Perspective Plan of Bangladesh 2021-2041	• Green areas in Dhaka and major cities to reach 5–12 m^2 per capita, 100 % of cities flood-free with proper drainage, and PM 2.5 reduced from 86 $\mu g/m^3$ to 10 $\mu g/m^3$. • Emphasis on sustainable city planning, decentralized governance, and integration of geo-spatial data (e.g., urban heat-mapping and land-use zoning). • Urban development must integrate environmental management and climate resilience to reduce urban heat, flooding, and pollution.
8th Five-Year Plan of Bangladesh (2021–2025)	• By 2030, cities should adopt integrated urban policies focusing on resource efficiency, mitigation and adaptation to climate change, and disaster resilience, aligned with the New Urban Agenda (NUA) and SDG-11. • Integrate climate change risk management into urban planning and governance. • Strengthen local institutions for urban climate and disaster risk management and build municipal–community partnerships to improve services and neighborhood resilience

1.4 Local Level Climate Action

Despite notable advances in national climate policies and strategic frameworks, a critical gap persists in local-level implementation, particularly within municipalities. As the core of urban settlements, municipalities are at the frontline of climate impacts—facing heightened risks from urban flooding, heat stress, infrastructure vulnerability, and public health threats. Yet, municipal institutions often have limited capacity, resources, and localized data to translate national priorities into actionable interventions on the ground.

A Municipal Climate Action Plan (MCAP) provides a structured mechanism to address this gap by enabling evidence-based, localized climate action. Through ward-level vulnerability assessments, municipalities can identify climate risk hotspots, set clear priorities, and design targeted interventions that address the most pressing needs. The MCAP will serve as both a strategic planning tool and a critical data source, supporting the integration of climate actions into master plans, local development plans, and municipal budgets.

Importantly, the MCAP will promote community engagement and local empowerment, ensuring that climate strategies are context-specific, inclusive, and supported by local stakeholders. By aligning municipal initiatives with national climate strategies, the MCAP will enhance institutional capacity, optimize resource allocation, and promote resilient, low-carbon urban development at the local level.

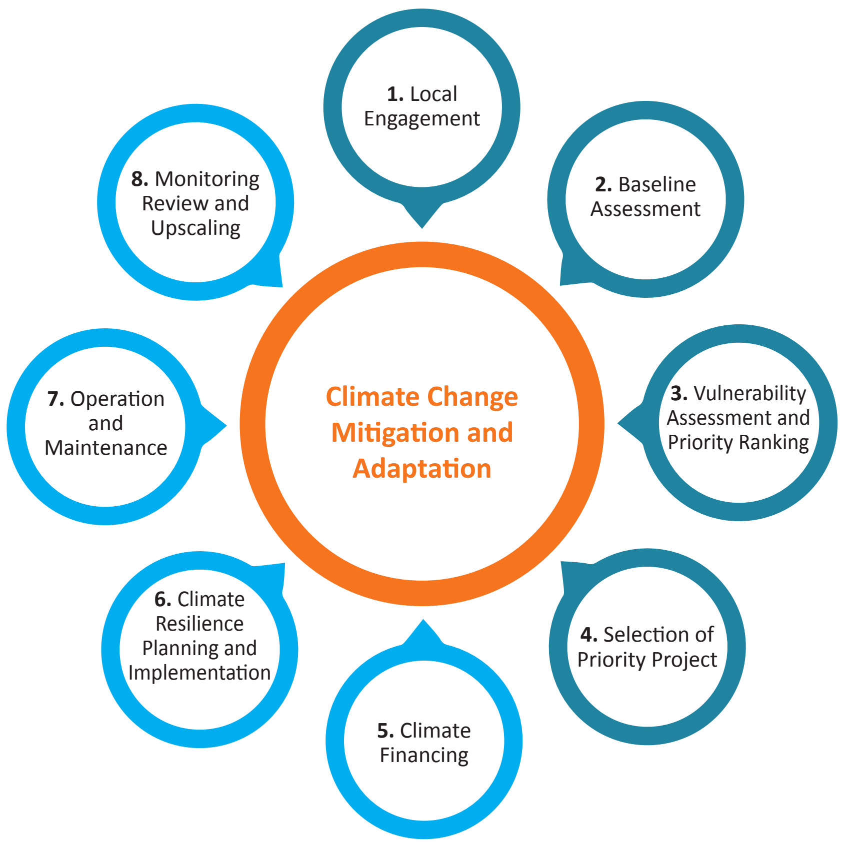


Figure 2: *Development of Local Level Climate Action Plan*

1.5 Preparation of Municipal Climate Action Plan

The preparation of the Climate Action Plan (CAP) for Savar Municipality followed a structured, participatory, and data-driven approach to ensure local relevance, inclusivity, and comprehensiveness. Active participation of municipal officials and local residents, including marginalized groups, was ensured throughout the process to capture diverse perspectives and community priorities, as shown in Figure 2. The first four segments(1-4), from local engagement to priority projects, represent the CAP preparation, while the subsequent segments (5-8) reflect its implementation.

The CAP preparation process is described in five key steps in the following subsection and is further summarized in Figure 3. An example of project implementation based on this CAP is provided in Annexure 2.

Step 1: Orientation Meeting with Municipal Authority

The process commenced with an orientation meeting between Kushtia Municipal Officials and Waste Concern to introduce the concept of the Climate Action Plan. The session highlighted climate impacts across national to local scales and stressed the importance of local action, community engagement, and inclusive planning. It also outlined the CAP's scope, objectives, and implementation approach, leading to strong municipal commitment and technical collaboration with Waste Concern.

Step 2: Data Collection

Data collection combined both secondary and primary sources to ensure comprehensive coverage of climatic, environmental, and socio-economic conditions.

- **Secondary Data:** Collected from institutional sources such as the Kushtia Paurashava Master Plan, UNDP, BBS, UDD, and Waste Concern. Additionally, Landsat satellite images were collected to analyze the spatiotemporal dynamics of land use and climate-induced extreme weather events.
- **Primary Data:** A town-level stakeholder consultation was conducted to initially understand Kushtia-specific climate change impacts and ensure the active

participation of diverse stakeholders in the CAP preparation process. This was followed by a structured questionnaire survey targeting local residents to assess household-level exposure and perceptions of climate risks.

Step 3: Data Analysis

The collected datasets were analyzed at both ward and municipal levels to (i) understand the existing condition of the municipality, (ii) estimate greenhouse gas (GHG) emissions from municipal operations, and (iii) assess ward-wise climate vulnerability.

- **Vulnerability Assessment using Secondary Data**: Satellite imagery and GIS-based analysis were conducted to identify spatial variations in extreme climate events and land use changes contributing to local vulnerability. This helped compare climate exposure across wards and determine the areas at greatest risk.
- **Vulnerability Assessment using Primary Data**: Community perceptions were captured to complement the spatial analysis. The HIGS framework, covering Hazard, Infrastructure, Governance, and Socio-economic dimensions, was adopted and contextualized for Kushtia Municipality. Originally developed by Integrated Research and Action for Development (IRADe), the framework was scaled down to capture ward-level vulnerabilities, rather than a broader city-level approach.

Step 4: Prioritization of Vulnerable Wards and Urban Systems

Based on the vulnerability findings, wards and critical urban systems were prioritized according to their level of risk. This step guided the identification of where interventions are most needed and what actions should be prioritized, ensuring resources are directed toward the most vulnerable communities and sectors.

Step 5: Recommendations and CAP Implementation Pathway

Finally, recommendations have been developed incorporating community inputs and local insights. The CAP outlines actionable measures that translate national climate policies into local implementation strategies, focusing on both mitigation and adaptation. The plan provides a clear way forward for Kushtia Municipality to build climate resilience and integrate sustainable practices into municipal governance and service delivery.

1.6 Implication of Municipal Climate Action Plan

The Climate Action Plan (CAP) provides a clear, actionable roadmap for Kushtia Municipality to strengthen climate resilience and reduce vulnerability across all wards. By combining ward-level vulnerability assessments with community-driven insights, the CAP ensures that interventions are targeted, evidence-based, and locally relevant. It translates national climate policies into practical local actions, bridging policy with implementation.

The CAP also enhances municipal capacity for planning, governance, and monitoring, while fostering inclusive participation to ensure that the most vulnerable populations are protected. By guiding sustainable investments in infrastructure, disaster risk reduction, and urban services, the CAP positions Kushtia for climate-resilient growth and long-term urban sustainability. It establishes a framework for measurable outcomes, accountability, and adaptive management, setting a precedent for other municipalities to follow.

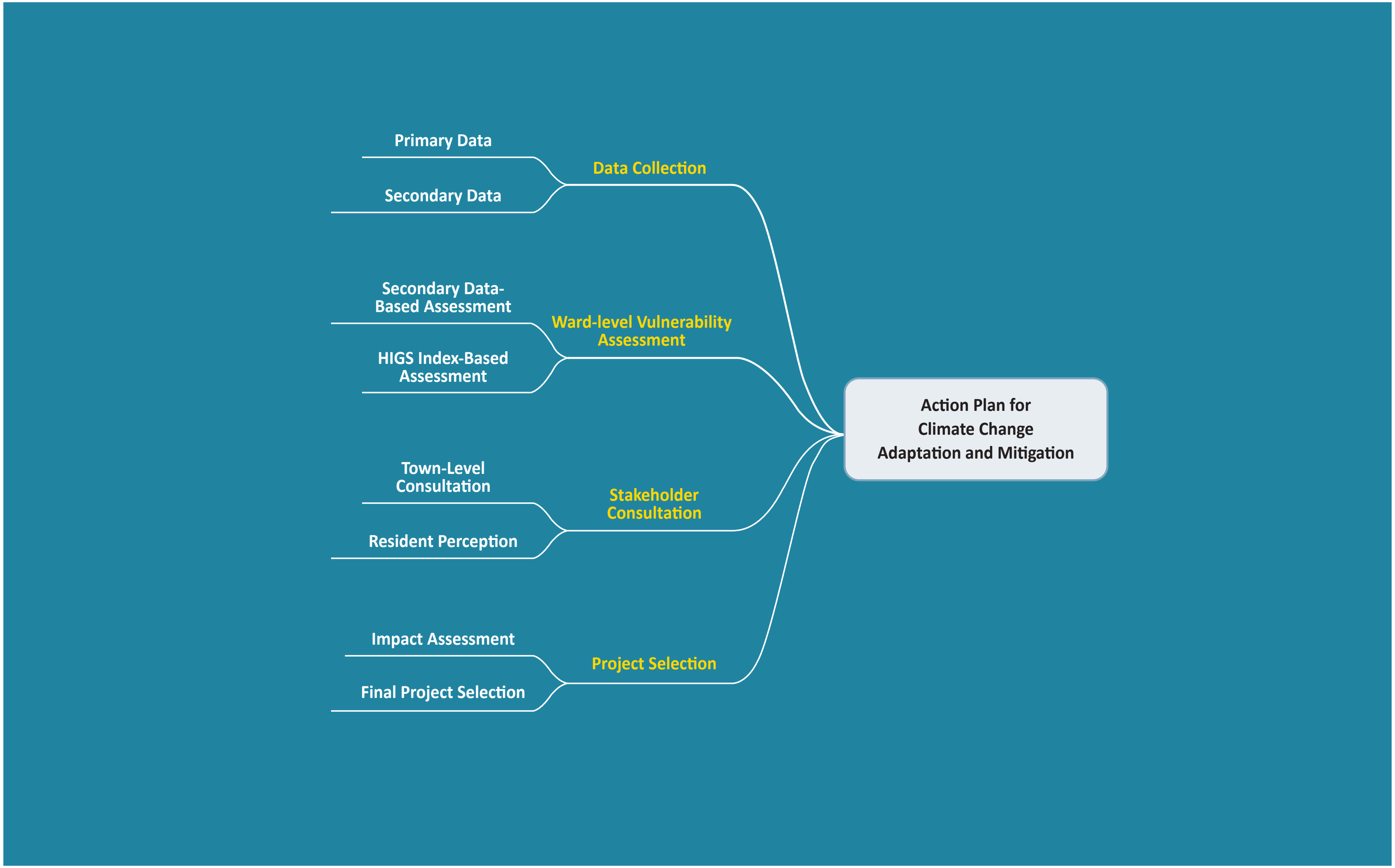


Figure 3: *Methodology of Climate Action Plan (CAP) Development*

2. PROFILE OF KUSHTIA MUNICIPALITY

2.1 Establishment, Area, and Location

Establishment and Area: Kushtia Municipality was established on April 1, 1869, under the provisions of the Municipal Act of 1868 (LGED, 2017). The area expanded in 1981 to 13.4 sq. km with 12 wards, and again in 2015 to 42.79 sq. km with 21 wards and 19 mouzas (BBS, 2016), earning 'A' category status. Wards 1–12 represent the older areas, while 13–21 are the newly added ones (UNDP, 2019).

Location: The municipality is situated in Kushtia Sadar Upazila, Kushtia District, within the Khulna Division, in southwestern Bangladesh, just south of the Padma River. It is about 245 km from Dhaka, 169 km from Khulna, and 104 km from Rajshahi, located between 23º52'26''–23º56'54'' N and 89º4'18''–89º9'32'' E (Waste Concern 2021).

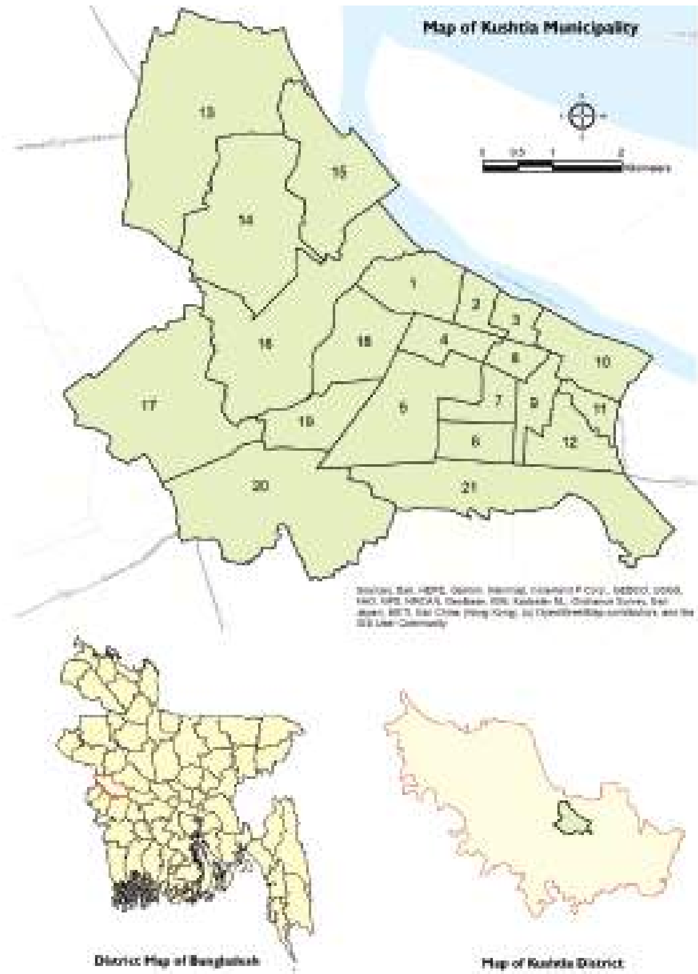
2.2 Boundary and Connectivity

Boundary: Kushtia Municipality falls under Kushtia Sadar Upazila, which is bounded on the North by the river Padma, Pabna Sadar Upazila and Ishwardi Upazila of Pabna District, East by Kumarkhali Upazila, South by Sailkupa Upazila and Harinakunda Upazila of Jhenaidah District, and West by Alamdanga Upazila of Chuadanga District and Mirpur Upazila of Kushtia District (BBS, 2011).

Connectivity: The town is well-connected to Dhaka, North Bengal, and South Bengal through the N704 Highway, Lalon Shah Bridge, Hardinge Bridge, the Padma and Garai Rivers, and Jashore Airport (96 km away) (LGED, 2017).

2.3 Urban Development and Growth Pattern

Kushtia has grown as a major urban center due to its strong road, rail, and waterway connections. Development has primarily occurred along major transportation



Map 1: *Location and Map of Kushtia Municipality*

routes, with commercial and mixed-use areas predominating in the central areas. Growth is focused in the central, northwestern, and northeastern zones, while the outskirts remain less developed, with expansion mainly along the Kushtia–Rajshahi, Kushtia–Jhenaidah, and Kushtia–Rajbari routes. The town is expected to expand southward**,** driven by migration and the conversion of agricultural land for urban use (LGED, 2017).

2.4 Land Use Pattern

Twenty types of land use categories exist in the town, out of which residential use is the most dominant category (occupies 37.51% of the total land of the municipality), followed by agricultural use (the second largest category occupies 34.87%), and then water body (the third largest category occupies 10.87%). The other categories include circulation network (4.16% of land), education and research (2.19% of land), commercial use (2.12% of land), industrial use (1.70% of land), mixed-use (1.67% of land), government services (1.63% of land), and others. Thereby, consolidation of the twenty categories under five broad categories shows that the most dominant category is the built-up area that occupies more than half (52.93%) of the municipal land, followed by agricultural use that occupies more than one-third (34.87%) of land, water body occupies one-tenth (10.87%) of land, other uses (only 0.71%) and vacant land & open space (only 0.63% land) (LGED, 2017).

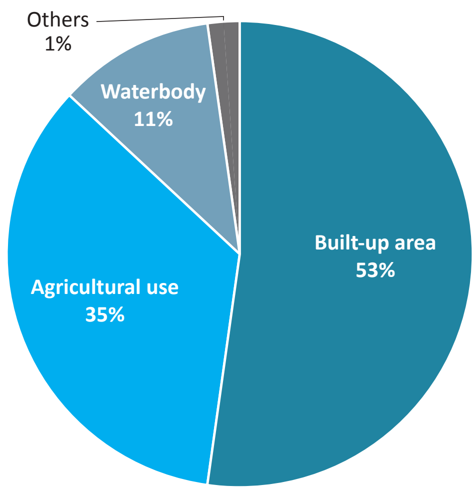


Figure 4: *Percentage of consolidated land use category*

2.5 Demographic Features

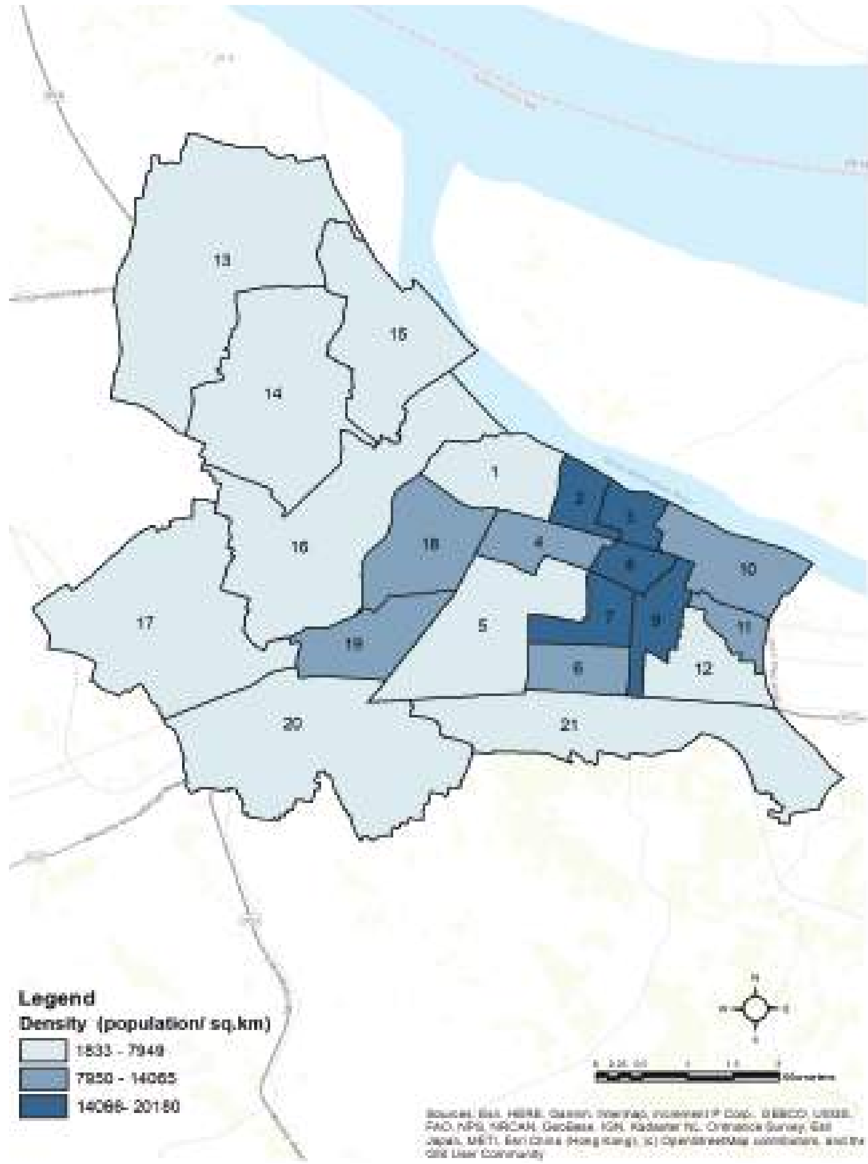
Town Population: The total population of the Kushtia Municipality was 221,804 (male-112,226 and female-109,578), and the total number of households was 58,295 in 2022 (BBS, 2022). Population projection based on an annual growth rate of 1.33% indicates that the municipality's total population in 2024 will be 227,743 (male: 115,231 and female: 112,512), increasing to 249,811 in 2031 and 285,097 in 2041.

The total number of households in 2024 is 61,887. The population density per square kilometer was 5,184 in 2022 and is 5,322 in 2024, indicating a tendency for the growing population number and density in the town. The average household size is 3.68, and the sex ratio (male to female) is 97.64. Regarding population density per square kilometer in 2024, the municipal wards can be broadly categorized into the following three groups; also refer to Map 2.

LIC Population: A total of 53,265 people (male-26,951, i.e., 50.60%, and female-26,315, i.e., 49.40%) live in 14,474 households across 226 critically underdeveloped LICs in 21 wards of Kushtia Municipality. This means more than one-fifth (23.39%) of the town's population lives in these LICs.

Educational Status: According to BBS (2022), the overall literacy rate in the municipality is 83.13% (which is higher than the national rate of 74.80%). The rate is higher in males (85.61%) than in females (80.72%). Again, 27.44% of the total population are students, and 78.28% have achieved education in different fields, including 92.22% in general, 3.30% in religious, 2.30% in technical, and 2.18% in other fields of knowledge (Annexure 1 Figure 1).

Map 2: *Existing land use of Kushtia Municipality*



Map 3: *Ward map showing population density*

2.6 Employment Status

About one-third (32.48%) of the total population is employed (male- 88.49% and female- only 11.51%), whereas 39.12% do not work, and 1.45% of people are looking for a job/work. Besides, 26.94% of people are engaged in household work, dominated by females (99.09%). The economic base of the municipality shows that about 95% of the employed population is engaged in non-farm activities (industry and service sectors) and only 5.29% in agriculture-related activities. Kushtia's economic activities include services that account for 74.69% of the total (BBS, 2022).

2.7 Local Government Bodies

Functions and Responsibilities: As per the Local Government (Paurashava) Act, 2009, Kushtia Municipality is responsible for roads, waste management, water supply, public safety, and registration services. DPHE and LGED provide technical support for water, sanitation, roads, and drainage, while the municipality also relies on donor and NGO assistance for high-level technical support for these services.

Elected Personnel, Structure and Staff: The council consists of 29 elected members—a Mayor, 21 Ward Councilors, and 7 Female Councilors. The Mayor leads policy decisions, supported by the Chief Executive Officer (CEO), who heads administration. A total of 164 staff serve under 11 sections and three wings to manage municipal operations.

Wing:	(A) General Administration Wing	(B) Engineering Wing	(C) Public Health Wing
Section:	1. General Section 2. Accounts Section 3. Tax Assessment Section 4. Tax Collection Section 5. License Section 6. Municipal Bazar Section 7. Education, Culture & Library Section	1. Civil Engineering Section 2. Electrical and Mechanical Engineering Section	1. Health and Family Planning Section 2. Conservancy Section

According to the organogram, Kushtia Municipality has 156 sanctioned posts and currently employs 164 staff members. The excess is due to additional staff in the engineering wing, while there are 5 vacancies in general administration and 13 in public health (see Table 2 for details).

Table 2: Present human resources as per the organogram

	Number of Wings	Number of Sections	Staff Required as per Organogram	Present Staff	Vacant Positions
1	General Administration Wing	7	55	51	5
2	Engineering Wing	2	68	93	0
3	Public Health Wing	2	33	20	13
	Total	**11**	**156**	**164**	**18**

Source: Kushtia Municipality, October 2024.

The positions of Mayor and councilors are currently vacant due to the political situation, and the municipality is run by an administrator appointed by the Interim Government. There is no dedicated slum development section; the task is managed by a Social Development Officer and two Community Mobilizers under the Engineering section, mainly through donor- and NGO-supported programs**.**

Committees: Kushtia Municipality has formed several committees for coordination and governance, including a Town Level Coordination Committee (TLCC), 21 Ward Committees (WCs) under the Local Government (Paurashava) Act, 2009. Besides, it also has a Municipal Disaster Management Committee (MDMC), and 17 Standing Committees (SCs) to work on different issues. However, many of these committees face limited effectiveness due to a lack of awareness, political will, and financial resources (UNDP, 2022).

Town Level Coordination Committee (TLCC): The Town Level Coordination Committee (TLCC) is chaired by the Mayor, with the Paura Nirbahi Officer (PNO) serving as Member Secretary. It consists of 50 members, including representatives from government offices, NGOs, civil society, and academia. The committee meets quarterly, ensuring 40% women and 10% low-income representation (UNDP, 2022).

Ward Committees (WCs): There are 21 Ward Committees, each chaired by the Ward Councilor and vice-chaired by the Female Ward Councilor. Each committee has 10 members, with 40% women and 10% from LICs. The committee meets quarterly to identify and prioritize local issues for the Municipal Council, though its overall performance remains weak

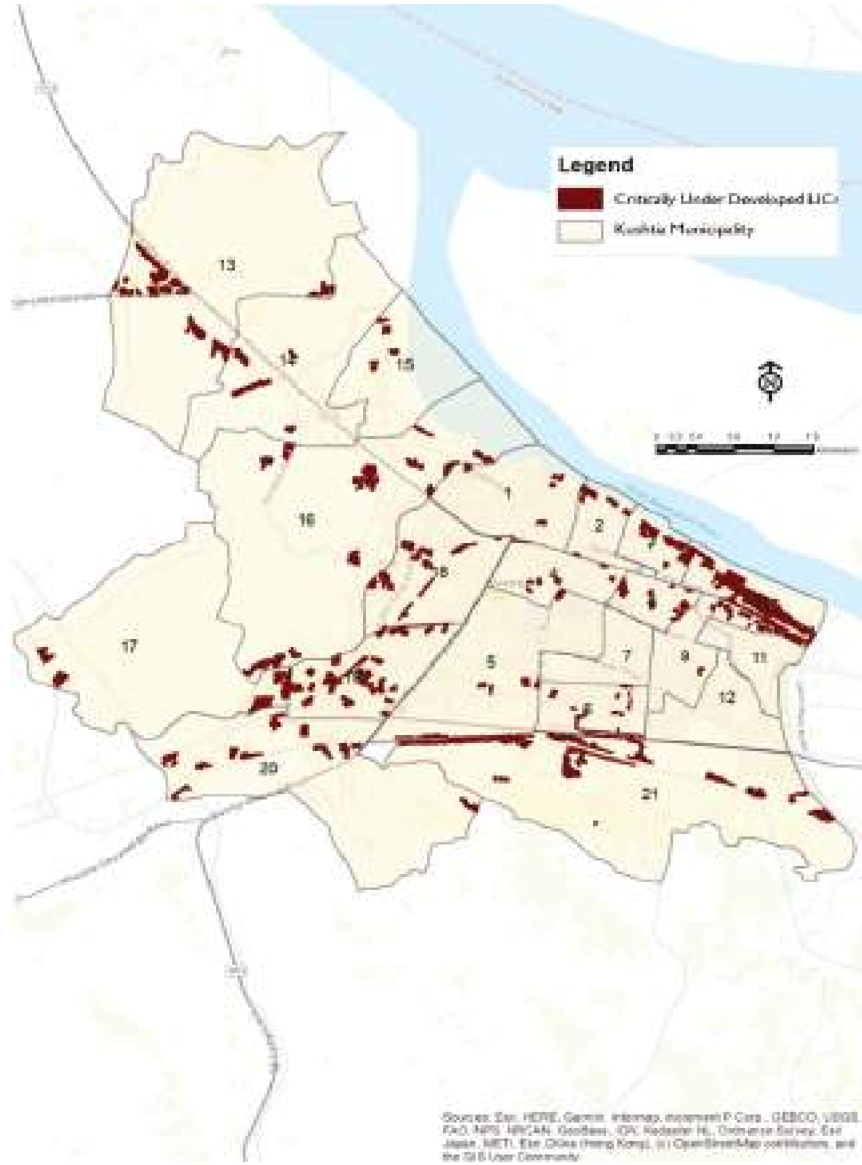
Municipal Disaster Management Committee (MDMC): As per the Standing Order on Disaster (2019), Kushtia Municipality established a Municipal Disaster Management Committee (MDMC) on 16 April 2016, comprising 40 members led by the Mayor, with the Panel Mayor and PNO serving as Vice-Chair and Member Secretary, respectively. The committee includes councilors, officials, and representatives from government, NGOs, and the community, responsible for coordinating activities before, during, and after disasters. However, no ward-level DMCs have been formed yet.

Standing Committees (SCs): The municipality has 17 Standing Committees, each covering a specific subject, with 6 members, except for the Women and Children Committee, which has 11 members. These committees review project proposals and provide recommendations to the council.

Training for Staff: Municipal staff have participated in a few government and donor-funded training sessions, but no training needs assessment has been conducted. Most training opportunities remain issue-based and limited in scope.

2.8 Ecological Resources

The terrestrial floras in the Kushtia Municipality are typically observed in roadside and homestead forestry areas. Some of these grow naturally, while most have been imported. Generally, terrestrial flora is a complex ecosystem where wildlife develops direct relationships through their ecological niche. The faunal diversity in the region comprises typical amphibians, birds, reptiles, fish, and mammals found throughout the rest of the country. However, no protected area or reserve forest/biodiversity conservation areas exist in and around the town.



Map 4: *Critically underdeveloped LICs of Kushtia Municipality (2024)*

2.9 Baseline Condition

2.9.1 Poverty Scenario

The UPSM study (2019) shows that LICs are widespread throughout the Kushtia Municipality. Altogether, there are 226 LICs in the town that are critically underdeveloped; refer to **Map 4** for the locations and distribution pattern of these LICs. A total of 53,265 people (Male-26,951 and Female-26,315) live in 14,474 households across the 226 critically underdeveloped LICs in 21 wards of Kushtia Municipality, meaning more than one-fifth (23.39%) of the total population of the town lives in these LICs.

Residents live in distressed conditions, characterized by poor access roads, inadequate drainage, irregular waste collection, unreliable piped water, insufficient toilets, dim streetlights, limited employment opportunities, and inadequate social services.

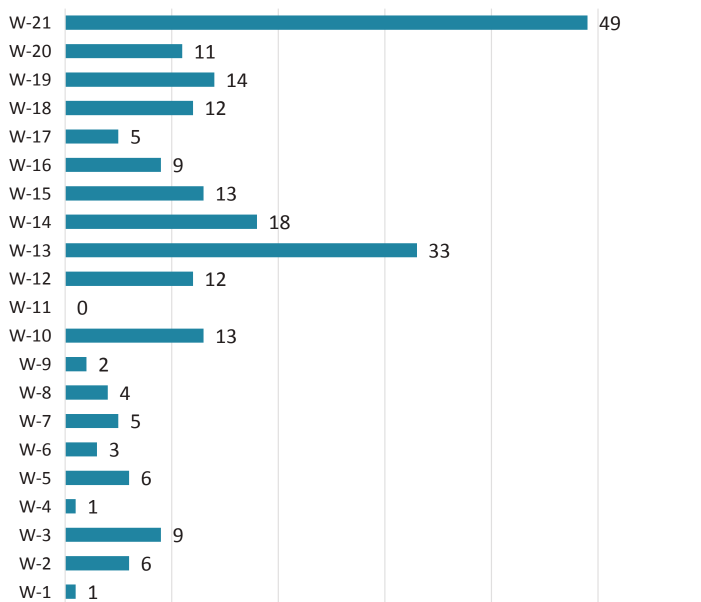


Figure 5: *Number of LICs by ward*

However, access to electricity, income level, tenure security, and school attendance are comparatively better.

Approximately 61.04% of the total LIC population resides in the new wards (13–21), while 38.96% reside in the old wards (1–9), indicating that most low-income residents are concentrated in the newer parts of the municipality (see Figures 5 and 6).

2.9.2 Water Supply

Kushtia's main surface water sources include the Padma, Gorai, and Kaliganga rivers, along with several canals, ponds, and small depressions. The groundwater level naturally drops to around 6 meters during the dry season and returns to normal before the monsoon, as reported by DPHE.

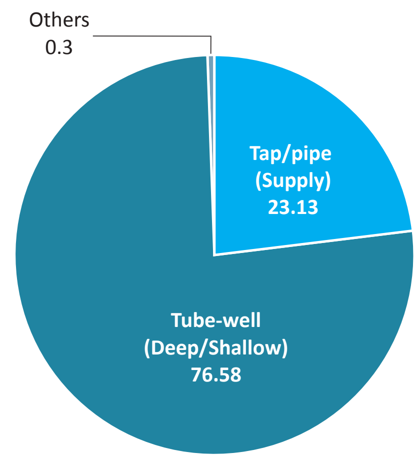


Figure 6: *HHs by main source of drinking water*

Most households (76.58%) rely on deep or shallow tube wells for drinking water, while 23.13% use the piped water supply, and only a few depend on bottled, well, or surface water sources (Figure 7) (AIIB, 2023). The municipal authority provides piped water through a system comprising 3,660 hand tube wells, 22 deep tube wells, 3 treatment plants, 4 overhead tanks, and 3 reserve tanks, with a total supply of about 14 million litres per day through 181 km of pipelines. The service covers 18 wards (excluding wards 13, 17, and 20) and delivers approximately 120 litres per person per day, which is below the GoB standard of 180 litres per capita per day. Water is available for only 2–3 hours daily, and most LIC areas still lack access to piped water or shared water points.

2.9.3 Solid Waste Management

Primary Collection and Transportation: The municipality generates approximately 110 tons of waste daily, projected to increase to 185 tons by 2045. Around 50% of waste is collected through door-to-door service, covering 14 of 21 wards, while LIC areas remain unserved. Many residents dispose of waste in vacant spaces, open drains, or low-lying areas near settlements (AIIB, 2023).

Secondary Collection and Transportation: There are two secondary transfer stations, but sorting is done manually and inefficiently. The municipality collects about 63 tons daily, with an overall collection efficiency of 51%. The remaining 49% of waste remains uncollected, contributing to environmental pollution and waterlogging during monsoons.

Waste Processing and Disposal: Currently, all the collected waste is disposed of at Majhidanga in an uncontrolled manner. A composting plant processes part of the waste, but it requires repair and maintenance as it was built over 15 years ago.

Street Sweeping and Drain Cleaning: The municipal conservancy section employs workers for street and drain cleaning. Waste removed from drains is left to dry along the roadsides before being collected for final disposal.

2.9.4 Sanitation and Wastewater

Sanitation: Most households (99.14%) have access to toilet facilities, whereas only 0.80% use raw/open/hanging latrines and 0.06% have no access to latrines; refer to **Figure 8**. Again, 82.27% of the households use separate toilets and 17.73% use shared toilets; refer to **Figure 7**.

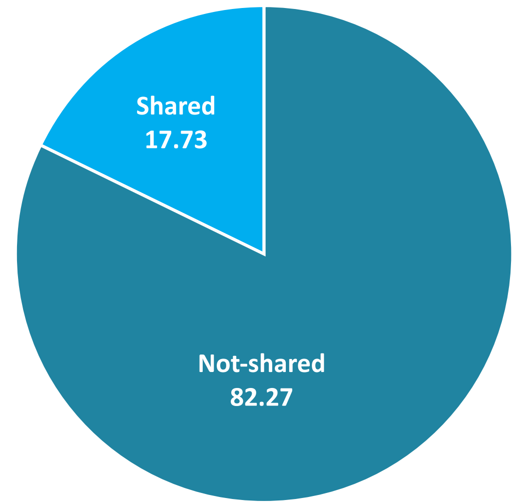


Figure 7: *Percent of general households by type of toilet use*

Wastewater: The municipality has about 44% septic tanks and 54% pit latrines as sanitation containment coverage. The soak pit cannot function during the rainy season as the water table remains very high. There is an on-site sanitation system with a Vacutug service for sludge collection and transportation. It has one FSTP for treating collected Fecal sludge from on-site sanitation. However, it has no sewerage line installed within its municipal area. The municipality has an 18 KL capacity drying bed in its FSTP for treating percolates from the drying beds. The dewatered sludge from the drying bed is used to produce co-compost in the compost plant located within the FSTP. The co-compost plant has been operational since 2012. However, Kushtia Municipality has no grey water management system. All the grey water is discharged into the open municipal drains.

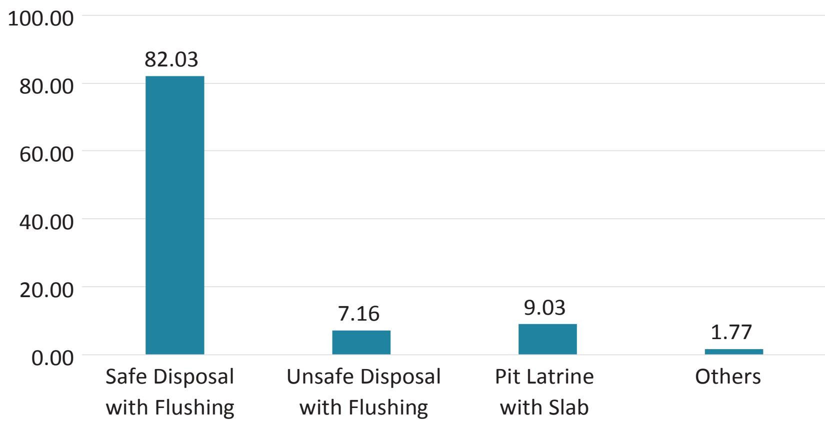


Figure 8: *Percentage of general households by toilet facility*

Source: BBS District Report for Kushtia, 2022.

2.9.5 Drainage

Kushtia Municipality has a limited and largely open drainage system, resulting in frequent disposal of solid waste into drains, which leads to clogging and reduced drainage efficiency. During heavy rainfall, these blocked drains often overflow, resulting in severe waterlogging across the town. The municipality's 229 km drainage network includes 69.64 km of primary, 76.65 km of secondary, and 79.51 km of tertiary drains, covering both natural and man-made channels (Annexure 1 Table 1).

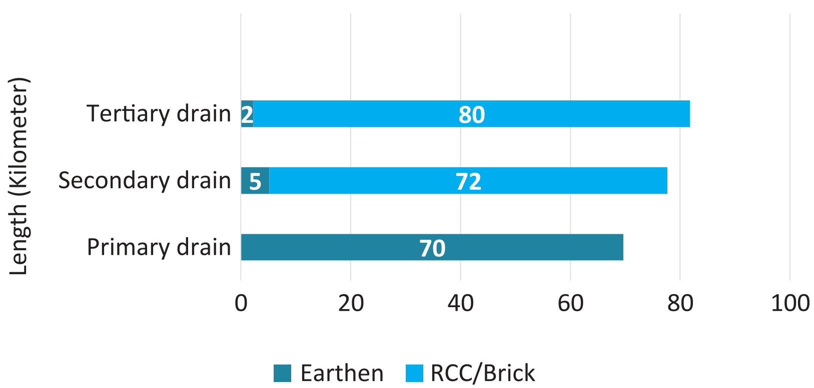
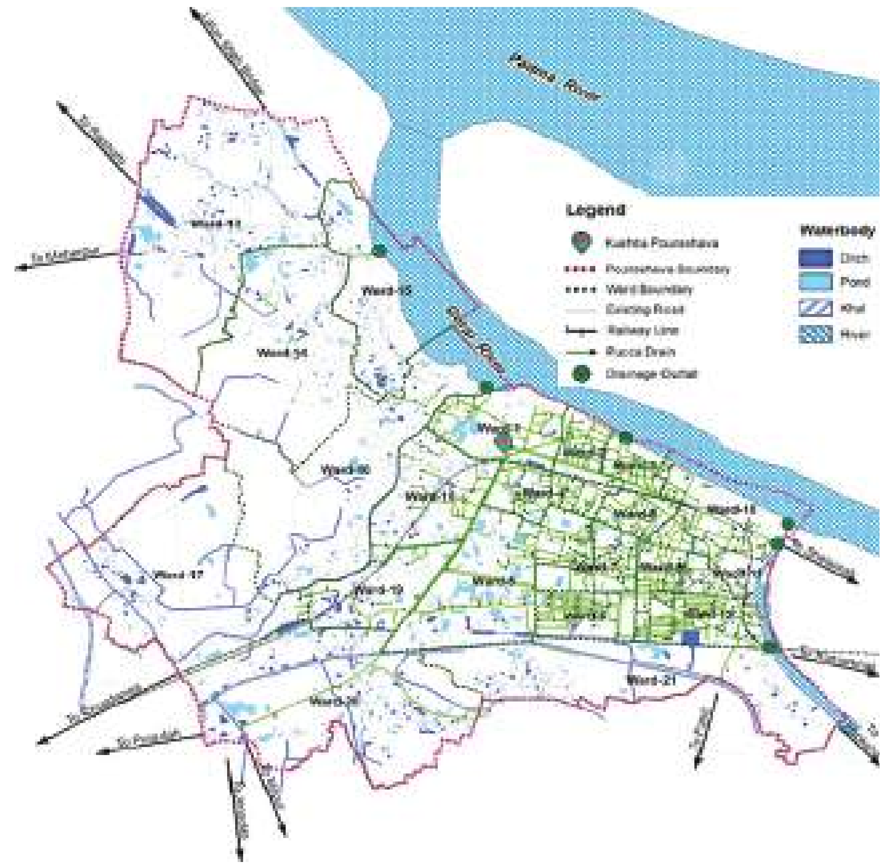


Figure 9: *Drainage system classification of Kushtia municipality*

The secondary and tertiary drainage systems primarily cover the town's core area and consist mainly of RCC or brick drains, with a few earthen sections.

However, discontinuous links and improper slopes in several parts of the network often lead to drainage backflow (LGED, 2017).



Map 5: *Drainage netwrok of Kushtia Municipality*

Drainage in most areas follows a gravity flow toward the Gorai River, the main outfall that carries wastewater and storm runoff from central Kushtia. In the fringe areas, wastewater is discharged into ditches or family pits, while the older parts of the town have discontinuous roadside drains that often cause backflow. The drainage network also connects to several natural canals and outfalls, including the Kaliganga River, Fulbaria, Manna, Goral, and Kushtia Main Canals, along with DRBP, GK Khal, GPA Khal, Baradi Vagar lowland, Taki Mari Beel, and Mora Gorai.

2.9.6 Housing Condition

The housing condition of Kushtia municipality represents three types of information: (a) land used for residential purposes, (b) ownership status of the houses, and (c) structure of the main dwelling houses (BBS, 2022).

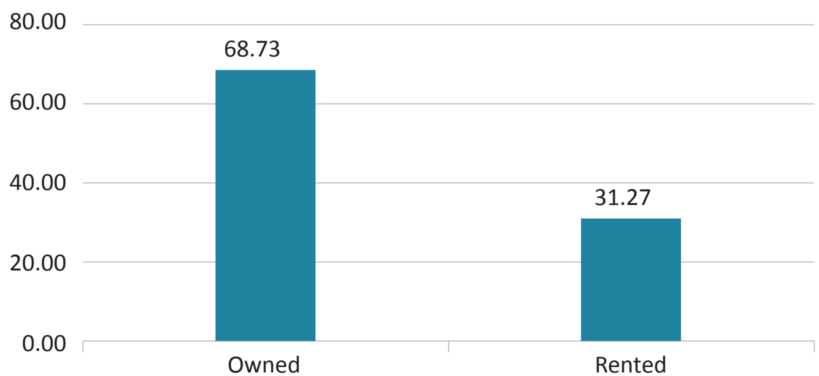


Figure 10: *Percentage distribution of HHs by ownership of dwelling*

(A) Land used for residential purposes: The residential and homestead land use category occupies 37.51% of the municipality's total land, the town's highest single land use category. **Figure 12** shows that, among all wards, Ward No. 11 has the least amount of land (approximately 1%) under this category, whereas Ward No. 20 and 13 have the highest amount (about 10%).

(B) Ownership status of the houses: The majority (68.73%) of the households live in their own dwelling units, whereas the remaining 31.27% live in rented dwelling units; refer to **Figure 10**.

(C) Structure of the dwelling houses: More than half (50.50%) of the dwelling houses in the town are pucca, followed by 28.79% semi-pucca houses, 20.64% Kancha houses, and 0.07% jhupri houses; refer to **Figure 11**.

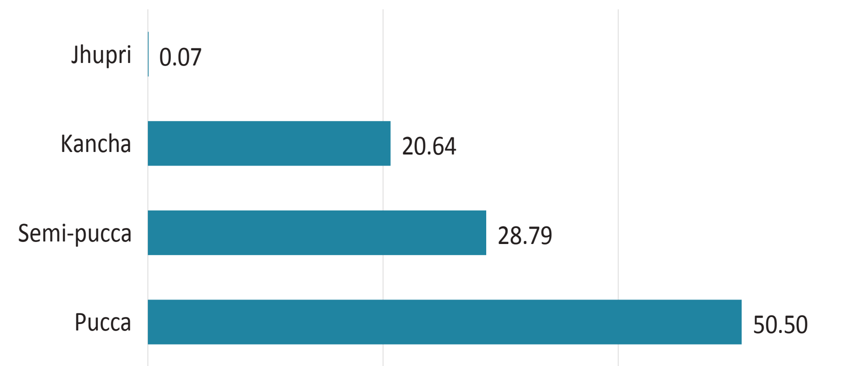


Figure 11: *Percentage distribution of dwelling units by structure type*

Source: BBS District Report for Kushtia, 2022

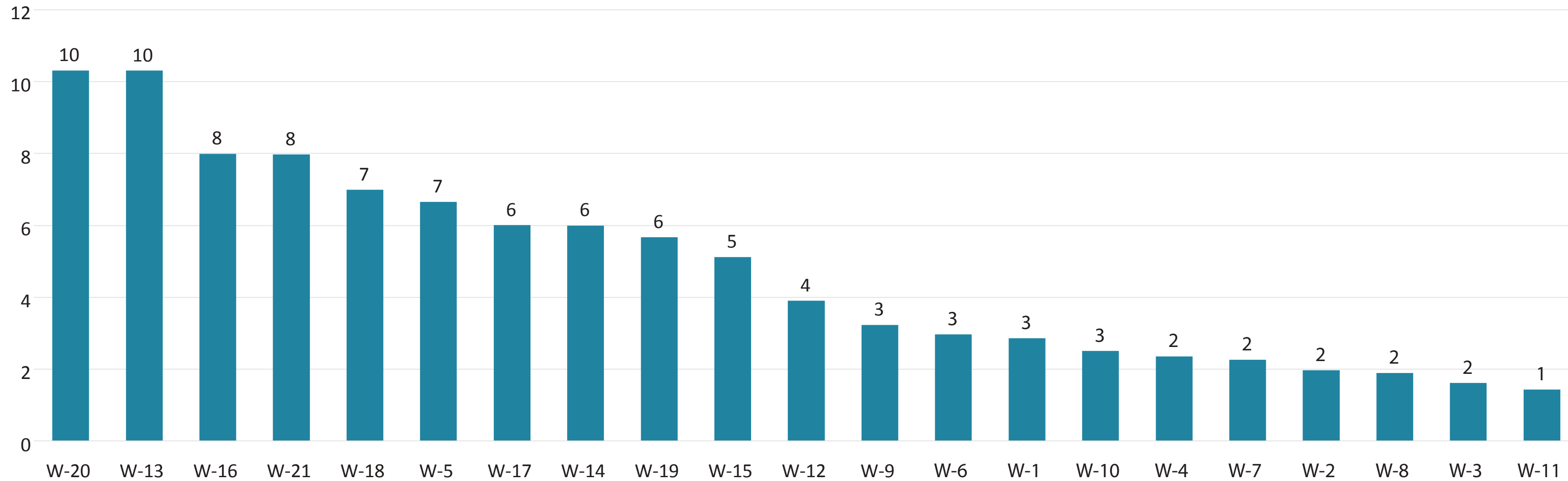


Figure 12: *Percentage distribution of residential land use by ward*

2.9.7 Transportation System

Kushtia town possesses multi-modal communication networks connected with the country's other regions. The networks are managed through highways, railways, and waterways (AIIB, 2023) (Figure 13).

(A) Roadway: The municipality has a total of 436.85 km of road, out of which a major portion (59.46%) is Pucca, followed by Kancha Roads (31.99%) that mostly lie in the urban periphery area, and Semi-pacca (8.55%) Roads that are broken and Herring Bone Bond (HBB).

(B) Railway: The railway line that runs through Kushtia Municipality connects the southern part of the country to the northern part. There are three railway stations – Kushtia Court Station, Jogotee Rail Station, and Kushtia Boro Station. Besides, the line is connected with the capital city of Dhaka. The rail line crosses 8-10 points of the municipal core areas, creating significant traffic jams.

(C) Waterway: The Padma River flows adjacent to the Kushtia Municipality, and its distributary rivers – Gorai and Kaliganga River flow through Kushtia. There is a ghat in ward no. 10 named Ghorar Ghat, located near Boro Bazar Railway Station. Another one is Jagessor Ghat, which is comparatively less busy and less used than Ghorar Ghat.

2.9.8 Electricity and Communication

Electricity: Kushtia Municipality enjoys excellent electricity coverage. In the town, 99.86% of households have access to electricity, whereas only 0.14% have no electricity connection. Of the total households, 99.86% get electricity from the national grid, 0.04% from solar power, and 0.03% from other sources; refer to **Table 3**. Electricity is mainly provided by PDB and REB in Kushtia Municipality. There are 6,500 electric poles and 6,000 street lights in the town. Besides, there is only one high-voltage electric pole. Uninterrupted electricity should be ensured for better industrial development in the city (LGED, 2017).

Table 3: Percentage of households by main source of electricity

Percentage of Households by Main Source of Electricity			
National	**Solar**	**Others**	**No electricity**
99.86	0.04	0.03	0.14

Source: BBS District Report for Kushtia, 2022

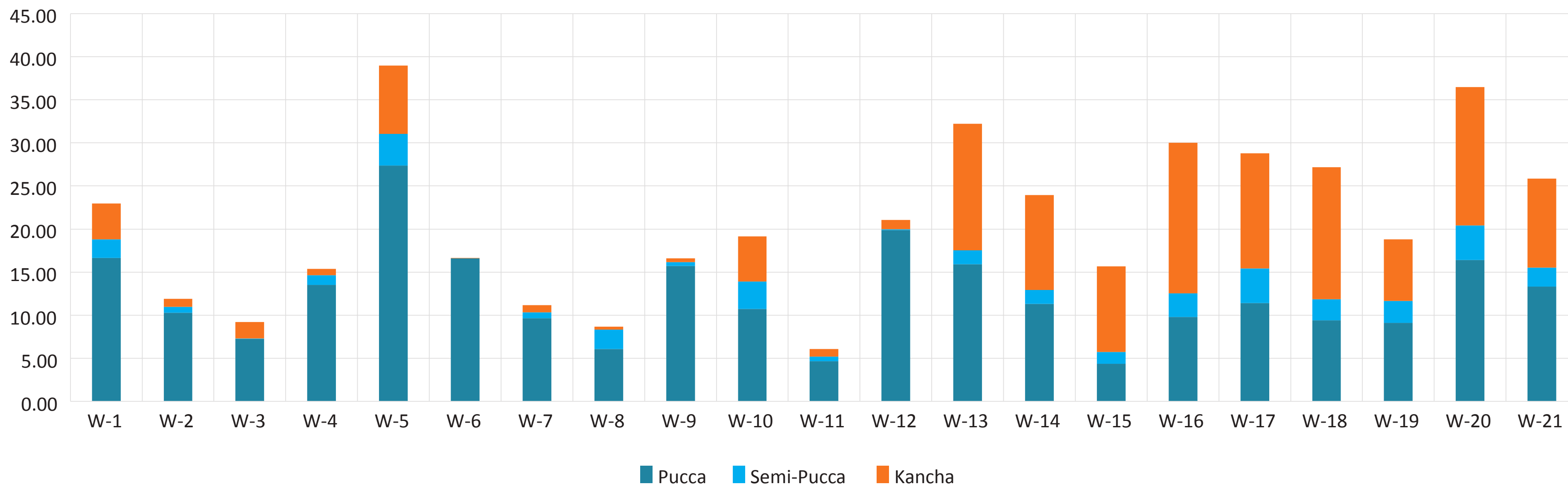


Figure 13: *Percentage distribution of roads by ward*

Source: Kushtia Paurashava Master Plan (2017-2037)

3. CLIMATE RISK: NATIONAL VS KUSHTIA

This chapter is based on the "Climate Risk Country Profile: Bangladesh," published by The World Bank in 2024, which provides information on the current and projected impacts of climate change on Bangladesh, specifically the Khulna Division, including Kushtia.

1. **Climate Type:** Bangladesh has a moist, humid, tropical monsoon climate (average mean temperature of 25.71°C) with one rainy and dry season (2,174.10 mm annually), influenced interannually by the El Niño Southern Oscillation (ENSO) and Indian Ocean Dipole (IOD).

2. **Temperature:**

	National Level		Khulna	
	Max	**Min**	**Max**	**Min**
Warmest May - June	32.01⁰C	25.49⁰C	34.53°C	25.26°C
Coolest January	25.26⁰C	12.31⁰C	25.84°C	12.41°C

Between 1991 and 2020, the mean temperature increased by 0.16°C per decade at the national level and by 0.11°C in the Khulna region. Khulna also records the highest number of high-heat days annually, primarily due to its geographical setting and rapid urbanization, which have contributed to reduced vegetation cover and greater heat retention.

Projected Temperature:

- 2020-2039: Will increase by 0.41°C (–0.19°C, 0.76°C) from the historical reference period to 26.03°C (25.26°C, 26.65°C)
- 2040-2059: Will increase by 0.89°C (0.45°C, 1.70°C) from the historical reference period to 26.59°C (25.78°C, 27.56°C).

Extreme Heat Risk

By midcentury, Bangladesh is expected to face higher day and night temperatures, along with more intense heat due to greater moisture in the air.

Days with Heat Index above 35°C:

- **2020–2039:** Around **99.66 days per year** (range: 55.70–129.48)
- **2040–2059:** Increases to about **133.47 days per year** (range: 85.88–172.12)
    - **Regional trends:**
        - **Southern coastal areas:** Will see the biggest rise in very hot days, especially during the **pre-monsoon** (spring) season.
        - **Northern and eastern floodplains:** Will face the highest increases during the summer months.
    - **Days with Heat Index above 41°C:**
        - **Western regions (including Khulna):** Will be most affected, with extremely hot days increasing by about **one month (≈31 days)** each year by midcentury (range: 10.33–75.56).

3. **Precipitation:**

(A) National Level (1971–2000):

- Mean annual precipitation: **2,174.10 mm**.
- **Regional trends:**
  - **Eastern divisions:** Drier annually, especially during spring pre monsoon months.
  - **Western divisions:** Wetter annually, particularly in post-monsoon fall months.

Projections (SSP3-7.0):

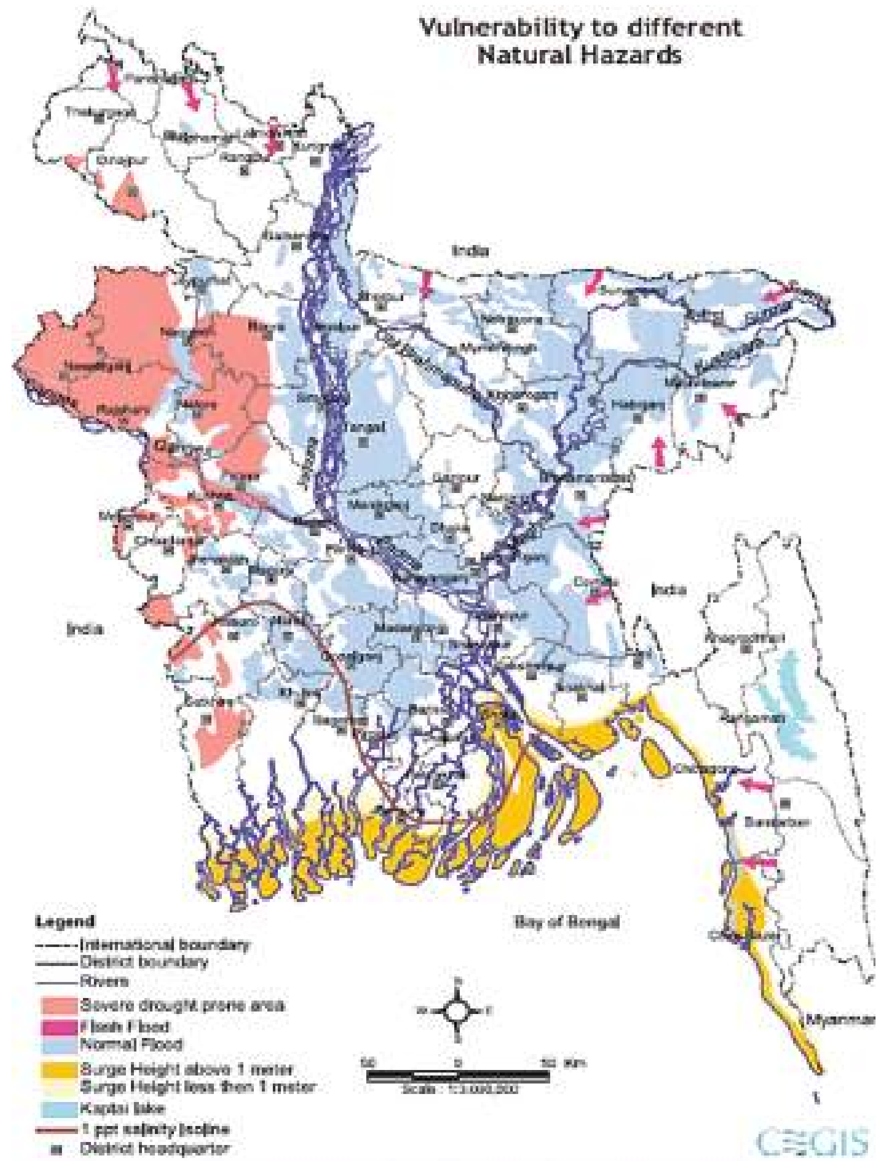
- Overall annual precipitation expected to increase by midcentury, with regional and seasonal variability.
- **Southern divisions:** Decrease in 2020–2039, mainly in pre-monsoon months.
- **Northern divisions:** Highest increase by 2040–2059, during monsoon months.
- **Central region (Dhaka):** Minimal annual change, with a slight overall rise.

(B) Khulna Region (1971–2020):

- **Largest decadal increase:** +27.79 mm per decade.
- **Projected rainfall:**
  - **2020–2039:** 1,779.82 mm (range: 1,455.86–2,155.74 mm).
  - **2040–2059:** 1,812.95 mm (range: 1,435.91–2,306.12 mm).

Precipitation Intensity & Risk (2040–2059):

- **Average largest 5-day rainfall:** Increase by 24.96 mm (97.20 to 143.48 mm).
- Greater flood risk due to more intense rainfall events.
- **Northern divisions:** Most significant rise in extreme 5-day and 1-day rainfall events; 100-year events may recur every ~58 years, heightening flood and infrastructure risks.



Map 6: *Bangladesh's Climate-Related Hazards*

4. **Climate-Related Hazards:**
   - Sea level rise and inundation will increasingly threaten Bangladesh's **deltaic coastal zones**, causing a significant retreat of the coastline by the end of the century without mitigation measures.
   - The frequency and intensity of flooding **along major river systems** and droughts in the **northwest divisions** have increased and will likely continue to persist.
   - Climate variability can exacerbate Bangladesh's moderately high seismic risk conditions. Earthquake and landslide hazards pose the greatest risk **along the northern and eastern borderlands**.

Khulna's climate exhibits a clear rise in average temperature over time, characterized by more frequent hot days and warmer nights. Alongside shifting rainfall patterns, its coastal location and urban growth make the area more vulnerable to heat stress, waterlogging, and salinity intrusion. These trends underscore the need for improved urban planning, increased green spaces, and enhanced climate adaptation measures to foster resilience for the future.

4. GREENHOUSE GAS (GHG) EMISSION INVENTORY

To assess the greenhouse gas emissions from the municipal services provided by the Kushtia Municipality, the following activities have been identified:

i) Street lighting;

ii) Electricity consumption by public buildings owned by the municipality;

iii) Fuel consumption by municipal vehicles;

iv) Fuel consumption by waste management vehicles;

v) Solid waste generated within the municipal boundary;

Data for the 2020-21, 2021-22, 2022-23, and 2023-24 financial years, including electricity consumption, fuel consumption, and solid waste generation, have been collected and analyzed. The greenhouse gas emissions from the activities mentioned above have been calculated using the IPCC Guidelines (2006). Collected data from the municipality is shown in Table 4:

Table 4: Fuel Consumption, Electricity Consumption, and Solid Waste Generation Data

Sl No	Source	2021	2022	2023	2024
1	Fuel Consumption of Vehicles (Excluding Waste Management) (Liters/year)	11,793	20,762	17,963	15,789
2	Fuel consumption for Vehicle (Waste Management) (Liters/year)	51,787	41,557	39,298	61,403
3	Electricity Bill (General Head) (kWh/year)	204,960	226,437	206,605	439,328
4	Electricity Bill (Water Head) (kWh/year)	551,909	609,742	556,338	1,183,006
5	Electricity/Others (kWh/year)	268,363	522,593	247,845	897,867
6	Solid Waste Generation (tons/year)	33,215	35,405	37,960	40,880

Source: Kushtia Municipality, 2024

Based on the data mentioned above, the GHG emissions of Kushtia Municipality are presented in Table 5.

Table 5: Table CO_2 Emissions from Different Sources in Kushtia Municipality

CO_2		Y2021		Y2022		Y2023		Y2024	
		(Tons/Year)	% of total emission	(Tons/Year)	% of total emission	(Tons/Year)	% of total emission	(TonsYear)2	% of total emission
Fuel Used by vehicle	Excluding Waste Management	31.7	0.42	55.8	0.46	48.3	0.30	42.5	0.22
	Waste Management	139.3	1.84	111.8	0.92	105.7	0.67	165.1	0.84
Electricity	General Head (Tons/Year)	136.68	1.81	151.42	1.25	138.42	0.87	294.32	1.51
	Waster Head (Tons/year)	369.77	4.89	408.53	3.36	372.74	2.35	792.61	4.05
CO2 Emission from SWM		6885	91.04	11434	94.02	15191	95.81	18259	93.38
Total CO2 Emission		7562.45		12161.55		15856.16		19553.33	

Table 5 shows that the solid waste sector is the largest contributor to greenhouse gas emissions in the municipal services provided by the Kushtia municipality. Figure 14 illustrates the trend in CO2 emissions in Kushtia Municipality (in tons per year). To reduce emissions from the solid waste sector, the following interventions, as shown in Figure 15, may be considered.

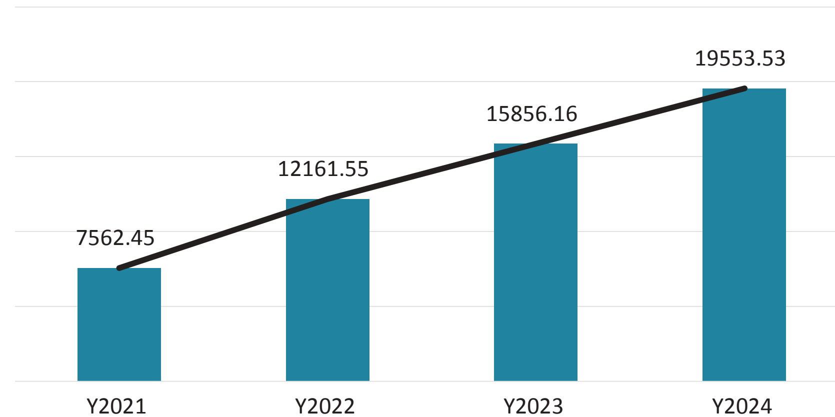


Figure 14: *CO_2 Emission Trend in Kushtia Municipality (Tons/Year)*

Separation, collection and Transportation

- Segregating waste at source
- Imposing collection fee
- Increasing collection coverage
- Banning open burning of waste
- Optimizing collection routes
- Use of cleaner fleet for primary collection and transportation of waste

Disposal

- Legacy waste management
- Diverting organic waste from dumpsites and landfills
- Imposing landfill fees and bans
- Energy recovery from landfills

Recycling

- Integrating the informal recycling sector
- Requiring the use of recyclable materials
- Establishment of EPR

Treatment

- Appropriate capacity of treatment facility
- Improving O&M
- Emission reduction (reporting and verification systems)

Figure 15: *Probable Interventions to Reduce GHG Emission*

5. METHODOLOGY OF CLIMATE VULNERABILITY ASSESSMENT OF KUSHTIA MUNICIPALITY

The methodology for assessing municipal vulnerability under this Climate Action Plan follows two primary approaches. One approach focuses on adapting to the hazard, and the other focuses on mitigation.

5.1 Vulnerability Assessment Using Secondary Sources

A comprehensive vulnerability assessment of Kushtia Municipality was conducted using satellite imagery to analyze key climatic parameters, such as rainfall and temperature, identifying wards most exposed to extreme weather events. For this assessment, satellite images have been collected from reliable sources, including the USGS (United States Geological Survey), CRU (Climatic Research Unit), and the Center for Hydrometeorology and Remote Sensing (CHRS). Satellite observations overcome gaps in station-based weather data, providing insights into local variations and supporting detailed comparisons at the ward level.

5.1.1 Development of Overlay Analysis of Vulnerability Assessment

A comprehensive climate action plan requires a detailed analysis of land use, temperature fluctuations, rainfall patterns, and flood vulnerability to pinpoint urban areas most susceptible to climate extremes. These four factors provide a holistic view of a region's exposure to climate-related risks.

5.1.1.1 Land Cover Classification and Land Use Change

Land use and land cover (LULC) classification is crucial for assessing climate vulnerability in urban areas, as it reveals how natural and human-modified landscapes evolve over time. The conversion of green spaces to built-up areas intensifies waterlogging and exacerbates the urban heat island effect. Using GIS-based satellite imagery analysis, we prepared LULC maps for Kushtia Municipality, identifying wards affected by deforestation, urban expansion, or other land cover changes, and highlighting areas most vulnerable to climate hazards.

5.1.1.2 Land Surface Temperature Map:

Rising temperatures are a direct impact of climate change, causing frequent heatwaves that threaten public health, strain energy systems, and exacerbate environmental degradation. Using satellite-derived data, Land Surface Temperature (LST) maps for Kushtia Municipality have been prepared to assess spatio-temporal temperature dynamics and identify wards most exposed to extreme heat. This Ward-wise LST mapping guides municipal climate planning by identifying priority areas and supporting targeted heat mitigation strategies.

5.1.1.3 Rainfall Map

Climate change is altering rainfall patterns, resulting in more frequent and intense rainfall events over shorter periods. Such heavy rains increasingly overwhelm drainage, causing frequent flash floods and waterlogging that threaten urban infrastructure and public health. Hence, local rainfall data is essential for identifying vulnerable areas. Using satellite imagery, a rainfall map was created to capture spatial variations in rainfall intensity across wards, informing climate adaptation strategies to better manage the impacts of rapid-onset rainfall events.

5.1.1.4 Flood Risk Map

Floods are becoming more frequent and severe, driven by climate change. Sudden upstream rainfall often triggers rapid overflow of rivers and canals, causing damage not only to infrastructure but also to human lives, livestock. A flood risk map was developed using GIS-based analysis of topography, land elevation, rainfall intensity, and proximity to water bodies. This assessment highlights spatial variations in flood vulnerability, identifies high-risk areas, and supports targeted interventions and effective flood protection measures to minimize damage from flood events.

5.1.1.5 Overlaying Secondary Data

To identify areas most affected by extreme climate events in Kushtia Municipality, an overlay analysis was conducted by superimposing land surface temperature (LST), rainfall, and flood risk information. This assessment identified "hotspot" wards with consistently high temperatures, frequent heavy rainfall, and elevated flood risk, highlighting areas of compounded vulnerability. This method also uncovers spatial patterns that might not be apparent when examining each hazard individually. The findings provide crucial guidance for prioritizing adaptation and mitigation, ensuring targeted interventions in areas that are vulnerable. This approach strengthens climate resilience by addressing local needs and reducing exposure to multiple hazards.

5.2 Vulnerability Assessment Using Primary Sources (HIGS)

5.2.1 Development of HIGS Framework for Climate Vulnerability Assessment at Ward Level

The HIGS framework supports climate-resilient city planning by identifying where and how cities are most vulnerable. However, urban services and infrastructure are neither uniformly distributed nor equally impacted across the city, so some wards require specific attention. For example, certain areas may have housing predominantly consisting of Kancha and semi-pucca structures, while other wards may need strengthened transportation infrastructure. Similarly, the coverage and quality of critical services such as water supply, sanitation, and solid waste management vary across wards, highlighting the need for ward-specific strategies in the municipal climate action plan.

Therefore, HIGS framework has been adopted and contextualized to assess climate vulnerability at the ward level rather than the broader city level to achieve a more precise, localized understanding of climate risks within the city. Climate vulnerabilities vary significantly from one ward to another due to differences in factors such as land use, socio-economic conditions, and infrastructure quality. While a city-wide approach provides a broad overview, it can obscure critical variations at the

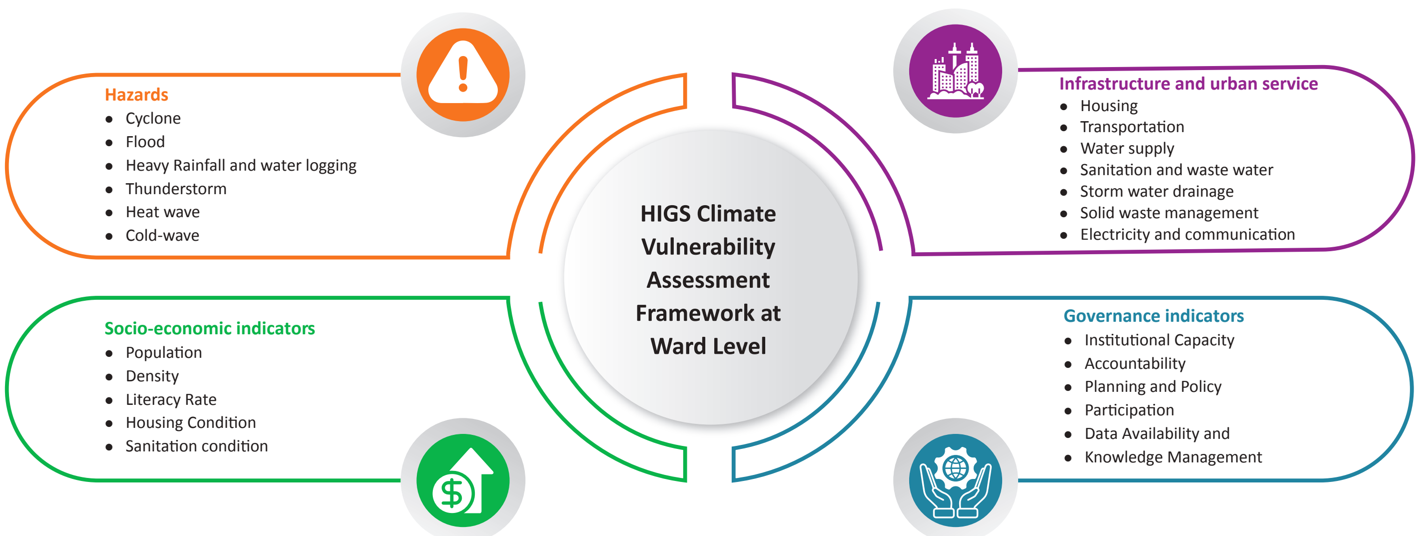


Figure 16: *Components of HIGS Framework*

neighborhood level, where climate impacts may be far more severe or specific. We can identify precise vulnerabilities and tailor interventions by focusing on the ward level. For instance, some wards may require enhanced flood protection infrastructure, while others may benefit from expanded green spaces to mitigate urban heat. This ward-level assessment enables targeted interventions tailored to each ward's specific challenges, enhancing the effectiveness of adaptation efforts.

Using the HIGS framework at the ward level also ensures optimized resource allocation and promotes social equity in climate adaptation efforts. By pinpointing the wards most at risk, municipalities can prioritize investments and interventions where they will have the greatest impact, ensuring that funds are used with maximum efficiency and efficacy. Additionally, this localized approach fosters equity by addressing the unique needs of vulnerable communities that are disproportionately affected by climate risks, such as low-income populations or areas with aging, fragile infrastructure. By adapting the HIGS framework to this level of detail, we create a model for climate resilience planning that is more effective and inclusive, leading to a more resilient and equitable urban landscape.

5.2.1.1 Hazards

The "Hazards" dimension reveals the diverse risks associated with climate change, including cyclones, floods, extreme temperatures, and other climate-induced events. By assessing these hazards at the ward level, we can identify areas that are particularly vulnerable to specific climate threats. As previously mentioned, some wards may be more prone to flooding and waterlogging due to their proximity to rivers or low-lying topography, while others may experience more intense heat waves due to increased built-up areas or a lack of green spaces. Understanding these spatial patterns of hazard exposure is essential for designing targeted adaptation strategies and prioritizing resources in the municipal climate action plan.

The hazards selected for the HIGS framework are cyclones, floods, heavy rainfall and waterlogging, thunderstorms, heatwaves, and coldwaves, which represent the most significant climate-related threats Bangladesh is experiencing nowadays. These hazards are selected following an in-depth review of extreme climatic events over the past 50 years in Bangladesh, focusing on those events that have shown a notable increase in frequency, intensity, or impact due to changing climate patterns. The hazards included were chosen for their prominence in the broader national context and their particular relevance to Kushtia. Data sources, including the Bangladesh Environment Statistics 2020, Bangladesh Disaster-related Statistics 2021, and Weather Atlas, guided the selection process. These sources provide reliable data on historical and current climate trends, offering a basis for identifying which climatic events are most pressing for Kushtia Municipality.

Cyclone

Cyclones are powerful tropical storms that bring destructive winds, heavy rain, and storm surges, often causing severe damage along Bangladesh's coastal and inland regions. While Kushtia is further inland, cyclones can still impact the area by triggering intense rainfall, power disruptions, and structural damage as they move across the country. The growing frequency and intensity of cyclones in recent decades highlight the importance of preparedness for such events.

Flood

Floods are a recurrent hazard in Bangladesh, especially during the monsoon season when rivers overflow and low-lying areas become inundated. Kushtia Municipality, situated near major river systems, is vulnerable to flooding, which can disrupt transportation, damage housing, and affect livelihoods. Increasing rainfall variability and changing river dynamics due to climate change are heightening the flood risks.

Heavy rainfall and waterlogging

This is a common challenge in urban areas, where drainage infrastructure is often inadequate to manage intense rain. In Kushtia Municipality, intense rainfall frequently exceeds the capacity of drainage systems, resulting in prolonged waterlogging that hampers daily activities. With climate change intensifying rainfall events, these disruptions are becoming more frequent, highlighting the need for effective and resilient drainage solutions.

Thunderstorm

Thunderstorms bring sudden bursts of rainfall, lightning, and strong winds, which can cause infrastructural damage and service disruptions. In recent times, thunderstorms have become more frequent and intense, occurring not only during the monsoon season but also in the post-monsoon period, disrupting electricity supply, threatening outdoor activities, and in some cases, causing casualties. Due to their unpredictable nature, thunderstorms pose a constant threat, particularly in densely populated or inadequately sheltered areas.

Heatwave

Heatwaves have become more severe and frequent across Bangladesh as global temperatures rise, impacting both urban and rural communities. Kushtia Municipality experiences intense heatwaves that disrupt daily life, increase energy demand, and threaten public health, particularly affecting vulnerable populations and those without access to cooling. As urban areas expand, the urban heat island effect intensifies these heatwaves, underscoring the need for effective cooling infrastructure and green spaces.

Coldwave

Although less frequent, coldwaves can have severe impacts, particularly during winter and in recent decades when temperatures drop unexpectedly. In Kushtia, cold waves pose health risks to low-income residents and those without adequate shelter, affecting both daily life and economic productivity. With climate shifts, coldwave patterns are becoming less predictable, creating additional challenges for local preparedness.

5.2.1.2 Infrastructure and Urban Services

This dimension focuses on key urban systems that are essential for residents' quality of life and resilience, such as housing, transportation, and water supply. By examining these infrastructures at the ward level, specific vulnerabilities can be identified in each ward's infrastructure. For instance, a ward with inadequate drainage may be more susceptible to waterlogging and flooding during heavy rains, while one with limited water supply services may struggle with drought periods. This analysis enables urban planners to prioritize infrastructure upgrades in the most vulnerable wards, ensuring that investments are directed toward areas with the greatest need.

The Infrastructure and Urban Service component of the HIGS framework includes critical urban systems—housing, transportation, water supply, sanitation and wastewater, stormwater drainage, solid waste management, electricity and communication. These urban systems were selected for their integral role in maintaining urban resilience and are prioritized in climate action planning to address each ward's unique vulnerabilities and service needs. Together, they provide a comprehensive foundation for ward-level resilience, focusing on targeted infrastructure improvements, emergency response capacity, and continuity of services under changing climate conditions.

Housing

Housing provides shelter and stability, forming the core of urban living spaces where people reside and seek safety. Natural hazards have a profound impact on housing, affecting not only the physical structure but also the broader homestead and its associated functions. Damage to homes incurs substantial rebuilding costs and often leads to increased utility expenses, such as reliance on backup power sources or alternative lighting like candles. Beyond the residence itself, residents may suffer loss of property and livestock, furthering their economic burden, while interruptions to utilities disrupt daily life. Hazard-induced displacement, whether temporary or permanent, adds to the risks, with specific safety concerns, including the potential rise in gender-based violence.

Transportation

Urban transportation is a crucial component of a city. The impact of hazards on the transportation system extends beyond just vehicle movement, affecting various critical aspects. Infrastructure damage often leads to high rebuilding costs and operational challenges, disrupting regular maintenance and placing additional strain on transportation networks. Hazards also increase health risks, including physical injuries and mental stress for individuals using or relying on the transportation system.

Water Supply

Water supply vulnerability in Kushtia Municipality extends beyond merely ensuring water reaches residents, encompassing several critical impacts due to natural hazards. Disruptions to maintenance and operational routines can lead to significant service interruptions, particularly when supply routes are impacted. Infrastructure damage from hazards like floods leads to increased repair costs and ongoing challenges for maintaining supply.

Sanitation and Wastewater

The urban sanitation system reveals several common vulnerabilities that become prominent during hazards. These include damage to sanitation and wastewater infrastructure, often resulting in high repair costs and operational disruptions. Flooding of facilities can lead to environmental contamination, exposing communities to untreated sewage and waste, and significantly increasing health risks.

Stormwater Drainage

Stormwater drainage is key to preventing water accumulation and minimizing flood risks in urban areas. Proper drainage management helps protect infrastructure, reduce waterlogging, and maintain safety and accessibility. Climate-resilient drainage planning aims to enhance drainage capacity, manage rainfall patterns, and avoid disruptions.

Solid Waste Management (SWM)

Solid waste management is a critical component of the urban system and is severely affected during hazards, leading to issues such as the discontinuation of waste collection, waste pile-ups, and increased environmental pollution. In this context, the SWM sector faces several challenges, including blockages and overflows at waste disposal sites. Additionally, the increased decomposition of waste, coupled with damage to waste management infrastructure, leads to higher repair costs. Disruptions in waste collection and transportation further complicate the situation.

Electricity and Communication

Electricity and communication systems support daily operations, enable emergency response, and keep residents connected. Reliable energy and communication are critical in emergencies, as they support evacuation, information sharing, and recovery. Climate resilience in this sector includes strengthening power grids and ensuring uninterrupted communication channels during extreme events.

5.2.1.3 Governance

Governance plays a central role in building resilience, as effective policies, planning, and community engagement are necessary to mitigate climate change-related risks. This dimension includes indicators such as institutional capacity, accountability, planning and policy, participation, and data availability and knowledge management. This local-level governance assessment helps identify gaps in the planning and implementation of interventions, including delays in resource allocation and shortcomings in disaster preparedness. These gaps often result in inefficient responses during climate events, leaving vulnerable communities without adequate support or resources. Additionally, the absence of a clear institutional framework and responsibility at the ward level may hinder the implementation of proactive climate adaptation measures. Strengthening governance at the ward level ensures that climate adaptation efforts are not only well-planned but also effectively implemented, ensuring the effectiveness and sustainability of resilience-building initiatives.

5.2.1.4 Socio-economic characteristics

The socio-economic dimension of climate vulnerability assessment focuses on how social and economic factors influence a community's ability to anticipate, respond to, and recover from climate impacts. The socio-economic indicators selected for the HIGS framework include population size, population density, housing conditions, education level, and sanitation conditions, all of which shape a community's resilience. These factors determine the degree of exposure to climate risks and influence the capacity to implement adaptive strategies and access recovery support. For example, infrastructure and services may be overstretched in densely populated areas, reducing the capacity to manage disaster risks effectively.

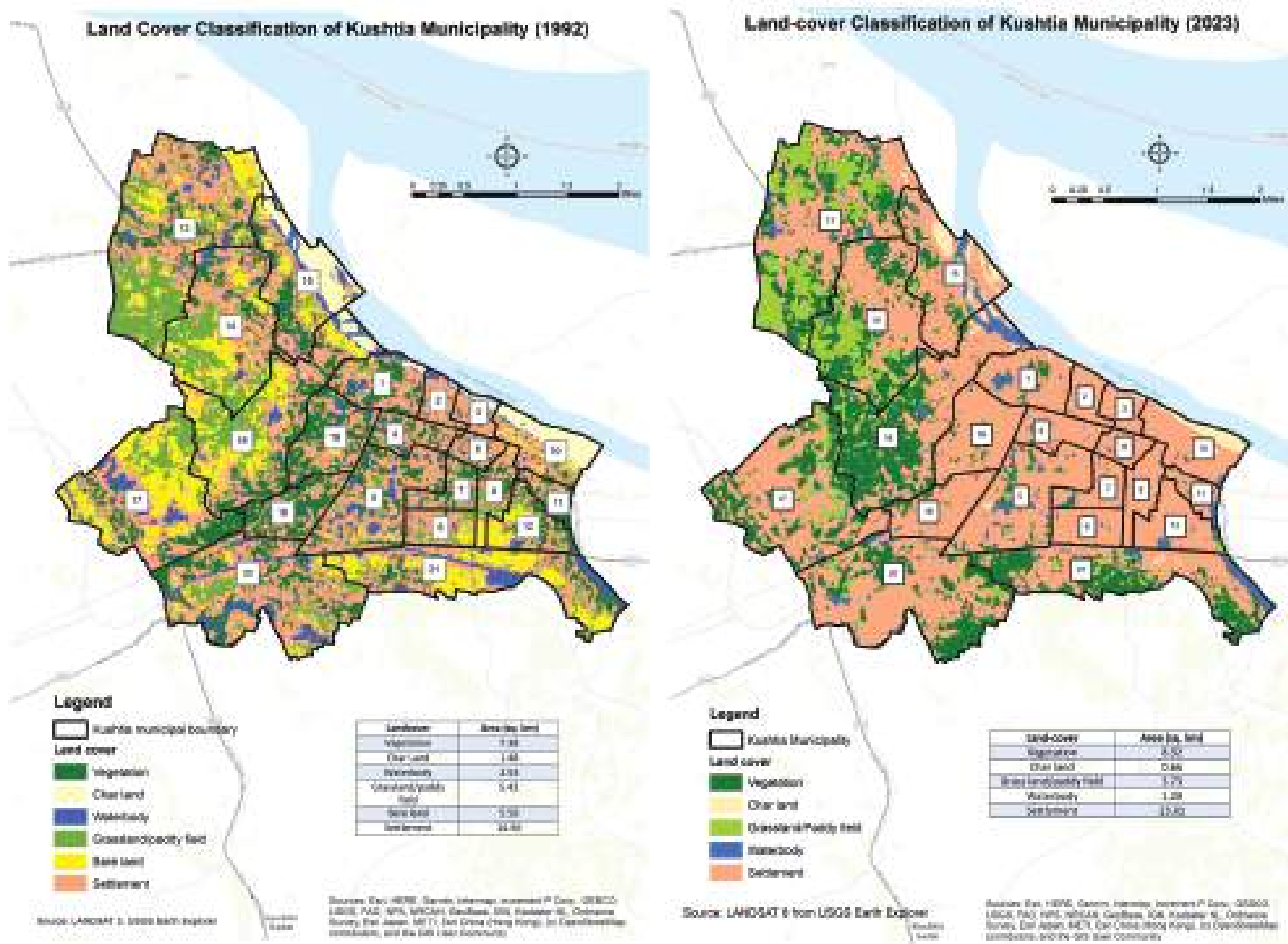
6. VULNERABILITY PROFILE ANALYSIS

This chapter presents the vulnerability profile of Kushtia Municipality, integrating findings from both secondary and primary data sources.

6.1 Ward Climate Vulnerability Profile Using Secondary Data

6.1.1 Land Cover Classification and Land Use Change

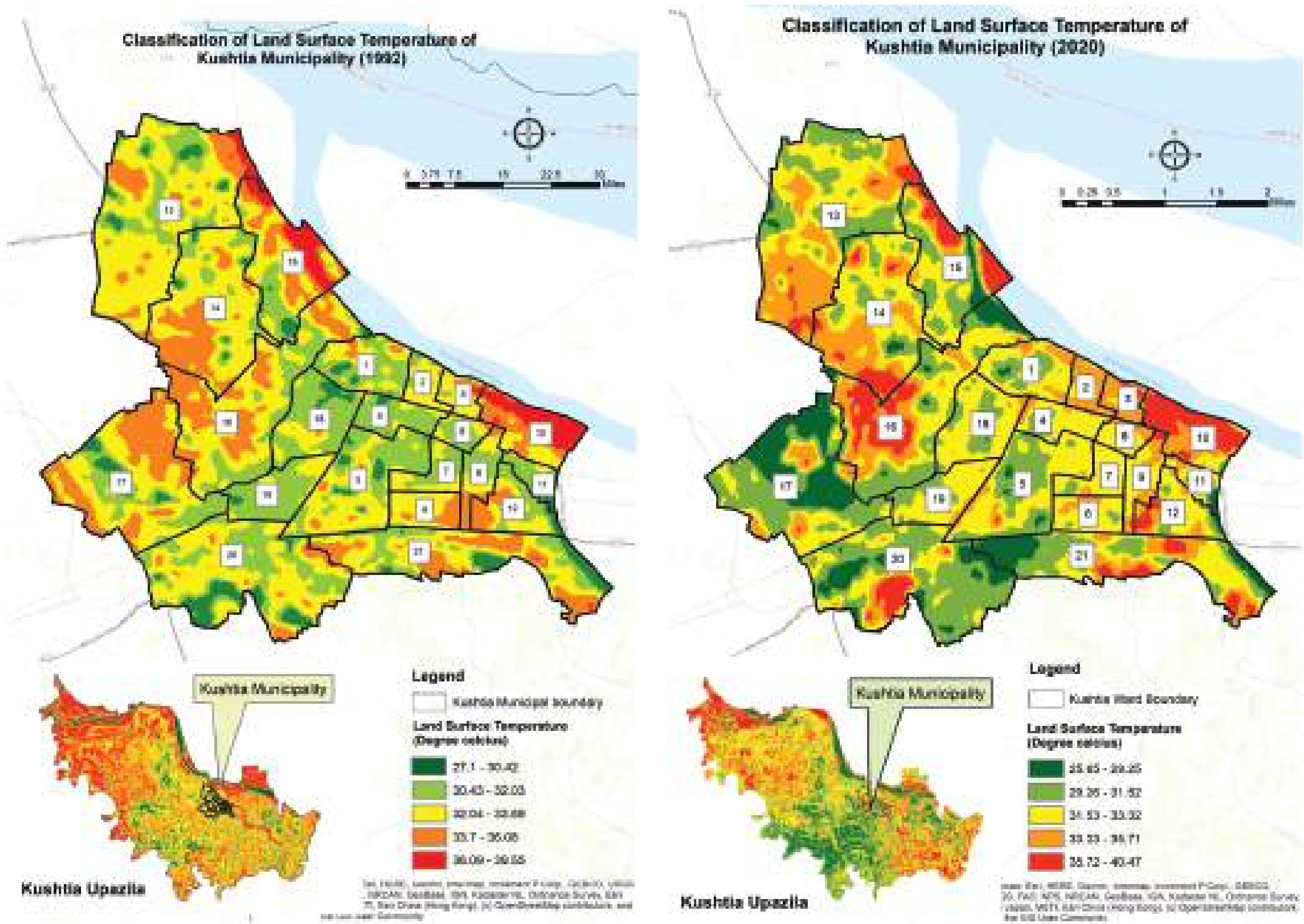
Map 7 illustrates the land cover classification of Kushtia Municipality in 1992 and 2023, respectively, revealing a sharp decline in vegetation (from 20% to 12%) and water bodies (from 2.53% to 1.28%), alongside a significant expansion of built-up areas (from 14.56% to 23.01%). These land use changes have reduced natural resilience, intensifying the urban heat island effect, degrading environmental balance. The decline in vegetation and water bodies weakens the city's ability to regulate temperature, manage runoff, and support biodiversity. Meanwhile, rapid urban expansion increases flood risk, energy demand, and greenhouse gas emissions, underscoring the need for integrated, climate-responsive planning.



Map 7: *Land Cover Classification and Land Use Change from 1992 to 2023*

6.1.2 Land Surface Temperature (LST)

Map 8 presents the variation in land surface temperature across Kushtia municipality for 1992 and 2022, highlighting a significant temperature rise over time. Notably, wards 10, 12, and 16 have experienced pronounced warming, while high-temperature concentration has increased in wards 7, 8, 9, 10, 11, 12, 13, 14, 15, and 16. These patterns indicate emerging heat stress zones, reflecting the municipality's growing vulnerability to urban heat islands and climate change. Such trends can exacerbate public health risks, reduce productivity, and strain local infrastructure and services. Identifying these hotspots is crucial for climate vulnerability assessments, as it helps prioritize areas that require immediate intervention. Incorporating these findings into a climate action plan will support targeted strategies, such as enhancing green cover, improving urban planning, and building heat-resilient infrastructure to mitigate future risks.



Map 8: *Land Surface Temperature (LST) Comparison between 1992 and 2020*

6.1.3 Rainfall

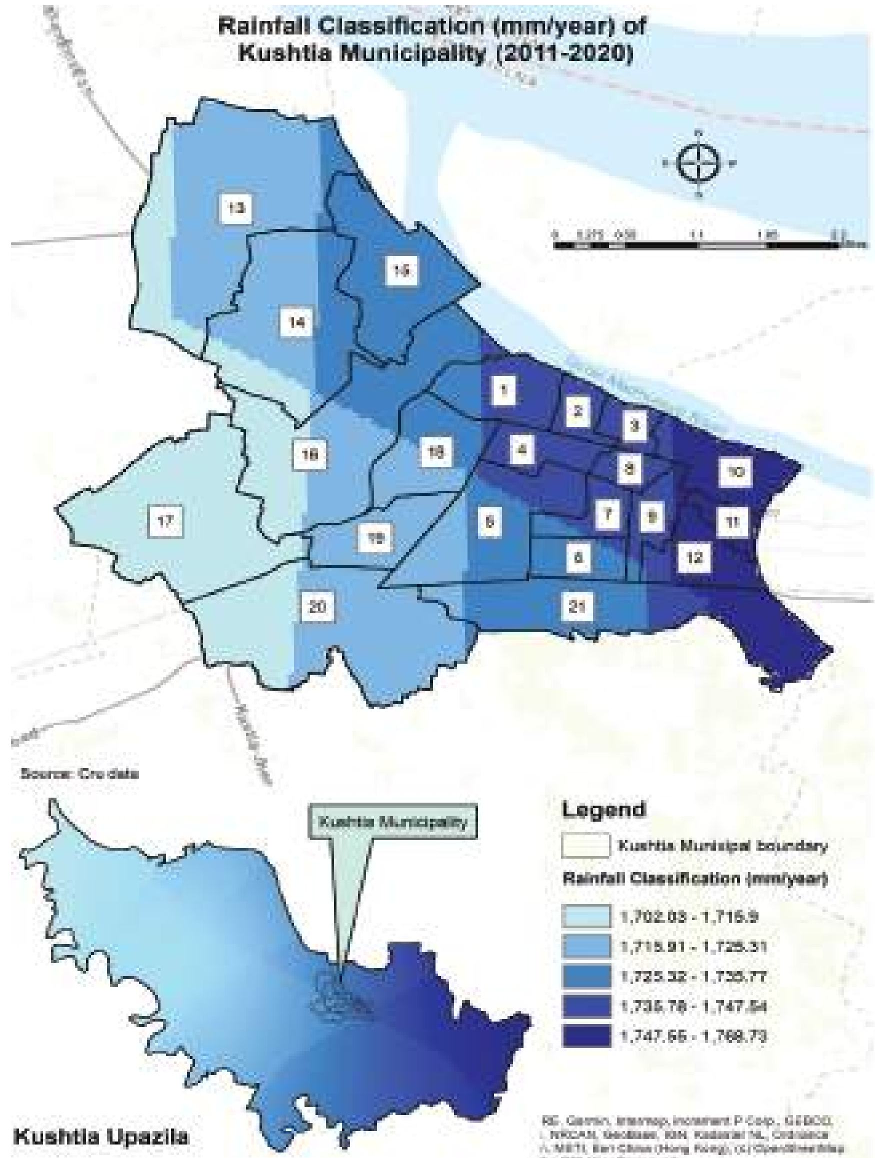
Map 9 presents the spatial distribution of average annual precipitation in Kushtia Municipality over a 10-year period (2011–2020). On average, the municipality experiences 1,735 mm of rainfall annually. Rainfall patterns in Kushtia municipality exhibit a significant geographical gradient, with the southeastern region consistently recording markedly higher precipitation levels.

In the southeastern region, specifically, wards 1, 2, 3, 7, 8, 10, 11, and 12, located primarily in the northern and eastern parts of the municipality, experience the highest annual rainfall. This concentration is likely due to the hydrological influence of the Gorai-Madhumati River and proximity to other water bodies. Consequently, these wards constitute high-vulnerability zones, facing intensified risks of flooding, chronic waterlogging, and systemic drainage failure, which necessitate the urgent deployment of a more comprehensive stormwater management system and resilient infrastructure.

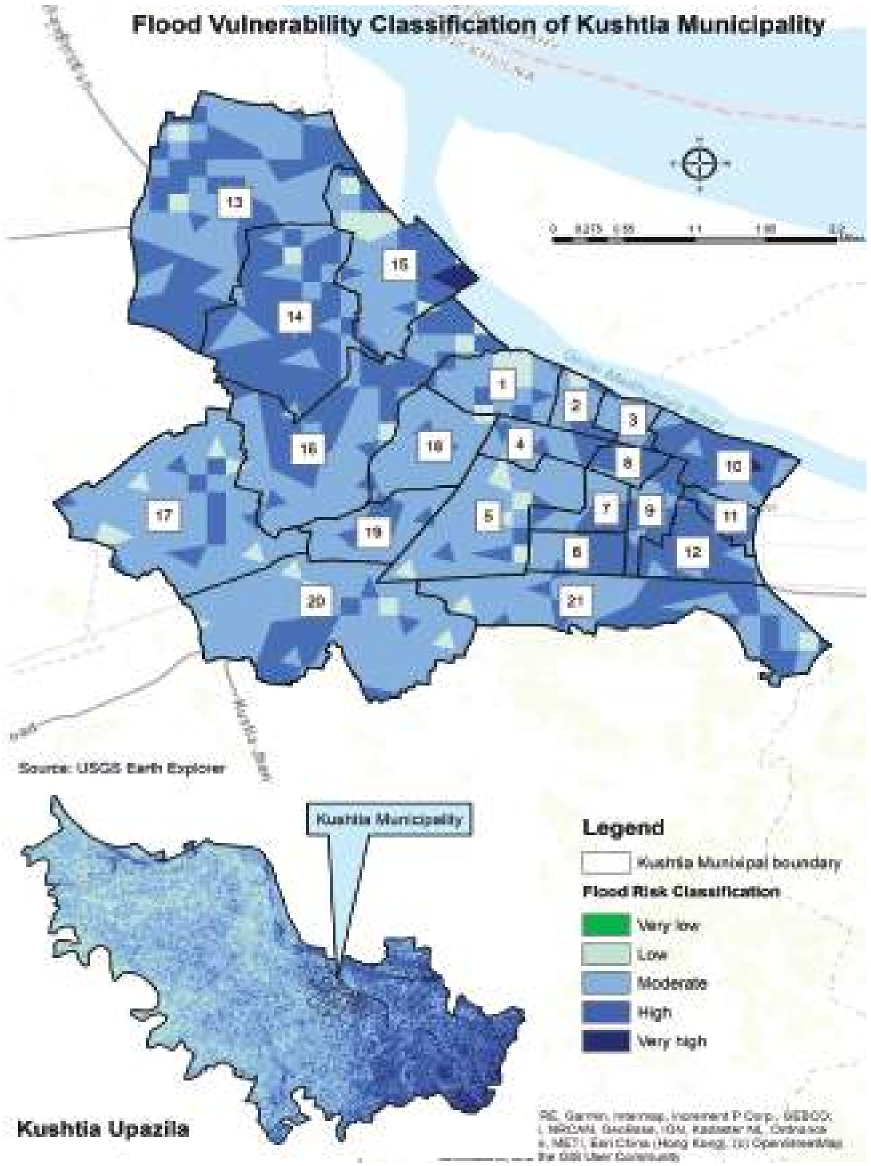
In the western wards of Kushtia municipality, including 17, 13, and portions of 14, 16, and 20, the lowest annual rainfall is recorded, while wards 15, 18, 19, 5, and 21 observe moderate precipitation. This varying rainfall concentration is likely driven by localized microclimatic factors. These microclimatic conditions, influenced by local temperature, humidity, wind speed, solar radiation, terrain, urban structures, and existing vegetation cover, create unique climate conditions at the ward level. Consequently, this regional variation in precipitation significantly affects local drainage management and soil saturation, leading to diverse and localized risks of waterlogging and urban flooding. Therefore, developing ward-level Climate Action Plans is essential to implement targeted interventions such as improved drainage systems, rainwater harvesting, and localized flood mitigation measures to strengthen resilience against uneven rainfall events across the municipality.

6.1.4 Flood Risk

Map 10 clearly delineates the spatial distribution of flood risk within Kushtia Municipality, an essential component for assessing the vulnerability of local populations and critical infrastructure. The analysis identifies two major zones of



Map 9: *Rainfall Classification Map of Kushtia Municipality (2011 – 2020)*



Map 10: *Flood risk map of Kushtia Municipality*

heightened risk: the northwestern section, which includes Wards 14 and 16, and the southeastern section, encompassing Wards 8, 9, 10, 11, and 12.

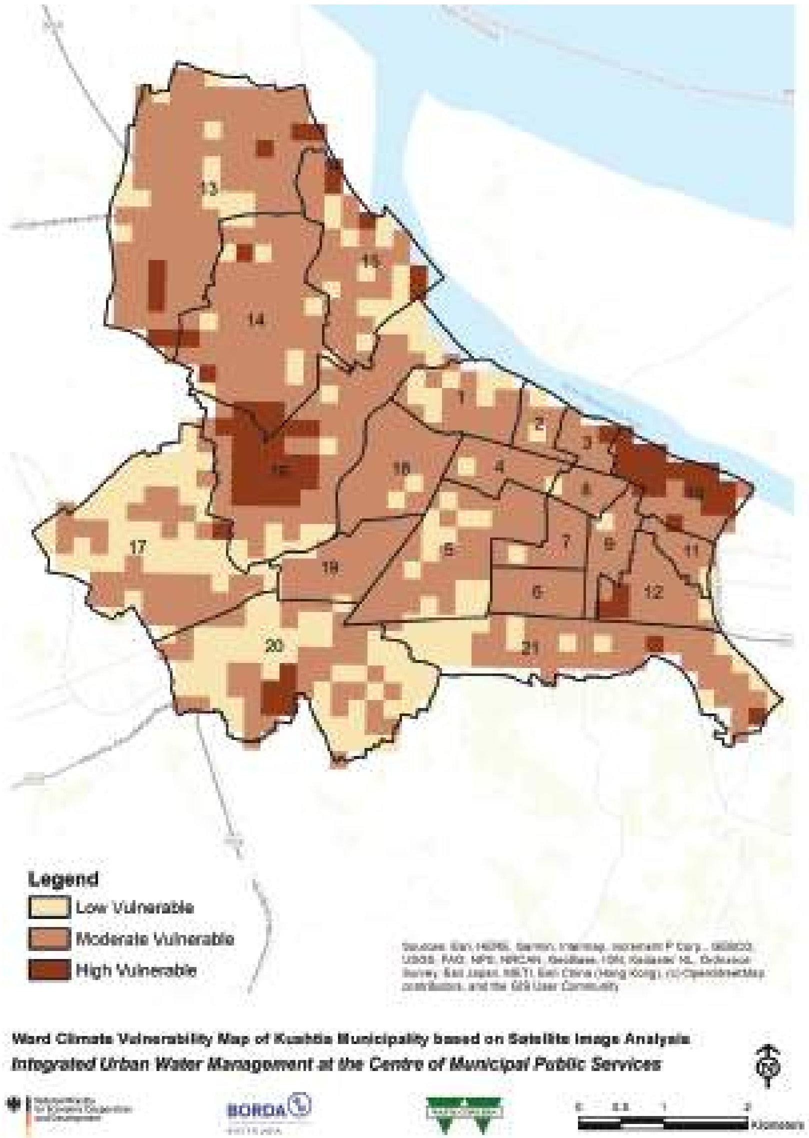
This extreme vulnerability in both regions is fundamentally rooted in a confluence of adverse geographical and hydrological factors. Chief among these is the low-lying topography of these wards, which inherently impedes natural drainage and encourages severe water accumulation. This issue is critically exacerbated by the high concentration of local rainfall and the close proximity of these areas to the Gorai River. Consequently, these wards face increased susceptibility to inundation, not only during periods of intense and heavy precipitation but also from river overflow events, which are particularly prevalent during the monsoon season or other extreme weather events. To effectively mitigate these impacts and protect local communities, these high-risk areas require dedicated, targeted flood management strategies and meticulously resilient infrastructure planning.

6.1.5 Overlay

Map 11 presents the Ward Climate Vulnerability Map for Kushtia Municipality. The map was developed through an overlay analysis of satellite-derived data, integrating local temperature, rainfall, and flood risk information to identify wards with combined vulnerability to multiple hazards. This analysis effectively highlights significant spatial variations in overall climate vulnerability across the municipality.

The map employs a clear color scheme to categorize wards into low, moderate, and high vulnerability zones, with darker shading indicating areas of higher risk. The wards that stand out as highly vulnerable are 10, 12, and 16, indicating that these areas face particularly severe cumulative exposure to a combination of climate hazards, including extreme heat, heavy rainfall, and flood risk. Conversely, wards represented by lighter shades, such as 17 and 20, demonstrate lower overall climate vulnerability. The majority of the remaining municipal wards fall within the moderately vulnerable category.

This pronounced spatial distribution of climate risk underscores the uneven exposure to extreme hazards across the municipality. Consequently, the map serves as a vital strategic tool for identifying priority areas for climate adaptation planning and disaster risk reduction efforts. By guiding resource allocation specifically toward the



Map 11: *Ward Climate Vulnerability Map Based on Secondary Information*

high-vulnerability wards, the municipality can implement targeted interventions to effectively enhance the overall climate resilience of the entire municipal area.

6.2 Ward Climate Vulnerability Profile of Kushtia Municipality Using Primary Sources

A Climate Vulnerability Index for each ward of Kushtia Municipality was developed by integrating hazards, infrastructure, governance, and socio-economic indicators. This index considers both the intensity and frequency of hazards, with higher values indicating greater vulnerability. A weighting system was applied to quantify the impact intensity and frequency of hazards for the index calculation. Impact intensity and frequency responses were assigned numerical values, as presented in the following table. This approach allows the Climate Vulnerability Index to capture both the severity and likelihood of hazards, ensuring that more frequent and severe hazards contribute proportionally more to the overall vulnerability score.

Table 6: Weightage Information for Intensity and Frequency of Hazard

Dimension	Category	Description	Weight
Frequency	< 3 times/year	Low frequency	0.25
	3–5 times/year	Low to moderate frequency	0.50
	5–7 times/year	Moderate to high frequency	0.75
	> 7 times/year	High frequency	1.00
Intensity	Low impact	Minor service disruption	0.33
	Medium impact	Moderate service disruption	0.66
	High impact	Severe service disruption	1.00

Hazard Vulnerability

The Hazard Vulnerability Index (H) quantifies the extent to which a ward is vulnerable to a specific hazard, considering both its frequency of occurrence and the cumulative intensity of its impact on all infrastructure and urban systems. While satellite imagery analysis revealed only spatial variation in hazards, this quantitative assessment establishes a robust basis for comparing hazard vulnerability across wards. A higher value indicates that the ward experiences frequent hazard events with widespread and severe impacts on multiple infrastructure and urban systems.

Infrastructure Vulnerability

Similarly, the vulnerability of a specific infrastructure type within a ward is determined as the Infrastructure Vulnerability Index (I) by aggregating the effects of all hazards based on their frequency and intensity of impact on that infrastructure. The resulting infrastructure vulnerability index provides a combined score for each infrastructure type, reflecting the cumulative influence of multiple hazards on its overall risk level within the ward.

Governance Vulnerability

In the absence of quantifiable, ward-level governance indicators for climate adaptation, a uniform governance score was assigned to all wards. The governance index (G) was set at 1, reflecting the lack of measurable adaptation actions at the ward level and representing consistently high governance-related vulnerability across the municipality.

Socio-economic Vulnerability

The indicators selected for the socio-economic vulnerability assessment have different units and ranges. Therefore, min–max normalization was applied to convert them into a unitless scale from 0 to 1, allowing direct comparison across wards. After normalization, the resulting socio-economic vulnerability index (S) values range from 0 (least socio-economically vulnerable) to 1 (most socio-economically vulnerable).

HIGS Climate Vulnerability Index

The final HIGS Climate Vulnerability Index integrates four dimensions of vulnerability: Hazards (H), Infrastructure (I), Governance (G) and Socio-economic (S). The hazard vulnerability index and the infrastructure vulnerability index were subsequently rescaled to a common range [0, 1] using Min–Max normalization. The final HIGS Climate Vulnerability Index for ward w was calculated as the summation of the four dimension scores.

$$\mathbf{HIGS_w = H_w + I_w + G_w + S_w}$$

Since each dimension is normalized to the range [0, 1], the composite HIGS index ranges from 0 (the lowest possible vulnerability) to 4 (the highest possible vulnerability). The higher the HIGS index, the greater the ward's overall vulnerability to climate change.

Table 7: Hazard Vulunerability Index of Kushtia Municipality

Hazards	Ward Hazard Vulnerability Index of Kushtia Municipality																					
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	Total
Cyclone	1.13	1.36	1.40	1.41	1.20	1.33	1.60	0.74	1.79	1.50	1.47	1.89	1.37	0.81	0.80	1.08	1.36	1.39	1.47	1.17	2.24	**28.51**
Floods	1.08	1.15	1.52	0.69	1.30	091	0.67	0.86	0.66	1.13	1.28	0.68	1.80	0.75	1.80	0.66	1.31	1.53	1.22	1.10	0.69	**22.81**
Heavy Rainfall and WL*	1.10	1.16	1.15	1.63	2.00	2.30	2.50	3.30	2.85	1.66	2.62	3.03	2.77	1.40	2.01	4.36	2.27	1.25	2.09	0.82	2.93	**45.20**
Thunder-storm	0.67	1.52	1.07	2.45	1.11	1.98	2.29	3.88	2.47	1.48	2.03	2.49	2.22	0.98	2.06	3.58	2.23	1.01	1.08	0.73	2.96	**40.29**
Heatwave	1.07	4.47	3.93	4.15	4.15	4.79	4.39	3.71	4.78	5.86	3.88	4.93	5.15	4.32	2.61	4.74	3.10	3.46	4.79	2.19	4.75	**85.20**
Coldwave	0.67	1.33	1.30	1.53	0.98	1.40	1.37	2.04	1.39	2.52	2.17	1.32	2.72	1.58	1.62	1.74	1.49	0.95	2.13	0.69	1.58	**32.51**
Total	**5.72**	**10.99**	**10.37**	**11.86**	**10.75**	**12.70**	**12.81**	**14.52**	**13.96**	**14.15**	**13.46**	**14.33**	**16.03**	**9.84**	**10.89**	**16.15**	**11.75**	**9.61**	**12.79**	**6.69**	**15.15**	

**Waterlogging*

6.2.1 Hazard Vulnerability Profile of Kushtia Municipality

Based on the vulnerability index calculation, the hazard vulnerability index at the ward level is presented in Table 7, using a color-gradient system where "Red" indicates the highest vulnerability levels and "Green" represents the lowest. The gradient visually highlights varying levels of susceptibility across wards. The total exposure values in the last column reflect the cumulative hazard impact for each ward, indicating that heatwaves are the most predominant of all the hazards (Table 7). The last row represents the cumulative index values, with Ward 16 showing the highest vulnerability (16.15) and Ward 1 the lowest (5.72). This represents a wide variation, underscoring the significance of this study. Policymakers must understand that some wards require special attention. The specific areas where such interventions can be made are discussed later.

The "Ward Exposure to Hazards" chart in Figure 17, based on the vulnerability index table 7, highlights variations in hazard exposure across Kushtia Municipality's wards. Each bar's height represents cumulative exposure, with taller bars indicating higher overall vulnerability. Color segments within the bars depict the impact levels of specific hazards, with WVI scores ranging from 5.72 to 16.15. The average WVI is 12.12, with a standard deviation of 2.75, reflecting notable variability. Of the 21

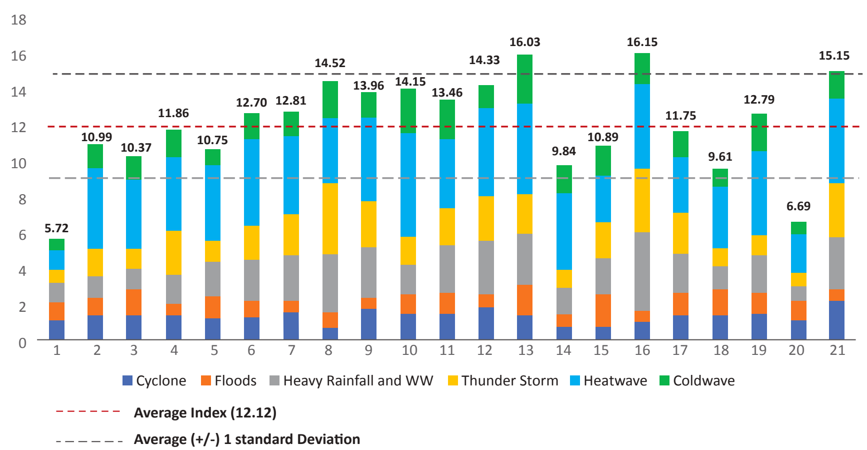


Figure 17: *Wards' Exposure to Hazards on selected Infrastructures and Urban Systems*

wards, 11 wards' scores are above the average, with Wards 16 (16.15), 13 (16.03), and 21 (15.15) significantly exceeded the mean by more than one standard deviation, indicating heightened vulnerability. Conversely, Wards 1 (5.72) and 20 (6.69) exhibit remarkably low vulnerability levels, with WVI scores significantly below the mean by more than one standard deviation. Additionally, some wards, such as 2 (10.99), 4 (11.86), and 17 (11.75), though below the average, are very close to the average index, indicating that the majority of the wards in the Kushtia Municipality exhibit moderate to high vulnerability to the impacts of climate change.

6.2.1.a Cyclone

- Cyclones have a less severe impact on Kushtia due to its inland location, far from the Bay of Bengal, where cyclones form.
- Kushtia experiences high winds and rainfall associated with cyclones that damage infrastructure, disrupt utilities, and affect local communities (Annexure 1 Figure 2).
- Wards 21 and 12 in Kushtia are highly vulnerable to cyclones due to their structural compositions and socioeconomic characteristics. In Ward 21, 43.96% of buildings are Kancha and Jhupri, while Ward 12 consists of 80.89% low-income communities.

6.2.1.b. Floods

- Kushtia is less vulnerable to river flooding due to its elevated position, reducing the risk of seasonal flood inundation common in lower-lying areas of Bangladesh.
- Still, flooding remains a risk due to its proximity to the Gorai River, causing threats to infrastructure damage, water and sanitation service interruptions, etc.
- Particularly in wards 13 and 15, which are most exposed to seasonal floods due to their proximity to both the river Gorai and the Padma (Annexure 1 Figure 3).

6.2.1.c. Heavy Rainfall and Waterlogging

- Kushtia is highly vulnerable to heavy rainfall and waterlogging due to its localized topographic variation, inadequate drainage system, and high urban density.
- Wards in low-lying areas and with insufficient drainage are prone to prolonged waterlogging after heavy rainfall, such as wards 16 and 21 (Annexure 1 Figure 4).
- This phenomenon causes damage to infrastructure, including eroded roads and submerged buildings, disrupts transportation, contaminates water supplies, increases public health risks through waterborne diseases, and leads to economic losses.
- The severity of these impacts fluctuates across wards, influenced by factors such as local topography, infrastructure quality, and drainage capacity.

6.2.1.d. Thunder Storms and Lightning

- Kushtia is moderately vulnerable to thunderstorms and lightning due to its geographical location in Bangladesh and experiences frequent monsoon-related storms and intense weather systems.
- The impact of thunderstorms varies across the municipality, with some wards experiencing more severe damage due to factors like urban density, high-rise buildings, infrastructure quality, and tree cover. Also, areas with less developed infrastructure or more open spaces may face greater risks, particularly from fallen trees and power outages (Annexure 1 Figure 5).
- Ward 8 is greatly exposed to thunderstorms due to being a core urban area with a density of more than 20,000 people per sq. km., while Ward 16 and Ward 21 are severely defenseless for having more Kancha and semi–pucca structures.
- Thunderstorms are a common cause for the disruption of electricity supply, affecting daily activities and services.

6.2.1.e. Heatwaves

- Kushtia Municipality is increasingly vulnerable to heatwaves, with several prolonged and extreme heat events being recorded in recent years (Annexure 1 Figure 6).
- Urbanization in Kushtia has led to more concrete surfaces and buildings, which absorb and retain heat, creating a stronger urban heat island effect. This effect is intensified by the scarcity of vegetation and green spaces.
- Almost all the wards in Kushtia are experiencing prolonged heat spells, with the impact being particularly severe in the core urban areas.
- Vulnerability varies across Kushtia, with densely populated wards experiencing higher temperatures due to factors like impervious surfaces, limited airflow, and lack of vegetation.

6.2.1.f. Coldwaves

- Kushtia municipality has experienced a few notable cold wave events in recent years, with the increase in the frequency and unpredictability of extreme weather events, potentially heightening Kushtia's vulnerability to cold spells in the future (Annexure 1 Figure 7)

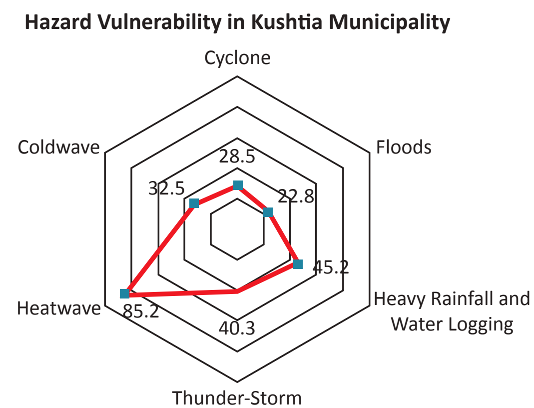


Figure 18: *Hazard Vulnerability in Kushtia Municipality*

- The cold wave has been particularly challenging for the residents, especially vulnerable populations, such as the elderly, young children, and low-income groups living in Kancha or semi pucca structures in wards 10, 13, and 21, who are particularly at risk.

Figure 18 from the Hazard Vulnerability Index (HVI) outlines Kushtia Municipality's exposure to various climate hazards, serving as a strategic tool for aligning its climate action plan with the region's specific risks. **Heatwaves** stand out as the most severe threat, with an index of 85.2, far surpassing other hazards and reflecting the increased frequency and intensity of extreme heat events due to climate change, which endangers both the local population and infrastructure.

Next, **heavy rainfall and waterlogging** (45.2) **and thunderstorms** (40.3) pose substantial risks. The frequent and unpredictable weather extremes due to climate change often lead to intense rainfall over short periods, overwhelming drainage systems and causing localized flooding. As a result, waterlogging becomes a significant issue in Kushtia Municipality, especially in core urban areas with inadequate drainage infrastructure. The warming atmosphere increases the capacity for moisture, which can lead to more powerful storms. These intense storms often result in lightning strikes that cause fires, damage electrical infrastructure, and disrupt internet and mobile communication**.**

Cold waves (32.5 °C) present a moderate risk but may increase in frequency as climate patterns shift, adding new challenges for the community. While **cyclones** (28.5) are less frequent in inland Kushtia, their impacts are growing as climate change intensifies storm patterns, bringing strong winds and heavy rainfall.

Though **flooding** has the lowest score (20.8) for Kushtia Municipality, it remains a significant concern due to the effects of heavy rainfall, inadequate drainage, and nearby river overflows. Recent floods in Bangladesh demonstrate how intense rainfall can overwhelm infrastructure, suggesting that even lower-risk areas, such as Kushtia, could face severe flooding under extreme weather conditions exacerbated by climate change. By prioritizing these risks, the municipality can allocate resources effectively toward impactful, targeted interventions that reduce economic losses while enhancing public health and infrastructure resilience. Ultimately, the HVI supports a data-driven, adaptive approach that aligns climate action with the specific vulnerabilities Kushtia faces.

6.2.2 Infrastructure and Urban Systems Vulnerability Profile of Kushtia Municipality

The urban system components are categorized into two parts: Non-WASH Urban Systems and WASH Systems. Non-WASH Urban Systems include critical sectors such as housing, transportation, and electricity & communication, which form the backbone of

Table 8: Infrastructure and Urban System Vulnerability Index

Infrastructure	Ward of Kushtia Municipality																				
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
Housing	0.83	202	1.42	1.98	1.63	2.21	2.07	2.22	2.16	2.25	2.07	2.50	2.60	1.56	1.71	2.66	1.90	156	2.13	1.12	2.60
Transportation	0.76	1.61	1.47	1.75	1.56	1.86	1.99	2.47	2.11	2.11	1.94	2.24	2.43	1.42	1.50	2.72	1.76	1.31	1.87	1.00	2.37
Elec and Comm*	0.84	1.80	1.58	1.40	1.55	1.63	1.74	2.54	1.75	1.85	1.80	1.81	2.10	1.42	1.46	2.53	1.68	1.42	1.56	0.98	2.06
Water Supply	0.76	1.53	1.34	1.58	1.61	1.89	1.87	1.89	2.15	2.02	1.91	2.13	2.32	1.43	1.70	2.05	1.50	1.43	1.87	1.00	2.21
Sanitation and WW**	0.76	1.19	1.54	1.66	1.44	1.0	1.46	1.65	1.67	2.04	1.96	1.60	2.26	1.34	1.50	1.94	1.56	1.28	1.75	0.84	1.68
Storm Water Drainage	0.83	1.15	1.47	1.60	1.43	1.77	2.05	1.99	2.22	1.94	1.71	2.17	2.13	1.34	1.44	2.43	1.75	1.27	1.77	0.95	2.34
SWM***	0.85	1.69	1.54	1.89	1.51	1.75	1.62	1.77	1.89	1.93	2.08	1.87	2.18	1.35	1.57	1.81	1.59	1.33	1.85	0.74	1.90

*Electricity & Communication,**Wastewater, *** Solid Waste Management urban infrastructure and daily life. WASH Systems, on the other hand, encompass water supply, sanitation & wastewater, stormwater drainage, and solid waste management, focusing on essential services that ensure public health and environmental sustainability. Each ward's index in Kushtia Municipality was measured based on hazard intensity and frequency, with data collected from residents' perceptions. These hazard indexes for Infrastructure and Urban Systems are represented in the table above with color-coding, where "Red" indicates high vulnerability and "Green" denotes low vulnerability. The gradient between these colors reflects areas with varying degrees of vulnerability, ranging from high to low vulnerability.

Infrastructure Vulnerability in Kushtia Municipality

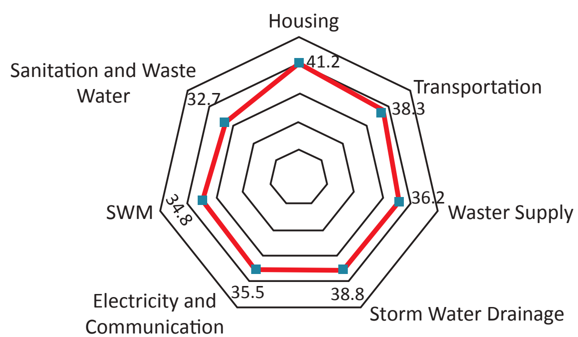


***Figure 19:** Infrastructure Vulnerability in Kushtia Municipality*

Figure 19 provides an overview of the infrastructure and urban system vulnerabilities in Kushtia Municipality. The index evaluation reveals that all seven systems have comparable vulnerability scores, indicating that each system faces similar risks from hazards.

Housing emerges as the most vulnerable system, with the highest score of 41.2. This reflects not only damage to physical structures but also broader impacts on homesteads and their functions. Damage to homes leads to significant rebuilding costs and increased utility expenses, such as the use of backup power or alternative lighting. Vulnerabilities faced by residents of low-income communities (LIC) further elevate the housing index.

Transportation ranks as the second most vulnerable system (38.3), with impacts extending beyond vehicle movement to operational disruptions and costly repairs.

Other infrastructure systems, particularly WASH systems—**Water Supply** (36.2), **Sanitation and Wastewater** (32.7), **Stormwater Drainage** (35.8), and **Solid Waste Management** (34.8)—have close vulnerability scores, indicating that these systems are similarly affected. Water supply scores slightly higher due to challenges like high iron content in usable water and limited piped water access, particularly in LIC areas.

6.2.2.1 Infrastructure and Urban Systems Vulnerability of Non-WASH Urban Systems

The vulnerability of non-WASH infrastructure and urban systems has been assessed, identifying the most vulnerable wards for each system and those with better urban systems. These findings are visually represented in Figure 20.

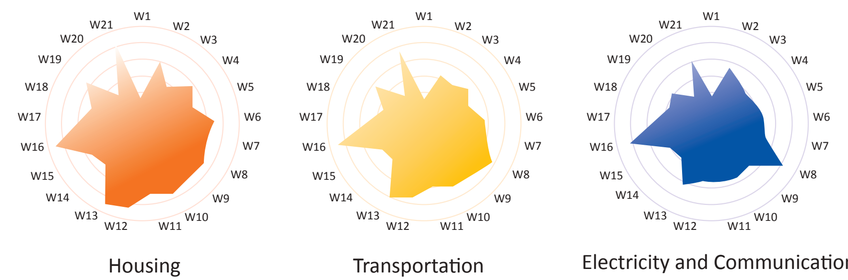
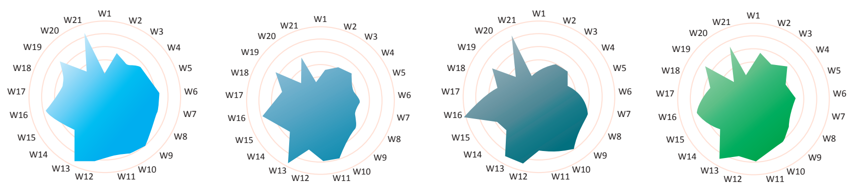


***Figure 20:** Non-WASH System Vulnerabilities Across the Wards*

6.2.2.2 Infrastructure and Urban Systems Vulnerability of WASH Urban Systems

The vulnerability of WASH infrastructure and urban systems has also been assessed, identifying the most vulnerable wards for each system and those with better urban systems. These findings are visually represented in Figure 21.



Water Supply | Sanitation and Waste Water | Storm Water Drainage | Solid Waste Management

Figure 21: *WASH System Vulnerabilities Across the Wards*

6.2.2.3. Ward-Wise WASH System Assessment

Analyzing the WASH systems in Kushtia Municipality at the ward level has yielded two key outcomes. First, it identifies the most vulnerable WASH system in each ward based on the hazard index. Second, it highlights which wards require immediate intervention to reduce vulnerability effectively (Table 9).

The following table presents the ward-wise vulnerability of WASH systems. Red indicates the most vulnerable WASH sector for a specific ward (e.g., the SWM system is most vulnerable to hazards in Wards 1, 2, and 4). Shades closer to red suggest high vulnerability, signaling the need for prioritized intervention in those systems. Conversely, green represents the least affected WASH sectors, as perceived by residents of Kushtia Municipality.

Table 9: WASH Vulnerability Index of the Wards

Ward	W1	W2	W3	W4	W5	W6	W7	W8	W9	W10	W11	W12	W13	W14	W15	W16	W17	W18	W19	W20	W21
Water Supply	0.76	1.53	1.34	1.58	1.61	1.89	1.87	1.89	2.15	2.02	1.91	2.13	2.32	1.43	1.70	2.05	1.50	1.43	1.87	1.00	2.21
Sanitation and WW	0.76	1.19	1.54	1.66	1.44	1.60	1.46	1.65	1.67	2.04	1.96	1.60	2.26	1.34	1.50	1.94	1.56	1.28	1.75	0.84	1.68
Storm Water Drainage	0.83	1.15	1.47	1.60	1.43	1.77	2.05	1.99	2.22	1.94	1.71	2.17	2.13	1.34	1.44	2.43	1.75	1.27	1.77	0.95	2.34
SWM	0.85	1.69	1.54	1.89	1.51	1.75	1.62	1.77	1.89	1.93	2.08	1.87	2.18	1.35	1.57	1.81	1.59	1.33	1.85	0.78	1.90

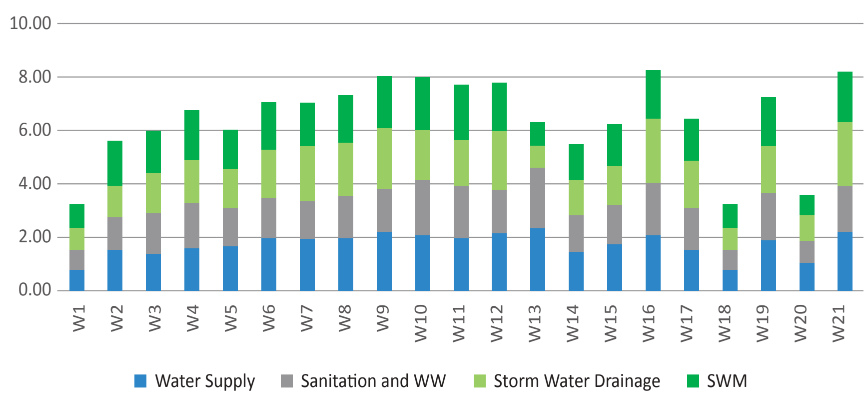


Figure 22: *Ward-wise Wash Vulnerability*

Assessing the overall index for WASH systems reveals the most vulnerable wards in Kushtia Municipality, identifying those that require immediate intervention in the WASH sector. As shown in Figure 22, Ward 13 has the highest index value, indicating the greatest vulnerability, followed by Ward 16 and Ward 21.

6.2.2.5 Impacts on the Infrastructure and Urban Systems during Hazards

The questionnaire survey captured the various impacts on each infrastructure and urban system that residents experienced during hazards. The severity of these impacts was measured by considering both the intensity and frequency of hazards. This analysis was essential for determining the priority needs assessments for Kushtia Municipality.

Figure 23 highlights the specific impacts of hazards on urban infrastructure and services, identifying which components of the urban system are most affected. By capturing residents' sexperiences, the analysis provides insights into where targeted interventions are needed to enhance resilience. These findings help prioritize actions to strengthen infrastructure, maintain essential services, and build resilience against climate hazards.

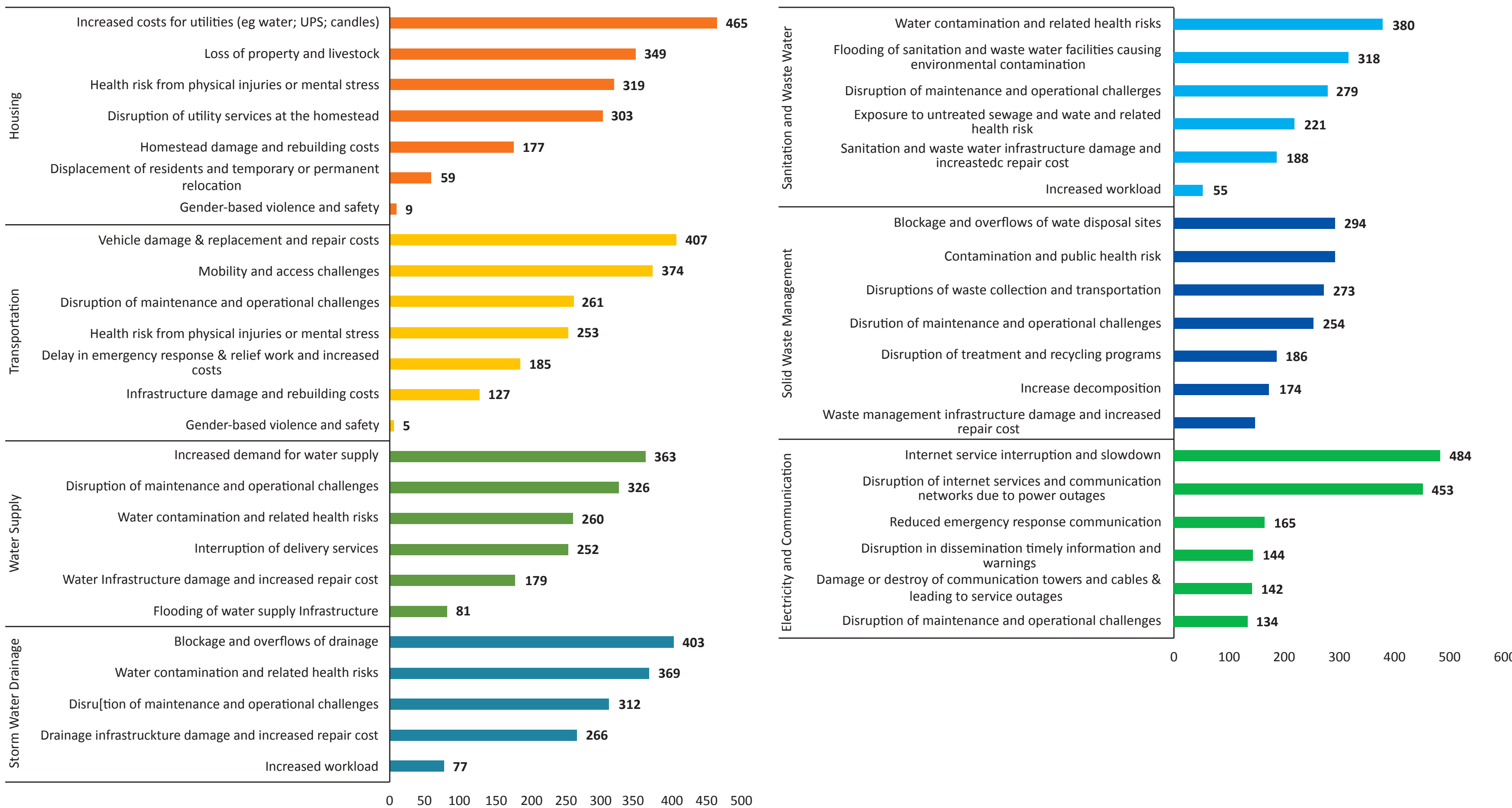


Figure 23: *Impacts Severity of Infrastructure and Urban Systems*

6.2.3 Governance Vulnerability Profile of Kushtia Municipality

The table below summarizes the key governance vulnerabilities of Kushtia Municipality. As previously mentioned, since there are no ward-level activities for climate action, the available qualitative information could not be quantified or scored for comparative analysis. Hence, the table provides an overall summary for the municipality as a whole. These findings highlight critical areas that require attention to enhance effective climate action planning.

Institutional Capacity	No dedicated framework for climate action or disaster preparedness at the ward level.
	Lack of trained personnel and specialized units for climate resilience activities.
	No mechanism to support awareness-raising initiatives and capacity-building efforts for climate change adaptation.
Accountability	No ward-level disaster management committees.
	No clear responsibility for implementing ward-level climate resilience measures.
	Weak enforcement of development regulations is causing unplanned growth.
Planning and Policy	No dedicated climate action plan for Kushtia.
	Climate adaptation considerations remain overlooked in municipal master plans and local budgetary frameworks.
Participation	Limited stakeholder involvement in climate resilience planning.
	Low public awareness of climate risks and adaptation measures.
	Lack of formal structures for community participation in climate resilience planning.
Data and Knowledge Management	Lack of ward-level climate data and associated risk or exposure information.
	No data-sharing platforms for disseminating climate data and vulnerability assessments to stakeholders, including the public, local authorities, and the private sector.

6.2.4 Socio-economic Vulnerability Profile of Kushtia Municipality

Table 2 illustrates the socio-economic vulnerability profile of Kushtia Municipality. Given the variation in measurement units across the selected indicators, all variables were normalized to a common scale between 0 to 1. A color gradient system was then applied to aid interpretation, where red denotes the highest level of vulnerability and green represents the lowest, as shown in Annexure 1.

The results show that wards 3, 6, 10, 13, 15, 16, 18, 19, 20, and 21 exhibit relatively high vulnerability across multiple indicators. High-population wards such as 5, 13, 18, and 21 may face increased socio-economic vulnerability due to the greater demand for sufficient infrastructure and services to meet residents' needs. Wards 1 to 12, which are the core urban areas, have higher population density, especially wards 2, 3, and 8, as referred to in figure 9 of annexure 1. These densely populated areas face higher exposure to climate hazards and greater strain on resources during such events.

As illustrated in Figure 10 of Annexures 1, poor housing conditions, characterized by a high prevalence of Kancha/jhupri structures, are concentrated in Wards 10 to 21. In particular, Wards 10, 15, and 21 have nearly half of their houses built as Kancha/jhupri structures. Areas with such housing types are highly vulnerable to severe damage during extreme weather events. Low literacy rates are particularly notable in Wards 11, 13, 15, and 19, as shown in Table 2 of Annexures 2. Limited literacy can significantly hinder the effective communication and use of climate-related information, as communities may struggle to understand and respond to guidance during extreme events. Sanitation vulnerability is also pronounced in Wards 3, 15, 20, and 21, where high rates of open defecation increase public health risks, especially during floods and periods of heavy rainfall. In contrast, Wards 1, 4, 7, 8, 9, and 11 generally exhibit low vulnerability across most socio-economic indicators, with better housing conditions, higher literacy levels, and improved access to sanitation facilities.

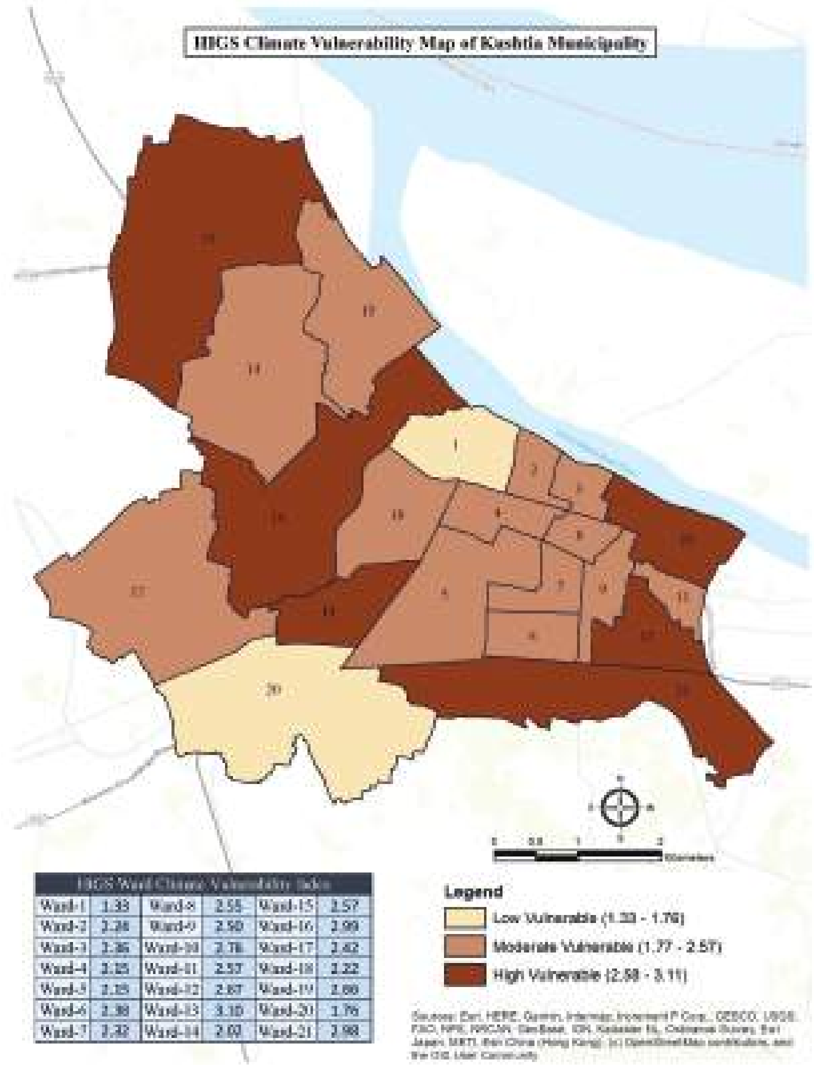
These findings underscore the importance of integrating socio-economic vulnerability into the Climate Action Plan, with targeted interventions in high-risk wards to strengthen community resilience and reduce exposure to climate-related hazards.

6.2.5 HIGS Climate Vulnerability INDEX

The Ward Climate Vulnerability Index, displayed in the table at the bottom of Map 12, presents the varying degrees of vulnerability across wards in Kushtia Municipality. The vulnerability index integrates the four dimensions of the HIGS framework: Hazards, Infrastructure, Governance, and Socioeconomic indicators. Each dimension is normalized to a range of 0 to 1, resulting in a composite HIGS index ranging from 0 (lowest vulnerability) to 4 (highest vulnerability), providing a comprehensive understanding of ward-level vulnerability. These scores are crucial for the climate action planning process, as they identify the wards most at risk and highlight areas requiring targeted interventions. Higher index values indicate greater vulnerability, reflecting intensified climate hazards, limited infrastructure resilience, or significant socio-economic challenges.

The index further categorizes wards into three vulnerability levels—Low, Moderate, and High —using equal interval classification. Wards with the highest vulnerability scores, including Wards 10, 12, 13, 16, 19, and 21 (shaded in dark brown), are exposed to significant climate risks and require immediate attention. In contrast, Wards 1 and 20 (shaded in lighter tones) exhibit low vulnerability, while the remaining wards fall under moderate vulnerability. This classification shows that most of Kushtia Municipality lies within moderate to high vulnerability zones, with only a few wards at relatively low risk.

By identifying high-risk areas, the Ward Climate Vulnerability Index provides a data-driven basis for prioritizing interventions in the Climate Action Plan. Aligning resources and strategies with these vulnerability hotspots ensures that adaptation measures are both equitable and effective. Ultimately, this approach fosters long-term urban resilience and sustainability, enabling Kushtia Municipality to better prepare for and respond to the impacts of climate change.

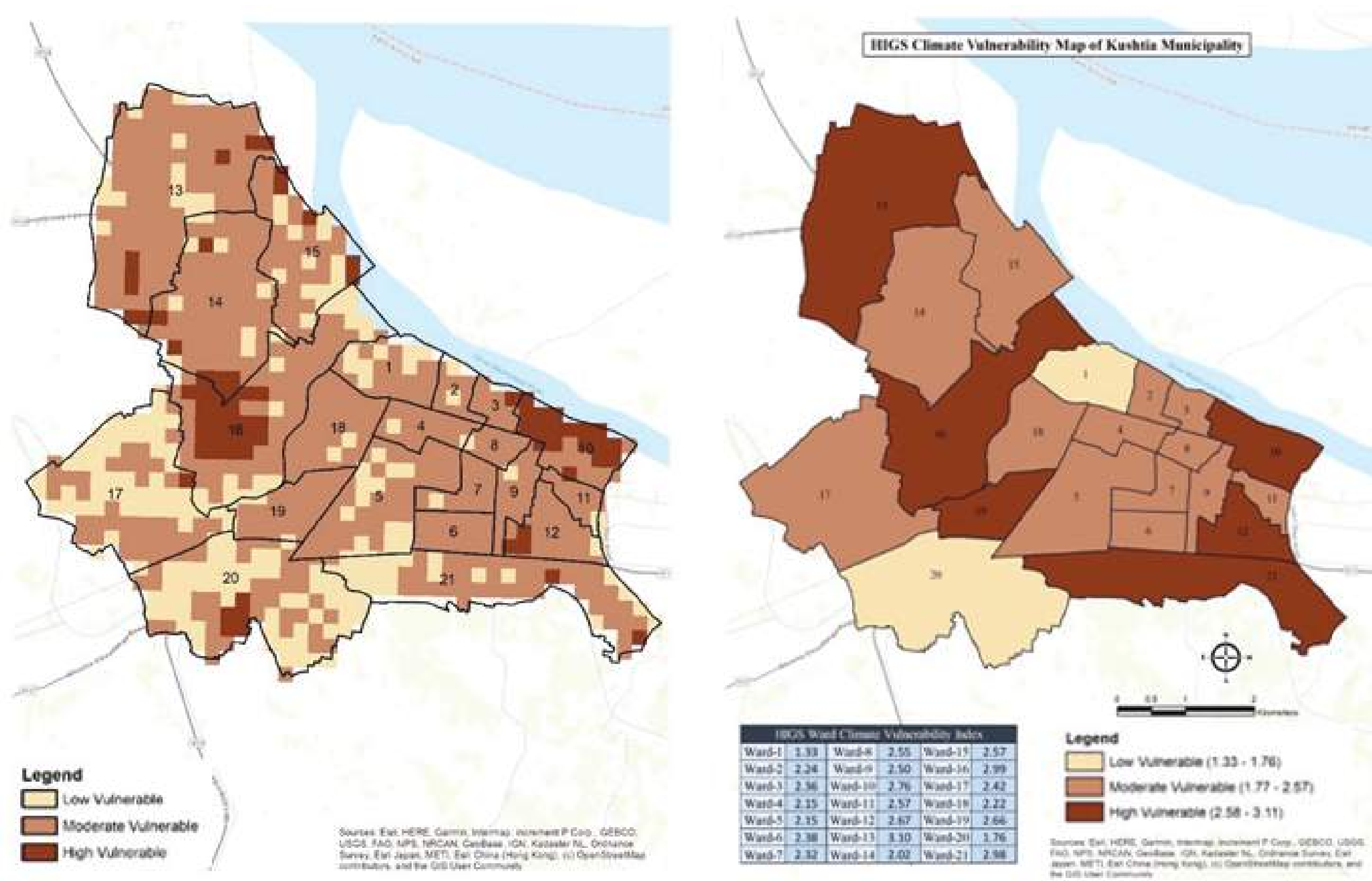


HIGS Ward Climate Vulnerability Index					
Ward-1	1.33	Ward-8	2.55	Ward-15	2.57
Ward-2	2.28	Ward-9	2.50	Ward-16	2.99
Ward-3	2.36	Ward-10	2.78	Ward-17	2.42
Ward-4	2.25	Ward-11	2.57	Ward-18	2.22
Ward-5	2.19	Ward-12	2.87	Ward-19	2.88
Ward-6	2.30	Ward-13	3.10	Ward-20	1.76
Ward-7	2.32	Ward-14	2.02	Ward-21	2.98

Map 12: *Climate Vulnerability Map based on HIGS Frameworks*

6.2.6 Correlation findings between the Satellite Vulnerability Map and the HIGS Vulnerability Map

The climate vulnerability assessment for Kushtia Municipality combined satellite-based analysis of secondary data with a community perception survey based on the HIGS framework to present localized spatial variation of hazards across the municipality, capturing how different socio-economic groups perceive the impact of extreme events on urban infrastructure and services. Both approaches demonstrated strong alignment, consistently highlighting highly vulnerable wards such as 10 and 16, thereby enhancing the credibility and reliability of the findings for climate action planning. Overall, this assessment provides a robust foundation for identifying vulnerable areas, prioritizing targeted interventions, and guiding evidence-based, climate-resilient urban development (Map 13).



Map 13: *Ward Climate Vulnerability Map of Kushtia Municipality using Primary and Secondary Data.*

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7. WAY FORWARD AND RECOMMENDATIONS

To address urban system vulnerabilities to hazards, the residents of Kushtia Municipality have shared valuable suggestions. In most cases, the opinions align across different wards, reflecting similar demands and responses based on shared experiences and challenges. This section outlines the overall priority intervention, short-term and medium-term interventions identified by the residents, which, if addressed, could significantly reduce the vulnerability of municipal infrastructure to various hazards. In line with the project objectives, short-term interventions will focus on addressing vulnerabilities in the WASH systems, while medium-term measures will be implemented to address non-WASH needs. These priorities underscore the need for improved planning, enhanced maintenance, and targeted investments tailored to address specific vulnerabilities in both Non-WASH and WASH urban systems. Ensuring community engagement in implementing these measures will also foster resilience and better preparedness.

7.1 Way Forward and Intervention for WASH Urban Systems (Short Term)

7.1.1 Water Supply System

- Ensuring access to a piped water supply for all residents, especially LICs, with safe drinking water available during hazard events is a top priority.
- Controlling the depletion of groundwater resources through interventions such as rainwater harvesting and restoring wetlands is crucial.
- Adopting mitigation measures for the use of deep tube wells is essential to address the depletion of groundwater, as they remain a significant concern.
- Providing backup water sources, like groundwater wells, in flood-prone areas can maintain a supply of potable water when surface water sources are contaminated.
- Building or retrofitting water supply pipe systems and pumping stations using water-resistant materials will ensure resilience against floods.
- Focusing on digging more canals, liberating canals from encroachment, preventing illegal sand extraction from the Garai River, and stopping the filling up of ponds, canals, and rivers and increasing the navigability of rivers.

Figure 24: *Suggested Way Forward for Water Supply*

7.1.2 Sanitation and Wastewater System

- Supporting LIC residents with financial contributions and assistance to build hygienic toilet systems is essential to improve sanitation conditions.
- Increasing the availability of shared toilets in suitable locations can significantly enhance hygiene, particularly for slum dwellers.
- Preventing the overflow of septic tanks and wastewater-carrying drainage systems during hazards is a critical priority.
- Educating the public on proper sanitation practices during and after hazards, including safe waste disposal and water contamination prevention, is vital for community health.

- Setting up a high-capacity Faecal Sludge Treatment Plant (FSTP) and ensuring proper channels for transporting faecal sludge to the facility

Figure 25: *Suggested Way Forwards for Sanitation and Wastewater*

7.1.3 Storm Water Drainage System

- Increasing the number of street gutters with proper channel systems to effectively prevent flooding during heavy rainfall.
- Expanding the capacity of stormwater drainage systems, such as larger storm drains and retention basins, to handle intense rainfall and minimize urban flooding risks.
- Implementing Sustainable Urban Drainage Systems (SUDS) features like permeable pavements, green roofs, and rain gardens, commonly used in developed countries, to manage excess stormwater and reduce pressure on conventional drainage systems.

Figure 26: *Suggested Way Forward for Stormwater Drainage*

- Improving the integration of stormwater and wastewater systems to better manage increased runoff during hazardous events.

7.1.4 Solid Waste Management System

- Establishing suitable waste disposal points across Kushtia Municipality to address the lack of proper dumping locations faced by many residents.
- Increasing the capacity and initiatives of authorities to improve waste collection efficiency, including adding manpower, waste collection vehicles, and training programs, ensuring continuity even during hazards.
- Conducting awareness programs for residents on waste segregation, particularly for organic, inorganic, and hazardous waste.
- Setting up emergency waste disposal sites outside cyclone-affected areas to manage large volumes of debris during hazards.

Figure 27: *Suggested Way Forward for SWM*

- Implementing waste-to-energy (WTE) technologies, such as Material Recovery Facilities (MRF) or compost plants, to reduce waste volume and promote sustainable waste management.

7.2 Way Forward and Intervention for Non-WASH Urban Systems (Medium Term)

7.2.1 Housing System

- Improving housing conditions, especially in LIC areas where Kancha Jhupri structures are prevalent.
- Providing government support to construct houses on elevated land.
- Providing government support in the transition of vulnerable housing to pucca structures along with planned urbanization for better resilience.
- Ensuring utility services are maintained at affordable costs during hazardous events.
- Making factories environmentally friendly and relocating them to suitable areas away from residential zones to improve housing conditions.
- Establishing multiple hazard shelters in suitable locations beforehand to ensure safety.

Figure 28: *Suggested Way Forward for Housing*

7.2.2 Transportation System

- Fixing the deteriorated access roads in Kushtia Municipality, especially those impacted during hazards, is the residents' most prominent demand, as these roads hamper relief measures.
- Developing roads at higher elevations with modern features such as medians and proper drainage systems is suggested to enhance resilience.
- Improving road accessibility by installing energy-efficient streetlights is another key priority of the residents.

Figure 29: *Suggested Way Forward for Transportation*

- Rebuilding access roads that are damaged during hazards should be prioritized by the government to ensure quick recovery and accessibility.

7.2.3 Electricity and Communication System

- Ensuring an uninterrupted electricity supply throughout Kushtia Municipality is a primary demand of the residents, not only during hazards but also before and after hazard events.
- Establishing necessary infrastructure through government intervention is required to guarantee a consistent electricity supply.
- Placing power distribution infrastructure at elevated locations is crucial to prevent risks to human life, particularly during hazards like thunderstorms and lightning.
- All infrastructure should be able to resist the maximum predicted wind speeds in the locality.
- Installing lightning resistors in suitable locations as part of modern protective measures is essential for safeguarding residents from thunderstorms and lightning.

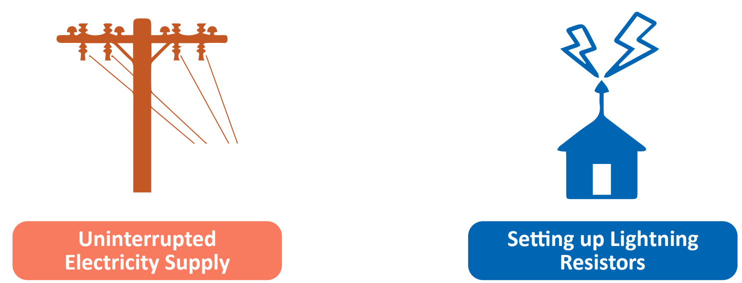

Figure 30: *Suggested Way Forward for Electricity and Communication*

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8. CONCLUSION

The Climate Action Plan (CAP) presented in this report offers critical insights into local-level hazard vulnerabilities, highlighting the need for a shift in policy focus. While national-level hazard responses to climate change predominantly address coastal challenges such as sea level rises, storm surges, cyclones and floods, and inland challenges such as temperature increases and lack of rainfall leading to desertification, findings from this CAP reveal that urban residents in towns like Kushtia perceive hazards such as heatwaves, cold waves, and lightning as more threatening. One probable reason for this is that national-level hazard assessments do not specifically consider urban areas and tend to concentrate more on rural and coastal areas. These locally significant hazards often remain overlooked in broader national strategies.

This underscores the necessity for policymakers to adopt a people-centric approach that prioritizes local needs and perceptions. By identifying vulnerabilities specific to towns and integrating community-driven demands, decision-makers can develop hazard-resilient infrastructures and implement targeted interventions. The CAP serves as a crucial step toward creating adaptive, inclusive, and sustainable solutions for urban resilience, ensuring that no community's concerns are left unaddressed in the face of climate change.

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Annexures 1: Table and Graphs

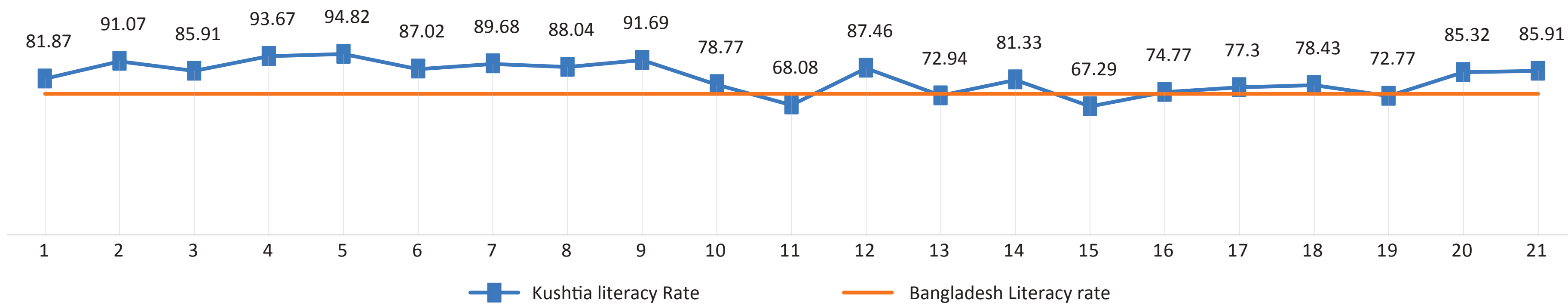

Figure 1: *Ward-wise literacy rate: National-level vs Kushtia Municipality*

Table 1: Drainage and waterlogging conditions by ward in Kushtia Municipality

Ward No.	Length of Drainage (Meter)				Outfall of the Drains	Waterlogging	
	Secondary Drain		Tertiary Drain			Name of Waterlogging Locations	Duration
	Earthen	RCC/Brick	Earthen	RCC/Brick			
1	0.00	6918.48	206.16	4948.34	For 60% drain: Gorai River For 40% drain: Dhaka road borrow pit	Kamolapur, Police line, Thana Para	2 hours
2	0.00	1090.06	49.34	4988.44	For all drains: Gorain River	Char Thana Para	7 hours
3	0.00	3185.20	0.00	2897.43	For 80% drain: Gorai River For 20% drain: Dhaka road borrow pit	Baro Bazar	2 hours
4	0.00	4527.33	276.99	4950.73	For all drains: Dhaka road borrow pit	Char Para (whole ward)	4-5 hours
5	201.26	5075.86	0.00	5389.52	For all drains: Dhaka road borrow pit	SP & DC Office, Hospital, Chorhash	4-5 hours

Ward No.	Length of Drainage (Meter)				Outfall of the Drains	Waterlogging	
	Secondary Drain		Tertiary Drain			Name of Waterlogging Locations	Duration
6	262.39	3930.41	217.10	9052.80	For all drains: DRBP	Housing area	2 hours
7	0.00	3293.51	159.43	2003.79	For all drains: DRBP	Kalisankarpur, Kataikhana Mor	4-5 hours
8	0.00	2384.94	255.89	3707.89	For all drains: DRBP	Arwa Para	1.5 hours
9	240.68	4312.24	0.00	7395.07	For all drains: DRBP	Arwa Para Housing	2 hours
10	0.00	2173.14	272.08	2449.71	For all drains: Gorain River	Mill Para, Baro Bazar	2 hours
11	0.00	382.52	0.00	2069.85	For all drains: DRBP	Mill para, Mohini Mill Quarter	2 hours
12	0	3948.945	149.82	11320.81	For all drains: DRBP	Horisankar Pur	3 hours
13	884.5	4432.37	454.73	12892.35	For 50% drain: Gorai River For 50% drain: GK Khal	Whole ward	No limit
14	2109.07	323.83	166.05	68.28	For 20% drain: Gorai River For 80% drain: Baradi vagar low land	Whole ward	No limit
15	0	2289.415	0.00	86.43	For all drains: Mora Gorai River	Kana Beel, Gujoa	No limit
16	294.09	790.93	0.00	257.84	For all drains: Mora Gorai River	Whole ward	No limit
17	800.43	10570.18	0.00	430.44	For all drains: Mora Gorai River	Meena Para, Dhaka Shalugora	No limit
18	0.00	2315.96	0.00	2255.68	For 50% drain: Mora Gorai River For 50% drain: DRBP	Udi Bari, West Mazompur, East Mazompur	No limit
19	0.00	1446.31	0.00	2179.34	For 50% drain: Mora Gorai River For 50% drain: DRBP	Chorhash, College, Shahpur, Karigor Para	No limit
20	383.38	1665.77	42.68	62.22	For 90% drain: GPA Khal For 10% drain: Taki Mari Beel	Whole ward	No limit
21	0	7415.895	0.00	104.40	For 50% drain: Kali River For 50% drain: GK Khal	Lahini Para, Lahini Battola, Molla Tayghoriya, Judge Para	No limit

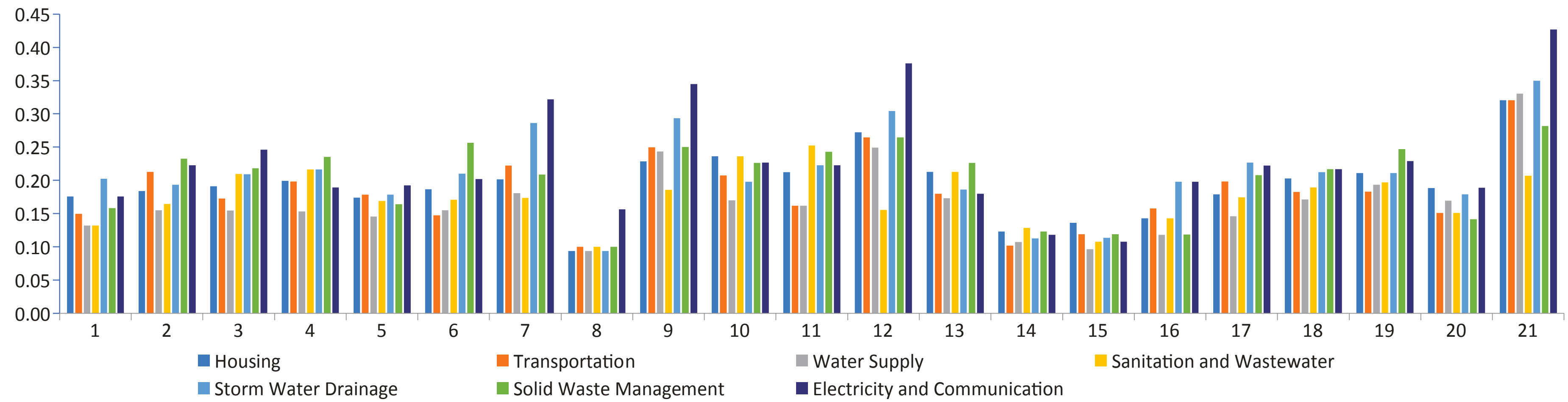

Figure 2: *Impact of Cyclone on Infrastructure and Urban Services across the Ward*

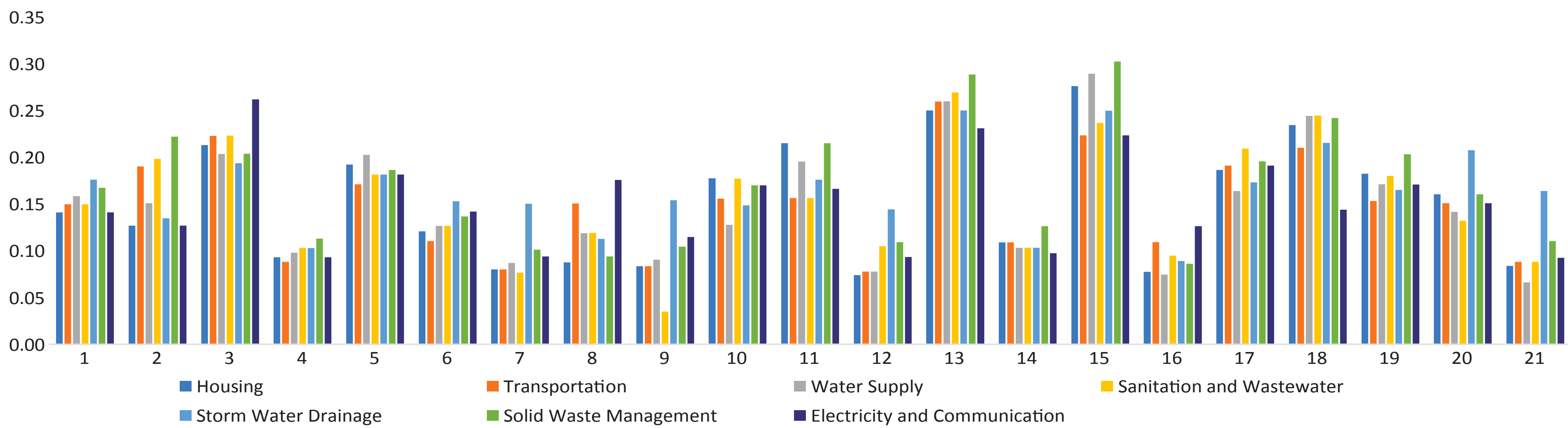

Figure 3: *Impact of Floods on Infrastructure and Urban Services across the Ward*

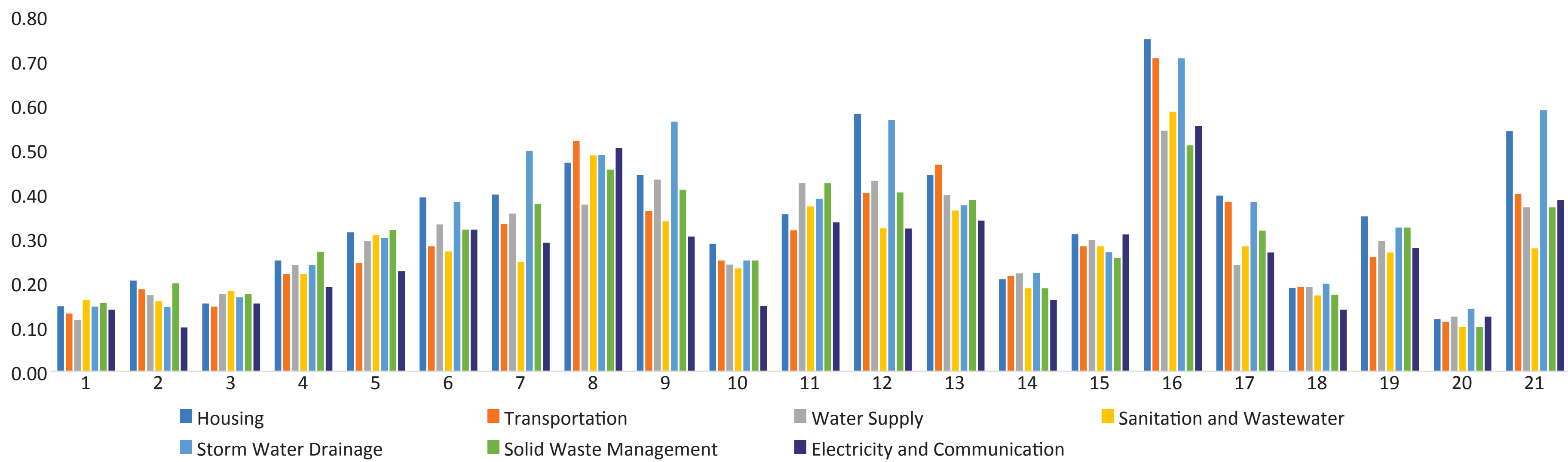

Figure 4: *Impacts of Heavy Rainfall and Water Logging on Infrastructure across Kushtia Municipality*

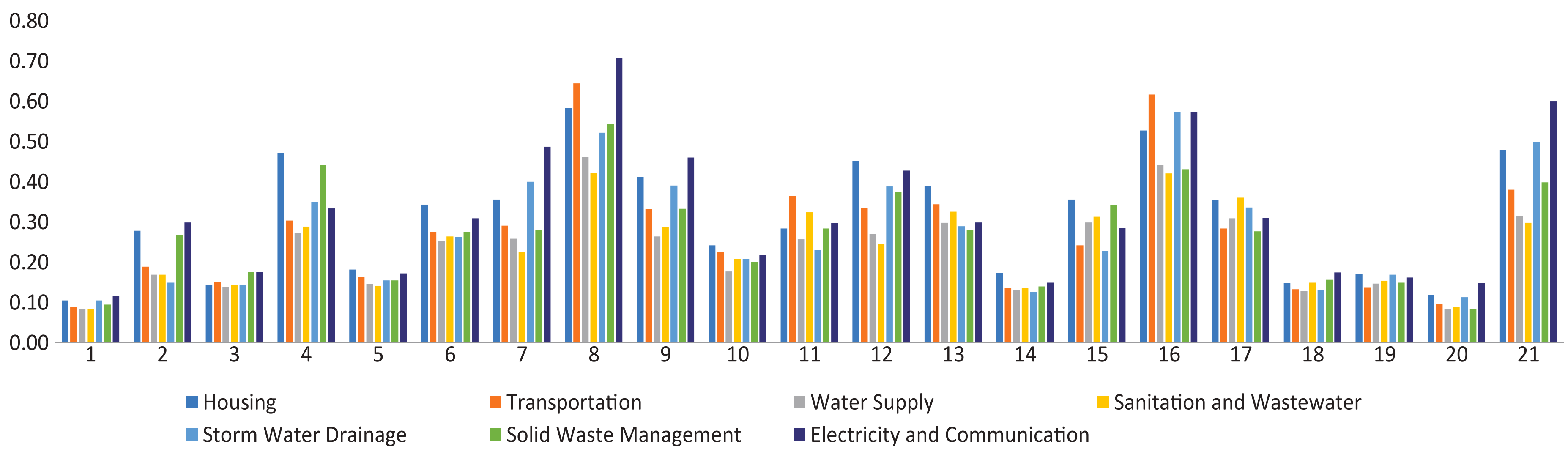

Figure 5: *Impacts of Thunderstorms on Infrastructure and Urban Services across Kushtia Municipality*

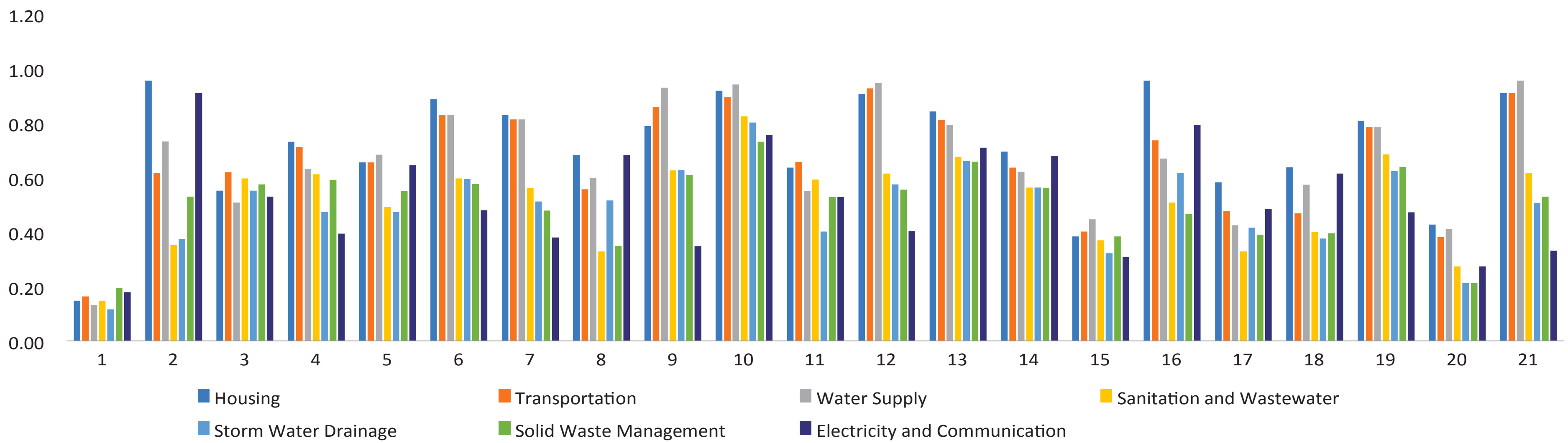

Figure 6: *Impacts of Heatwaves on Infrastructure and Urban Services across Kushtia Municipality*

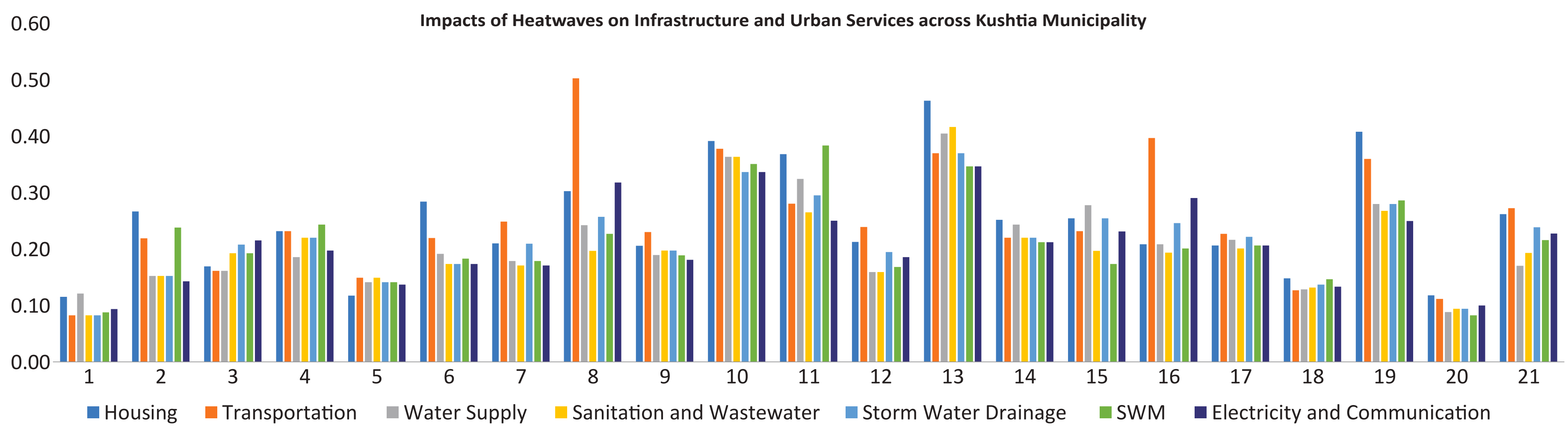

Figure 6: Impacts of Heatwaves on Infr astructure and Urban Services across Kushtia Municipality

Figure 7: *Impacts of Coldwaves on Infrastructure and Urban Services across Kushtia Municipality*

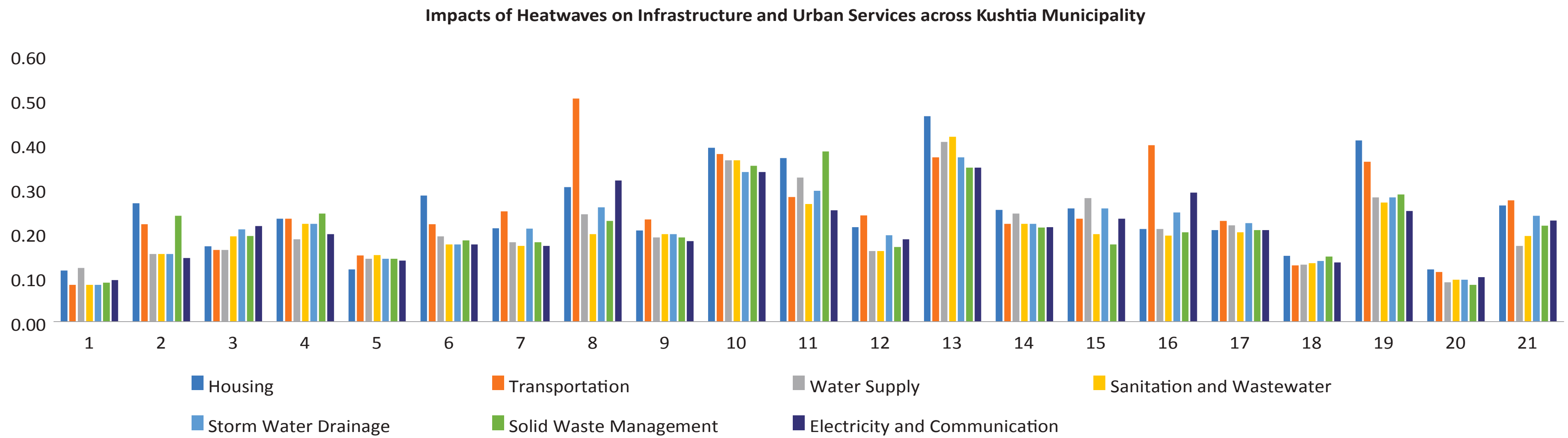

Figure 7: *Impacts of Coldwaves on Infrastructure and Urban Services across Kushtia Municipality*

Table 2: Ward Socio-economic Vulnerability Index of Kushtia Municipality

	Ward of Kushtia Municipality	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
Socio-economic indicator	Population	0.26	0.31	0.30	0.35	0.91	0.31	0.35	0.18	0.43	0.49	0.00	0.27	0.66	0.27	0.33	0.60	0.19	1.00	0.52	0.57	0.59
	Density	0.26	0.93	1.00	0.61	0.28	0.59	0.72	0.89	0.77	0.38	0.53	0.34	0.04	0.03	0.11	0.07	0.00	0.56	0.45	0.05	0.11
	Housing Condition	0.01	0.36	0.38	0.03	0.24	0.24	0.06	0.00	0.04	0.84	0.13	0.57	0.71	0.65	0.90	0.45	0.75	0.11	0.36	0.72	1.00
	Literacy Rate	0.47	0.14	0.32	0.04	0.00	0.28	0.19	0.25	0.11	0.58	0.97	0.27	0.79	0.49	1.00	0.73	0.64	0.60	0.80	0.35	0.32
	Open Defecation	0.00	0.24	0.76	0.00	0.29	0.24	0.00	0.00	0.00	0.00	0.00	0.53	0.18	0.53	1.00	0.71	0.59	0.35	0.53	0.88	0.76

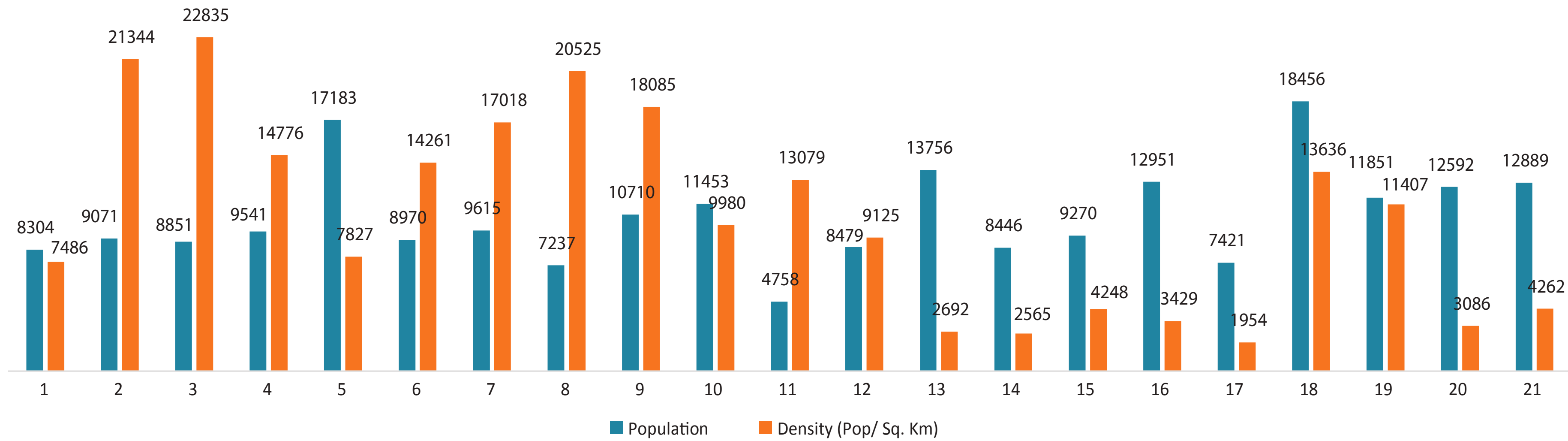

Figure 9: *Population and Density of Kushtia Municipality*

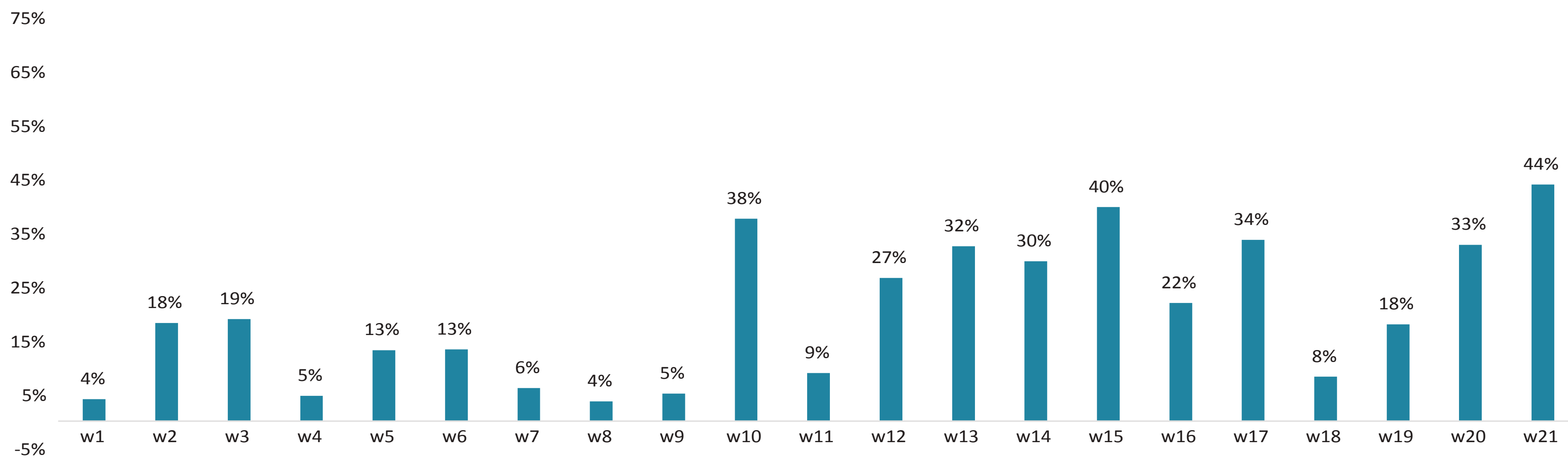

Figure 10: *Figure 10: Percentage of Kancha and Jhupri Structure across Kushtia Municipality*

Annexure 2: CAP Implementation Example

The prepared Climate Action Plan (CAP) for Kushtia Municipality has successfully demonstrated a practical implementation project, the development of a Material Recovery Facility (MRF) in the Low-Income Community (LIC) of Gorai Badh, Ward 10.

This initiative represents both ward-level climate adaptation and mitigation action. It is a unique example in Bangladesh of translating policy commitments into on-ground practice through a structured, data-driven methodology.

Figure 11: *From Policies to Practice*

1. Policy Support

The establishment of the MRF was initiated in response to both national policy priorities and international climate commitments:

- **National Adaptation Plan (NAP) 2023–2050:** The Government of Bangladesh has committed to spending USD 4 million for developing municipal-level Climate Action Plans across the country.
- **Nationally Determined Contribution (NDC):** Calls for reducing GHG emissions across sectors, including the waste sector, as part of Bangladesh's global climate commitments.
- **National Strategy for Water Supply and Sanitation:** Directs that all municipal projects integrate the 3R (Reduce, Reuse, Recycle) strategy into their design and operation.

2. Preparation of the CAP

A comprehensive Climate Action Plan (CAP) was developed for Kushtia Municipality. Using satellite imagery and the HIGS framework (Hazard, Infrastructure, Governance, and Socio-economic characteristics), ward-level vulnerability was assessed. The analysis identified which wards are most exposed to hazards, what types of support are needed, and how municipal systems can be strengthened for climate resilience.

3. Identification of Priority Projects

Based on the vulnerability assessment findings, community feedback, and stakeholder consultations, a list of priority projects was identified. These were grouped into two categories:

- WASH systems (Water Supply, Sanitation & Wastewater, Stormwater Drainage, and Solid Waste Management)
- Non-WASH systems (Housing, Transportation, and Electricity & Communication)

4. DPR Preparation

Several Detailed Project Reports (DPRs) were prepared to address the key challenges identified in the CAP.

a) DPR for Solid Waste Management (SWM)

The SWM system was found to be severely affected by recurring hazards, particularly in LIC areas where waste collection is irregular. Residents of Ward 10, Gorai Badh LIC expressed the need for a sustainable waste management solution. In response, a DPR was developed to establish a Material Recovery Facility (MRF) and improve waste segregation, recycling, and disposal efficiency.

b) DPR for Sanitation & Wastewater

Ward 10 also faces significant sanitation and wastewater management issues, particularly during flooding and periods of heavy rainfall. A separate DPR was prepared for the development of a Wastewater Treatment Plant (WWTP) to prevent contamination, improve hygiene, and reduce waterborne diseases in the LIC.

5. Development of the MRF in Ward 10, Gorai Badh LIC

The MRF was established to bridge policy goals with local community needs. It is one of the first community-operated MRFs in Bangladesh. The system is managed by local micro-enterprises and supported by community-led waste collection, ensuring ownership and sustainability.

Waste flow from the community:

- **Organic waste:** Sent to Kushtia Municipality's compost plant operated by the municipal authority.
- **Inorganic/recyclable waste**: Processed at the MRF for recycling or resale.
- **Non-recyclable waste**: Disposed of safely at Baradi Landfill.

Figure 12: *Material Recovery Facility (MRF) in Gorai Badh, Ward 10*

This MRF has several unique features that make it stand out, including a community-led operation by local micro-enterprises, strong participation by women in management and the workforce, and a fully integrated waste segregation and recycling system implemented within the community itself.

a) **Operated by Local Vangari:** Engaging local waste pickers (Vangari) provides them with stable income opportunities, formal recognition, and safer working conditions. It also improves segregation efficiency as they have practical expertise in waste sorting.

b) **Community Empowerment:** As the MRF is located within the community, it encourages local ownership and accountability. Residents actively participate in waste segregation, strengthening their capacity to maintain a cleaner environment.

c) **Gender Mainstreaming:** A management committee, consisting mostly of women, oversees the MRF operations. Women also represent the majority of direct beneficiaries, gaining both financial independence and leadership roles in environmental management. This initiative promotes gender inclusion and social empowerment within the LIC.

Figure 13: *MRF operated by local micro entrepreneurs*

Figure 14: *Community empowerment through MRF*

6. Ward-Level Climate Adaptation and Mitigation Outcomes

The MRF has already begun delivering measurable adaptation and mitigation benefits:

- **Source Segregation:** Residents now segregate waste at the household level, motivated by income opportunities and awareness of environmental benefits.
- **Improved Collection Efficiency:** Regular waste collection has significantly reduced the accumulation of waste in public spaces and drains.
- **Reduction in GHG Emissions:** By diverting organic waste to composting and recyclables to reuse channels, methane emissions from open dumping are notably reduced.
- **Reduced Littering in Gorai River:** Cleaner surroundings have led to less waste entering nearby water bodies, protecting the Gorai River ecosystem.
- **Lower Flood Risk:** Blocked drains and waste-induced waterlogging have decreased, reducing flood vulnerability in Ward 10.
- **Promotion of Organic Fertilizer Use:** Organic waste sent to the compost plant supports sustainable agriculture by replacing chemical fertilizers.
- **Future Carbon and Plastic Credit Potential:** As the MRF scales up, it can contribute to carbon and plastic credit programs, aligning with global circular economy trends.

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