GOUVERNER LE BRAHMAPOUTRE : DE L'AMENAGEMENT DES DIGUES A L'AVENEMENT DES CATASTROPHES

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VULNÉRABILITÉ & RÉSILIENCE
13-15 NOVEMBRE 2019

Communication au Colloque « Vulnérabilité et Résilience dans le renouvellement des approches du développement et de l'environnement » (vr2019), Université de Versailles Saint Quentin-en-Yvelines (UVSQ)

vr2019.sciencesconf.org

www.cemotev.uvsq.fr / cemotev@uvsq.fr

Thématique 7 : Gouvernance de l'eau : nouveaux modèles de gestion intégrée des ressources en eau, nouvelles pratiques

Gouverner le Brahmapoutre : de l'aménagement des digues à l'avènement des catastrophes

Governing the Brahmaputra: from the construction of embankments to the advent of disasters

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Abstract:

The states that successively ruled the alluvial plain of the Brahmaputra (Ahom kingdom, British, independent India) have built dikes to control the river and ensure abundant rice production. However, these developments are disrubing the river dynamics and ultimately tend to exacerbate floods as a result of unforeseen dike ruptures. The people of Brahmaputra still face recurring floods and their lands disappear eroded by the river or buried under sand deposits. This article questions the effects of embankments on peasant livelihoods. Indeed, the present river management policies increase peasant's vulnerability. Peasant's react through adaptation of their livelihood. This may outcome in a better resilience to socially constructed hazards.

Key words: Governance, river management policies, adaptation, resilience, fluvial dynamic vulnerability, socially constructed hazards, mobility

Résumé :

Les États qui ont successivement gouverné la plaine alluviale du Brahmapoutre (royaume d'Ahom, Inde britannique indépendante) ont construit des digues pour contrôler le fleuve et assurer une production de riz abondante. Cependant, ces développements perturbent la dynamique de la rivière et tendent finalement à aggraver les inondations à la suite de ruptures de digues imprévues. Les habitants du Brahmapoutre sont toujours confrontés à des inondations récurrentes et leurs terres disparaissent érodées par la rivière ou enfouies sous des dépôts de sable. Cet article remet en question les effets des levées sur les moyens de subsistance des paysans. En effet, les politiques actuelles de gestion des fleuves augmentent la vulnérabilité des paysans. Les paysans réagissent en adaptant leurs moyens de subsistance. Cela peut se traduire par une meilleure résilience aux aléas socialement construits.

Mots clefs : Gouvernance, politiques de gestion fluviale, adaptation, résilience, vulnérabilité dynamiques fluviales, risques naturels, mobilité

Introduction

Throughout the world interactions between hydrological dynamics and human activities are shaping flood plain's agro-ecosystems. Indeed, human beings relate to components of their environment in the activities of subsistence procurement. The ways of acting in the environment are also ways of perceiving it (Ingold 2000).

In the modern thinking, nature is most frequently separated from culture (Descola 2005). This is probably the reason why modern human societies have attempted to control river dynamics. In that regard, building embankments is an ancient structural mean, which has dramatically transformed large river systems (Baghel 2014). This way of managing river is not only a fact of the western world, as it is also practiced in the east, as demonstrated by Karl Wiffogel (1957). For Wittfogel, political power was pursued and consolidated in Asia through programs of large-scale hydraulic engineering to dominate land and people in the aim of economical efficiency. Indeed, embankments were already constructed more than 10,000 years ago from the early "hydraulic civilizations" that have dominated Mesopotamian, Egyptian, Chinese or Indus valleys (Guru, 1936; Bethemont 2002; Dixit, 2009). Unlike other major human impacts like anthropogenic climate change, the alteration of river systems has been deliberated and planned by a small, powerful set of experts (Baghel, 2014). This dominating vision of river control transforms hydrosystems around the world. River management has an important effect on the river flow and its dynamics, transforming social organizations and people's livelihoods.

Along the Brahmaputra, floods, riverbank erosion and siltation are recurrent phenomena (Bhattacharyya 1997, 2011; Coleman, 1969; Sarma, 2005). River settlers have adapted their practices to an ever-changing fluvial environment as their means of subsistence (livelihood) are benefiting from river's natural resources (Haque, 1988, 1997; Elahi 1989; Haque & Zaman, 1993; Zaman 1994; Hoffer & Messerli, 1998; Hutton, 2003; Lahiri-Dutt, 2014; Lahiri-Dutt & Gopa, 2013). They are fishing in braided river channels, swamps, wetlands and pounds. Their cattle are grazing on grass-covered sandbars. They are cultivating the fertile alluvial floodplain and are collecting firewood in the tropical forest on Himalayan slopes. As the farmers of Assam have for a long time transformed the land for agricultural purposes, they have played a vital role regarding the creation of Brahmaputra floodplain's current landscape (cf. Ingold 2000).

The Ahom kingdom was the first to introduce this form of river regulation in Assam from the 13th century onward (Lahiri 1984). The British succeeded them after their arrival in the region in 1826. Following British rule established policies after independence, the government of Assam built further embankments along both sides of the river. Moreover, those embankments are associated to administrative boundaries defined by local authorities that freeze territories and restrict mobility.

Villagers have settled behind embankments and adapted their farming practices to diked areas. They became less and less prepared to cope with floods. However, during monsoon, the river discharge tends to take back ancient channels, erodes riverbanks and exerts pressure on embankments. Consequently, breaches in those embankments trigger unexpected flash floods inundating villages and lands. When the river flow recedes, sandy sediments deposited by the river cover agricultural lands. Those "natural disasters" are closely connected to the engineering-driven management of the river promoted by government officers (D'Souza, 2007). Indeed, the risk exposure of peasant societies results from changes in the interactions between human activities and hydrological processes.

Within the Anthropocene period, human have transformed river systems by building infrastructures like dams and embankments. Various forms of water pollution, river regulation, and the hydrologic implications of anthropogenic climate change mean that virtually all water sources on earth now bear a human imprint. Thus, the nature of the circulation of water on earth has to be described in social as well as hydrologic terms. Most of the rivers are now managed through strong engineering projects. Proponents of river control argue that embankments are necessary for irrigated agriculture and flood control. However, dam building fragments rivers, transform the hydrological system and the river related ecosystems. These infrastructures are built to dominate nature, to make it more productive but don't necessarily consider the livelihood of the riverbanks and floodplain dwellers. Moreover, the modern way to manage rivers is dominated by a strong separation between human and nature. That separation has led to an increasing risk of so-called "natural hazards". Those risks result from a modern representation of the environment in which there is a dichotomy between nature and society (Latour 1997). As said by Blaikie & al. 2004: "Many 'disasters' are usually a complex mix of natural hazards and human action. […] In 'natural' disasters, a geophysical or biological event is clearly implicated in some way in causing it. Yet, even where such natural hazards appear to be directly linked to loss of life and damage to property, the social, economic, and political origins of the disaster remain as the root causes. People's vulnerability is generated by social, economic, and political processes that influence how hazards affect people in varying way and differing intensities". We must consider the social, economic and political context that increases human vulnerability (Blaikie & al. 2004). It's important to point out that, in most parts of the world, local ecological knowledge and livelihoods of populations in close relations with environment have been neglected by dominating States (Ingold 2000).

In this paper, we focus on the interactions between the river and local communities. As proposed by Linton & Budds (2014), through the hydrosocial cycle we seek to transcend the dualistic categories of 'water' and 'society', and employ a relational-dialectical approach to demonstrate how instances of water become produced and how produced water reconfigures social relations. The hydrosocial cycle is the socio-natural process by which water and society make and remake each other over space and time. Linton & Budds (2014), cycle is iterative in the sense that it comprises a dialectical relation between water and society, whereby interventions in the hydrologic cycle will produce changes in society, and so on. As a cycle, there is no necessary beginning or end to this process: alteration of the hydrologic cycle is always preceded by, or presupposes, a social structure and the application of social power to technological interventions. We identify the hydrosocial cycle as a socio-natural process, suggesting other than a dualistic conception of the relationship between water and society. This cyclical process is also socio-natural in the sense that water, society, and technology are all hybrid objects, internalizing the relation they have with each other. The hydrosocial cycle, moreover, is a dynamic historical and geographical process, meaning that the assemblage that gives rise to a particular kind of water and a particular socio-political configuration is always changing. A change in any moment of the process, moreover, has the potential to affect all the others, such that the entire hydrosocial assemblage is constantly in the process of transformation. Indeed, recent work in the hydrologic sciences shows that the very 'character' of the hydrologic cycle is being affected by human society (Vörösmarty et al., 2004).

Through the hydrosocial cycle, water becomes a mean of investigating and analysing social practices and relations, and of tracing how power infuses these connections.

Within this applied analytical framework, this paper firstly emphasizes on how river management has been implemented to control the Brahmaputra dynamics, such as flood and erosion. It focuses then on the effects of these policies regarding “natural hazards”. It finally presents how local peasant communities perceive and cope with the risks and adjust their livelihoods in flood-affected areas.

1 Context and Methods

Context

The Brahmaputra River flows 2,880 km from Tibet to Bangladesh. It takes its source in the Tibetan Autonomous Region (China), where the river is known as Tsang-Po, then make a loop just before entering into the State of Arunachal Pradesh in India. It further flows into the alluvial plain of Assam. In Bangladesh, the river joins the Ganges forming the Bengal delta (Goswami 2003) **(Fig.1).**

Surrounded by the hills and mountains of the Himalayan range, Northeast India concentrates 80 % of the annual rainfall (2500 mm/year) throughout the monsoon season from mid-June to mid-September. Since the Brahmaputra regularly overflows during the rainy season, agricultural activities depend mostly on hydro-climatological conditions. The great Brahmaputra River formed a landscape composed of a vast network of active and abandoned channels, sand banks (revealed during the dry season) and vast wetlands that give some indication of the river paths of the past (Sarma 2005). Channels oscillate in the plain and show broad sandbanks, called *chars* in Bengali or *chaporis* in Assamese, which are typical characteristic of a complex braided river system (Sarma, 2005; Goswami et al., 1999; Amoros, 1993). (Sarma, 2005; Dutta, 2001). Residents of the area use the different landforms of this fluvial system for fishing (streams), livestock grazing (sandbanks), and crop cultivation (floodplain).

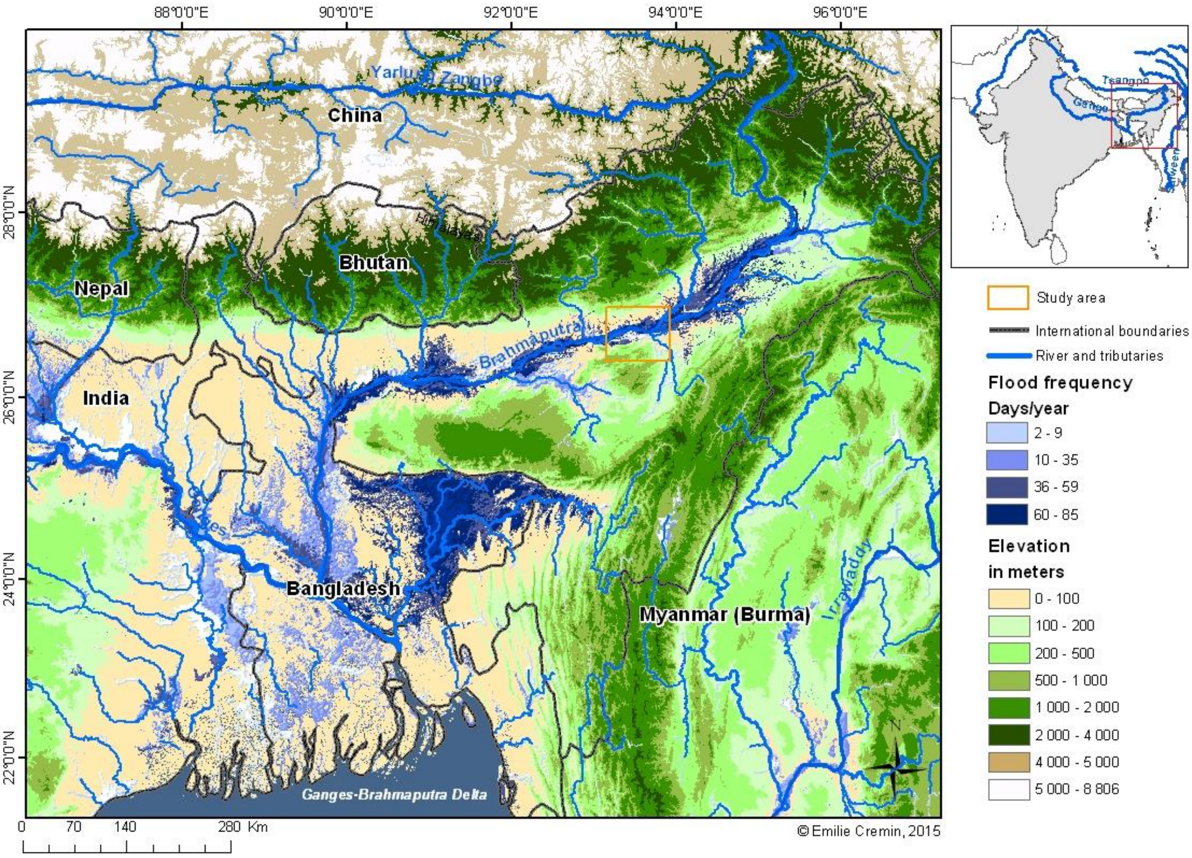

Fig. 1: Location of the study area in the Brahmaputra floodplain. Sources: SRTM, Hydro watersheds (USGS, WWF). Cartography: É.C. 2015.

During the monsoon season from mid-June to mid-September, water discharge in the rivers is directly correlated to rainfall (Sarma 2005). Therefore, floods arise during monsoon and the rivers discharge decreases during the dry season. In some areas, the flood may remain for 85 days as shown on the fig. 1. The annual floods are beneficial to the plain ecosystems, bringing water to wetlands, promoting feeding and breeding cycles for fish and increasing soil fertility through silt deposit (Goswami & al. 1993; Goswami 2003). However, beyond certain thresholds of duration and water level, floods can damage farms, crops and housing. These thresholds depend on the micro-topography and are related to river control infrastructures.

Flood recession reveals large amounts of sediments covering the land. Deposits are mainly composed of sand, called *bali* in Assamese. To a lesser extent loam, called *poloh*, is fertilizing the soil.

Northeast India has experienced a dozen of earthquakes during the 20th century. One of the most disastrous of all occurred on August 15th in the year 1950. Its magnitude was recorded as high as 8.6 on the Richter scale (Sarma, 2005; Kingdom -Ward, 1955). This earthquake released large masses of sediments in the catchment area. These masses of sediments contain fewer fertile alluviums and more sand. Once deposited in the plain, they contribute to the rise of the riverbed and an increase the process of riverbank erosion and accretion. Consequently, settled and cultivated lands were damaged. Seismic activity contributes to changing sediment loads in the river system and channels configuration. Moreover, these dynamics can damage flood control infrastructures.

Several ethno-linguistic communities (e.g. the Assamese, Koïbotras and Mising) inhabit this area. Among them, the Mising tribe (also called Miri) is classified by the Indian constitution of 1950 as a Scheduled Tribe (ST) of Assam. These people live in lowlands, highly exposed to the vagaries of the river. Looking for land that suits rice cultivation, they have migrated from the hills of Arunachal Pradesh (a state of Northeast India) to the plains of Assam from the 13th century onwards (Pegu, 2005). They have long led a mobile lifestyle, transferring its villages according to the movements of the river.

According to the 2001 census, 80% of the population of North Lakhimpur district and even 94% of the population of Dhakuakhana subdivision depends solely on agriculture, as most of the crops are cultivated for subsistence. Moreover, the part of the population living below the poverty line (BPL), around 59% in Dhakuakhana subdivision, remains very vulnerable to natural hazards.

Methology

In this case study, I took the example of Matmora village situated in Dhakuakhana subdivision. The Brahmaputra and its tributary, the Subansiri, create the limits of this subdivision. Other rivers and abandoned channels compose the river system of this area. Population density is quite low in this subdivision (182 inhabitants per km^2) in comparison to the average for Assam (340 inhabitants per km^2) or for the Bengal delta (1500 inhabitants per km^2).
Considering that the landscape of Brahmaputra is resulting from the interaction between human and the river, the analysis of the floodplain area through the approach of landscape ecology prompts us to consider human activities as part of an ecological system (Berkes and Folke 1998;

Burel & Baudry 1999; Berkes et al. 2003). To find out how people and the river are related and interacting, the applied methods consisted of interviews with different categories of stakeholders (local residents, government officials and representatives of non-governmental organizations). Those interviews and observation have provided information on engineers and peasant perception of river infrastructure (embankments), peasants agricultural practices and livelihoods.

A project of GIS (Geographical Information System) was developed to analyze the land use in the subdivision and to understand the river channel dynamics and its configuration during time. Within that project, I could correlate different data (e.g. old maps maps; SPOT, Landsat satellite images and fieldwork survey.

2 A river under control?

2.1 River control during the Ahoms and British colonial period

Since the 13th century, the Ahom kingdom (1228-1826), a strongly centralized, stable and hierarchical state based in Upper Assam, imposed strict management of water resources over large paddy cultivated areas. The Ahom kings introduced advanced rice cultivation technics, which were associated to dykes and irrigation systems in marshy areas and the sparsely populated floodplain (Lahiri, 1984; Guha, 1983). The river protections and agricultural technics have modified the river ecosystem mostly on the south bank of the river around Sibsagarh.

River control policies were extended in India during the British colonial period. The objective was to create large irrigated areas and elevated roads to fuel the region’s economy. From 1855, the East India Company took control of these structures and of the related land (Mishra, 1999). Floodwaters had to be controlled, regulated and subsequently brought under absolute subjugation. In other words, the imperatives of rule and administration were decisive in determining and organizing an agenda for flood control. Embankments were the first structural measures adopted as flood control measures to prevent floodwaters from submerging revenue-generating land. At the end of the British rule, 5,280 km of dikes where constructed along the Indian rivers and most of the peasants were accustomed to leave and cultivate protected areas.

As rightly put forth by Rohan D, Souza (2000): “A century of tampering with the natural drainage and reconfiguring the topography and agrarian production regime to suit exigencies of rule and administration had led to the creation of several ‘protected enclaves’, substantially insulated from flood-spill. These protected zones, surrounded by embankments, were now decisively committed to the continuation of the embankment system as many of them had sunk below the beds of the rivers”. As experience was gained, it rapidly became apparent that embankments not only clogged drainage systems and magnified flood heights, but also were a substantial drain on the resources of the colonial government.

An extensive debate about river management and embankments took place throughout the 20th century. British engineers recognized as early as 1937, during the Patna conference on flood, that embankments produce many side effects, including the raise of the riverbed, reducing fertile alluvial deposits on lands as well as producing waterlogged malaria prone areas due to a poor drainage (Qazi, 2006; Fanchette, 2006; Mishra, 2008). They opted against the general containment strategies and stressed that “[e]mbankment merely transferred troubles from one area to another and give a false sense of security” (quoted by R. Sinha, 2008).

2.2 Strengthening the embankments after the independence

Following India's independence in 1947, the development policies of the new government took up the idea of river management and flood control in order to improve irrigation and land drainage (Moench & Dixit 2004, Baghel 2014). Flood management schemes based on the construction and commissioning of dams, regulators, valves and other water control infrastructures were adopted (Shapan, 2006).

The major earthquake of 1950 has shaken up the hydromorphology of the Brahmaputra watershed. River channels configuration has changed, causing land erosion and severe floods, disrupting thus people's livelihood. The Assamese government, based on the "Assam Embankment and Drainage Act" of 1953, took over the construction of embankments to protect farmlands and villages from floods.

The Master Plans policies defined by the Planning Commission gave priority from 1956 to 1985 to structural solutions for flood management: the construction and building of hydraulic structures such as dams, embankments, drainage channels, platforms as shelters for villagers, irrigation. By the end of the 3rd Plan (1961-1966) 7,000 km of new embankments, 8,700 km of drainage channel, 164 town protection schemes and 4,582 villages raising projects were constructed all over India (Moench & dixit 2004). The 5th Plan (1974-1978), shifted emphasis to raising and strengthening embankments.

In 1976, the Government of India decided to set up the Rashtriya Barh Ayog (National Flood Commission) (RBA). This commission has submitted a report in 1980 that recommended integrated flood management measures taking into account various factors such as demographics, climate, hydro-geomorphological and others. The creation of this commission attested the emergence of a more holistic approach. Despite the advancement of the integrated approach, the 7th Plan (1985-1990) placed the emphasis on the importance of introducing structures against erosion to stabilize existing facilities.

Meanwhile, the *Brahmaputra Board* was formed in 1980 under the aegis of the Ministry of Water Resources following the Brahmaputra Board Act No. 26. The board is since then in charge of the Master Plan for the control of floods and bank erosion in the Brahmaputra floodplain. Central and State flood control boards were established in order to implement the Plan's activities. It reveals the will of decentralizing the primary responsibility of undertaking flood control measures to the State governments.

The 8th (1992-1997) Plan proposed to pursue substantial investments in maintaining embankments. In this context, maintenance of the flood control facilities was seen as an opportunity to provide employment. By linking maintenance with employment generation programs such as the India Jawahar Rozgar Yojana, the twin objectives of flood protection and rural income creation could be fulfilled.

From the 9th Plan (1997-2001) onwards, the idea of implementing non-structural strategies, such as early warning systems and disaster preparedness, was introduced to mitigate damages. Revealing the rise of the holistic approach, the 10th Plan (2001-2006) emphasized the limits of structural and non-structural strategies. As said by Moench & Dixit (2004) "It also emphasized the need to develop long-term and permanent solutions to flooding through a variety of measures, including constructing storage, raising villages, modifying cropping patterns (sowing crops which can tolerate waterlogging), setting up a nationwide network of communication, forecasting and forewarning systems, and ensuring people's participation in the maintenance of embankments".

In 2005, following the order of the Disaster Management Act, the central government established the National Disaster Management Authority (NDMA). The mission of this new institution is to conduct an integrated disaster management for risk reduction, which requires better coordination of all administrative services (Water Resource Department, Brahmaputra Board, Agriculture Department and others) and across scales, from National to District. This new authority is guided by a holistic and integrated approach for disaster management. These evolutions of river control policies demonstrate a paradigm shift and changes in the strategies guiding the government's action plans. According to official statistics, the flood management measures undertaken so far have provided a reasonable degree of protection to an area of 15.81 million ha across India.

However, Master Plan policies have so far been designed and implemented despite warnings from experts and without enough consideration for people's livelihoods. There has been little attempt, however, to evaluate whether or not this has actually reduced people's vulnerability to flood hazards or the scale of vulnerability and marginalization among those affected by floods (Moench & Dixit 2004). There are no local governance initiatives taken till now.

Moreover, scientists (hydrologists, seismologists, geomorphologists) have shown that river engineering is only viable as a temporary solution (Goswami, 2003). In the long run, embankments tend to provoke a rise of the riverbed within its bounds, and thus worsen the situation. Large unstable rivers like the Ganges and the Brahmaputra, with high flow rates, are difficult to control. In 2000, the Ministry of Water Resources also admitted that "[f]loods being natural phenomena, total elimination or control of floods is neither practically possible nor economically viable. Hence, flood management aims at providing a reasonable degree of protection against flood damage at economic costs" [1] (GoI, 2000).

Amita Baviskar remarks in her book *In the Belly of the River*: "Ironically, embankments and dams were constructed in order to control the damage caused by floods. Instead, they have prevented the nutrient-rich silt carried by rivers from being deposited in the soil, thereby depriving flood plains of valuable source of fertilizer. The sediment now accumulates on riverbed, raising it so that the river in spate overflows its sides and devastates more land, lives and property." (Baviskar, 1995: 29). Instead of protecting people, land and public amenities, those infrastructures tend to produce hydrological risks. As a sign of protest, some peasants of the Bengal delta open breaches in the levees to reactivate the drainage or to benefit from the fertile alluvium brought by floods (Fanchette 2006; Shapan, 2006).

The idea of building river engineering structures has been questioned several times, during both the colonial and postcolonial era, yet 15,675 km of dikes have been built in India since 1954 including 5,027 km in Assam, 32 % of the total (Goswami, 2003). The quality of these facilities as well as their maintenance often remains inadequate, leading to unpredictable breaches in the levees. Dikes have not always provided the expected protection against floods. As embankments give an illusory sense of security, people living within these "protected" areas become increasingly vulnerable to flood and erosion.

[1] Government of India, Ministry of Water Resources (2000)

2.3 Embankment failure and disaster occurrence

The case of Dhakuakhana subdivision perfectly illustrates the vulnerability of villagers facing flash floods due to breaches in embankments. Indeed, an embankment was constructed in 1954 to protect this area. However, those flood control facilities were not able to endure the strength of the water flow and have been rebuilt several times as shown on fig 3.

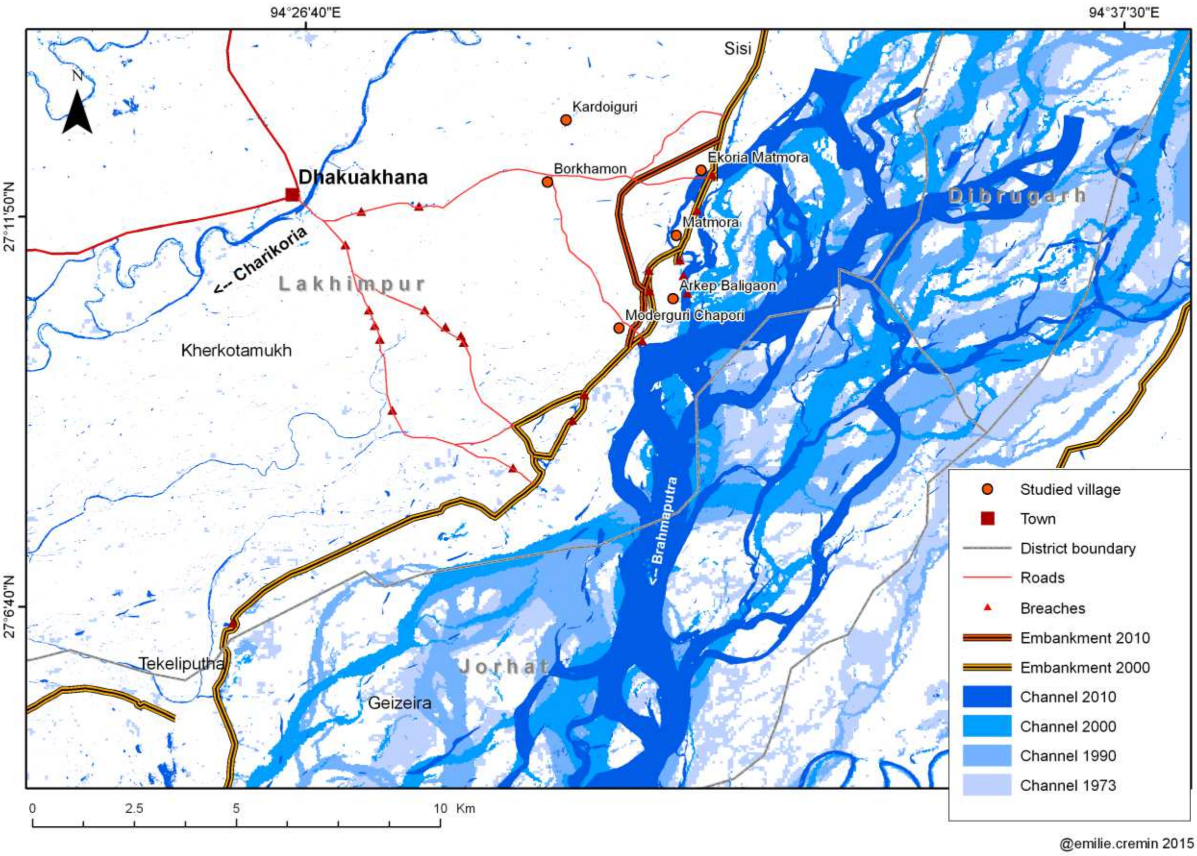

Fig. 2: Changing channels configurations of the Brahmaputra River at Dhakuakhana in 1973, 1990, 2000 and 2010. Scale: 1/ 100 000. Sources: HydroSHEDS (WWF, USGS), Landsat 2000, Geofabriks. Landsat 1973, 1990, 2000 and SPOT 2010. Cartography: É.C. 2013.

Despite river control measures, riverbank erosion, embankment breakdowns and floods are still common phenomena along the Brahmaputra, as assessed during fieldwork. Villagers are explaining that the Sissi-Tekeliputha embankment, which was protecting Dhakuakhana subdivision, broke in 1998. It was rebuilt and for a decade, villages have settled behind it. The villagers had the feeling that they were protected and that flood may not come.

But suddenly in 2007 and 2008 a segment of 1.5 km was completely devastated by river erosion **(Fig. 2 & 3)**. Consequently, a major flash flood has inundated and has deposited large amounts of sand, destroying most of the paddy fields and making the land unfertile for several years. Sandy sediments damaged 5,874 ha of farmland **(Fig. 2)**, and the rice cultivation was no longer possible. Moreover, riverbank erosion has taken away a large amount of land. As a consequence, 89 villages (from a total of 260) of the Dhakuakhana subdivision were flood-affected and 956 families became homeless. They have lost their houses, their plots of land and, thus, their livelihoods. Even if, the Sissi-Tekeliputha embankment has frequently been raised and strengthen as recommended in the fifth Master Plan, it didn't prevent the river to reopen its path and flow over land to join one or another sub-channel. The facilities became ineffective and increase the risk of flash floods.

To overcome recurrent breaches in the embankment, the central government opted to adapt through structural means. The central government, State government and the Brahmaputra board have hired a Malaysian company to construct an innovative embankment. It consists of a series of "Geotubes", large bags filled with sand (available on site). Their technique was tested on coastlines affected by marine erosion. Work began in late 2008 but was not completed before the monsoon due to administrative and technical problems. As a result, all the gears were swept away by the flood in 2009. The flood has again flow over the Matmora area from the 1st July to first week of September. However, after renewed efforts the new 5 km long infrastructure was finally completed and inaugurated in late 2010 and now protects the subdivision. Upon request of the local administration, all villages had to shift behind the new embankment. From that time, some residents of Dhakuakhana subdivision have managed to harvest rice in the cultivable areas. However, sand casted lands remain uncultivable in 17 villages of the 89 villages affected, including Matmora. Whilst the Geotubes are expected to withstand heavy floods, hydro-geomorphological dynamics inexorably continue to erode lands **(Fig. 2)**. Erosion fronts are progressing on both sides and attack the oldest and weakest embankments both up-stream and down-stream. This failure in controlling the river shows that land is far from being protected from floods. The risk of breaches still worries Matmora inhabitants.

2.4 Adapting to flood

How the peasants face of the vagaries of the river environment and land constraints imposed by the State in the middle Assam flood plain? We question the adaptation processes of Farmers.

We observed that peasant communities have adapted their practices by developing different types of rice crops depending on the water level. Floods are generally fertilising the soil for cultivation. Deep-water rice can support floods. These types of rice can grow so rapidly that they can keep pace with rising floodwater. Moreover, fish is abundant in the ponds once the floodwater recedes. Taking cattle to graze on river islands is always a challenge for the shepherd, which is looking for the best grassland. As Mising peasant communities are practising diverse agricultural activities, they can adjust with the vagaries of the river. Thus, flood is not a disaster for everyone as the communities can adapt to it. Even after worst floods the harvest can be good. However, a household whose cattle have died in a flood, or which for other reason cannot take advantage from floods. The risk of the death or injury of these animals in floods adds a further measure of vulnerability (Blaikie & al. 2004). Nevertheless, those traditional and flexible responses to natural patterns of inundation practiced by the inhabitants of the Brahmaputra flood plain are systemically undermined by the administration of the Water Resources Department.

When affected by frequent floods and river erosion, flood plain inhabitants are remaining mobile. Some household are moving their settlements on dikes and alluvial ridges even if this land occupation remains without rights or titles. Houses and granaries of the Mising families are most frequently reconstructed on levees and are adapted to flood as they are constructed on high stilts. Crossing the Brahmaputra's channel seasonally during dry season and going back to mainland before monsoon is also remaining as a seasonal mobility. But also, many households choose to shift permanently to another place or to town to get better life conditions. The mobility of young people towards urban spaces appears as a new perspective for the rural communities of this densely populated plain.

3 Conclusion and discussion

In June 2015, the Brahmaputra board has emphasized: "on priority in the interest of optimum management of river water to provide reasonably permanent protection from flood and erosion and development of water resources potential for economic prosperity of the people of the region in particular and country as a whole". The Brahmaputra's river channels are extremely dynamic, and the control of its course is a challenge for the state (Sarma 2005, Goswami & Das 2003). Constructed as part of a dualistic approach of the relationship between the river and its inhabitants, embankments freeze territories in a rather fluid environment. The long-standing debate around strengthening or deconstructing river embankments is still crucial in Assam among experts of river management. Despite regular breaches, the Brahmaputra board and local authorities still consider embankments as the most appropriate way to control the river, and to protect farmland and villages. The rural communities of Assam, such as the Mising tribe, have adjusted their livelihood to hydro-geomorphological dynamics and to an environment protected by embankments.

The disaster results from failure in the embankments as it breaks in 1998 and 2008-2009. In fact, the case study of Dhakuakhana and the village of Matmora has shown that the river control instead of protecting people generates risks, because people are becoming dependent of embankment and are settling in flood prone areas. Consequently, the villages were swept away due to the failure of the embankment. Indeed, there was a physical process by which land is destroyed by the erosive capacity of the flood streams and recreated in the areas where silt is deposited as sediment-laden waters are slowed down. The layer of sand deposited over agricultural land renders it useless for up to a decade. Rivers carve new channels in this way, often kilometres away from their previous course (Blaikie & al. 2004). Landscapes are thus perpetually under construction, and resident communities continually adjust their livelihoods and movements in response to their on-going perceptual monitoring of processes of hydromorphological dynamics.

Those who lose their land due to sand casting and river erosion may get compensations only if their land were registered at the circle office. Villagers do not receive compensation for lost plots, as administrative procedures are complicated and most of villagers still do not have proper documents to prove their ownership. Most of the household of Dhakuakhana had to shift without any official approval, as there is no land available for resettlement. Customary strategies are constrained by administrative procedures and land demarcations, especially since they limit the mobility of people. Once the embankment of Dhakuakhana was reconstructed in 2010, a part of the flood-affected families came back on their land, even if their houses were buried under sand. Farmers fears to be outside of the protected areas. They perceive now embankments as necessary to get back to their farming activities and they become dependent on it.

The residents of Matmora became increasingly vulnerable to hydrological risks, due to lack of consideration of local livelihoods in the land management policies. Coping strategies and livelihoods were not taken into account during the preparation of flood master plans until 2005. With the Disaster Management Act (2005), the government initiated a paradigm shift, moving from a technical and structural approach to a holistic and integrated one. The government proposes to incorporate the spatio-temporal dynamics of hydrosocial systems into their policies of regional development. To be effective, however, river policies have to be designed as part of a social and political organization supported by a continuous dialogue between local authorities and the inhabitants of the Brahmaputra basin. Living with floods requires to rethink river management, land control and to involve local populations in decision-making about their land and territories (Fanchette, 2006). The implementation of a "sustainable" development path requires a good understanding of land ownership and management procedures in order to adjust land regulations to the existing multifaceted realities in those places. Different stakeholders seek solutions to suit the hydrosocial systems, where human activities interact with the hydrological dynamics. In this process, considering the solutions proposed by the local population seems essential to solve environmental and social vulnerabilities (Blaikie & al. 2004).

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