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Legal and Illicit Sand Mining Practice in Bangladesh: Exploring Supply Chain and its Value

RESEARCH

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ABSTRACT

The paper is one of the first attempts to explore and identify sand mining supply chain and its value in Bangladesh in the following three river basins: Meghna, Brahmaputra and Jinjiram. It also aims to stir interest in the topic for future research and provide policymakers a background evidence to take informed policy measures. To carry out the study a total of 266 questionnaire-based survey responses were collected from the local people and 40 key informant interviews (KIIs) were conducted with major stakeholders. The results of the study reveal that although sand mining is done illegally in the Brahmaputra river basin, the value addition per cubic feet of mined sand is comparable to that of the legal sand mining sites of the Meghna basin. In the Jinjiram basin, value addition is comparatively lower. Riverine people from smaller basins are deriving significantly higher economic benefits from sand mining activities and experiencing significantly lower incidences of river erosion than the people from larger river basins. Riverine communities of nearby legal sand mining sites perceive significantly less social conflict, improved water navigation, less incidences of embankment damage. In contrast to people residing nearby illegal sand mining sites, they are also more aware of the fact that government is losing significantly higher potential revenue from rampant extraction of sands from different river banks. The paper finally argued that after making proper environmental assessments and feasibility study government of Bangladesh should consider to provide legal permit to more sand mining sites and divert a portion of potential revenue earned from these additional permits to riverine communities to offset some of their future adaptation and mitigation costs.

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INTRODUCTION

Sand is a widely consumed common pool natural resource. It is used as a key ingredient for construction materials such as cement, brick, glass, ceramics, tiles, etc. as well as for computer screens and silicon chips (Gavriletea 2017; Beiser 2018). The total value created by sand industry was equivalent to USD 1.71 billion in 2016 in the United States (Department of Economic and Social Affairs/United Nations Statistics Division 2018). Globally, the use of sand is on the rise in commensurate to the growth of construction and transport industry (Krausmann et al. 2009; Torres et al. 2017). All across the globe, sand production and its trade has been increasing (Gavriletea 2017). Despite wide documentations of the negative consequences of illegal sand mining on river ecology there is no respite in mining from river basins which is usually controlled by strong political elites and their allies (de Leeuw et al. 2010; Sonak et al. 2006; Peduzzi 2014; Padmalal & Maya, 2014; Khan & Sugie 2015; Martinez-Alier, Temper & Demaria 2016; Rege 2016; Torres et al. 2017).

Bangladesh has one of the largest river networks in the world with hundreds of rivers and tributaries. The main four river systems are the Brahmaputra-Jamuna, the Ganges-Padma, the Surma-Meghna, and the Chittagong region river system. Many riverine people are dependent on the river ecosystems for their livelihoods. Therefore, apart from creating an ecological crisis, unregulated sand extraction from these rivers may create misery for these people. The World Bank reports that Bangladesh was the fastest-growing South Asian country in 2019, growing at 8.2%. Despite the pandemic situation of COVID-19, Bangladesh economy performed relatively better than most of the countries of the world. The growth of construction sector has been above 8.0% since 2013 while the size of construction sector alone was USD 24 billion in 2019 (Ministry of Finance, Government of Bangladesh 2019). The construction sector alone is contributing nearly 7.0% to the gross domestic product (GDP) of Bangladesh. As well, the rate of urbanization is significantly high in Bangladesh; urban population is growing by over 3.0% each year since 2016 (The World Bank). Besides, ceramic industry is also growing rapidly in Bangladesh.

In the absence of proper statistics on sand mining in Bangladesh, the abovementioned interdependent industry-level statistics of the backward and forward linkages may be used as a proxy indicator to understand the magnitude of increasing demand for sand. The rapid growth of urbanization is triggering illegal sand mining activities more as the scale of legal sand mining operation is not sufficient to meet input demand for the construction sector. If the leasee extracts sand from the sites demarcated by the government agencies under '*Balu Mohal O Mati Babosthapona Ain, 2010*' (Sand Quarry and Soil Management Act 2010) - it is defined as legal sand mining practice, otherwise it is considered to be illegal sand mining activity (Ministry of Land 2010). In fact, globally, illegal sand mining is found to be very common (Young & Griffith 2009; Rege 2016); particularly in developing countries where government regulations are relatively weaker (Gavriletea 2017). For instance, in India, in the discourse of sand mining 'sand mafia' is a very commonly used term (Peduzzi 2014; Rege 2016).

Over time, sand mining alters the direction and flow of rivers and may permanently impact the lives and livelihood of riverine communities (Krausmann et al. 2020). In Bangladesh, the print and digital media often feature news on illegal sand mining in different river basins. Nevertheless, to our best of knowledge, apart from these newspaper and television reporting, there is limited work that informs us about sand mining supply chain in Bangladesh and how local communities are involved in the process.

According to the *Balu Mohal O Mati Babosthapona Bidhimala*, 2011, the Government of Bangladesh primarily allows (legal) sand mining to improve river water navigation rather than to generate revenue (Ministry of Land 2011). However, in practice, the objective of allowing sand mining at river basins may extend beyond improving water navigation. Formulation of '*Jalmohol Babosthapotha Niteemala* 2009' (Water Bodies Management Policy 2009) essentially talks about '*efficient management of water bodies to benefit the poor fishermen and women for the income generation and livelihood improvement*' and therefore, one may argue that the objective of sand mining operations may be multifaceted (Ministry of Land 2009). Given the texts under 2009 Policy and 2010 Act, deciphering sand mining supply chain in different river basins of Bangladesh is critical for policymakers for the following reasons: (1) to identify the actors involved in supply chain and their role in the process, (2) to have an understanding of value addition at each supply chain segments, and (3) to understand how local communities are involved in the sand mining supply chain (business).

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LITERATURE REVIEW

The supply chain of a good can be defined as the sequential value-adding stages of production, starting from the supplier of raw materials, then the manufacturer, followed by the wholesaler/retailer and finally the consumer. In the case of sand mining supply chain, the process begins with the extraction of sand from the river beds using dredgers to fill up bulkheads and then transportation either to the wholesaler or to the retailer directly to be then sold to the consumers. Globally, sand extraction and its trade are critically important to support the rapid growth of urbanization (Krausmann et al. 2009; Schandl et al. 2017; Marschke et al. 2021). However, sand mining is environmentally sensitive and most governments take precautionary measures before granting legal permits for sand extraction from different river banks (Koehnken et al. 2020). Hence, illegal sand mining activities are very commonly observed to meet the additional input demands for construction industry (Rege 2016). Although illegal sand mining is punishable by law in Bangladesh, many riverine communities report that pervasive illegal sand extraction exists due to lack of proper monitoring from the government, weakly designed penalty mechanisms and involvement of the influential political elites in this lucrative business (Khan & Sugie 2015). As such, studies on the economic and ecological impact of sand mining activities in Bangladesh is mostly absent. One such study has been done by Khan and Sugie (2015) which investigates the process of and agents in sand mining in Tangail, Bangladesh and its impact on local people. They find that the government rules and regulations regarding sand mining is openly being flouted by the local elites through illegal extraction of sand causing considerable damage to local people who live at the vicinity of those riverbanks. Farahani and Bayazidi (2018) have examined the socio-economic and environmental effects of sand mining on Tatao River in Iran by using the cost-benefit analysis. They also tried to make an impact assessment on local communities using confirmatory and exploratory factor analyses. Johnbull and Brown (2017) assessed the socio-economic consequences of sand mining on communities along the Victory River, Nigeria. Although we found some literature on the environmental and social impact of sand mining in the international domain but to our best of knowledge Khan and Sugie (2015) is the only paper that attempted to identify the actors involved in the sand mining process in Bangladesh. In this regard, our study is going to be one of the first attempts to investigate the sand mining supply chain and its value addition at each stage in Bangladesh.

BACKGROUND AND OBJECTIVE

This study has been carried out in three different river basins of Bangladesh: (1) Meghna near Chadpur district, (2) Brahmaputra (at Rowmari and Chilmari in Kurigram district) and (3) Jinjiram. Among these, Meghna and Brahmaputra are large river basins while Jinjiram is a small river basin. In all three basins sand mining exists but in different forms and magnitude. Both thin and thick sand are found in all basins. Although both types of sand are found near streams and river banks, in terms of local understanding, thin sand is like fill sand while thick sand is used as concrete sand. According to key informant interviews (KIIs), the deposit of thin sand is relatively higher in the Meghna and Jinjiram basins. In contrast, the deposit of thick sand is relatively higher in different parts of Brahmaputra basin.

Sand mining is legal in the Meghna river basin and illegal in the Brahmaputra and Jinjiram river basins. Differences in legal status and scale of sand mining operation (due to differences in size of basins) provide a unique opportunity to compare and contrast the prevailing supply chains by river basins. It should be noted that the Jinjiram river basin is included in the study to understand whether local community participation in sand mining supply chain is different in smaller river basins compared to the larger ones.

The broad objective of the study is to identify sand mining supply chain in Meghna, Jinjiram and Brahmaputra river basins. In addition, the following are two specific objectives: (1) to compute value addition in different stages of sand mining supply chain by the selected river basins, and (2) to understand the perceptions of local people in regards to sand mining supply chain from nearby villages.

SURVEY METHOD, SAMPLE SIZE AND SELECTION

The study utilizes mixed methods of analysis by using both quantitative and qualitative techniques. In this regard, two different methods were used to collect data from study

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locations: (1) questionnaire based semi-structured format to conduct key informant interviews (KIIs), (2) questionnaire based fixed-structured format to collect survey responses from the local people residing nearby a sand mining site. To complete the analysis, a total of 266 questionnaire-based survey responses were collected from the local people and 40 KIIs were conducted with major stakeholders. We have followed a systematic random survey procedure to collect responses from the nearest villages around a particular sand mining site. Along the same river bank, we collected responses from households by maintaining the gap of five interval points. For instance, if we collect response from 1st household, then second sample response was collected from the 6th household. Among the three basins, the practice of sand mining in Chilmari and Rowmari are different within the Brahmaputra basin. Therefore, the highest individual responses (135) were collected from the Brahmaputra river basin to capture the diversity in sand mining activities. In the Meghna basin, as survey responses were quite similar (more homogenous), therefore, a total of 63 community responses were collected. In contrast, in the Jinjiram river basin, community responses were diverse and hence, we collected a relatively higher sample size (68) despite the scale of sand mining activities being relatively lower in this basin. Among 40 KIIs, 17, 13 and 10 KIIs were conducted in the Brahmaputra, Meghna and Jinjiram river basins, respectively. Table 1 summarizes the data described above.

Table 1 Sample size by different river basins. Source: CNRS Survey and KII, 2019.

RIVER BASIN	SURVEY RESPONSES	KEY INFORMANT INTERVIEWS
Meghna (Chandpur)	63	13
Brahmaputra (Kurigram)	135	17
Jinjiram River (Kurigram)	68	10
Total	**266**	**40**

Information collected through KIIs were primarily used to identify and explore basin-wise sand mining supply chain. An attempt has been made to calculate corresponding value addition at respective stages of the supply chain. As there are differences among the abovementioned three basins in terms of legal status of sand mining and size of river basins, different types of supply chains have developed around them. Thus, in the pre-testing stage major actors involved in different stages of sand mining supply chain were identified mainly through consultation with local stakeholders. Information was then collected through KIIs by involving different actors, e.g. dredger machine operators, bulkhead owners, wholesalers, boatmen, onsite staff including the manager, shallow machine operators, truck drivers, transportation workers, and local elites, etc.

IDENTIFICATION AND VALUATION OF SAND MINING SUPPLY CHAIN IN BANGLADESH

In legal sand mining sites of the Meghna basin government agencies are playing a critical role within the sand mining supply chain. In contrast, in illegal basins like the Brahmaputra and Jinjiram, government law making agencies are trying to keep underground sand mining activities in check by making periodic patrolling, by seizing dredgers and at times by arresting people involved in the process. In the Brahmaputra and Jinjiram river basins, sand mining supply chain lacks structure in the operation that is usually observed in the Meghna basin. Nevertheless, a robust attempt was made to compute value addition in each stage of sand mining supply chain regardless of its legal status of operation. Figure 1 illustrates all stages of sand-mining supply chains in these three selected river basins.

The value addition at each stage of sand mining supply chain is calculated by converting component wise values to per cubic feet (cft) sand extraction rate. Details of the computational process are spelled out in respective sections of the paper. An effort was made to collect information on the total number of dredgers and bulkheads that operate in different river basins. Unfortunately, local bulkhead associations and administrative offices could not provide complete or consistent information. Thus, we traveled the whole sand mining sites by boat in the Megha river basin (near Chandpur Ghat) and found that 37 dredgers were in operation at that time. We reckon it was worthwhile to identify the scale of sand mining operations using this tedious approach.

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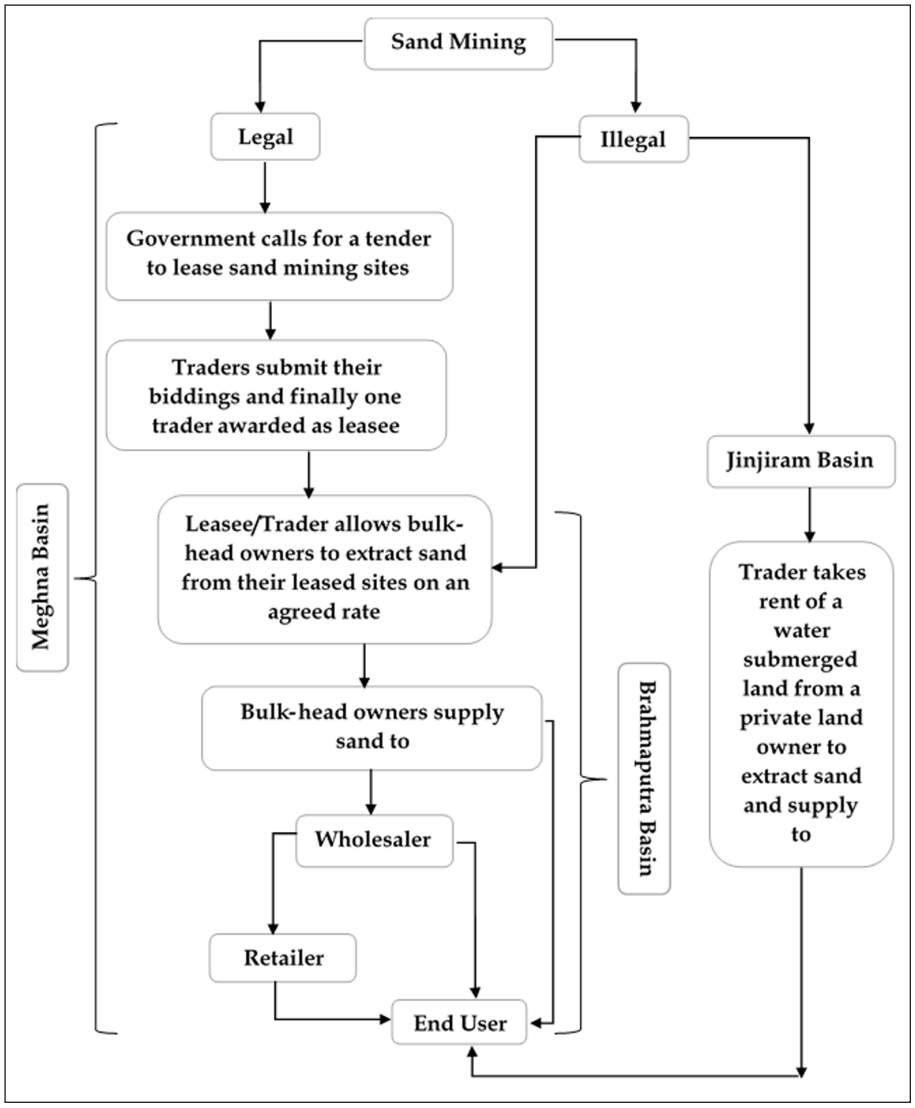

Figure 1 Sand mining supply chain in different river basins of Bangladesh.
Source: Developed by the Authors.

ANALYTICAL FRAMEWORK TO ASSESS COMMUNITY LEVEL PERCEPTION ON SAND MINING ACTIVITIES

Local community perception (survey responses) on sand mining activities was collected using the *Likert scale* method. The differences in community responses were then tested using the t-test under two broad segments of river basins: *legal status of the sand mining basin* and *size of the basin*.

In the Meghna and Brahmaputra[1] basins, sand mining is active throughout the year. Only the Meghna (legal) and the Brahmaputra (illegal) have been used to analyze perceptions of the local people by legal status of sand mining sites. In contrast, sand mining is irregular and subject to local demand for sand use in the Jinjiram river basin. Thus, the Jinjiram basin has been excluded from the analysis due to its limited scale of commercial sand mining operation. The underlying null hypothesis with regard to sand mining by its legal status is *'local perception at various indicators were not affected by the legal status of sand mining activities.'* The alternative hypothesis is that *differences in legal status influence people's perception about sand mining activities*.

Irrespective of their legal status to analyze perceptions of local people by the size of river basins, two relatively large basins (Meghna and Brahmaputra) were merged together and defined as the larger river basin. At the same time, Jinjiram was considered as a small river basin. It should be noted that size of river basins can be used as a proxy to measure the scale of sand mining operation at different river basins. The underlying null hypothesis with regard to sand mining activities by the size of river basin is *'local perception at various indicators are not affected by the*

1 Sometimes within a year at different parts of Brahmaputra river basin, sand mining traders do not operate business when surveillance or monitoring is higher from government agencies.

size of river basins or by the scale of sand mining activities.' The alternative hypothesis is that *differences in size of river basins or scale of sand mining operations influence people's perception about sand mining activities*. Depending on the results of t-test for each indicator, one may draw an inference on how differences in the legal status or the size of river basins may create or offset incentives for local people to participate in the sand mining supply chain.

EXPLORING SAND MINING SUPPLY CHAIN AND ITS VALUE ADDITION AT SELECTED RIVER BASINS

MEGHNA RIVER BASIN

In the Meghna basin the deposit of thin sand is found to be higher than that of thick sand. Thus, in the Meghna basin during KIIs, we received more reliable and consistent information about thin sand mining from the Meghna basin. Table 2 presents sand mining supply chain for thin sand in the Meghna basin.

STAGES	SAND MINING ACTIVITIES AT DIFFERENT STAGES OF SUPPLY CHAIN	VALUE ADDITION (PER CFT IN TAKA)
1	**Government provides lease to the highest bidder (leasee)**	–
2	**Leasee receives from the bulkhead owner**	**0.50**
2.1	*Leasee hires dredger machine*[2]	0.01
2.2	*Operational cost of dredging*[3]	0.01
2.3	*On-site staff cost*[4]	0.00
2.4	*Unidentified estimated value*	0.48
3	**Bulkhead owner receives from the wholesaler**	**1.70**
3.1	*Staff costing to operate bulkhead*[5]	0.21
3.2	*Food cost for staff*[6]	0.07
3.3	*Fuel cost (oil and diesel)*[7]	0.47
3.4	*Estimated margin for the bulkhead owner*	0.45
4	**Wholesaler receives from the end user/consumer**	**4.00**
4.1	*Re-dredging cost*[8]	0.80
4.2	*Excavation cost*[9]	1.00
4.3	*Estimated margin for the wholesaler*	0.50

Table 2 Supply chain of (thin) sand mining activities in the Chandpur basin.
Source: Author's calculation from the information collected from KIIs in Meghna basin.
Note: 1 US dollar (USD) was equivalent to 85 Bangladeshi taka (BDT).

As sand mining is legal in the Meghna river basin, the government calls for a tender as the first stage. After receiving bidding from traders, the designated government authority usually awards the lease to the highest bidder. Therefore, the value addition at this stage is not fixed. Anecdotal information suggests that although the government authority manages official tender process all leasing sites in this basin are heavily controlled by one or two local elites (and their allies). It creates more ambiguity to compute actual value addition at this stage.

2 Per day rent of a 320 HP dredger is 5000 BDT. The dredger (with the mentioned feature) takes on average of 40 minutes to fill an average 8000 cft bulkhead. On average, per day a dredger can fill sand to 12 bulkheads equivalent of 8000 cft capacity.

3 Per day the dredger consumes on average 200 liters of oil to complete sand mining operation. 1-liter costs 65 BDT (rate at the time of data collection).

4 On average, monthly on-site staff costing for leasee is equivalent of 10,000 BDT.

5 On average, monthly staff costing to operate a bulkhead is 42,000 BDT. In general, a 5-member team operates the activities of bulkhead.

6 On average, the monthly food cost for bulkhead staffs is 14,000 BDT.

7 On average, to complete per day operation a bulkhead consumes 50 liters of oil and 500 BDT equivalent of diesel. 1-liter costs 65 BDT (rate at the time of data collection).

8 Re-dredging cost implies that the cost incurred by the wholesaler to transfer sand from bulkhead to a sand reservoir.

9 Excavation cost involves cost to carry and lift the sand from the sand reservoir to truck.

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In the second stage, the leasee allows the bulkhead owner to extract sand from the sites under contract of the lease. In the Meghna basin, bulkhead owners pay 0.5 Bangladeshi taka per cubic feet (cft) of mined sand to the leasee. However, the leasee provides dredging facility to extract sand from the respective sites which costs nearly 0.02 taka per cft. The leasee also hires staff to oversee on-site mining activities, whose cost becomes very nominal when converted to cost per cft of sand mining. KIIs inform that the remaining 0.48 taka per cft value addition that is created within this supply stage includes the bidding price of lease, staff and administrative costs for maintaining office, rent to different rent-seeking groups or individuals and profit margin of the leasee.

In the third stage of supply chain at the Meghna basin, bulkhead owners either directly sell sand to end consumers or to wholesalers. In the Chandpur region of the Meghna basin, bulkheads usually carry sand to a sand reservoir located in Hajiganj. On an average, a wholesaler buys per cft sand for 1.7 taka from bulkhead owners. A bulkhead owner incurs the following costs for a single bulkhead: payment for per cft sand price to leasee, operational cost of bulkhead including labor cost, food cost for staff and fuel cost per trip. Adjusting for all these costs, the average profit margin for bulkhead owners is calculated to be roughly 0.45 taka per cft sand that they supply to wholesalers.

In the fourth tier, on an average, wholesalers receive about 4.0 taka for per cft supply of sand to the end user. Retailer may be included as an additional actor in this supply chain in a few cases. Wholesalers usually carry the cost of re-dredging and excavation. After adjusting for these costs, the calculated profit margin of a wholesaler is roughly 0.5 taka per cft sand that they supply to end users. In the Meghna basin, instead of thin sand if thick sand is extracted, then roughly an additional Bangladeshi taka will be added to each stage of the sand mining supply chain.

BRAHMAPUTRA RIVER BASIN

In contrast to the Meghna basin, the deposit of thick sand is higher in the Brahmaputra basin. During the KIIs we received more consistent information about mining of thick sand in this basin. It is also important to note that on average per cft sand price is relatively higher for thick sands than that of thin sands within this vicinity.

Sand mining is illegal in this basin. So, the government as an actor is absent within the supply chain. Instead, governmental law-making agencies play a key role in controlling illegal sand mining activities by seizing dredgers and arresting people engaged in these unauthorized activities during their periodic patrols. Despite government embargo, activities involving sand mining operate for nearly 240–300 days in a year at different parts of the Brahmaputra basin. Similar to the Meghna basin, mining sites in the Brahmaputra basin are controlled by local elites. In contrast to the Meghna basin, a number of elites have equal or similar hegemony over different sand mining sites in the Brahmaputra basin. So, the underground market structure is rather oligopolistic than monopoly. Due to the illegal status of sand mining, these abovementioned actors within this supply chain are neither documented nor openly observed. As a result, unlike the Meghna basin, the first two actors (government and leasee) within the supply chain are not found in different parts of the Brahmaputra basin. Table 3 presents the sand mining supply chain for thick sand in the Brahmaputra basin.

At the first stage of the supply chain, in different parts of Brahmaputra basins (Chilmari, Rowmari, etc.), bulkhead owners[10] receive about 3.0 to 4.0 taka for per cft sand supply. We intentionally presented the computed values in range rather as point values; as significant variance was found in sand mining supply chains at Chilmari and Rowmari points within the Brahmaputra basin. Within the process, bulkhead owners and their rent-seeking allies spend roughly about 2.0 taka for per cft sand mining to bear operational costs of dredging, transportation cost for carrying sand, administrative cost for off and on-site staff management and other works etc. Understandably, the cost of dredging is relatively higher in the Brahmaputra basin than that of Meghna basin due to risk of being seized by government law enforcing agencies during their periodic patrolling.

10 The actor could be the illegal trader also.

STAGES	SAND MINING ACTIVITIES AT DIFFERENT STAGES OF SUPPLY CHAIN	VALUE ADDITION (PER CFT IN TAKA)
1	**Bulkhead owner receives from the wholesaler**	**3.0–4.0**
1.1	*Operational cost for dredging*[11]	1.0–1.2
1.2	*Staff costing to operate bulkhead*[12]	0.2–0.3
1.3	*Food cost for staff*[13]	0.05–0.1
1.4	*Fuel cost (oil and diesel)*[14]	0.3–0.4
1.5	*Estimated margin for the bulkhead owner*[15]	1.0–2.0
2	**Wholesaler receives from the end user/consumer**	**5.0–7.0**
2.1	*Re-dredging, excavation and transfer cost*[16]	1.5–2.0
2.2	*Estimated margin for wholesaler*	0.50–1.0

Table 3 Supply chain of sand (*thick sand*) mining activities in Brahmaputra basin.
Source: Author's calculation from the information collected from KIIs in Brahmaputra basin.

At the second stage of supply chain, wholesalers receive nearly 5.0 to 7.0 taka payment for per cft sand supplied to the end users. Similar to the Meghna basin, the retailer may be involved in this supply chain as an added actor. The wholesaler incurs nearly 1.5 to 2.0 taka cost for per cft sand management that includes costs for re-dredging, excavation and transportation. Adjusting for all these costs the calculated profit margin for wholesaler is roughly about 0.5 to 1.0 taka for per cft supply of sand to the end users in this basin.

JINJIRAM RIVER BASIN

Similar to the Meghna basin the deposit of thin sand is higher in the Jinjiram basin compared to that of thick sand. In this basin, mainly local traders are engaged in sand mining business to primarily meet the local demand. The sand supply chain is as follows: the trader (often the owner of shallow machine) receives an order from an end user; the trader then rents a private land from its owner. Which is usually submerged under water and offers the required amount of sand deposit underneath.

At the first stage of supply chain, on an average, a trader needs to pay a rent equivalent to 0.25 to 0.30 taka for per cft sand extraction from a private land. It is also imperative to note that a large number of private lands get submerged under water for six months in a year in this basin.

At the final stage of supply chain, the trader receives equivalent of 1.5 to 2.0 taka for per cft sand supplied to the end user. The trader incurs operational costs, such as cost of dredging and cost of transporting sand from the place of extraction to the place of end user and the labor cost. Only a single shallow machine is required to complete the task of sand extraction and transportation if the distance is within 500 meters between the digging point and the end point. For each additional 200 to 300 meters of distance, an additional shallow machine is required. After adjusting for all these costs a trader roughly gets a profit margin of 0.30 to 0.75 taka for per cft sand supply.[17] Table 4 presents the sand mining supply chain for thin sand in the Jinjiram basin.

11 Per day rent of a 32 HP dredger is 10,000 to 15,000 taka (including fuel cost for operation). The dredger (with the mentioned feature) takes on average 1 hour and 20 minutes to fill an average 2000 cft bulkhead. On average, per day a dredger can fill sand to 5 to 6 bulkheads equivalents of 2000 cft capacity. Per day the dredger consumes on average 40 liters of oil to complete sand mining operation. 1-liter costs 70 BDT (rate at the time of data collection).

12 On average, monthly staff costing (bulkhead and site staffs) is about 50,000 BDT. In general, a 4 to 5-member team operates the activities of bulkhead.

13 On average, monthly food cost for bulkhead staffs and site staff is 10,000 to 15,000 BDT.

14 On average, to complete per day operation a bulkhead consumes 20 to 35 liters of oil and 400 to 500 BDT equivalent of diesel. 1-liter costs 70 BDT (rate at the time of data collection).

15 Including unidentified cost e.g. rent that is used to manage rent-seeking allies/groups to continue such illegal sand mining activities.

16 Re-dredging cost implies that the cost incurred by wholesaler to re-dredging the sand from bulkhead to a sand deposit (reserve) reservoir. Excavation cost means that the cost incurred to carry and lift the sand from the sand deposit area to truck.

17 On average, a 32 HP dredger can extract 5000 cft sand per day from Jinjiram river sites. The fuel (oil) required to operate shallow machine one and two for an hour are roughly 2.5 liters and 1.5 liters respectively. Both machines operate for 8 hours. The per liter oil cost in the nearby market place is 70 BDT.

STAGES	SAND MINING ACTIVITIES AT DIFFERENT STAGES OF SUPPLY CHAIN	VALUE ADDITION (PER CFT IN TAKA)
1	**Trader takes land from the private land owner for rent**[18]	**0.25–0.30**
2	**End user buys the sand from trader**	**1.5–2.0**
2.1	*Shallow machine 1*[19]	0.28
2.2	*Shallow machine 2*	0.17
2.3	*Labour cost for shallow machine owner*[20]	0.5
2.4	*Estimated margin for the trader*	0.30–0.75

Table 4 Supply chain of sand (*thin sand*) mining activities in Jinjiram basin.
Source: Author's calculation from the information collected by KIIs in Jinjiram river basin.

COMMUNITY PERCEPTION ON SAND MINING AT SELECTED RIVER BASINS

SAND MINING AND ITS ECONOMIC IMPACT

The economic impact of sand mining (business) activities at the community level were assessed in terms of the following five indicators, whether it: (1) created local employment, (2) improved household income, (3) improved economic condition at the community level, (4) diversified economic activities and (5) increased social conflict (e.g, verbal threats and physical involvement etc.). In other words, our hypothesis is sand mining activities will bring about the abovementioned economic changes in nearby communities.

Results from our analysis suggest that irrespective of the legal or illicit sand mining practices across these selected river basins of Bangladesh, there is statistical evidence that local communities did not perceive any economic benefit in terms of employment creation, income generation, improved or diversified economic condition (Table 5). Information gathered from KIIs suggest that people who are employed in bulkheads or in different stages of mining supply-chain often require some specific form of skills which local people usually lack. In addition, illegal sand mining activities are perceived to create significantly higher social conflict among stakeholders when compared to ongoing sand mining practices of legal basin. About 90% of local people from Brahmaputra basin have mentioned that sand mining activities caused significantly higher social conflicts (e.g., incidences of verbal threats, physical fights etc.) among parties involved in the supply chain (Table 5). In contrast, only 10% local people perceive that sand mining activities have created additional social conflict within the shared vicinity.

ECONOMIC IMPACTS	LEGAL STATUS OF THE RIVER BASIN		SIZE OF THE RIVER BASIN	
	ILLEGAL	LEGAL	LARGE	SMALL
Created local employment	0.19	0.18	0.19	0.34**
Improved household income	0.19	0.14	0.18	0.35***
Improved economic condition of the community	0.22	0.13	0.20	0.48***
Created diversity in the economic activities	0.21	0.18	0.20	0.32*
Increased social conflict	0.90***	0.10	0.62	0.54

Table 5 Local perception on sand mining and its impact on local economy.
Source: Authors calculation from CNRS community responses 2019. Note: Statistically Different at 1% (***), 5% (**) and 10% (*).

In comparison to relatively larger river basins (Meghna and Brahmaputra), riverine people from nearby smaller river basin (Jinjiram) are statistically more involved in sand mining activities. Roughly, at least one-third of the respondents from the Jinjiram river basin have mentioned that sand mining activities have helped in generating employment for local people, improved income for poor households, improved economic condition of the local community and created diversity in economic activities (Table 5). Furthermore, KIIs reveal that sand mining mainly takes

18 Information collected during the KIIs reveals that on average the leasee pays 250 to 300 BDT to private land owner (lessor) for 1000 cft sand mining.

19 Trader usually receives 1500 to 2000 taka from the end user for per 1000 cft sand. However, it often varies with distance and peer (personal) relationship between the trader and end user.

20 Usually, a four-member team works to transfer sand from river to the end user. On average, a team charges 2500 BDT for per day labor efforts.

place to meet local demand for sand in the Jinjiram river basin. Trade involved in the process also belong to their own community. Although sand mining in the Jinjiram river basin is illegal and irregular, it usually occurs through a mutual understanding among traders, consumers and other community stakeholders (villagers). Despite the involvement of local people in sand mining activities in the Jinjiram basin; the very nature of illegal sand mining practice often induces social conflict and is found to be statistically no different than the magnitude it happens in the relatively larger basins.

SAND MINING AND ITS EFFECT ON RIVER WATER FLOW

The community perception on sand mining activities and on the effects on the river flow were assessed in terms of the following five indicators, whether it: (1) improved water navigation, (2) increased frequency of river erosion, (3) increased rate of embankment damage, (4) declined the rate of fish catch and (5) declined the availability of fish variety. It is important to realize that changes in river flow can create or reduce their current and future livelihood opportunities and therefore, significantly influence their perception.

In the Meghna basin, majority of people believe that sand mining activities have significantly helped to improve water navigation. However, opposite perception is found to be more prevalent among the local people from the Brahmaputra basin (Table 6). The finding is significant because in accordance to the 2010 Act, the primary objective for allowing sand mining by the government is to improve water navigation at the different river basins. Majority of people, regardless of its legal status, mentioned that sand mining activities have increased frequency of river erosion as well as intensified the rate of embankment damage (Table 6). Similar (negative) perception was found when people were asked to respond on how sand mining activities have influenced fish capture and its variety. In summary, indifferent to the legal status of sand mining practices, local people perceive that it is creating more '*bads*' than '*goods*' in terms of river morphology.

EFFECT ON RIVER WATER FLOWS	LEGAL STATUS OF THE RIVER BASIN		SIZE OF THE RIVER BASIN	
	ILLEGAL	LEGAL	LARGE	SMALL
Improved water navigation	0.36	0.98***	0.58	0.54
Increased the frequency of river erosion	0.95	0.92	0.94***	0.68
Increased the rate of embankment damage	0.95**	0.82	0.94***	0.51
Decline the rate of fish catch	0.94	0.90	0.92***	0.65
Decline the availability of fish variety	0.93	0.93	0.93***	0.69

Table 6 Local perception on sand mining and its effect on change in river water flows. Source: Authors calculation from CNRS community responses 2019. Note: Statistically Different at 1% (***), 5% (**) and 10% (*).

When compared to people from smaller river basins, people from larger basins perceived that sand mining activities have caused significantly higher incidences of river erosion and embankment damage. Similarly, there is significant drop in the rate of fish capture and reduction in the extent of fish variety (Table 6). Further inference from information collected from KIIs and survey responses suggest that two reasons may influence abovementioned responses - in larger basins (1) communities are less involved in sand mining activities (regardless of its legal status) and may hold asymmetric information on overall sand mining supply chain and its consequence, or (2) the scale of sand mining operation in quite substantial or aggressive that people may observe or differentiate the consequential outcome that occurs in the mining process.

CURRENT SAND MINING PRACTICE AND ITS SUSTAINABILITY

The riverine community's perception on current sand mining practice and its sustainability were assessed through the following five indicators: (1) any direct benefit received by the respondent or any household member, (2) any direct cost experienced by the respondent or any household, (3) respondent's willingness to observe sand mining activities to continue, (4) their insights on the current rate of sand mining with regard to sustainability, and (5) response on potential revenue loss by government due to current sand mining practice. The first two indicators were set to find what percentage of people are directly benefitted or suffered from

current sand mining activities while the latter three indicators were set to understand their interest in future sand mining activities.

Basin wise analysis reveals that riverine people from the Jinjiram basin have received some direct benefits from the current sand mining activities while there was hardly any positive response received from the respondents from the Brahmaputra and the Meghna basin (Table 7). On the other hand, riverine communities from illegal sand mining sites perceived that they have incurred significantly higher cost than that of people living near to the legal sand mining basin.

PARTICULARS	LEGAL STATUS OF THE RIVER BASIN		SIZE OF THE RIVER BASIN	
	ILLEGAL	LEGAL	LARGE	SMALL
Direct benefit faced by the household	0.07	0.02	0.05	0.37***
Direct cost incurred by the household	0.31***	0.08	0.22	0.35*
Interested to see sand mining business to continue	0.15	0.12	0.14	0.36***
Current rate of sand extraction is unsustainable	1.00	1.00	1.00***	0.73
Government is losing potential revenue	0.80	0.96**	0.89	0.89

Table 7 Local perception on current practice of sand mining and its sustainability. Source: Authors calculation from CNRS community responses 2019. Note: Statistically Different at 1% (***), 5% (**) and 10% (*).

Among all survey respondents, only one-third of people from the Jinjiram river basin want current sand mining practice to continue as it is. In terms of sustainability of current sand mining practice, all respondents from both the Brahmaputra and Meghna basin have perceived that the current rate of sand mining is unsustainable (Table 7). In contrast, less than one-third of people from the smaller river basin perceived that the current rate of extraction is sustainable. People from nearby legal sand mining area (the Meghna basin) are also more aware of the fact that government is forgoing significantly higher potential revenue due to weak monitoring of sand mining activities. In this particular case, one may argue that as sand mining is illegal in the Brahmaputra basin – the issue of potential revenue loss by the government from ongoing sand mining activities is not even common in public discourse. Hence, little awareness or reflection persists among the local people from the Brahmaputra basin when compared to the riverine people from the Meghna basin.

DISCUSSION AND POLICY RELEVANCE

The results of the study reveal that opportunities for participation of local people in prevailing sand mining supply chain is limited irrespective of its legal and illegal practice. In addition, riverine local communities are not receiving indirect economic benefits from the current sand mining business practices as was originally envisaged.

More disaggregate analysis suggests that riverine people from the smaller river basins are deriving significantly higher economic benefits from sand mining activities than the people from relatively larger river basins. In contrast, under prevailing sand mining practice, people from the larger basins have perceived significantly higher incidences of river erosion when compared to people from the smaller river basins. Besides, riverine communities from nearby legal sand mining sites perceive significantly less social conflict, improved water navigation, less incidences of embankment damage than that of communities residing nearby illegal sand mining sites. Also, riverine people from legal sand mining sites are more aware of the fact that government is losing potential revenue from such rampant extraction of sand mining.

In the Meghna, Brahmaputra and Jinjiram river basins, sand mining activities are on the rise due to rapid urbanization in the country but it did not start too long ago. Therefore, communities are yet to observe or experience any morphological change that may cause severe environmental hazards and ecological imbalance. Although the private sector currently involved in sand mining business have little or no connection to the riverine communities, it is imperative to realize that a significant portion of the value created in the prevailing sand mining supply chain (business) are derived from an anticipated future cost of adaptation by the local communities. Hence, sharing or transferring a portion of value created within sand

mining supply chain (businesses) to local communities is likely to create a win-win situation for all parties involved in the process. If this argument is somewhat reasonable, the next step should be to explore issues relating to the different modes and rates of benefit-sharing with the riverine communities, for instance, to improve access to market, to invest in livelihood generation programs to take adaptation measures, etc. However, complete information on the total value created in the current sand mining practice is needed (to advance this matter in the policy discourse). In this regard, per cft rates that are calculated for different stages of supply chain can be used as a priori information. For example, only in one site of the Meghna basin about 3.7 million cft sand can possibly be extracted per day. Corresponding market value that it creates only in the first stage of sand mining value chain is estimated to be more than USD 21,000 per day.[21] It provides only a glimpse of this million-dollar industry and how local communities can be benefited if even a small portion of market value is transferred to them.

Finally, given the large extent of river basins in Bangladesh, policymakers should realize that preventing illicit sand mining activities with legal sanctions is next to impossible because substantial public resources are required to keep illegal sand mining activities under check. Thus, the resources (including human resource for policing) that are currently being employed to prevent illegal sand mining is neither adequate nor efficient to employ. Instead government should allow legal permits for more sand mining sites after appropriate feasibility study and environmental assessments. The potential revenue that the government can expect to make from additional legal permits may also be employed to meet development needs or to take adaptation measures for the local riverine communities. Moreover, it is likely to create a conducive environment for the government to regulate private sand mining firms (in formal settings) by pursuing legal policy instruments such as tax. It will help policymakers to create incentives for private sectors involved at different stages of sand mining business to invest in the development of riverine communities under corporate social responsibilities. Furthermore, under a legal sand mining regime, traders (e.g., bulkhead owners) involved in different stages of sand mining supply chain, may get better access to bank loans or insurance services.

CONCLUSION

Hundreds of rivers are flowing through Bangladesh and millions of riverine people in the country depend on these aquatic ecosystems for food, navigation and their livelihoods. Rapid urbanization has increased the demand for sand in Bangladesh. As the current scale of legal sand mining activities is insufficient to meet the growing demand for sand to support construction work, land filling, other manufacturing production system, etc., rampant illegal sand mining activities are observed in most of the river channels of Bangladesh. Given, sites of illegal sand mining activities are managed by strong political elites and their allies, extraction goes on and on in these river banks and streams without considering its current and future impact on river ecosystem and its potential negative consequence on the riverine communities. This paper has attempted to dissect the sand mining supply chains in the Meghna, Jinjiram, and Brahmaputra river basins in Bangladesh to recognize the major actors, estimate the value addition in different types and stages of supply chain and finally to learn the perceptions of the local communities about different aspects of the mining operation. It has been found that sand mining supply chain in the Meghna river basin (legal) includes more actors due to the legal status of its sites. Although illicit sand mining practice is prevailing in the Brahmaputra river basin, the value addition per cubic feet of mined sand is comparable to that of the Meghna basin. In the Jinjiram basin, the amount of value addition for per cubic sand extraction is significantly lower given its limited operational scale. Riverine people from smaller basins are deriving significantly higher economic benefits from sand mining activities and perceived significantly lower incidences of river erosion than the people from larger river basins. Riverine communities living near legal sand mining sites perceive significantly less social conflict, improved water navigation, less incidences of embankment damage. Riverine communities from legal sand mining sites are more aware of the fact that government is losing

21 During the pretest, 37 dredgers were found operational only in one sand mining site of Meghna basin. Information collected from KIIs suggest that a 320 HP dredger roughly can extract 0.1 million cft sand per day. Here, the assumption is all these 37 dredgers have 320 HP capacity and are equally functional. KIIs also informed that in Meghna basin, leasee (in the first stage of sand mining operation) receives 0.5 taka for per cft sand extraction. Dollar to taka conversion rate is USD 1 equals BDT 85.

significant potential revenue due to unchecked extraction of sands at different river banks. Based on our results, given the growing demand for sand, the government of Bangladesh, after making proper environment assessment and feasibility study, should consider to allow permit (licenses) for more sand mining sites to better manage the river navigation channels by promoting a sustained rate of sand extraction. It will also help government to potentially earn higher revenue by issuing additional permits. As current sand mining activities may change the river morphology and its flow in future, a portion of the potential revenue generated by government then can be transferred to local riverine communities to offset some of their likely future adaptation and mitigation costs.

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COMPETING INTERESTS

The authors have no competing interests to declare.

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