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When hydrosociality encounters sediments: Transformed lives and livelihoods in the lower basin of the Ganges River

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Abstract

The hydrosocial cycle is a central analytical framework in political ecological approaches to water. It helps foreground multiple and subtle interactions between water and society, culture and politics. However, to date it has dealt little with matters other than water flows. In river contexts, biotic and abiotic components play critical roles in the way people engage with and make a living out of rivers, beyond water. This article aims to advance the hydrosocial framework with a deeper consideration of the materiality of rivers. To initiate this approach, the focus is here on sediments. Lives and livelihoods connected to river sediments remain both officially and academically under-explored. This certainly applies to the context of the Lower Ganges basin whose active channels transport huge loads of sediments mainly originating from the Himalayan slopes. Building upon an environmental history perspective and drawing on three spatially nested cases in West Bengal, India, the paper analyses instances of water-sediment-society interactions. The general case study presents colonial state interventions in the Lower Ganges basin waterscapes. The second case study zooms the focus on the 2 km long Farakka Barrage. These explorations reveal how an 'imported' conceptual land-water divide infused those interventions, leading to unforeseen effects on riverine lives and livelihoods. Focusing on Hamidpur *char*, situated few kilometres upstream of the barrage, the third case study recounts the contemporary efforts of local communities to obtain revision of administrative decisions unable to deal with 'muddyscapes'. Finally, the paper engages with recent debates on the concept of hybridity in land-water nexus to reflect on the specific meaning and role of sediments.

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Highlights

- Hydrosocial research tends to focus on water flows.
- In river contexts, one must also engage with other material elements like sediments.
- Reflecting on sediments leads to questioning categories like land, water and hybridity.
- Hegemonic conceptual divides exist between water and land, ignoring sediments.
- Cases from the Lower Ganges basin show impact of such divides on waterscapes and livelihoods.

Introduction

A large corpus of physical geography studies shows how sediments play a key role in fluvial geomorphology, river ecology and erosion or flood hazards. Despite a considerable growth in the study of sediment transport in rivers from the 1950s, in many cases, river management still focuses on flow regime at the expense of sediment regime (Wohl et al., 2015). Similarly, lives and livelihoods connected to sediments remain often both officially and academically under-explored. However, in geography and anthropology, theoretical and empirical explorations of lives in shifting land(water)scapes like meandering rivers (Abizaid, 2005; Coomes et al., 2009), temporary river islands (Lahiri-Dutt, 2014; Lahiri-Dutt and Samanta, 2013) or in deltas (Krause, 2017a, 2017b; Sultana, 2010) increasingly document the role of sediments in the forms and dynamics of river-society interactions.

This article aims to advance the understanding of socio-natural processes around rivers with a renewed perspective on the materiality of rivers, notably in incorporating sediments. To do so, we mobilize the political ecology of water, and particularly the hydrosocial framework that we enrich with insights from critical physical geography. The hydrosocial cycle as defined by Jamie Linton and Jessica Budds, 'is a socio-natural process by which water and society make and remake each other, over space and time' (2014: 175). Hydrosocial analyses aim to reveal intertwined 'flows of water and power relations' (Budds et al., 2014), while studying material and discursive dimensions of water. In a related vein also linked to political ecology, the critical physical geography approach engages centrally with biophysical processes while calling for the greater attention to power relations (Lave et al., 2014).

We chose to explore this approach in the context of the Lower Ganges basin, in the West Bengal State of India. The Lower Ganges basin is an interesting case for pushing hydrosocial theory as it combines extreme features: situated within the Ganga-Brahmaputra Delta, the product of two of the world's most silted rivers and their distributaries, it is also one of the most densely populated deltas. Highly altered by terrestrial and riverine infrastructure including railway lines, roads, embankments, ports or barrages, the terrain is crisscrossed by intense human activities dependant on rivers. It is also increasingly vulnerable to climate change. The Lower Ganges basin is shaped by cyclones, coastal storms, river-induced floods, erosion and accretion phenomena, but also, indirectly, by ways of thinking about the river. The large dams and high embankments that were developed in the country since India's independence were the result, as geographer Kuntala Lahiri-Dutt puts it, of 'objectification of rivers, depriving them of their right to spread over space [...]. The sense of oneness with rivers and attachment to them was replaced with the sense that a river, like a wild horse, needs to be "harnessed", "tamed" and "controlled"' (2000: 2399). Ruling paradigms, economic expectations and power relations around water, from close to far distances (notably in the case of the British Empire), shaped Lower Ganges basin's rivers and waterscapes that in turn shaped people's livelihoods, rulers' decisions, institutional configurations and even political movements or ideas. Thus, this part of the Indian Bengal basin, through its history and up to its contemporary dynamics, fully embodies the concept of hydrosocial cycle.

In the particular context of *chars* (the silt islands, sandy shoals or bars that frequently emerge and disappear within the riverine channels of the basin), human engagements with sediments are critical. As shown by Lahiri-Dutt and Samanta (2013), though fragile, unstable, and at risk of disappearance, these places remain attractive possibilities to some, generally marginal, human communities, as they are fertile. *Choruas* (inhabitants of *chars*) put all their efforts in making a living from these stratified silt/sandy lands that often turn into muddy waters in monsoon seasons or get entirely submerged in one flood. These *chars*, which evolve not as landscapes or waterscapes, but as composite *muddyscapes*, exemplify instances of water-sediment-society dynamic relations.

The paper consists of five sections. Following this introduction, the next section discusses the existing literature and justifies the relevance of proposing to enrich hydrosocial analyses in river contexts with a focus on sediments. Then, we introduce the Lower Ganges basin and three nested cases where water, sediment and society interact. The Lower Ganges basin case and the zoomed focus on the construction of the Farakka Barrage reveal how colonial and post-colonial state interventions dramatically altered the natural deposition pattern of its alluvial sediments and disrupted *Choruas*' livelihoods as well as socio-political equations. With a greater zoom in Malda district, upstream of the Farakka barrage, the third case recounts the contemporary efforts of *Choruas'* communities to obtain the revision of administrative decisions unable to deal with 'muddyscapes' (*Hamidpur char*). In the subsequent section, further insights are drawn from the incorporation of sediments into the hydrosocial framework. We also engage with recent debates on the concept of hybridity in the land-water nexus. The last section wraps up the argument, raising possibilities for further lines of inquiry.

Confronting the hydrosocial literature with river sediments

The materiality of rivers

Our approach positions itself within the 'political ecology of water', a critical literature that studies the social and political dimensions of water (Loftus, 2009). This literature mainly criticizes apolitical analyses of water-related phenomena. Case studies related to drought for example show how power relations affect access to water as well as scientific knowledge produced about water, while water scarcity gets 'naturalized' in discourses (Budds, 2009; Kaika, 2003; Mehta, 2011). In this vein, the concept of hydrosocial cycle emerged within the field to emphasize the *internal* and *dialectical* relation between water and society, drawing attention to 'how water is made known and represented, and its effects' (Linton and Budds, 2014: 177). Such analysis may for example reveal the political processes behind the scientifically produced 'Minimum Flow Requirements' of the Garonne River in south-western France and their effects on water control decisions (Fernandez, 2014).

Conversely, the role of the materiality of water is also acknowledged in this framework. 'We contend that the hydrosocial cycle comprises a process of co-constitution as well as material circulation' (Linton and Budds, 2014: 170). In Linton and Budds' terms, water materiality is characterized by its 'agential role' in hydrosocial relations (2014: 176). For example, hydrologic processes produce material flows of water but may also be agents of social, economic or cultural reorganizations (like after a severe flood); other studies also showed the agential properties of assemblages of water and technology/infrastructure (Barnes, 2012; Birkenholtz, 2009; Swyngedouw, 2007). Political ecology of water, and within it, hydrosocial analysis, have been applied to study rivers and river basins (Alatout, 2012; Bakker, 1999; Matthews, 2012; Molle, 2005; Norman and Bakker, 2009; Peterson, 2000; Sneddon and Fox, 2006; Vogel, 2012 and for hydrosociality, Bakker, 2000; Boelens, 2014; Bouleau, 2014; Bourblanc and Blanchon, 2014; Budds, 2009; Budds and Hinojosa, 2012; Fernandez, 2014; Hommes et al., 2016; Mollinga, 2014; Perreault, 2013; Swyngedouw, 2007). However, to date, we observed that in river contexts, hydrosocial studies often restrict considerations of the materiality of rivers to water flows. For instance, the sediments that rivers carry, or the biodiversity they shelter, are often not considered or only briefly taken into account. The perspectives of dominant actors and available data often promote a view of river waters as a liquid resource only. Lack of available data on river ecosystems may be a constraint for researchers. For example, in their hydrosocial study in Peru, Budds and Hinojosa (2012) mentioned that the impacts of mining extraction on the ecology of headwaters are scarcely documented. Mollinga's (2014) study of an irrigation canal in south India also corroborates this argument as he showed that singularising the meaning of river water in productive terms was the result of a state strategy.

Some scholars however mobilize more than water flows in their analyses. Bouleau (2014) highlights the mutual shaping of scientific categories used to describe hydrosystems, like bioindicators such as diatoms or habitats such as wetlands, and the waterscapes themselves; Perreault (2013) shows the significance of distinguishing different 'forms of nature', like sediment and water, and different qualities, like clean or contaminated, to reveal instances of local communities' dispossession in a mining region of the Bolivian Andes. This attention to materiality is also stressed by Birkenholtz (2016) in his study of water transfers from rural to urban areas in Rajasthan, showing that water's variability, spatially and temporally, affects hydrosocial relations as well as capital accumulation.

Drawing on these works and on critical physical geography that calls for integration of physical and human geographies while acknowledging the politics of environmental science (Lave, 2015), we seek to enrich hydrosocial analyses with greater attention to materiality of rivers 'over space and time'. In this regard, we choose to focus here on the sediment component of rivers.

Looking at sediments

Sediment regimes are crucial to aquatic and riparian ecosystems (see Wohl et al., 2015). Unintended ecological effects occur if sediment supply and transport are overlooked in river management (Poff et al., 2006). These findings from physical geography, sedimentology, fluvial geomorphology, hydrobiology or biochemistry on hydrosystems, confirm the importance of sediment circulation in river systems.

Building on these works, we propose to more fully incorporate sediment in hydrosocial analysis, drawing on a body of recent, critical literature that emerged in anthropology and geography dedicated to *muddy terrains*, or those places where sediments, rivers, and societies intersect (Cortesi and Carmago, forthcoming; Krause, 2017a; Lahiri-Dutt, 2014). We notably mobilize useful concepts and insights from Franz Krause and Kuntala Lahiri-Dutt for our approach.

Krause (2017a) proposes an 'amphibious anthropology' to adequately account for lives in deltas. This approach encompasses concepts of wetness (recognizing the spectrum of realities between dry and wet, and their local importance), volatility (instability and fluidity of humans and non-humans' interactions) and rhythms (analysis of clashing and/or corresponding ecological and social interrelated rhythms). These latter two concepts rightly reflect the high variabilities of sediment regimes; moreover, 'rivers respond to changes in water and sediment inputs at varying temporal and spatial scales, but such scales can be substantially different for sediment and water' (Wohl et al., 2015: 359). Thus incorporating sediments leads to a greater attention to temporalities and rhythms (Krause, 2017b).

Lahiri-Dutt's work has been a major inspiration for the present article. Lahiri-Dutt strongly argues for the need to '[reconsider] one of the foundational binaries [of geography], that of land and water' (2014: 1). Engaging with the concept of hybridity beyond mere material forms (or a simple mix of water and land), she reworks the 'wet theory' conceived by anthropologists like Appadurai and Breckenridge (2009). One of her aims is to bring 'more fluidity in speaking of hybrid environments' (Lahiri-Dutt, 2014: 2), noting that most of geographical metaphors are related to land only. As an instance of not excluding complexities or ambiguities, she further invites critical geographers 'not to give up mud and silt in favour of either land or water' in their explorations of hybridity (Lahiri-Dutt, 2014: 8), drawing empirical insights from the Bengal context. In the section What do we miss when we miss sediments? Rethinking hybridity, we therefore engage with recent debates on hybridity to further reflect on the meaning, place and role of sediment in human geography.

Incorporating sediments in the hydrosocial cycle

In order to better guide our empirical investigation, our proposition is to revisit the model of the hydrosocial cycle proposed by Linton and Budds (2014), with its three components: (1) H_2O, standing for water's materiality; (2) social power/structure and (3) technology/infrastructure. In this conceptualization, other aspects like discourses, ideas, representations of H_2O or knowledge are internalized in what the authors call 'water', at the centre of the cycle (see Figure 1).

In our proposition of a materially enriched hydrosocial cycle, we instead articulate four components. Referring here to the dialectical approach that infuses the concept (Harvey, 1996; Linton and Budds, 2014), we understand these components as intimately connected processes, sustaining, undermining, shaping or disrupting each other into new configurations, though belonging to different levels of abstraction and to different space-time dimensions (including the distinction between experienced or external spatialities and temporalities). The four components we propose are: (1) Meanings and interpretations (including knowledge, scientific and/or local) of *land* and water ('muddyscapes'); (2) *Land* and water-related governance and power relations; (3) Resource (here water and *sediment*) use and exchange patterns; (4) Physical and biological processes, partly mediated or affected by technology. The seemingly prominence of social processes (3 out of 4) over physical processes do not refer to a quantified representation of the relative importance of those processes. The idea here is rather to make the possibilities of interactions among varied social dimensions and physicalities more visible. Figure 1 aims to illustrate these components with a limited choice of key words.

As in Linton and Budds' conceptualisation, each component exerts actions and eventually brings changes to other components affecting the whole cycle. As a consequence, the cyclical process does not follow a regular path among components; the idea of a cycle is however kept as all components of the cycle finally become affected along a historical trajectory, as shown in the empirical section that follows.

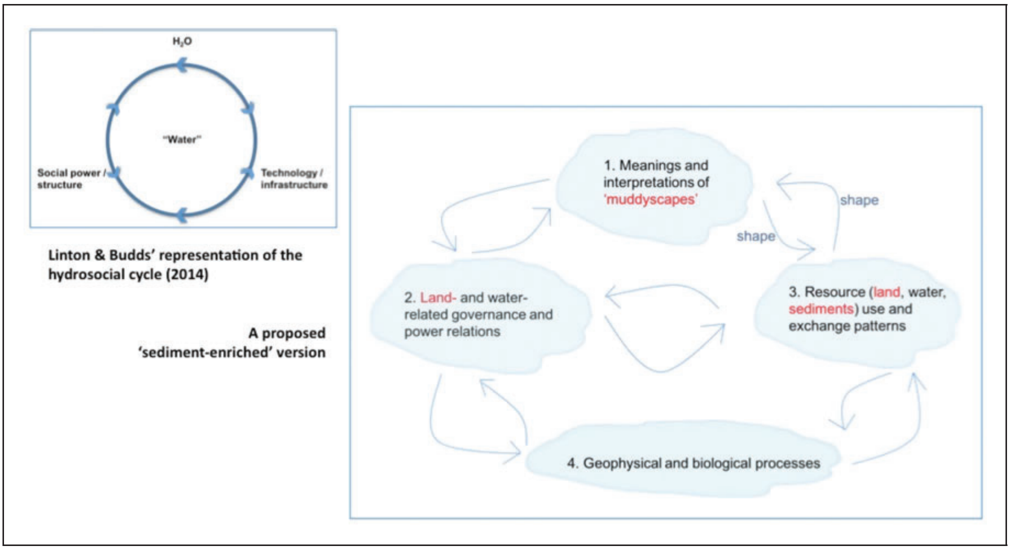

Figure 1. A 'sediment-enriched' hydrosocial cycle.

Our aim is now to illustrate why sediments matter in river-society dynamics. The next section presents three cases in West Bengal, India. Our case studies are nested in temporal and spatial scale from large to small: the general environmental history of the Lower Ganges basin, the Farakka barrage construction event and its consequences, and Hamidpur *char* that is located about 11 km upstream of Farakka barrage.

In each of these cases, we shed light on mutual interactions and shaping processes among the four (proposed) components of the hydrosocial cycle (see Figure 1). We particularly study the role of conceptual frames of thought (i.e. component 1) and how *Choruas*, as well as authorities, adjust and react to such 'moving terrains' (components 2 and 3). We incorporate physical processes (component 4) through qualitative descriptions, rather than through quantitative research on sedimentation and erosion, for such work in the Ganges basin lacks sufficient data (see notably Wasson, 2003; Singh, 2008a). In this way, we depart from a true socio-sedimentological case of the kind that critical physical geography would call for. Through our cases, we focus instead on how the land/water divide worldview has affected people's living conditions in the Lower Ganges basin until now.

The Lower Ganges basin: Transformed lives and livelihoods

Introducing the lower basin of the Ganges River

> ...a riverine plain that is part land, part water, but is neither in its entirety...
> from the breadth of the delta mouth
> to the microcosmic worlds of silt islands or chars that lie within the riverbeds.
>
> (Lahiri-Dutt, 2014: 4)

Shared by India and Bangladesh, the vast alluvial plain of the lower basin of the Ganges River is characterized by an intricate network of interlacing channels and abandoned meanders, as well as marshes and occasional higher lateritic tracts. The Ganges–Brahmaputra delta is a tide-dominated delta with highly turbid estuarine channels. Deposition processes characterise the delta, as the river slope is only about 4 cm/km (Singh et al., 2007). The active Ganges channel upstream of the delta is highly sinuous, making large meander loops within a 20–30 km wide valley (Singh, 2008a). Two hydrological phenomena dominate. First, there is huge seasonal variation in flow discharges due to the monsoon regime: monsoon flows (July–September) reach 10 to 100 times non-monsoon flows (Singh et al., 2007). Second, the river transports a considerable amount of sediments to the delta area (600 to 1200 million tons/year bedload, Wasson, 2003), mainly from upper Himalayan highly erodible slopes (Wasson, 2003). Singh et al. (2007) note that about half of the sediment discharge to the world's oceans originates from the rivers of South-East Asia due to the morphodynamic evolution of the Himayalan range. Monsoon flows thus carry about 90% of the annual sediment load into the delta region (Singh, 2008a). As a consequence, in monsoon period, 'bankfull discharges result in an enormous spontaneous transportation of sediments to the Bay of Bengal along with changes in the river channel morphology' (Singh et al., 2007: 157). The Ganges riverine system therefore remains dynamic, with bank erosion, accretion, and changing courses of rivers (Rudra, 2014).

Our empirical focus is on the Indian part of this geographical unit, within the state of West Bengal. The river Ganges enters the West Bengal State in the Malda district, with the Rajmahal Hills on the right side. After some 35 km, at Farakka, the Ganges bifurcates[1] into two major branches, the Padma River (in a south-east direction, towards Bangladesh) and the Bhagirathi River (to the south, towards the city of Kolkata). In the centuries leading up to the Farakka Barrage, the Ganga–Padma River was the main branch. The slowly decaying Bhagirathi River used to birfucate about 40 km downstream, near Mithipur, Murshidabad district. However, the commissioning of the Farakka Barrage in 1975 on the Ganges, a diversion structure designed to increase the flow in the Bhagirathi River, put an end to the natural degeneration of that channel. The Bhagirathi River is now constituted of a 39 km long feeder canal that is derived from upstream of the barrage, and joins the sea about 300 km downstream. In its tidal stretch, notably in Kolkata, the river is named Hugli River. The river finally merges with the Indian Ocean near Sagar Island, on the western side of the Sundarbans, a complex of coastal islands. Dynamic phenomena of coastal erosion, accretion and submersion continuously shape and reshape these deltaic islands or tidal bars (see Figure 2).

The dynamicity and the changing courses of the Bengal basin's rivers also lead to the creation of channel bars or 'sandy islands'. Locally termed as *chars*, these silted/sandy bars frequently emerge or disappear among riverine channels, as the sediment is deposited then gradually moved downstream. The distinction between suspended load and bedload is difficult to make in the Lower Ganges basin: Ganges River sediments show a strong overlap of grain size between bed load and suspended load deposits (Singh, 2008a). Both bed and suspended load consist of mainly fine to very fine sand; the suspended load also includes a high proportion of silt and clay. In particular, very fine sand and silt-clay fraction constitutes the sediment of the Bhagirathi (Singh, 2008a). Nearly 80% of bedload is transported as 'graded suspension' due to bottom turbulence during monsoon flows (Singh et al., 2007). A large amount of suspended load, rich in silt, is transported, then deposited on *chars*: 'several centimetres thick muddy sediment is found deposited on top of channel bars after each flood, essentially representing the suspended load' (Singh, 2008a: 354). The *chars* are made of deposited sand and silt strata, and, as a consequence, they are highly vulnerable to fluvial erosion processes (see Figure 3).

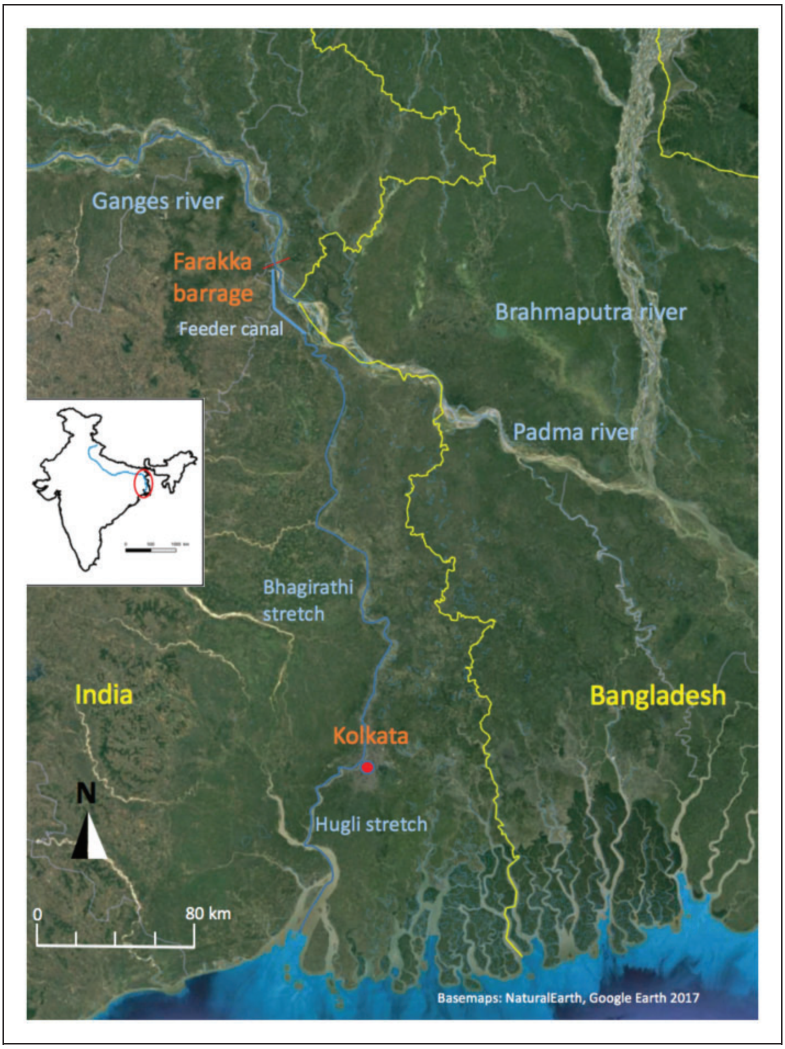

Figure 2. Schematic map of the Lower Ganges basin.

Though temporary, and at risk of floods and erosion, many of these *chars* are inhabited by *Choruas* who farm and reside there. Richer in silt than coastal *chars* (where this term is also used), the riverine *chars* are fertile. They are rendered attractive by the difficulties of accessing agricultural land, as in India overall.[2] The entire delta is highly populated (in West Bengal only, there are about 57.2 million inhabitants in the nine districts through which the Bhagirathi/Hugli River passes through;[3] 4 million in the Malda district alone) with human density average at district level in so-called rural areas up to 1700 people/sq · km (Hoara district, Census India, 2011).

The next section studies water-sediment-human dynamic relations in the Lower Ganges basin. Inspired by the Indian environmental, and more specifically water history literature (Mukherjee, 2018), this retrospective situates the Farakka Barrage project within two generic 'moments' in the history of the Lower Ganges basin: the colonial and the post-colonial periods.

Figure 3. Nirmal *char* in Murshidabad district, West Bengal (India).

Why sediments matter, case 1: From land/water divide to increased erosion in colonial era

This section narrates shifting configurations of the hydrosocial cycle, in relation to the disruptions introduced by colonial rulers on water-sediment-society dynamics. At the end of each paragraph, we briefly note which of the cycle components presented in Figure 1 are involved. As shown below, these material and discursive practices were largely infused by a modernist paradigm that conceptualized land and water as strictly separate entities (the land/water divide) and that restricted rivers to productive *water* channels (D'Souza, 2009).

In the 17th century, just before the establishment and consolidation of the East India Company in Bengal, the dominant physical features of the basin were similar to modern ones: monsoon-type climate, silt-rich lands suitable for rice and other cultures and geomorphic dynamicity of rivers and channels (Bernier, 1981). Overflow irrigation was widely practised (Klingensmith, 2007). In this system, the nutrient-rich, silt-laden monsoon floodwaters were distributed, watering and more importantly fertilizing fields, spreading fish over the countryside and sweeping away mosquitoes (Klingensmith, 2007). Floodwaters were directed through a system of wide, shallow canals (*khals*) with minimal embankments (*bunds*); during the monsoons, breaches were made to these canals to allow flooding (Willcocks, 1930). As an outcome, in the 17th century, the French traveller

François Bernier praised the prosperity of the region, stating that Bengal is richer than Egypt, producing abundant surpluses in rice and sugar and attracting foreign traders from many parts of the world for its crops, spices, silk clothes and other goods (Bernier, 1981).

The colonial era introduced major changes to existing river-society relations. The latter were characterized by *rapports d'accommodation*, or 'relations of adjustment' (Reclus, 1889, our translation) or 'dancing with the mood of the River' (Lahiri-Dutt and Samanta, 2007). The British rulers carried with them the classical modern western paradigm that considered the environment as a mere externality (Berque, 2014) that should be tapped, in contrast to the pre-modern viewpoint of reciprocal nature-society relations (Chatterjee, 2017). For instance, Colonel Cotton proclaimed in *Report on the Mahanuddy*, 'all deltas require essentially the same treatment' (Cotton, 1858: 3). This is an example of components 1 and 3 (see Figure 1) mutually shaping each other.

Moreover, the colonizers introduced a land/water divide (Bhattacharyya, 2018; D'Souza, 2009; Lahiri-Dutt, 2014) or a sharp conceptual separation between river water and its sediments. In the modernist European tradition, notably since early 17th century, land-water hybrids like swamps, silt islands, and sandbanks were considered treacherous, leading to innumerable drainage, reclamation and embankment campaigns (Cosgrove, 1990; Morera, 2011). This mental framework was applied to colonial territories where modern hydraulic techniques (using pumps, dredging devices, locks and sluices) were used to transform precarious waterscapes into durable landscapes (see for example Bhattacharyya, 2018). While 'land exorcised of water' is transformed into property, fostering revenue generation and management, flowing waters were valorised in engineering visions to generate resource output (D'Souza, 2006: 3). Rivers were seen as liquid flows and represented in financial units. For instance administrator Trevelyan mentions in *On Godavari Irrigation and Navigation*, about monsoon flows: '4,20,000 cubic yards of water/hr flowed into the sea at the rate of Rs. 500/hr i.e., 12,000/day for 240 days and it gave Rs. 2,880,000' (Rao, 2011: 149).

The British colonizers transformed the ruling paradigm towards a 'rule for profit', subordinating the region to colonial capitalist relations and to British administrative and financial needs. With their smooth liquid surfaces, waterways were designated to serve as the cheapest and quickest means of transportation (Reynard, 2005). As in Orissa's Mahanadi delta, watercourses 'calibrated as arteries for trade, however, principally serve as technical arrangements to circulate the economy of land' (D'Souza, 2009: 4). In accordance with this 'colonial hydrology' (D'Souza, 2006), loaded with 'imperial science' (Gilmartin, 1994) and 'technochauvinism', rivers were channelized, shortened, dredged, embanked and straightened; numerous meanders, bends, loops, braids, adjoining wetlands, marshes, swamps and other forms of water-soil admixtures were eliminated (D'Souza, 2009). Newly excavated canals were constructed,[4] with high banks that impeded easy overflow of water as well as silt deposition.

Many socio-economic consequences unfolded. An embankment regime was established. While the maintenance of overflow irrigation had previously been paid out of the general land tax and was available to all cultivators free of additional charge, the new arrangements expected peasants to pay for water use and for embankment works. The age-old overflow irrigation practiced in the Lower Ganges basin was replaced by perennial irrigation (D'Souza, 2002, 2006; Mishra, 1997, 2008; Singh, 2008b, 2011). From community-managed small-scale structures, the overall irrigation system became centrally designed and engineered by scientists and technocrats under the aegis of the Irrigation Department (Gilmartin, 1994; Weil, 2006), with a clear neglect of sediments' roles and benefits.

Authorities perceived floods as an obstacle restraining routine and regular revenue collection, especially after the Permanent Settlement in eastern India (Allen et al., 2017). A flood (water/silt) dependent agrarian regime transformed into a flood vulnerable landscape (D'Souza, 2002).

With the continuous extension of fixed embankments (dikes created by railway lines, road networks and further for flood protection itself), the flood situation only worsened with time; some places got regularly 'trapped into water' for long period of time, affecting lives and livelihoods of the inhabitants (Mishra, 2008). On the other hand, the British rulers started to consider *chars* as land or assets as shown in the introduction of the *Bengal Alluvion and Diluvion Act* (BADA) act of 1825. In this act, the key factor to establishing land rights in the court of law was for instance the payment of rent, even on diluviated land. Massive survey operations were also initiated to produce cadastral maps for revenue survey lists (or *khatian*s).

Why sediments matter, case 2: The Farakka Barrage or a new cycle of disruption

This section focuses on the Farakka Barrage project that created a major disruption of the hydrosocial relations in Bengal with far-reaching consequences spatially (up to Bangladesh) and temporally (up to today). For our analysis, we however focus on river-related sedimentation and erosion issues in India.

Conceived during the colonial times, but implemented by Indian authorities in the post-independence period, the Farakka Barrage initiated a new cycle of disruption within the Lower Ganges basin. This huge infrastructure, among the longest barrages in the world (2.6 km long), was initially designed to address the recurrent and massive siltation of the Kolkata Port and to improve the navigability of the Hugli River. Sediments were perceived as a problem and 'clear water' as the solution to generate revenue through riverine trade and transportation. Between 1853 and 1946, British experts periodically reiterated the idea of a barrage on the Ganges near Jangipur with a feeder canal to bring water surplus to the Bhagirathi river (Ministry of External Affairs, 1978; Mukherjee, 2011a). It is interesting to note here that the Boundary Commission under the Chairmanship of Cyril Radcliffe also considered the immense importance of the Farakka Barrage and hence deviated from the principle that contiguous Muslim majority areas should form Pakistan. Murshidabad (with a Muslim majority), where Farakka is situated hence remained in India and in exchange a non-Muslim majority district of Khulna went to the former East Pakistan (Ministry of External Affairs, 1978). Re-appropriated by the Indian authorities, the Farakka Barrage Project then began in 1962 and was completed in 1971. Between 1971 and 1975, the 39 km long feeder canal was excavated and the project was finally commissioned in May 1975, becoming a national emblem of Indian technocracy and sovereignty.

However, the outcome of the project related to sedimentation processes was largely ill-planned. Notably, induced discharge from the barrage has not been able to reduce sedimentation at the Kolkata Port; the annual quantum of dredging in the shipping channels of the Kolkata and Haldia Ports' area has actually increased during the post-Farakka period (Rudra, 2003). The barrage has disrupted not only downstream water flow but also river sediment movements in diverse ways. The barrage has been contested by Bangladeshi authorities due to the contentious sharing of Ganges water between India and Bangladesh[5]; it has also been challenged within India by activists, politicians and local residents (press or website reports[6] and field interviews). These actors notably denounce the amplitude of sedimentation changes and their consequences in the two channels (Ganges/Padma and Bhagirathi rivers), upstream and downstream. In addition, because the barrage gates are never fully open (in order to stabilize the expected upstream pond water level, even during most of monsoon season), sediment deposition has increased, resulting in the formation of several shoals upstream of the barrage. These shoals have led to increased meandering and sinuosity of the river as well as lateral flow instability (Mazumder, 2017; Thakur et al., 2012). The ecology of the main channels, upstream and downstream, has also been transformed due to flow velocity reduction and abiotic changes (temperature and turbidity); these changes have contributed to modifications of fish diversity and abundance, notably the reduction of a high-value commercial species (Hilsa fish) population (Indian Institutes of Technology, 2012: 11–12) as well as the decrease of the emblematic Ganges dolphin (Sinha, 2000; Sinha and Kannan, 2014).

Since sedimentation has increased upstream, the riverbed has been raised, intensifying lateral erosion of sandy banks (Thakur et al., 2012). As the upstream right bank is of hard rock at the Rajmahal hills area, deep erosion mainly occurs on the left bank. As a result, for instance, in Malda district, the river channel was displaced to the left by 7 km between 1923 and 1999 (Mazumder, 2017) and more than 1 km between 2003 and 2005 within the Kaliachak-II block, erasing some villages (Thakur et al., 2012). Repeated floods have weakened soil structure of the banks. On many occasions, marginal embankments or spurs have been breached, causing higher flood damages. In the 1995 and 1998 floods, 450 people died and properties worth about 10 billion INR were damaged (Mazumder, 2017). In Murshidabad district, downstream of the barrage, erosion patterns were disrupted leading to destruction of 'mature' *chars,* already inhabited and cultivated (Rudra, 2003). Due to the increased emergence, submergence, re-emergence and re-submergence of *chars*, *Choruas* suffer from what has been called a 'SDRR' (settlement>displacement>re-settlement>re-displacement) syndrome, with some people being forced to move more than four times, and even up to 16 times within a time span of 15 years with a relative indifference from authorities (Mukherjee, 2011b).

Why sediments matter, case 3: Hamidpur char, West Bengal

The case of Hamidpur *char* in Malda district briefly captures some reactions and political initiatives of local *Choruas* towards these moving 'muddyscapes'. Our aim here is to narrate a story where water-sediment-society relations and processes not only generate uncertainty and fragility, but also zones of possibilities.

We visited this *char* and its inhabitants several times in 2010 for a study on livelihoods and ecosystem services, then again in July 2017 for the purpose of this research. We also visited other *chars* in the Murshidabad district. We travelled in pre-monsoon period, where one has to walk kilometres (no vehicle apart from tractors may drive on the thick sand layer) on sandy land, sometimes cultivated with underground water use or sometimes bare; we also travelled in monsoon or post-monsoon periods, when only small boats or ferries allow one to reach destinations and when green and dense fields of jute or rice demonstrate the fertility of the plain's soils (see Figures 4 and 5).

We interviewed local administrators at district and local levels (district magistrate, block development officer and staff, state delegate to *Gram Panchayat*, i.e. the local council of the 'village'). We consulted relevant local documentation in administrative offices (reports and maps). To complement these sources of information, we had on-site discussions with *Choruas* engaged in public activities (member of *Gram Panchayat*, local coordinator of the West Bengal State's *Nirmal Bangla* programme, representative of the *Gram Panchayat* to the Block Disaster Management team) or in daily activities (women, elderly, farmers, etc.).

In order to illustrate the dialectical co-production of river, sediment and society, and instead of labelling each paragraph as in the previous section, the main features of the hydrosocial cycle in this story, here shifting assemblages of representations and meanings of land and water, technology, materiality of river, uses, institutional arrangements and power equations, are first summed up in Box 1 with 10 main points.

Box 1. Hamidpur *char* case, Malda district, West Bengal.

(1) The post-colonial ruling paradigm, inherited from British representations such as the land/water divide and the preeminence of Kolkata port economics, led Indian national authorities to assert their capability and power through the construction of the Farakka Barrage on the main channel of the river Ganges.
(2) The barrage modified water flows, but affected deposition and erosion patterns within the riverbed as well as lateral embankments' strength.
(3) In the context of embankment and irrigation regimes inherited from colonial times, these changes led to increased flood and lateral erosion, with submergence of some mature *chars* and creation of some new *chars*. This caused displacement and migration of *Choruas* as well as deleterious impacts on people's livelihoods (the SDDR syndrome or settlement>displacement>re-settlement>re-displacement, see Mukherjee, 2011a).
(4) In response, authorities could not/did not want to deal with these uncategorized 'muddyscapes', neither fixed land nor water, subject to seasonal changes.
(5) People were refused welfare program support as their land, and their official identity attached to it were lost while the new *chars* retained the status of water-logged non-revenue land, thus 'administratively orphans'.
(6) In reaction, grassroots movements emerged in the Malda district to build a political force to push for recognition of *Choruas*' rights and fight administrative decisions.
(7) The discourse of the *Choruas* got strengthened by scientific arguments developed by scholar-activists like Kalyan Rudra about the impact of Farakka Barrage on the sediment regime.
(8) These movements finally became successful in Hamidpur *char* with the delivery of identity cards, voter cards and ration cards, later with the construction of schools, flood shelters and better roads.
(9) Though the *char* land remains categorized as *shikasti* (i.e. non-revenue land, whose literal meaning is 'defeated'), there is now an effective integration of Hamidpur *Choruas* in local institutions like *Gram Panchayat*, flood commission or Nirmal Bangla (state) programmes.

We now move to the detailed account of this narrative. Hamidpur *char* belongs to Kaliachak II development block, Malda district (see Figure 6). This block, situated 15 km upstream of Farakka Barrage, covers 15,700 ha and a population of about 210,000. The majority of the population are farmers. Among the 15 blocks of the Malda district, Kaliachak II is one of the most vulnerable to floods and river bank erosion. Over 20 years, about a fourth of the block territory has been eroded: 22 villages were completely destroyed and eight others partially swallowed by the River (Kaliachak II BDO, 2007). Besides

Figure 4. Pre-monsoon 'muddyscape', Nirmal *char*, Murshidabad district, West Bengal (courtesy: Koushik Chowdhury).

erosion, floods regularly destroyed crops and housings: within Hamidpur *Gram Panchayat* boundary, eight villages remained waterlogged in 2011, 2013, 2015 and 2016 (Kaliachak II BDO, 2017).

In Hamidpur, people who were affected by land erosion due to the progressive eastward shifting of the Ganges (with massive erosion in 1971 according to local residents) had to migrate to nearby available lands. Thus, they settled in newly emerged *chars* that had appeared on the other bank of the River, in the neighbouring state of Jharkhand. There, they renamed the place Hamidpur to retain the connection with their initial land. However, they were denied any property rights as those areas are considered as *shikasti* or governmental non-revenue land according to the Revenue bill.[7] As in other *chars* of West Bengal, Bihar or Jharkhand, the lives of newly settled *Choruas* remained precarious as migrations caused an oversupply of agricultural labour force, stressing wages to low levels. Moreover, migration, trade and land conflicts, lack of public utilities as roads, communications, hospitals and maternal health facilities were other significant constrains in the *chars* (Dutta, 2011; Lahiri-Dutt and Samanta, 2013; Mukherjee, 2011b). There were also instances of illegal trafficking and other criminal activities as these areas easily remained out of authorities' sight. In the official perspective, these places were emblems of uncertainty and vulnerability and hence unsuitable for any governmental investment (Mukherjee, 2011b) and rehabilitation issues were not considered (Rudra, 2003). Government social and health schemes were not implemented, as people were not registered as proper citizens (Mukherjee, 2011a).

In 1986, a severe flood in Jharkhand drove more than half of the population of that local 'Hamidpur *char*' to move back to West Bengal. People from three to four *mouzas* (groups of

Figure 5. Monsoon 'muddyscape', Hamidpur *char*, Malda district, West Bengal.

villages) however remained in Jharkhand. The newcomers settled on a large and new *char* (about 7 km long and 4 km wide) that re-emerged next to the left bank of the Ganges River, separated from the western mainland by a new small river channel. That area lied approximately at the same spot of mainland Hamidpur's previously submerged areas (interview of Hamidpur GP' executive assistant, July 2017). However, the *Choruas* experienced repeated erosion and floods, notably during 1995, 1998, and 2002. Moreover, being denied rights by West Bengal authorities, they had no identity cards, neither voter cards nor ration cards that allow Below-Poverty-Line (BPL) populations to access rice and other basic commodities at low prices.

In 1998 troubled by the loss of their houses and livelihoods, and against the negligible role of the government, a small group of villagers from nearby Panchanandapur created the *Ganga Bhangan Pratirodh Action Nagorik Committee* (GBPANC). This grassroots movement received the support of action groups and NGOs such as Child Rights and You. These organizations initially aimed at better rehabilitation and relief for the *Choruas*. They then surveyed and mapped the *chars*, in order to initiate the institutionalization of these lands. They also promoted activism towards recognition and assertion of citizenship rights of *Choruas*. Scholar-activists like geographer Kalyan Rudra from Kolkata supported their cause by disseminating studies on Farakka Barrage's responsibility in sediment regime disruptions and its impact on *char* erosion in Malda and Murshidabad districts (Rudra, 2003).

Finally, in December 2010, GBPANC managed to organize a meeting at the Hamidpur *char* itself, in the presence of the Additional District Magistrate of Malda district. Inhabitants

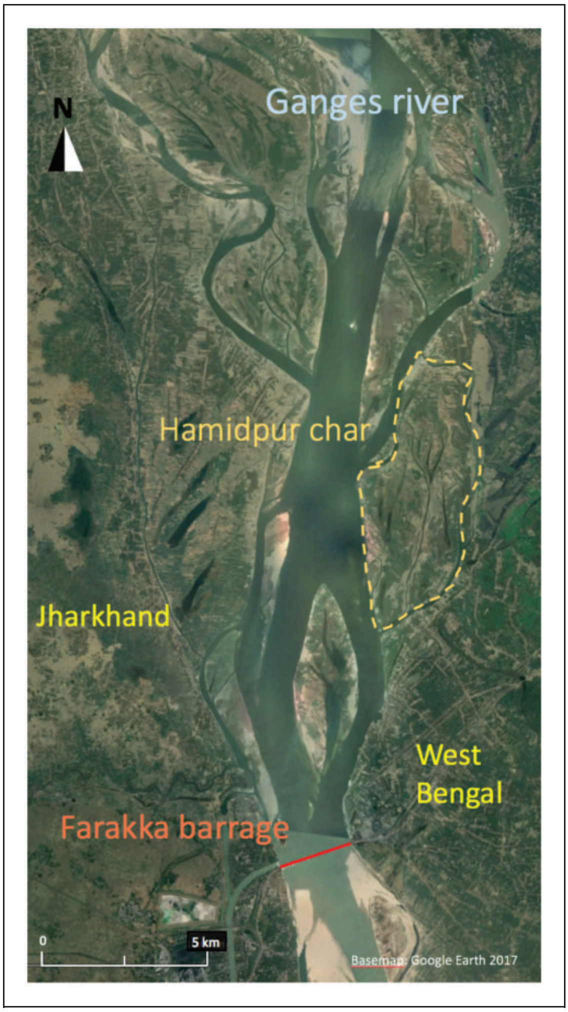

Figure 6. Location map of Hamidpur *char*, Malda district, West Bengal.

were told to bring and show to the administrator their past property entitlements. As a direct consequence of this event, in 2011, *Choruas* got identity cards and voter cards. Two primary schools and a junior school were constructed between 2012 and 2015, allowing children from the *char* to join schools. The *char* got access to electricity in 2015, a tangible sign of marginalization reduction. Since 2014, a woman from the *char* has been elected as Member of the Hamidpur Gram Panchayat. Since *char* residents were recognized officially, this paved the way for political participation (for instance within the local flood commission, or with *Nirmal Bangla* (Clean Bengal schemes, etc.), disaster planning, and delivery of government services (construction of emergency shelters, health programs, etc.).

Between 2005 and 2011, people thought that only classification of *chars* as *payasti* (i.e. revenue land) could lead to access to government schemes and provide official identities to *Choruas*. However, the *char* remains *shikasti* land or non-revenue land; no taxes are then collected on agriculture revenues. As a consequence, thanks to the high fertility of the *char* soil and according to the head of the Kaliachak II block, 'people are not poor there' (field interview, July 2017).

This particular case of a successful grassroots movement shows the potentials and possibilities of *moving terrain* where flood or erosion may come anytime. In this case, official recognition of the residents' existence and needs has been crucial. However, as the head of Kaliachak II Block explains, Hamidpur *char* is particular in the sense that some easy identifiable land was available for the settlers thanks to re-emergence of land. In contrast, in areas of the Jharkhand-West Bengal border, many *chars* remain like 'orphans': as of now, no decision has been taken to attribute these *chars* to one of the two states. Vulnerabilities of *Choruas* there remain unabated. In 2018, GBPANC was still an active association that defined its mission as promoting a 'complete awareness' about river erosion and the associated problems (GBPANC's website, accessed September 2018). Its aim remained to put pressure on government for conducting technical assessments, understanding empirical realities and crafting policies for welfare of erosion-victims in general and *Choruas* in particular.

What do we miss when we miss sediments? Rethinking hybridity

These Lower Ganges basin cases reveal how sediments transported by rivers are embedded in river-society interactions. We have shown the magnitude of Farakka Barrage's disruption of sedimentation processes in the Lower Ganges basin; and the effect of the submergence/re-emergence of *chars* on Hamidpur *Choruas*' political mobilization to fight against administrative decisions. As observed in these cases, as well as in projects like the Inter-Linking River project promoted by the current Indian government (the general aim of this project is to transfer water from water-rich river basins to water-scarce basins), river sediments are often absent from discourses and ideologies. When deposited or when in suspension, they are often misinterpreted as being only land or only water. They are however involved, along with water, in effective dynamic relations with society, shaping and being shaped by it.

Anthropologist Krause (2017b) argued recently that this land-water nexus does matter, socially and culturally, engaging with a debate around this nexus and the concept of hybridity. He suggests that a geographer's vision like Lahiri-Dutt's (2014) gives too much attention to the spatial aspect of the land-water nexus. According to Krause, it is not so much of a (spatial) hybrid but instead a lived and experienced *temporality*, 'a set of spatio-temporal rhythms of increasing and decreasing wetness and fluidity' that is significant (Krause, 2017b: 1). He illustrates his approach with two ethnographic cases from Northern Europe and shows how the experience of people engaging with their 'in-between environments' (wetland, floodplain) is closely intertwined with 'inherent rhythmicity' of temporalities like seasonal floods or hydropower-oriented manipulations on water level.

Krause's approach points to 'rhythmicity', 'rather than to historicity and futurity' (2017b: 5). In our interpretation, this approach pays less attention to long-term perspectives and political dimensions. In the Lower Ganges basin, these dimensions cannot be overlooked. We showed how the colonial legacy in land/waterscapes and in the land/water conceptual divide still very much infused contemporary dynamics. In such 'post-colonial' landscapes, one should use political and even ontological lenses to address them, as the hydrosocial framework rightly suggests. It is the way we understand the call from Lahiri-Dutt to rethink land as 'aqueous, fluid, spongeous and uncertain' (2014: 3). Beyond referring to outcomes of rhythmic physical processes like tides, floods or seasons, these terms are metaphors. They oppose colonial/hegemonic perspectives that consider lands as 'terra firma' and that reify a land-water divide.

Krause also engages with the concept of (land-water) hybridity: according to him, this concept often carries implicit spatial focus (it describes a particular environment) and rather reinforces the conceptual divide between land and water (it is thought as a mixture of both, thus '[positing] them as building blocks of the world') (2017b: 2). Krause notably cites Swyngedouw's writings in 2006, where the author takes some distance with the concept of hybridity he initially contributed to develop in political ecology of water: 'the notions of "hybridity" or "cyborg" are misleading if not radically reproducing the underlying binary representation of the world' (Swyngedouw, 2006: 113). However, Lahiri-Dutt expressly defines hybridity not as the mixture of two environments, but as the expression of flux, uncertainty and the tension between presence and absence: 'sometimes a given environment, sometimes another, sometimes both and sometimes neither' (2014: 18). In that debate, looking at sediments may open new conceptual directions. Sediments are neither water, nor land, they are mineral grains. Depending on the time, on magnitude of flows, on topography, on grain size and on many other subtle factors, they may be subsumed in one or the other. Water, even with suspended sediments, remains aqueous. Sediments may thus be a metaphor of the illusory fixity of categories of land and water, and even hybridity itself, as a third 'thing'. They also bring plurality (the absolute number of grains and their complex chemistry and size distribution), offering in that sense many more possibilities than a singular hybridity. They finally represent what remains to be known (the complexity of physical phenomena determining one mineral grain's trajectory), resisting the attempts to master representation of reality, while – in contrast to hybridity – being in the same time a resource directly in contact with the humans engaged with their environment.

Turning back to the hydrosocial framework, thinking on the roles and meanings of sediments confirms the relevance of paying better attention to materiality over space and time in this approach (Birkenholtz, 2016). It also confirms the significance of the question 'what is water and how is it made known?' that Linton and Budds point to (2014, see also Bouleau, 2014; Linton, 2010). Finally, it complements and confirms the dialectical thinking adopted in the hydrosocial cycle concept that emphasizes processes and relations instead of fixed things and categories (Harvey, 1996; Linton and Budds, 2014).

Conclusion

In this paper, we showed how sediments transported by rivers are intricately interwoven into river-society interactions. The Lower Ganges basin case testifies that sediments are sites of social/physical interactions. Until now, while scientific studies and modelling address some empirical dimensions, these socio-natural realities are not much considered by Indian official authorities. For instance, the draft sediment management policy posted by the Ministry of Water Resources, River Development and Ganga Rejuvenation gives little attention to social issues: no socio-economic assessment is mentioned alongside the scientific studies, mathematical model studies or physical model studies (MoWR, 2017). The draft seems to approve activities like sand and boulder mining, construction of storage reservoirs and riverbank protection/anti-erosion in floodplains, under the condition of respecting sustainable management guidelines edited in 2016. But potentially deleterious impacts on human occupation of downstream or upstream floodplains are not mentioned in the 2016 guidelines for sustainable sand and gravel mining, edited by the Central Ministry of Environment and Forests (MoEF, 2016). Human occupation in floodplains is for example qualified as 'encroachment' (MoWR, 2017: 2, 6–7) and not as existing occupancy that should be considered in the context of on-going changes and impacts.

The principal contribution of this paper has been to introduce and incorporate sediment within the ambit of hydrosociality. The Lower Ganges basin that is partly land and partly water, and neither in its entirety, inhabited by numerous marginalized communities, exemplifies the significance of incorporation of sediments in water research, not only from the physical [hydrological/geomorphological] point of view, but also from socio-economic, political and cultural aspects. Furthermore, these dynamics of river-sediment-society 'metabolism' extend across long-term temporal conjunctures, as we showed from environmental history.

The hydrosocial approach provides a critical alternative in considering the 'liminal spaces' of hybrid water/lands, reframing them as 'not [only as] lines of separation but zones of interaction... transformation, transgression and possibility' (Howitt, 2001: 240). Sediment-enriched hydrosociality, entering the muddy terrain of Bengal basin, critically interrogates the modernist view of the environment, which 'firmly believed in a watertight divide of water and lands, robbing the rivers of their histories and extracting them from their social contexts of human experience' (Lahiri-Dutt, 2014: 9). There is much more to rivers than just water. Here, we have only pointed to sediments. One could go further to the riverine biota, nutrients or micropollutants; all are socio-natural realities begging for a broader analysis.

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Notes

1. The description simplifies the situation, as the whole system is more complex with temporary disconnected or reconnected distributaries or channels, according to intensities of dry and monsoon seasons and sedimentation/erosion processes.
2. India counted more than 144 millions of landless farmers in 2011, near 55% of agriculture-engaged workers (source: Census India, 2011, http://www.censusindia.gov.in, consulted 5 September 2017).

3. Malda (4.0), Murshidabad (7.1), Nadia (5.2), Burdwan (7.7), Hooghly (5.5), Kolkata (4.5), Howarh (4.9) and 24 Parganas North (10.0) and South (8.2) districts. Kolkata metropolitan region counts about 14 million inhabitants. Figures from Census India, 2011.
4. At the same period, the emblematic Upper Ganga Canal system was excavated for irrigating the Doab region (Uttar Pradesh).
5. Although a water sharing treaty has been signed in 1997 and water data, however not available for the general public, is now shared among an Indo-Bangladeshi commission (Sen, 2017, personal communication).
6. See for example SANDRP report https://sandrp.wordpress.com/2014/11/25/lessons-from-farakka-as-we-plan-more-barrages-on-ganga/ (accessed 21 September 2017), Times of India article, 16 July 2016 http://timesofindia.indiatimes.com/city/patna/Bihar-CM-demands-removal-of-Farakka-barrage-on-river-Ganga/articleshow/53244938.cms (accessed 21 September 2017).
7. Once submerged by a river channel, a re-emerged land remains governmental property and no revenue can be collected from it.

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