List of Figures

	Page No.
Fig. 1.1:	Location of the coastal urban centres of the study areas
Fig. 1.2:	Geological formations of the Purba Medinipur district
	(South-eastern Coastal Plain of West Bengal)5
Fig. 1.3:	Geomorphological diversities in Purba Medinipur
	district with the study areas7
Fig. 1.4:	Drainage systems of the Purba Medinipur
	district with location of study areas
Fig. 1.5:	Month-wise variation of average rainfall and temperatures
	during 1949 – 2017 of the Purba Medinipur district9
Fig. 1.6:	Diversity in soil types of Purba Medinipur
	district with location of study areas10
Fig. 1.7:	Land use and land cover types of the coastal zones (littoral tracts)
	within Purba Medinipur district
Fig. 1.8:	Methodological flowchart of the study
Fig. 2.1:	Comparison of maximum elevation of three different urban centres27
Fig. 2.2:	Digital Elevation Model (DEM) of Digha-Mandarmani
	coastal stretch of Purba Medinipur district
Fig. 2.3:	Geomorphological diversities of Digha-Mandarmani coastal zones along
	the shore-fringe areas of the Bay of Bengal
Fig. 2.4:	Digital Elevation Model (DEM) of Contai Municipality areas
	in the littoral tract of Purba Medinipur district
Fig. 2.5:	Geomorphological diversities of Contai Coastal Plain with
	palaeo dune ridges in part
Fig. 2.6:	Digital Elevation Model (DEM) of Haldia Municipality areas in the
	littoral tract of Purba Medinipur district
Fig. 2.7:	Geomorphological diversities of Haldia urban centre along the
	Hugli-Haldi estuary complex (part of the inner littoral tract)
Fig. 2.8:	Temporal and spatial changes in areas of Digha urban centre
	along the shoreline
Fig. 2.9:	Temporal and spatial changes in areas of Contai urban centre
	along the inner coastal dune ridges
Fig. 2.10:	Temporal and spatial changes in areas of Haldia urban centre
	along the estuarine floodplain of Hugli-Haldi confluences

Fig. 2	2.11:	Land use and land cover types of Digha (1991) urban centre
Fig. 2	2.12:	Land use and land cover types of Digha (2001) urban centre
Fig. 2	2.13:	Land use and land cover types of Digha (2011) urban centre
Fig. 2	2.14:	Land use and land cover types of Digha (2018) urban centre
Fig. 2	2.15:	Changing pattern of land use and land cover types of
		Digha (1991 - 2018) urban centre
Fig. 2	2.16:	Land use and land cover types of Contai urban centre (1991)43
Fig. 2	2.17:	Land use and land cover types of Contai urban centre (2001)43
Fig. 2	2.18:	Land use and land cover types of Contai urban centre (2011)44
Fig. 2	2.19:	Land use and land cover types of Contai urban centre (2018)44
Fig. 2	2.20:	Changing pattern of land use and land cover types of
		Contai (1991 - 2018) urban centre
Fig. 2	2.21:	Land use and land cover types of Haldia urban centre (1991)48
Fig. 2	2.22:	Land use and land cover types of Haldia urban centre (2001)49
Fig. 2	2.23:	Land use and land cover types of Haldia urban centre (2011)49
Fig. 2	2.24:	Land use and land cover types of Haldia urban centre (2018)50
Fig. 2	2.25:	Changing pattern of land use and land cover types of
		Haldia (1991 - 2018) urban centre
Fig. 2	2.26:	Trend of increasing built-up area to the total area of
		three urban centres in Medinipur littoral tract55
Fig. 2	2.27:	Urban sprawling at Digha from 1991 – 2018
Fig. 2	2.28:	Urban sprawling at Contai Municipality area from 1991 – 201858
Fig. 2	2.29:	Urban sprawling at Haldia Municipality area from 1991 – 201860
Fig. 3	3.1:	Census Year-wise total population of three urban centres (1991-2011)64
Fig. 3	3.2:	Mouza-wise variation of population density at
		Digha urban centre (Census year- 2011)66
Fig. 3	3.3:	Ward-wise variation of population density at
		Contai municipality area (Census year - 2011)67
Fig. 3	3.4:	Ward-wise variation of population density at
		Haldia municipality area (Census year - 2011)
Fig. 3	3.5:	Mouza-wise decadal population growth at Digha urban centre
Fig. 3	3.6:	Ward-wise decadal population growth at Contai urban centre
Fig. 3	3.7:	Ward-wise decadal population growth at Haldia urban centre
Fig. 3	3.8:	Census year-wise population distribution and
		projected population (for 2021) at Digha urban centre

Fig. 3.9:	Census year-wise population distribution and
	projected population (for 2021) at Contai urban centre
Fig. 3.10:	Census year-wise population distribution and
	projected population (for 2021) at Haldia urban centre
Fig. 3.11:	Mouza-wise educational status during (a) 1991, (b) 2001,
	and (c) 2011 of Digha urban centre74
Fig. 3.12:	Ward-wise educational status during (a) 1991, (b) 2001,
	and (c) 2011 of Contai urban centre75
Fig. 3.13:	Ward-wise educational status during (a) 2001
	and (b) 2011 of Haldia urban centre76
Fig. 3.14:	Comparison of Census year-wise educational status of Digha,
	Contai and Haldia urban centres
Fig. 3.15:	Comparison of the involved population under different working groups
	at Digha during (a) 1991, (b) 2001, and (c) 201180
Fig. 3.16:	Different types of main workers at Digha urban centre
	during (a) 1991, (b) 2001, and (c) 2011
Fig. 3.17:	Comparison of the involved population under different working groups
	at Contai during (a) 1991, (b) 2001, and (c) 201182
Fig. 3.18:	Different types of main workers at Contai urban centre
	during (a) 1991, (b) 2001, and (c) 2011
Fig. 3.19:	Comparison of the involved population under different working groups
	at Haldia during (a) 2001, and (b) 2011
Fig. 3.20:	Different types of main workers at Haldia urban centre
	during (a) 2001, and (b) 2011
Fig. 3.21:	Total number of population involved in different main working activities
	in the urban centres of (a) Digha, (b) Contai, and (c) Haldia87
Fig. 4.1:	Tide gauge stations around the shoreline of Purba Medinipur coast
Fig. 4.2:	Fluctuation of mean tide level at (a) Diamond Harbour, (b) Haldia,
	(c) Gangra and (d) Digha gauge station during (a) 1948 – 2014,
	(b) 1971 – 2014, (c) 1974 – 2006 and (d) 1977 – 2012
	(showing the increased vulnerability of tidal elevations
	towards the low-lying areas of coastal urban centres)
Fig. 4.3:	Location of shore-across transects of Digha urban centre
Fig. 4.4:	Micro-zonation of surface morphometry
	along the different transects at Digha92

Fig. 4.5:	Water logging and saltwater inundation prone areas at Digha urban centre93
Fig. 4.6:	Location of transects across the dune ridges at Contai urban centre94
Fig. 4.7:	Micro-zonation of surface morphometry
	along the different transects at Contai
Fig. 4.8:	Areas prone to water logging at Contai urban centre
Fig. 4.9:	Location of transects across the floodplain-levees at Haldia urban centre97
Fig. 4.10:	Micro-zonation of surface morphometry
	along the different transects at Haldia97
Fig. 4.11:	Water logging and saltwater inundation prone areas at Haldia urban centre98
Fig. 4.12:	Year-wise cyclonic events of depression (D), cyclonic storms (CS),
	and severe cyclonic storm (SCS) and their trends in the
	Bay of Bengal during 1891-201899
Fig. 4.13	Regional distribution of severe cyclonic storm (SCS) events in the
	Bay of Bengal coast during 1891 – 2018 101
Fig. 4.14:	Areas prone to the vulnerabilities resulted from the track of severe
	cyclonic storm (SCS) within the West Bengal and Odisha coasts during
	(a) 1891-1910, (b) 1911-1930, (c) 1931-1950, (d) 1951-1970,
	(e) 1971-1990, and (f) 1991-2018102
Fig. 4.15	Position of shorelines and banklines during 1973 – 2018 in and
	around the study area. The positions of banklines along the river
	Champa, Jaldah, Pichaboni, Rasulpur, Haldi, and Hugli are
	selected for the bank shifting analysis104
Fig. 4.16	Distance of Net Shoreline Movement (NSM) along the coastal stretch
	of Digha, Shankarpur-Tajpur, Mandarmani, and Haldia during
	1973 – 2018. Transects are superposed over the recent image (2019)105
Fig. 4.17	Linear Regression Rate (LRR) of shoreline shifting and resultant
	erosion-accretion along the shoreline of Digha, Shankarpur-Tajpur,
	Mandarmani, and Haldia coastal stretch during 1973 – 2018106
Fig. 4.18	Transect wise shoreline shifting rate and resultant erosion-accretion in
	and around the study area of Medinipur littoral tract during 1973 – 2018 107
Fig. 4.19	Distance of net bankline movement during $1973 - 2018$ along the
	(a) Champa river, (b) Jaldah inlet, (c) Pichaboni inlet, (d) Rasulpur river,
	(e) Haldi river, and (f) right bank of Hugli river under the present
	littoral tract. Transects are superposed over the recent image (2019)108

Fig. 4.20:	Linear Regression Rate (LRR) of bankline shifting and resultant erosion-
	accretion along the banks of (a) Champa river, (b) Jaldah inlet,
	(c) Pichaboni inlet, (d) Rasulpur river, (e) Haldi river, and
	(f) right bank of Hugli river during 1973 – 2018 109
Fig. 4.21:	Severe nature of shoreline and bankline erosion at the Champa river
	mouth (Digha-Sankarpur) during 2002 – 2019111
Fig. 4.22:	Shoreline erosion and associated beach width reduction at the
	different coastal stretch during 2006 – 2018112
Fig. 4.23:	Gradual dune erosion and related reduction of dune elevation at the
	different coastal parts during 2006 – 2018112
Fig. 5.1:	Mean monthly variation of maximum temperature
	at Digha during 1982 – 2017117
Fig. 5.2:	Mean monthly variation of maximum temperature
	at Contai during 1949 – 2017117
Fig. 5.3:	Mean monthly variation of maximum temperature
	at Haldia during 1982 – 2017118
Fig. 5.4:	Seasonal variation of rainfall at Digha during 1982 – 2017118
Fig. 5.5:	Seasonal variation of rainfall at Contai during 1949 – 2017119
Fig. 5.6:	Seasonal variation of rainfall at Haldia during 1982 – 2017119
Fig. 5.7:	The nature of seasonal groundwater level at different coastal
	stretches of Medinipur littoral tract
Fig. 5.8:	Net depletion of groundwater level (mbgl) at Digha during 1996 – 2015 121
Fig. 5.9:	Net depletion of groundwater level (mbgl) at Contai during 1996 – 2015 122
Fig. 5.10:	Net depletion of groundwater level (mbgl) at Haldia during 1996 – 2015 122
Fig. 5.11:	Maximum and minimum levels of net groundwater depletion (mbgl)
	at three different sites during 1996 – 2015 (showing vulnerabilities)123
Fig. 5.12:	Different types of solid waste at Digha Township Area125
Fig. 5.13:	Sources of solid waste at normal days and peak tourist day at
	the Digha Township Area (during field survey in 2016) 126
Fig. 5.14:	Ward-wise production rate of solid waste at Haldia municipality area 126
Fig. 5.15:	Year-wise volume of solid waste collected by plant at Haldia municipal area127
Fig. 5.16:	Physical composition of solid waste at Haldia municipality area128
Fig. 5.17:	Composition of solid waste collected from the residential sector
	at Haldia municipality area
Fig. 5.18:	Groundwater quality data at the different sites of the study area130

Fig. 5.19:	Variation in groundwater quality of different parameters (a) pH,
	(b) Electrical conductivity, (c) Total hardness, (d) Calcium,
	(e) Magnesium, and (f) Sodium at the different sites131
Fig. 5.20:	Variation in groundwater quality of different parameters (a) Potassium,
	(b) Chloride, (c) HCO_3 , (d) SiO_2 , (e) SO_4 , and (f) PO_4 at the different sites132
Fig. 5.21:	Year-wise monthly variation of (a) suspended particulate matter (SPM),
	(b) Sulphur dioxide (SO ₂) and (c) Sulphur dioxide (SO ₂) in air
	at Haldia Super Market. The red line (dotted) indicates the
	WHO standard permissible limit of (a) 200 μ g/m ³ , (b, c) 80 μ g/m ³ 134
Fig. 5.22:	Ambient air quality of (a) Respirable particulate matter (RPM),
	(b) Sulphur dioxide (SO ₂) and (c) Nitrogen dioxide (NO ₂) at different
	sites of Haldia municipality area. The red line (dotted) indicates the
	WHO standard permissible limit of (a) 100 μ g/m ³ , (b, c) 80 μ g/m ³ 134
Fig. 5.23:	Coastal Regulation Zones (CRZ) at Digha-Mandarmani coastal belt136
Fig. 5.24:	The setting of micro-zonation for vulnerability assessment of Digha,
	based on estimated physical characteristics
Fig. 5.25:	The estimated standardized CVI based vulnerability
	assessment of Digha urban centre
Fig. 5.26:	The setting of micro-zonation for vulnerability assessment of Contai,
	based on estimated physical characteristics141
Fig. 5.27:	The estimated standardized CVI based vulnerability
	assessment of Contai urban centre
Fig. 5.28:	The setting of micro-zonation for vulnerability
	assessment of Haldia, based on estimated physical characteristics144
Fig. 5.29:	The estimated standardized CVI based vulnerability
	assessment of Haldia urban centre
Fig. 6.1:	Existing and DEM-based projected channel network at Contai150
Fig. 6.2:	DEM-based projected channel network along with the existing sewerage system at the Haldia municipality area152