Article

Not peer-reviewed version

Bengal Delta, Charland (Mid-channel Island) Formation, and Riparian Hazards: A Study of Dynamic Geophysical and Human Adaptations

C. Emdad Haque * and Mohammad Jakariya

Posted Date: 20 April 2023

doi: 10.20944/preprints202304.0629.v1

Keywords: accretion; adaptive responses; Bangladesh; erosion; floods; geophysical; hazards; river basin; river channel migration; resettlement.

Article

Bengal Delta, *Char*land (Mid-Channel Island) Formation, and Riparian Hazards: A Study of Dynamic Geophysical and Human Adaptations

C. Emdad Haque [1,*] and Mohammad Jakariya [2]

[1] Natural Resources Institute, University of Manitoba, Winnipeg, MB, Canada R3T 2N2; cemdad.haque@umanitoba.ca

[2] Department of Environmental Science and Management, North South University, Dhaka, Bangladesh; jakariya2009@gmail.com

* Correspondence: cemdad.haque@umanitoba.ca; Tel.: (001-204 474 8375)

Abstract: This study posits that for appropriately explaining the complex *char*land (mid-channel island) processes and formulating policy and planning measures, a comprehensive understanding of the dynamic characteristics of the geomorphological, ecological, and human systems holistically is essential. This is also valid for the territorial and maritime areas of Bangladesh. The objectives of this study are: (i) to analyze the salient features and characteristics of the geomorphological and riparian systems of the Bengal Delta; (ii) to analyze the evolutionary discourse of the legal systems concerning eroded (diluvion) and accreted (alluvion) land in Bangladesh; and (iii) to assess characteristics of coping and adaptation strategies of the charland inhabitants. The findings reveal that the delta-building processes, characterized by the dynamic shifts of river channels, and erosion and accretion of charlands have made the land and water systems of the territory very dynamic and unstable – resulting in consistent displacement of settlers and serious deterioration of their socioeconomic status. The historical evolution of land laws and regulations concerning the accreted land favoured vested interests. As no effective institutional framework and structure presently exists in Bangladesh for resettlement planning, formulation of a comprehensive national resettlement policy is therefore urgently needed.

Keywords: accretion; adaptive responses; Bangladesh; erosion; floods; geophysical; hazards; river basin; river channel migration; resettlement

---

1. Introduction

Located in the southern plains of the Greater Himalayan continental system, the land and water of the Bengal Basin are relatively recent geological formations characterized by recurrent channel shifts, riverbank erosion and slumping, *char*land (mid-channel island) accretion and erosion. Consequently, the Basin, most of which is occupied by the Brahmaputra-Jamuna and Meghna floodplains and the delta of the Ganges, is one of the most dynamic landscapes on earth. Historically, human occupancy of this land has been marked by recurrent displacements, multiple movements and resettlements, and continually adjusting cropping patterns. We posit here that, in consideration of the dynamic and unpredictable geomorphological and the socioecological processes in the Bengal Basin, the mid- and longer-term planning and policy decisions require serious attention to an adaptive land and water resources management strategy.

The 147,570 sq. km territory of Bangladesh, consists primarily of both deltaic and floodplain formations, is among the most rapidly changing landform systems in the world. The water bodies and flows here are found in various forms – as river flows, *beels* and *jheels* in the form of water reservoir supporting livelihood of millions of people, offering an ecology blessed with fertile land and ample supply of fresh water. More than 700 rivers, with three mighty and largest river basins in the world, drain more than 140,000 cu m/sec (4.9 million cu f/s) during the monsoon period and nearly

 doi:10.20944/preprints202304.0629.v1

half of it during the winter, dry period to the Bay of Bengal located in the south. From the Himalayan mountain ranges and a catchment area of 1,650,000 sq. km [1], these river systems carry down a total of 1 trillion cubic meter of water and sediment at a rate of 1 billion tonnes annually [2], helping the delta deposits in the lower Meghna River estuaries.

In building one of the largest deltas in the world by depositing these bed-load and suspended sediments, a dynamic river channel systems have been evolving over geological periods creating the most complex drainage systems characterized by both *braided* and *meandering* types of rivers. River channel migration, mid-channel sand bars and shoals (*char*land) formation, and rapid riverbank slumping constitute various activities of the dynamic delta-building processes. On one hand, while riverbank slumping and erosion causes land, settlement and crop-losses every year, one the other hand, new land re-emerges down streams from riverbeds, forming small islands – locally known as *chars* – providing hope for resettlement and livelihood reconstruction.

The charland management in Bengal has historically been matters of disputes, violent conflicts and means of local and regional political influence [3–6]. Since the Permanent Settlement of late 18th century in British India, the charlands have been subject of various form of legal rights of the state and individuals without much satisfactory settlement of the people displaced by river erosion and flood disasters. While the inhabitants of both mainland and charland areas have adapted to such dynamic socialecological conditions over centuries and created new avenues through local and indigenous innovations, their documentation and analysis remained by and large poor and scant.

In light of the above stated knowledge gaps, in this study, we explore, first, into the dynamic features of the physiographic and riparian systems of Bengal Delta; second, the historical and contemporary evolution of the legal and management systems concerning eroded (diluvion) and accreted (alluvion) land in Bangladesh; and third, from a policy and planning perspective, the implications of the learning from charland dynamics and inhabitants' adaptive capacity for institutional interventions.

2. Dynamic Bengal Delta and Charland Formation and its Associated Hazards

2.1. Morphology of Bengal Delta formation

In this section, first, geophysically active and unstable character of the Bengal Basin region, its land and related forms, such as forming and eroding charlands in the Bengal Delta and riparian floodplains, is explained. We, here, highlight chiefly the active tectonic, hydrological, and morphological properties of Bengal Delta and the fluvial systems of the Ganges-Brahmaputra-Meghna (GBM) rivers. The differences in the formation of chars between Bengal Basin's diverse geomorphological regions are then analyzed, followed by an account of the historical evolution of land tenurial system, human habitation, and institutional (e.g., the state) management of charland.

The location of the Bengal Basin is at a confluence of Indian, Burma and Tibetan (Eurasian) plates (Figure 1), and it occupies an area of about 200,00 sq. km. The present-day political territory of Bangladesh accounts for about 25% of this area. As Alam and Curray [7] cited, in the Indian Sub-continent, considerable volume of orogenic sediments was transported down during the Tertiary-Holocene period. The direction sediment movement was from the eastern Himalayas to the north and from the Indo-Burman Ranges to the east. These processes had resulted in excess of 20 km of sedimentary deposits into Basin (Figure 1). Recent research findings, relying primarily of stratigraphic and developmental analyses, have revealed that the tectonic factors and supply of sediments have influenced the Ganges-Brahmaputra-Meghna systems more profoundly than other major delta systems [8]. According to the Goodbred et al. [8] study, tectonics function as a critical continental control in the deltaic system of the Ganges and Brahmaputra rivers. Such roles are played by active tectonics (that is, tectonic plate-related activities versus passive-sedimentary-tectonics), changing the formation of the delta in the Basin area and affecting sedimentary volume and distribution.

In studying the charland formation, it is important to analyze and highlight the crucial elements associated with the processes of recent tectonic and fluvial sedimentary activities. These are also relevant to delineate the patterns in land occupancy, ecological changes, changing needs of

Preprints (www.preprints.org) | NOT PEER-REVIEWED | Posted: 20 April 2023 doi:10.20944/preprints202304.0629.v1

development planning. An intense earthquake in 1950, with Richter mag. 8.7, in Assam, India that have had considerable impact upon various reaches of the Brahmaputra River is an excellent example of a recent tectonic event. Both the middle and lower reaches of the river were severely impacted. The 1950 earthquake noticeably altered the slope and physiography of the northern regions of Bangladesh and resulted in changing the courses as well as morphological characteristics of several tributaries of the Brahmaputra River [9].

Poddar [10] cited that a large volume of sediment by means of slope-failures was introduced in the Bengal Delta by the 1950 Assam earthquake [10]. As a result, at the estuaries of Ganges-Brahmaputra rivers (forming chars in Noakhali district of Bangladesh), for several years, there had been a considerable rise in sediment load following the 1950 Assam earthquake [11]. There were several other tectonic features and events that have had significant effects upon the deltaic system of the Basin, influencing drivers of river channel courses, avulsion, the distribution of sediments, were faulting, earthquakes, and other tectonic activities. The Fergusson study [12] recorded that a vertical displacement in locations near Mymensingh, Bangladesh was caused by the 1782 earthquakes in the Sylhet region, and this tectonic event assisted avulsion (a process of gradual land erosion and river channel shift) of the Brahmaputra River. As recorded in Bengal's the then surveyor Major James Rannell's maps, during 1782-1830, the main channel of the Old Brahmaputra River completed its shift from its previous course east of the Madhupur Terrace region to its current channel of the Brahmaputra-Jamuna River (also see [6]).

Figure 1. Geographical setting and the location of Bengal Basin and the Ganges-Brahmaputra-Meghna River system. **Source:** Modified from Esri, HERE, Garmin, FAO, NOAA, USGS, @ OpenStreetMap contributors, and the GIS User Community.

The large sediment load initially (from Pliocene onwards) from the west and northwest and later (since later part of Pliocene and Pleistocene) from the eastern Indo-Burman ranges filled the Bengal Basin, leading to a very complex deltaic and riparian systems. Curray and Moore [13] estimated various parameters of the undersea fan of sediments carried down from the Himalayas by the Ganges-Brahmaputra-Meghna system: the width to be approximately 1,000 km, the depth over 12 km, and the length more than 3,000 km. These major rivers constitute the surface of the Bengal Basin.

2.2. Fluvial-riverine systems

Understanding the dynamic nature of land and char formation in Bangladesh requires attention to the geomorphic settings, patterns in historical shifts in river courses, and the processes of charland accretion (deposition) and erosion. On rounding the Rajmahal Hills, the Ganges River flows into Bangladesh near Rajshahi and moves east and southeastward towards and meets the Brahmaputra-

Preprints (www.preprints.org) | NOT PEER-REVIEWED | Posted: 20 April 2023 doi:10.20944/preprints202304.0629.v1

Jamuna River in Manikganj district. The Ganges River reaches from the location where it meets the Brahmaputra-Jamuna River to the location where it meets with the Meghna River near the city of Chandpur are called *Padma* River [6]. In categorizing various parts of the delta of the Ganges, Spate [14] divided them into three regions: the *moribund, mature* and *active* delta. Capturing most areas of the northwestern and north-central zones of Bangladesh, the moribund and mature delta regions occupy several districts, namely, Kushtia, Jessore, Faridpur and northern Khulna. These zones do not receive extensive silt or diluvion deposits [15].

Over the last three hundred years, the morphology of moribund and mature delta regions had been profoundly impacted by the eastward migration of the Ganges main channel -- as it acted as the primary drivers of geomorphological and hydrological changes (Figures 2 and 3). The details of these sequential shifts and the dynamics of the moribund and mature delta building processes are provided by Ahmed [16], Haque [6], and Akter et al. [2]. Sarker et al. [1] cited that the Ganges and joined discharges of the Old Brahmaputra and Meghna Rivers were flowing into two separate, distinct estuaries for delta formation (Figure 3). As can be seen in James Rannell's map produced from land surveys during 1764-1776 (Figure 4), the Ganges estuary was located close to the northern upstream reach of the Tetulia River. After joining the Brahmaputra-Jamuna River, by 1830, the active delta building estuary shifted towards the east, which resulted in the formation of both moribund and mature parts of the delta (Figure 5).

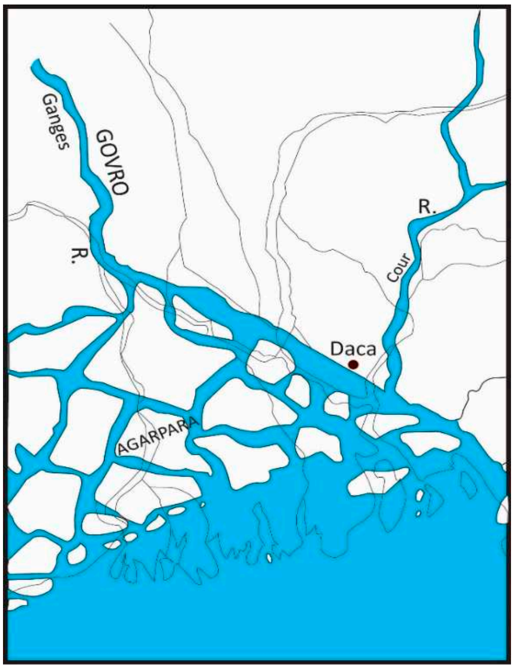

Figure 2. Jao de Barros's map (1550 AD).

Preprints (www.preprints.org) | NOT PEER-REVIEWED | Posted: 20 April 2023 doi:10.20944/preprints202304.0629.v1

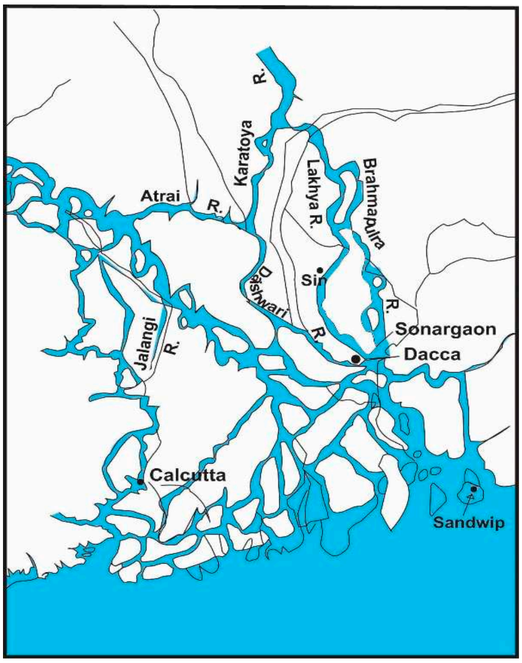

Figure 3. Van den Brouche's map (1660 AD).

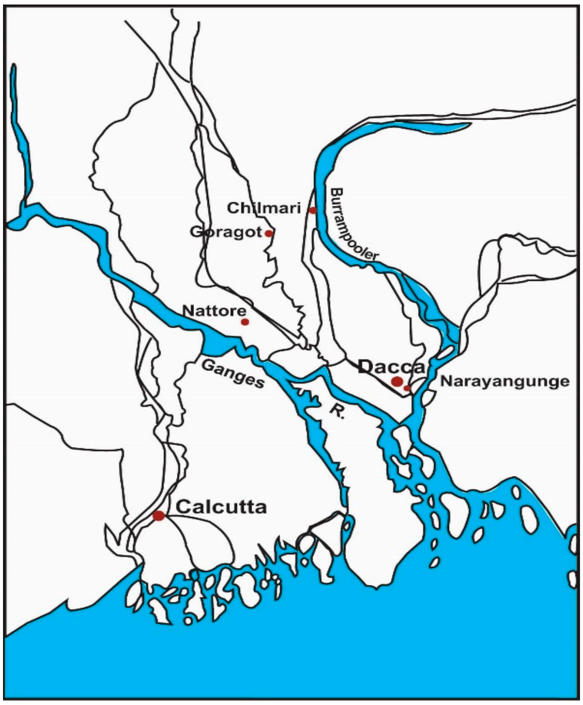

Figure 4. Major James Rennell's map (1764-1776 AD).

Preprints (www.preprints.org) | NOT PEER-REVIEWED | Posted: 20 April 2023 doi:10.20944/preprints202304.0629.v1

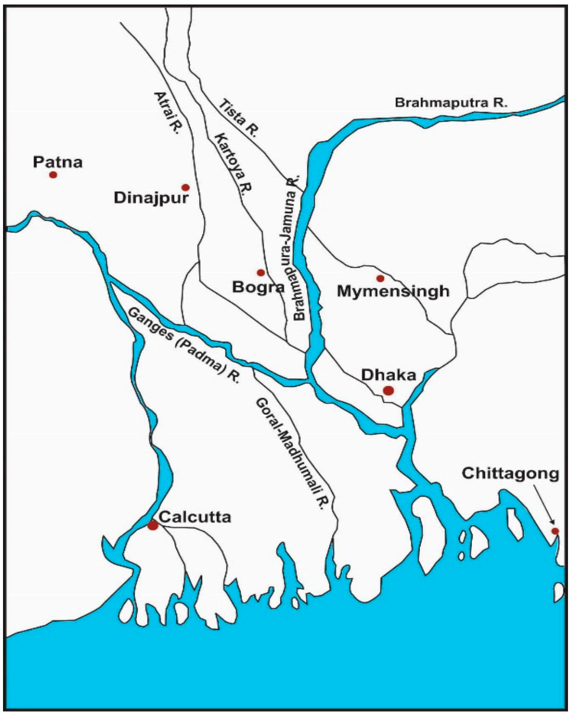

Figure 5. Recent Ganges-Brahmaputra-Meghna river systems

2.3. River Channel Patterns and Charland Formation

The characteristics of river channel patterns, categorized as *straight*, *meandering* and *braided* patterns, are largely determined by a number of geomorphological variables including the slope, discharge and bed material size [17–19]. Several scholars have classified channel patterns (the bird's eye view of channel configuration) of both the Ganges and Brahamaputra-Jamuna Rivers as *braided channels* as they are divided into multiple channels by the existence of chars (bars or islands), and these separated channels afterward converge as well as get divided again [9,20,21]. The primary characteristics of the braided rivers include highly variable discharge, bed-load abundance, easily erodible banks, steep slopes, and mid-channel bars, shoals and islands (charland) [22]. Generally, these islands are seasonally unstable.

The large islands, namely Ramgati, Hatya, Bhola, Sandwip, were created over the last few centuries in the *active* delta region of the country, which occupies lion-share of the coastal plains (Figures 2–5). In the deltaic plains, erratic nature of the fluvial morphology leads its landform to be very dynamic features, and therefore very unstable and unpredictable over time. Here, during the monsoon, land gets inundated every year, and emergence of new land (accretion) from the deposited sediments is a crucial outcome of delta formation processes. These features are more noticeable in the Meghna-Tetulia-Shahbazpur distributary systems than other systems [6].

Huge Brammer [11,23] has provided some insightful explanations of the erratic and intricate features of these estuarine chars. He asserts that the 'old land' on the older islands is characteristically different that those exist on the new charlands (for an example, *Bhasan char*). For instance, the 'old chars' would likely to have been in existence for several centuries. Here, soils are well-developed as well as fresh groundwater is usually available. In contrast, salinity is major problem in the newly accreted chars. Soils are undeveloped in these chars that are very unfavourable for both cultivation and settlement. In the Meghna estuary that covers the lower Meghna floodplains and the coastal plains, the yearly accretion rate is about 45 sq. km of new charland. However, in these estuarine areas, about 25 km^2 land, chiefly the settled land areas, is lost annually by erosion. Thus, although there is an annual net addition of 20 sq. km of land to the region, it embodies critical loss of some valuable cultivable and settled lands. These processes make land and settlement provisions quite unstable in these estuarine chars (also see [24])

The early maps exhibit that, in the early 19th century, the channel pattern of the Brahmaputra-Jamuna River was a *meandering* one [1,19]. Nonetheless, by 1830 AD, it changed into a braided river (Figure 4) as a result of continuous geomorphic process of channel widening. The current Brahmaputra-Jamuna River reaches in Bangladesh are convincingly *braided* whereby, in this riverine system, the numerous channels persistently shift over time by means of erosion of riverbanks and chars. These river channels are concurrently engaged in depositing alluvium and in forming accreted land. Locally, these new alluvial land within or at the channel sides are called *chars* [24]. The constant erosion and accretion processes of the Brahmaputra-Jamuna and creation of unstable charlands generate a high degree of uncertainty, particularly for settlement [1,23]. Both within and alongside a channel, with the deposited sediments, formation of charland begins as sandy shoals. In terms of shape, these formations are commonly linear or close to elliptical [23]. In turn, these new formations divert the flow of discharge against the opposite bank of the channel, resulting in undercutting and eroding it continuously. Lateral erosion rates along the Brahmaputra-Jamuna River are spatially varied. The extent of yearly lateral erosion is commonly less than 200 m; however, the rate is so variable that, in one single year, it could reach up to 1 km. In general, the channel widening processes are continuing with a westward shift of the main channel.

2.4. Charland temporal cycles

The Sarker et al. [1,19], and Brammer [23] studies offer insightful explanations of the dynamics of char associated with morphological characteristics of rivers. The studies revealed that two major factors have influenced charland settlements in the Bengal Basin area: (i) number of years of charland accretion (i.e., the age), and (ii) the legislative and legal statuses provided by the state regarding eroded and accreted land. Within the Meghna estuarine region, some of the old chars were attached to the mainland prior to Rennell's surveys in the late 18th century. Major Rennell illustrated that it was possible for anyone to travel from Vikrampur area to Dhakshin Shahbazpur (presently Hatiya Island) without any interruption by any major river. In the absence of any specific land and settlement record, it is plausible to infer that some of the large-old islands were populated as early as during the 15th-18th Centuries (i.e., Mughal period).

In the active delta region of the estuary, nonetheless, the chars were formed only in recent times. Brammer [23] insists that, to offer clues to appropriateness to opt for relatively permanent human habitation or other temporary socioeconomic activities, the ground water quality – in respect to whether saline of fresh – is an effective yardstick. Locals are aware of these attributes and adapt themselves according to the dynamism of the charland morphology. As suggested by Sarker et al. [1], in consideration of the Brahmaputra-Jamauna and Ganges-Padma River settings, it is crucial to differentiate between *island chars* that are commonly surrounded by water throughout the year and the *attached chars* that become connected with and thus part of mainland under normal discharge and flow conditions. It has been observed that abandonment of any outflank river channel can alter an island char into an attached char [24,25].

Using satellite imagery, a recent study on the charland forming processes along Bangladesh's major rivers by ISPAN [25] showed that, as the Ganges-Padma and Lower Meghna Rivers are characterized by a mix of meandering and braided channels (i.e., wandering river), in these basins the chars are more stable relative to the chars in Brahmaputra-Jamuna River system (Table 1). Characteristically, the chars in Brahmaputra-Jamuna River are relatively new formations – more than two-thirds were less than 6 years old, and only three-fifths (60%) of the chars 'persisted' in the range between 1 and 6 years. In 2000 AD, the chars that persisted more than 27 years had only 2.2% of the total char areas within-bank [24,25]. The Meghna River system has numerous channels discharging in parallel streams, and any of these streams can function as a single meandering river. Consequently, the chars in the Upper Meghna region are relatively stable; notably, most of them are island chars that endured over 70 years.

Table 1. Measurement of recent changes in landforms and waterbodies in major river systems in Bangladesh, 1984 and 1993.

Item	Total water area (ha)		Total sand area		Total vegetated land (chars) (ha)		Total area within the banks		Ratio of attached char area & island char area
Year	1984	1993	1984	1993	1984	1993	1984	1993	1993
Brahmaputra-Jamuna	55,740	61,240[a]	54,010	70,240[a]	89,580	98,760[a]	199,330	230,240	1.00
Change		*+5,500*		*+16,230*		*+9,180*		*+30,910*	
Ganges	28,620	28,980	36,230	35,660	24,350	35,560	89,200	100,200	1.56
Change		*+360*		*-570*		*+11,210*		*+11,000*	
Lower Meghna	45,610[b]	57,680[b]	-	-	11,070	18,070	56,680	75,750	All are island chars
Change		*+12,070*				*+7,000*		*+19,070*	

[a] Calculated based on 1992 data, [b] figure shows area of water and sand. Sources: [1], and [24].

Several research pursuits have examined the temporal cycles of char formation in the large estuaries of Bangladesh [26–28]. These studies inferred that, in the foreseeable future, the accretion and erosion of chars in the Meghna estuary will remain unstable. They further cited that, in terms of energy, while the river-dominated forms (i.e., bird-foot planform) prevail in the Mississippi Delta (USA), it is high tidal energy that considerably affects the morphology of the Meghna estuary. In the latter, the dynamic and erratic nature of the estuary and unstable formation of the newly formed chars are the outcome of voluminous sediment inputs from upstream and high tidal energy from downstream (also see [24]). Akter et al.'s [2] assert that, in this way, the Meghna estuary gets engaged in several thousand sq. km of land erosion and accretion every year. It is plausible to expect that instability associated with high tidal energy will continue to characterize the emerging chars downstream of the Meghna estuary.

3. The State, *Permanent Settlement* Scheme, and Administration of Alluvion and Diluvion Regulation

Historically, human habitation and occupancy of the plains and chars of Bengal territory have been influenced by both physical and societal factors. These influencing factors include the geomorphological dynamism that drove most aspects of the delta building processes, river channel shifts, and the distribution of land and water, on one hand. The state-driven land tenure and legal systems that significantly impacted social relations and resource entitlements have had profound influence on human occupancy, on the other hand [6,24]. These factors functioned interactively. For example, during the 18th century, sociopolitical spheres of Bengal experienced notable changes with major alternations in river systems. With the takeover of Bengal by the British East India Company in 1757, the process of sociopolitical land tenurial changes begun. Among the various social classes of claimants for the settlement of land revenue, Hindu *zamindars* (landlords) were particularly chosen by the Company as the most appropriate agents. Consequently, land tenure along with authority and responsibility to collect revenues and taxes were given to them by the Company [29,30]. Notably, it was presumed that a permanent structure of the tenure and fixed assessment would persuade individuals to reclaim massive areas of potentially arable wasteland, including charlands, and thereby increase the tax-bases. The Company hence approached and made agreements with *zamindars*, *talukdars*, and the "actual proprietors" of the land. In 1793 AD, this action by the colonial power was implemented all over Bengal by a proclamation -- known as the Permanent Settlement scheme.

Within three decades, the role and policies of the British Raj (the state) in administering areas of Bengal changed substantially, with several new regulatory provisions and features. For example, in 1825 AD, the Bengal Alluvion and Diluvion Regulation was enacted that had profound implications for riparian landownership [6]. Local customs and titles regulated claims to ownership of alluvion and diluvion land prior to the enactment of this legislation [31]. However, according to the newly enacted 1825 Regulation, in the cases of established and clearly recognizable matters, claims and disputes over alluvion land be decided upon by considering the local use of *payasti* (alluvion) and *sikosty* (diluvion) [32–34]. In fact, the goal of enacting this Regulation was to protect the common interests with the *zamindar* and large landlords – an outcome of a coalition among these leading groups during the British colonial regimes. Consequently, accreted lands from receding rivers were annexed to the tenure of the individual whose estate it adjoined [33]. However, in case of a submerged estate that became attached to an adjoining estate afterward, upon re-emergence, would not be given legal control of the adjoining estate. In such cases, the established owners would receive legitimacy [24].

By abolishing the Permanent Settlement scheme, the Act of 1950 - known as the East Bengal State Acquisition and Tenancy Act (EBSATA) - was introduced following the Partition of the Indian sub-continent in 1947 AD. The Act induced several constraints on the restoration to the former owners of lands lost by diluvion, of which the primary ones were: i) the restoration was legal if it occurred within two decades following the event of diluvion; and ii) such restoration was legal only if the possession of the land area was held by the rent receivers or cultivating *raiyats* (section 20 of the 1950 EBSTA) and fulfilled the constraint of transfer of holdings up to a maximum of 50 hectares (125 acres; section 90 of the 1950 EBSATA) [6]. The Act stressed the *de facto* possession of the land, and revealed the rise of Muslim landlords as the primary sociopolitical, and economic power in the riparian areas of Bengal. The process replaced most of the Hindu *zamindars* – overwhelming majority of them were absentees by then.

3.1. Post-Independence (1971) Land Reforms

Understanding of the recent (post-Independence) land reforms and their implications for riparian land management requires a reflection on the historical root of social differentiation in Bengal. A process of rapid social differentiation started in Bengal in the late 18th Century (i.e., late Mughal period) [35]. A deeply embedded pattern of revenue-demand from the peasant cultivators emerged to undercut the traditional bonds that had been formed and structured by the Hindu caste system over the centuries. With a steady rise in the proportion of marginal farmers and landless, new social relations evolved around land-based power politics. As a result, in rural Bengal, an unequal power structure and relations gradually got established, controlling land within a "patron-client" or "headman-subordinated follower" framework [36]. The Zaman study [36] asserted that, in charlands areas, such asymmetrical power structure was more conspicuous than in other riparian areas of Bengal.

Recognizing the emerging issues of rising landlessness among the peasants, the post-Independence (1971) national government of the country formulated some new policy measures to reclaim all alluvion lands from the control of *jotedars* (large landlords). The goal of such policy shifts was to procure and redistribute these alluvion lands among the landless and small landholders (who owned less than 15% of a hectare of land). In order to encourage farmers' cooperatives and other forms of collective farming, the Presidential Orders of 1972 (# 72, 35 and 135) were enacted with a provision that: all newly emergent lands previously lost by diluvion should be reinstated to the government as *khas* (public) land, instead of tenured to the original owners [6,24,37]. It was subsequently proclaimed that all charlands, irrespective of whether reformation in situ or new accretion, are to be considered as *khas* land.

There have been several modifications in recent decades to the alluvial land tenure polcies. For instance, the Presidential Order No. 135 of 1972 was amended in 1994 with the provision for abatement of rent lost by diluvion and subsistence of the right to land re-formed in situ for three decades, which would be subject to a ceiling of 49.4 hectares (20 acres) [24]. As Zaman and Hossain

Preprints (www.preprints.org) | NOT PEER-REVIEWED | Posted: 20 April 2023 doi:10.20944/preprints202304.0629.v1

[38] elaborated, the owner must pay rent, and a certificate from the revenue authority is required to claim the new land. If the land re-emerges after three decades, the land will be vested to the government as *khas* land. This considerable temporal gap of 30 years in effect favours the locally powerful individuals and/or groups to grab newly accreted land prior to surveys and settlements.

4. Contemporary Land Management Policies Relevant to Charland Inhabitants

4.1. Contemporary land laws and regulations

Among voluminous documents on contemporary land administration and management that have direct relevance and implications for charland ownership, use, and management, the Islam et al. [39], and Hossain [40] studies are useful for the purpose of the present study. Based on these studies, a synthesis of the contemporary land laws and regulations on land use, transfers, acquisitions and resettlement is presented here.

In Bangladesh, land can be owned by individual, the cooperatives, and the state under various prevailing legislations and regulations. Security of land interests and rights is associated with agricultural production and thus food security, on the one hand, and social security of the vulnerable groups in society. Presently, in case of agricultural land, the tenancy, the rights, and liabilities of owners of land are regulated by the 1950 EBSATA, and in case of non-agricultural land, by the 1949 the Non-agricultural Tenancy Act. *Maliks* (owner) or *raiyats* are the only holders of agricultural land, and their rights and liabilities are elaborated under the provisions of 1950 EBSATA, Section 81(1). However, *maliks* or *raiyats* are not entitled to any right to any interests in the sub-soil including rights to minerals in his/her holdings [39].

The 1984 Land Reform Ordinance enacted a ceiling of future land acquisition to 51.9 hectares (21 acres), and sharecropping as the only admissible form of tenancy contract. In 1997, the Agricultural Khas Land and Settlement Policy was enacted to distribute *khas* land to the landless on a 99-year lease provision [41]. An investigation by Tariquzzaman and Rana [42] revealed that the process of acquiring *khas* land, being a political course rather than legal process, has been favouring more of the interests and benefits of the prevailing elites than others. A considerable portion of *khas* land has been illegally occupied and "owned" by such elites. Consequently, the government did not have even ownership and control over such public lands. It is cited by numerous studies that such land grabbing is more acute in the charlands than on other areas [26,43]. Feldman and Geisler [43] state that:

> *State policies and their implementation, particularly in the countryside, continue to be plagued by various forms of corruption and an elite and bureaucratic formation that has been unable to mediate – and in fact takes advantage of – the costs of neoliberal reforms that have privatized and decentralized form of rule that were once part of local systems of accountability.*

In the context of charland areas, they further registered that it is usually the poor inhabitants, who remain the flood-prone and charland areas, are often "displaced in place" since they are among those who are likely to gradually lose access to land they once cultivated, or to those lands which emerge after diluvion. Such in situ displacement is characterized by considerable loss of life support services and functioning ecosystems upon which the producers' livelihood depends. The displaced families are often forced to move to the cities, slums, or designated settlement areas, to populate and compete with inhabitants already in place and add to the increasing pressure on urban or fringe area land use, other infrastructure, and services.

4.2. Regulations on Land Use, Acquisitions and Resettlement

In view of the critical need for regulatory interventions, the Government of Bangladesh formulated the 2001 National Land Use Policy, with the primary objective of providing guidelines for the usage of land for various purposes. The included agriculture, housing, afforestation, commercial and industrial establishments, rail an highways and tea and rubber gardens. Relevant to charland areas were the key policy objectives of prevention of alarming loss of agricultural land, protection of *khas* land, zoning of land, and establishment of a data bank for *khas* land, fellow land, acquired land, and charland for ensuring their effective utilization.

 doi:10.20944/preprints202304.0629.v1

Here, land acquisition by the government for large-scale infrastructure, development projects, resettlement schemes is particularly relevant to riparian and charland areas. The government of Bangladesh currently uses the 1982 Land Acquisition and Requisition of Immovable Property Ordinance for such purposes [40,44]. This 1982 Ordinance has its roots in the British colonial Land Acquisition of Act of 1894, used to colonize unsettled land and collecting revenue. The 1989 Act enables additional authoritative power to the District collectors to acquire property on an emergency basis; however, it is limited only to project related to flood and flood control infrastructure [44]. As Hossain [40] identified, there are significant challenges in its application due to is grounding on the "compensation rationale" only.

There is no existing national resettlement policy in Bangladesh [44] while millions of sedentary population is being displaced by the prevailing socioeconomic pauperization, periodic natural disasters such as floods, riverbank erosion and charland diluvion processes, and cyclones, and large-scale development projects. As Zaman [45] cited, in view of the absence of such a national policy, there are numerous variations in resettlement packages and benefits in current projects which heavily reply upon the individual Task Managers and his/her negotiation intent and skills. These have resulted in inconsistent compensation and resettlement outcomes, causing agony and frustrations among the displaced people [40,45].

5. Coping and Adaptations to Environmental Risks in Charlands

Numerous empirical investigations on inhabitants' coping and adaptation to environmental risks associated with floods and riverbank erosion in charland areas have revealed that people here have historically developed some distinct coping and adaptation behaviour [6,36,39,46–49]. The local communities, based on their decades of experiential and social learning for developing and enhancing *coping capacity* (i.e., immediate and direct response to the impact of an extreme event) and *adaptive capacity* (i.e., long-term strategies enabling change and transformation to deal with adverse effects; see [50]) enabled them to use indigenous and simultaneously adopt modern strategies effectively.

5.1. The Kazipur Charland of Jamuna-Brahmaputra River System Case Study

The first author of the present study carried out a pioneering international collaborative research project that studied the river channel shifts and its resultant displacement of population in the mainland as well as in charlands of Bangladesh. This research endeavour is known as the Riverbank Erosion Impact Study (REIS) [51]. The field studies of REIS were conducted in three *Upazilas* (sub-district) during 1983-1988: *Kazipur* and *Chilmari* of the Brahmaputra-Jamuna floodplain, and *Bhola* of the Meghna deltaic plain. Subsequently, with the same survey instrument, Haque [6] re-visited Kazipur *Upazila* (sub-district) during 1993-94. As the results of the 1993-94 surveys are more relevant here, an overview of these findings is offered below.

Located on the right bank of the Brahmaputra-Jamuna River, Kazipur Upazila (sub-district) of Serajganj district has numerous chars across the western channel. The REIS Study registered numerous coping and adaptation measures undertaken by the local communities and institutions to deal with charland erosion and slumping hazards. As part of coping strategies, in constructing their dwellings, the inhabitants in the charland area resolutely use easily dismountable and moveable materials (e.g., thatch, bamboo, wood, and corrugated iron sheets) rather than using brick, steel, concrete and other modern (*pucca*) housing materials [6,24]. An overwhelming majority of the respondents (77%; n=247) used corrugated iron sheets as their roof materials, and many others used thatch, bamboo, and other materials. House structures made of these local materials were found to be much less susceptible to flood-loss and riverbank erosion than are permanent masonry structures.

In addition, multitude agricultural coping measures to minimize potential flood impact and riverbank erosion disaster-loss have also been developed and implemented by the charland inhabitants (also see [52–54]). The charland soils along the Jamuna-Brahmaputra River are generally composed of calcareous loams [15]. Because these porous sandy soils (i.e., *bali*) do not suit *boro* paddy, but support pulses and other winter crops, cultivators in the charlands follow a distinctive cropping pattern than in the mainland (Table 2; also see [6]). As can be seen in the data presented in Table 2, most households in Charland Zone in Kazipur grow *aus* and *aman* paddies than Mainland Zones. The charland also seems to be more suited to the cultivation of pulses than other winter crops. The variations in cropping patterns between the Charland Zone and the Mainland Zone are found to be statistically significant [χ^2 = 148.4 (p <0.001 level)].

Overall, our examination of the cropping patterns in various zones reveals that settlers in hazardous areas (e.g., the charland areas) attempt to mitigate the risk of potential crop-loss due to natural hazards by investing lesser financial capital and cultivating low-cost varieties. For instance, in relation to water supply and management, *boro* paddy and potatoes require relatively higher investment-costs and intensive care (i.e., labour intensive) than other crops. In Kazipur, a substantially lower percentage of farm households cultivate these two crops than in the Charland Zone than in the Mainland Zone (also see [24]).

Table 2. Frequency and percentage distribution of cropping patterns, by zone, in Kazipur (%) (n=247; Multiple responses possible)

Type of Crop	Charland Zone (n=247)		Mainland Zone (n=73)	
	Frequency	%	Frequency	%
Aus (paddy)	230	93.0	26	35.5
Aman (paddy)	189	76.6	66	90.3
Boro (paddy)	37	15.1	59	80.6
Cane	30	1.2	-	-
Potato	58	23.3	35	48.4
Pulses	149	60.5	19	25.8
Oilseeds	85	34.4	49	67.7
Spices	145	58.7	47	64.5

χ^2 (p <0.001; df=7) = 148.4 (Significant)

5.2. The Shibchar of Ganges-Padma River System Case Study

The second case of this paper focuses on the char communities in the Ganges-Padma River system and their coping and adaptation mechanisms and measures, based on the findings of the Islam study [39]. In illustrating the hazard profiles in the Char-Janajat Union of Shibchar *Upazila* in Madaripur District, which is located on the left side of the Ganges-Padma River, Islam [39] described the intertwined relationships between floods and riverbank erosion. In 2003, a total of 13,958 people inhabited Char-Jananat Union in an area of 84.1 sq. km. Here, annual flooding that regularly inundate settlements, standing crops and infrastructure is common. Large-scale riverbank slumping and land loss occur in these riparian communities particularly at times of flood recession, causing catastrophic effects upon char livelihoods – often by destroying or damaging the housing structures, standing crops, cattle, and other capital-assets such as infrastructure (also see [24]).

Displacement of families due to land loss by floods, and riverbank erosion and slumping is frequent Char-Jananat. It was estimated that, on average, 971 inhabitants have been displaced only in one *mouza* (revenue village) annually by the loss of household land. It was found that, among the displaced families, approximately one-third (28.7%) prefer to stay in the area, with a coping behaviour of recurrent moves and resettlements (Table 3). Conforming to the Haque [6] study in Kazipur, a considerable proportion of displaced population in the Ganges-Padma River and char-systems prefer to move shorter distances with the expectation to ultimately move to a newly accreted land.

Table 3. Frequency and percentage distribution of causes of displacement and resettlement in Char-Jananat Union, Shibchar.

Reasons	Frequency (n=101)	Percentage
Floods, riverbank erosion and bank slumping	29	28.72
Unsafe livelihoods	10	9.90
Attracted by sociocultural amenities	19	18.81
Improvement of socioeconomic status	14	13.86
Entitlement to accreted land	10	9.90
Employment and educational opportunities in different location	9	8.91
Opportunity to move to an urban area	10	9.90

Source: Data compiled from Islam [39], based on 2003 and 2008 surveys.

In Char-Janajat in Shibchar, overwhelming majority of the uprooted households confronted displacements more than seven times in their lifetime (Figure 3). The characteristics of the coping measures and adaptation behaviour of the settlers in the charland areas overall indicate that they possess a high degree of experiential learning and are quite motivated to reclaim the lost land and socioeconomic status. In this regard, Wallace [55] suggested that in choosing to remain close to their place of origin, displaced families attempt to minimize the magnitude of cognitive restructuring to adapt to a new environment. In explaining this phenomenon of geographical movement, Oliver-Smith [56] cited the case of the Peruvian earthquake victims where survivors tended to be "conservative" to spatial mobility – "the conservatism is predominantly a defensive stance against the incursion of future stress." A concern of the continuity of socioeconomic support and cultural identity gets priority to such disaster victims.

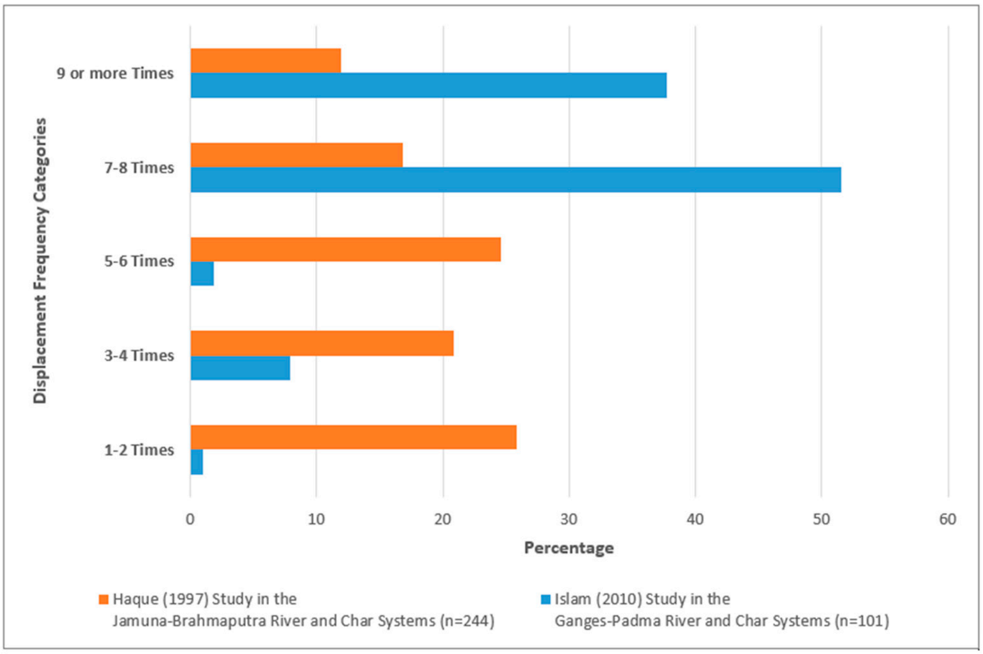

Figure 3. Distribution (%) of the frequency of displacement in Shibchar area in the Ganges-Padma River and Char Systems (n=101 and Kazipur charland of the Jamuna-Brahmaputra River and Char Systems (n=244).

As Zaman [31] rightly asserted, the 'cultural-psychological' explanation is not adequate, and therefore the study of such short-distance movements require in-depth investigation into other underlying factors. Zaman [31] appropriately asserts that the dream and hope to regain access to

 doi:10.20944/preprints202304.0629.v1

accreted land that remains a key factor in the migration decision of the local inhabitants, rather than being influenced by the so-called conservatism. The uprooted households who do not have their own land to resettle, or who cannot hope for any material support from their poor relatives or other local institutions, have their choices constrained by these factors [24]. These constrained choices are either to move to become illegal squatter settlers on the *khas* lands, or to stay in the char areas as 'dependent' on powerful landowners – not only for land and other necessary supports for resettlement, but also for low-paid jobs.

6. Discussion and Conclusion

In this study, we posit that the geomorphological and the socio-ecological systems and the associated processes in the Bengal Basin are not only dynamic but also complex that any mid- and longer-term planning and policy decisions need to adopt an adaptive and flexible strategy. The findings of this study reveal considerable variations in geomorphic and delta-building processes across the major river basins of Bangladesh (see [1,23]). It also infers that the delta-building processes, along with the dynamic shifts of river channels, erosion and accretion of charlands, and other depositional features will continue in the forthcoming decades [2,7].

As a significant proportion of floodplain and charland users are subject to displacement due to floods and charland erosion that results in serious deterioration of socioeconomic status of the displaced families [6], the formulation of a comprehensive national resettlement policy is urgently needed (see [44]). Presently, there is no effective institutional framework and structure nationally for resettlement planning, implementation and monitoring. In this regard, the concerned policymakers should recognize the need for improved legislation and their effective implementation, and a people-oriented institutional framework to assist families affected by both nature-induced disasters and development projects [38,39]. As Zaman [44] elaborated, resettlement programs in countries with a high population density like Bangladesh should be formulated relying primarily on people's initiative for "self-relocation" with the institutional roles to create conditions and facilitation of such activities.

A few recent national policy and planning initiatives regarding land and regional agro-climatic zone are relevant to our discussion here on the dynamic, flexible systems-based land and water resources, along with charland, planning. Recognizing the social-ecological vulnerability and sensitivity, on one hand, and resource potential, on the other hand, the Ministry of Water Resources of the Government of Bangladesh formulated the 2005 Coastal Zone Policy to offer a guideline to work towards achieving sustainable livelihoods, securing freshwater availability, reducing disaster vulnerability and conservation and enhancement of critical ecosystems [57]. In the subsequent 2006 Coastal Development Strategy [58] that set nine strategic priorities including the optimization of coastal land use incorporated assisting the resettlement and securing livelihoods on the charlands, particularly the most vulnerable, displaced people. The primary challenge in this regard is effective implementation that are largely hindered by corruption, nepotism, dominance of the powerful local elites, and only an accountable and transparent people-oriented governance with higher level of adaptive capacity is likely to be able to address these challenges.

The policy and planning approaches to land and water management in the coastal regions in Bangladesh follow conventional outlook, with sectoral biases. For example, the 1992 Environment Policy called for transferring the jurisdictional authority of newly accreted land from the Ministry of Land to the Department of Forestry of the Ministry of Environment and Forests so that through afforestation programs, the stabilization of the coastal chars can be expedited [59]. This was followed by the formulation of the 2001 Land Use Policy [60] enabling the Department of Forestry to plant mangroves as a coastal protection scheme for a 20-year period.

Although the objective of stabilizing these charlands with protection by mangrove forests is to eventually convert most of these lands into cultivable land and distribute among the displaced landless families, their successful implementation remains a major challenge to these policies and programs. Involving the organizations that represent the landless from the beginning of such afforestation programs could ensure that actual landless families eventually achieve the required legal rights as well as the right to possess the land.

Concurring with the main argument of the present study on the dynamic nature of char and therefore the need for an adaptive planning and management systems has been echoed strongly in the recent 2018 Bangladesh Delta Plan 2100 [61]. Recognizing that the complexity and dynamic nature of the "Bangladesh delta necessitates a long terms plan to address challenges and realize the opportunities of Bangladesh Delta" [62], the Delta Plan aims at achieving a "a safe, climate resilient and prosperous Delta" by 2100.

It is notable that for the first time in development planning history of the country, the Delta Plan considered climate change issue as an exogenous variable in formulating the macroeconomic framework; also, it adopted an Adaptive Delta Management" approach [62]. The Delta Plan underscores the significance of accreted land for the development planning of Bangladesh, and therefore has incorporated provisions for assessing and revising laws and regulations regarding alluvion and diluvion. It emphasizes the need of more efficient administration and management of charlands than the present regimes. It further appropriately calls for the establishment of a data bank, using the Management Information System for *khas* land, fellow land, acquired land and charland so that appropriate monitoring can be executed. The vision and aspirations regarding the dynamic delta and charland management are presently moving in the right direction, but how these way-forward paths will be evolving through time with effective implementation remains a critical concern.

Author Contributions: Conceptualization, C.E.H.; methodology, C.E.H., and M.J.; software, C.E.H. and M.J.; validation, C.E.H.; formal analysis, C.E.H. and M.J.; investigation, C.E.H.; resources, C.E.H.; data curation, C.E.H. and M.J.; writing—original draft preparation, C.E.H.; writing—review and editing, C.E.H. and M.J.; visualization, C.E.H.; supervision, C.E.H.; project administration, C.E.H.; funding acquisition, C.E.H. All authors have read and agreed to the published version of the manuscript.

Funding: This research was funded by the Social Science and Humanities Research Council (SSHRC), Ottawa, Canada, InSight Grant #435-2018-552.

Institutional Review Board Statement: The research was approved by the Joint Faculty Research Ethics Board of the University of Manitoba (Canada).

Data Availability Statement: The datasets used and/or analyzed during the present study are available from the corresponding author on reasonable request.

Acknowledgments: The authors are thankful to the Social Science and Humanities Research Council (SSHRC), Ottawa, Canada (InSight Grant #435-2018-552) for funding this research. We are also thankful to M. Anisul Islam, Director, Centre for Natural Resource Studies (CNRS), Dhaka, Bangladesh for facilitating the drawing of the maps.

Conflicts of Interest: The authors declare no conflict of interest. The funders had no role in the design of the study; in the collection, analyses, or interpretation of data; in the writing of the manuscript, or in the decision to publish the results.

References

1. Sarker, M.H.; Huque, I.; Alam, M.; Koudstaal, R. Rivers, *chars* and *char* dwellers of Bangladesh. *International Journal of River Basin Management* 2003, *1*(1), 61-80.
2. Akter, J.; Sarker, M.H.; Popescu, I.; Roelvink, D. Evolution of the Bengal Delta and its prevailing processes. *Journal of Coastal Research* 2016, *32*(5),1212-1226.
3. Mukerjee, R. *The Changing Face of Bengal: A Study in Riverine Economy*. Calcutta University Press, Calcutta, India, 1938.
4. Nicholas, R.W. Villages of the Bengal Delta: A Study of Ecology and Peasant Society. Unpublished PhD Thesis in Anthropology, University of Chicago, Chicago, USA, 1962.
5. Zaman, M.Q. The social and political context of adjustment to riverbank erosion hazard and population resettlement in Bangladesh. *Human Organization* 1989, *48*, 196-205.
6. Haque, C.E. *Hazards in a Fickle Environment: Bangladesh*. Kluwer Academic Publishers: Dordrecht, The Netherlands, 1997.
7. Alam, M.M., Curray, J.R. The curtain goes up on a sedimentary basin in south-central Asia: unveiling the sedimentary geology of the Bengal Basin of Bangladesh. *Sedimentary Geology* 2003, *155*, 175-178.

8. Goodbred, S.L., Kuehl, S.A.; Steckler, M.S.; Sarker, M.H. Controls on facies distribution and stratigraphic preservation in the Ganges-Brahmaputra delta sequence. *Sedimentary Geology* 2003, *155*, 301-316.
9. Morgan, J.P.; McIntire, W.G. Quaternary geology of the Bengal basin, East Pakistan and India. *Bulletin of the Geological Society of America* 1959, *70*, 319-342.
10. Poddar, M.C. Preliminary report of the Assam earthquake, 15th August, 1950. *Bulletin of Geological Society of India* 1952, *2*, 11-13.
11. Brammer, H. *The Geography of the Soils of Bangladesh*. The University Press Ltd.: Dhaka, Bangladesh, 1996.
12. Fergusson, J. On recent changes in the delta of the Ganges. *Quarterly Journal of the Geological Society of London* 1863, *19*, 321-354.
13. Curray, F.C.; Moore, D.G. Growth of the Bengal deep sea fan and dunudation in the Himalayas. *Geological Society of America Bulletin* 1971, *82*, 63-572.
14. Spate, O.H.K. *India and Pakistan: A General and Regional Geography.* E.P. Dutton & Co.: New York, USA, 1954.
15. Rashid, H.E. *Geography of Bangladesh*. University Press Ltd.: Dhaka, Bangladesh, 1977.
16. Ahmed, N. *An Economic Geography of East Pakistan.* Oxford University Press: London, U.K., 1968.
17. Leopold, L.B.; Wolman, M.G. River channel patters – braided, meandering and straight. *United States Geological Survey Professional Paper* 282-B, 1957.
18. Ackers, P.; F.G. Charlton, F.G. The slope and resistance of small meandering channels. *Proceedings of the Institute of Civil Engineers* 1970, *47* (supplementary paper7362-S):349-370.
19. Sarker, M.H.; Thorne, C.R.; Akter, M.N.; Ferdous, M.R. Morpho-dynamics of the Brahmaputra-Jamuna River, Bangladesh. *Geomorphology* 2014, *215*, 45-59.
20. Coleman, J.M. Brahmaputra River: channel processes and sedimentation. *Sedimentary Geology* 1969, *3*, 2/3, 129-239.
21. Rahman, S. The Brahmaputra Right Bank Flood Embankment: Its Problems and Probable Solutions. Water Development Board: Rajshahi, Bangladesh, 1984.
22. Knighton, A.D. *Fluvial Forms and Processes*. Edward Arnold: London, UK, 1984.
23. Brammer, H. *Can Bangladesh be Protected from Floods?* The University Press Ltd.: Dhaka, Bangladesh, 2004.
24. Haque, C.E.; Jakariya, M. Dynamic land and adaptive people of Bengal Basin and its charland. In *Living on the Edge – Char Dwellers in Bangladesh*, Zaman, M.; Alam, M. (eds.). Springer: Cham, Switzerland, 2021, pp. 41-56.
25. ISPAN. *The Dynamic Physical and Human Environment of the Riverine Charlands and Charland.* Socioeconomic RRA reports for the Brahmaputra-Jamuna, Meghna, Ganges and Padma rivers, and the Charland Flood Proofing Study. Prepared for Flood Action Plan Coordination Organization. ISPAN Irrigation Support Project for Asia and the Near East, ISPAN: Dhaka, Bangladesh, 1995.
26. ISPAN (Irrigation Support Project for Asia, near East. *The Dynamic Physical Environment of Riverine Charlands: Brahmaputra-Jamuna.* ISPAN: Dhaka, Bangladesh, 1995.
27. CEGIS (Center for Environmental, Geographic Information Services). *Long-Term Bank Erosion Processes of the Jamuna River.* Prepared for Jamuna-Meghna River Erosion Mitigation Project, BWDB (Bangladesh Water Development Board): Dhaka, Bangladesh, 2007, pp.74.
28. CEGIS (Center for Environmental, Geographic Information Services). *Impact of Climate Change on the Morphological Processes of Main Rivers and Meghna Estuary of Bangladesh.* Prepared for Asian Development Bank. CEGIS: Dhaka, Bangladesh, 2010.
29. Guha, R. *A Rule of Property for Bengal.* Monton: Paris, France, 1963.
30. Stokes, E. The Peasant and the Raj: Studies in Agrarian Society and Peasant Revolution in Colonial India. Vikas Publishing House: Delhi, India, 1978.
31. Zaman, M.Q. Endemic land conflict and violence in char villages in Bangladesh. *Eastern Anthropologist* 1987, *40*, 1-9.
32. Gupta, R.M.N. *Land System of Bengal*. Calcutta: University of Calcutta Press: Calcutta, India, 1940.
33. Ali, S.M. Administration of charland in Bangladesh. *Asian Affairs* 1980, *2*(2), 259-303.
34. Haque, C.E. 1987. Introduction: the need for a focus on the political economy of Bangladesh. In *Bangladesh: Politics, Economy and Society,* Haque, C.E. (ed.); Bangladesh Studies Assemblage, University of Manitoba: Winnipeg, Canada, 1987, pp. 1-14.
35. Abdullah, A. The peasant economy in transition: the rise of rich peasants in permanently settled Bengal. *The Bangladesh Development Studies* 1980, *8*(4),1-20.
36. Zaman, M.Q. Social structure and process in Charland settlement in the Brahmaputra-Jamuna floodplain. *Man* (new series) 1991, *26*(4), 673-690.
37. Malik, S. Land reclamation. *Bangladesh Today* 1983, *1*, 25-28.
38. Zaman, M.; Hossain, M.A. The charland administration and governance: need for a paradigm change. In *Living on the Edge – Char Dwellers in Bangladesh*, Zaman, M.; Alam, M. (eds.). Springer: Cham, Switzerland, 2021, pp. 403-414.
39. Islam, S.; Moula, G.; Islam, M. Land rights, land disputes and land administration in Bangladesh – A critical study. *Beijing Law Review* 2015, *6*, 193-198.

40. Hossain, M. *Improving Land Administration and Management in Bangladesh.* Bangladesh Institute of Development Studies (BIDS): Dhaka, Bangladesh, 2015.
41. Masum, F. Rural land management in Bangladesh: problems and prospects. *Geomatics, Landmanagement and Landscape* 2017, *4*, 79-93.
42. Tariquzzaman S.; Rana, S. Understanding the effectiveness of access to khas land: Comparing khas land receivers to non-receiver. Shiree Working Paper No. 24. Uttaran: Dhaka, Bangladesh, 2014.
43. Feldman, S.; Geisler, C. Land grabbing in Bangladesh: In-situ displacement of peasant holdings. Paper presented at the International Conference on Global Land Grabbing, University of Sussex, Sussex, UK, 2011.
44. Zaman, M.Q. Development and displacement in Bangladesh: Toward a resettlement policy. *Asian Survey* 1996, *36*(7), 691-703.
45. CARE. *Land Policy and Administration in Bangladesh: A Literature Review.* CARE SDU Reports and Studies, CARE: Dhaka, Bangladesh, 2003.
46. Haque, C.E. Human adjustments to river bank erosion hazard in the Jamuna floodplain, Bangladesh, *Human Ecology* 1989, *16*(4), 421-437.
47. Haque, C.E.; Zaman, M.Q. Coping with riverbank erosion hazard and displacement in Bangladesh: survival strategies and adjustments, *Disasters: The Journal of Disaster Studies and Management* 1990, *13*(4), 309-323.
48. Hutton, D.; Haque, C.E. Pattern of coping and adaptation among erosion-induced displaces in Bangladesh: implications for hazard analysis and mitigation. *Natural Hazards* 2003, *29*, 405-421.
49. Haque, C.E.; Zaman, M.Q. Human responses to riverine hazards in Bangladesh: A proposal for sustainable floodplain development, *World Development* 1993, *21*(1), 93-107.
50. Welle, T.; Birkmann, J. The World Risk Index – An approach to assess rick and vulnerability on a global scale. *Journal of Extreme Events* 2015, *2*(1), 1550003, 1-34.
51. Zaman, M.Q.; Haque, C.E. Working together: Reflections on collaborative research in Bangladesh, *Canadian Journal of Development Studies* 1991, *12*(2), 387-403.
52. Paul, B.K. Perception of and agricultural adjustments to floods in Jamuna floodplain, Bangladesh. *Human Ecology* 1984, *12*, 3-19.
53. Rasid, H.; Paul, B.K. Paul. Flood problems in Bangladesh: is there an indigenous solution? *Environmental Management* 1987, *11*(2), 155-173.
54. Islam, M.S.; Sultana, S.; Saifunnahar, M.; Miah, M.A. Adaptation of char livelihood in flood and river erosion areas through Indigenous practice: a study on Bhuapur riverine area in Tangail. *Journal of Environmental Science and Natural Resources* 2014, *7*(1), 13-19;
55. Wallace, A.F.C. Mazeway disintegration: the individual's perception of socio-cultural disintegration. *Human Organization* 1957, *16*(2), 23-27.
56. Oliver-Smith, A. Here there is a life: the social and cultural dynamics of successful resistance to resettlement in postdisaster Peru. In *Involuntary Migration and Resettlement*. Hansen, A; Oliver-Smith, A. (eds.), Westview Press: Boulder, CO, USA, 1982, pp. 85-103.
57. Rahman, M.S.; Chowdhury, F. Investment and Financing Strategy for Coastal Zone Development in Bangladesh, Working Paper WP037. Program Development Office for Integrated Coastal Zone Management Plan: Dhaka, Bangladesh, 2005.
58. WARPO (Water Resources Planning Organization). Coastal Development Strategy. Ministry of Water Resources, Government of the People's Republic of Bangladesh: Dhaka, Bangladesh, 2006.
59. Numan, M.; Mahabubul, A. Environmental policy of Bangladesh: A critical review on implementation scenario. *Dynamics of Public Administration* 2021, *38*(2), 129-145.
60. The Ministry of Land. National Land Use Policy 2001, Peoples' Republic of Bangladesh, 2001.
61. General Economic Division (GED). Bangladesh Delta Plan 2100 – Bangladesh in the 21st Century. Bangladesh Planning Commission, Ministry of Planning, Government of Bangladesh: Dhaka, Bangladesh, 2018.
62. Alam, S. Bangladesh Delta Plan 2100: Implementation challenges and way forward. *The Financial Express*, 23 March, 2019.