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Socio - ecomonic system mapping

Shifting Grounds

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1 Introduction

1.1 Introduction

The urbanization process of South Asia has been largely city centric (Friedmann 2011). Cities have seen steady growth, sustained by a real estate boom and the rapid growth of outsourcing and other services (Narain 2016). The change has been precariously seen around the edges of such rapidly growing cities —the Peri-Urban (from here refer as PU). PU is a zone produced by 'decisions that foster development, as the city perpetually expands horizontally engulfing and impacting its rural periphery' (Friedmann 2011). It is characterized by increasing intensification and co-existence of urban and rural interlinkages, lows of goods and services, conflicts over land tenures and water (in) security (Mehta *et al* 2014). It is a unique spatial construct that houses millions of urban hybrids whose interests are contested and appetite for space and the enjoyment of material prosperity are voracious. The peri-urban spaces of particularly the large metropolises of developing countries, accommodates new forms of inequalities that is probably not visible anywhere else. On the one hand, at least three kinds of poor, i.e. the locals that have that have suffered the consequences of land acquisition, relocated slum dwellers of the city and migrants from rural interiors whose mobility does not only represent aspirations, but lack of options in rural areas are inhabitants of these areas. On the other, landscapes with high end infrastructure along with real estate development that house the nouveau riche is superimposed on the existing semi-urban or rural landscapes, with little incremental provisions for the marginalized who often 'make' the city, with little 'rights' to it (Harvey 2008; Purcell 2003; Lefebvre 1996). Thus it is space of violence and pain or of new opportunities for better life (Friedmann 2011). Who gains or losses under such processes of hyper rapid change depends on host of socio-political factors co-opting this space (STEPS 2010; Mehta 2003; Mehta & Karpouzoglou 2015).

Our study focuses on groundwater resource utilization in a PU delta. Here PU acted as a proscenium where urban processes and policies interact with groundwater resource use to produce multiple opportunities and constraints. Such opportunities or constraints get reflected in the way groundwater is being used for drinking, domestic or irrigational purpose. Since PU is politically very sensitive zone in which the stakes are very high: government, real estate developers, farmers, workers, migrant labourers, its interactions with groundwater is much more complex. The idea is not to look into the dynamics of peri-urban in detail, but to unfolds such interactions of socio-economic processes embedded within the urban system with groundwater use-drinking, domestic and irrigation.

'Rapidly expanding and modernizing central cities stand in a symbiotic relation to PU spaces and thus regard them as essential to their own well-being and economic growth' (Friedmann 2011). It provides numerous services catering to the urban processes: fruits and vegetable, groundwater while receives city's waste in some form or the other. If we look into the current urban development paradigm, major economic investments are directed towards this space. But the current process of urbanization is qualitatively different compared to what it was experiencing three decades before this. In other words, the process of urbanization now is land intensive, capital intensive, has a low employment elasticity driven by private capital, one that encloses environmental commons, alienating those dependent on them (SaciWATERs unpublished report 2017).

The PU areas can also be understood as an interface, which exemplifies quantity and direction of groundwater flow, that shapes the socio-economic profile of the communities (Heynen *et al* 2006; Swyngedouw 1999; Mehta *et al* 2015). Particularly the wide range of activities or livelihoods co-opting this space influences and gets influenced by such flow. Even though it has generic connotations we agree to Friedmann (2011) who defined PU a place of encounter and its stories are as varied as the local conditions and historically defined patterns of local life. This makes it interesting to study the patterns of PU and its associated interlinkages in specific country and cities that require their own explanations. Its temporal nature: 'today's PU is tomorrow's city', makes it even more important to study considering the urban centric growth patterns.

PU is not a 'one-way road but space of fight back, adaptation and innovations along with more familiar stories of speculations, comparisons and accumulations' (Friedmann 2011). Thus we see frequent stories of protest for right to basic services like water, or against industrial pollution. In the case study of water provision in Ghaziabad, India, Mehta et al 2014 writes about a local leadership to capacitate PU community to access information on compensation for land acquisition and industrial pollution. 'While such mobilisations around the right to information have allowed certain people to access official information, they have not been successful in mobilising households to take direct action'. In a study conducted by SaciWATERs in Anjpur, a PU village of Hyderabad reveals fight of the marginalized farmers of dalit community against powerful industrial lobbies. The fight ended in loss of land and livelihood of the vulnerable farmers against the powerful industrial and political elites (SaciWATERs unpublished 2017). Several micro studies revealed land acquisition and force relocation of PU communities compromising their basic right to livelihoods (Rao 2010; Steinberg 2013). They largely have to fend themselves in an increasingly hostile environment.

Shifts in the livelihoods, mostly from farm to non-farm are shown in decreasing land ownership, and operational holdings, increase in landless labourers. Even in the agricultural labour domain dominance of casual labour hired on a piece meal basis increased over the years in the state (Dasgupta 1984). Mallik (2014) talked about land acquisition in the peripheries of Kolkata. She reported reduction in the mean size of ownership holding from 3.63 bigha to 0.66 bigha while operational holding declined from 5.22 to 0.56 bigha owing to land acquisition for urban expansion. In absence of any regulation, during land alienation from agriculture, results in complete loss of livelihoods of the farmers and landless labourers. They and are often pushed into menial jobs as they lack skills to get into white- or blue-collar jobs. They become mere spectators, as their own lands are up for grabs at a very high premium i.e. 10 times and more (Reddy & Reddy 2007).

Although the generic cause is urban spread through public and private interventions, the way PU communities fight for their right to livelihoods is largely based on their cultural and political realities. SaciWATERs study in the Ethanoor village of PU Hyderabad showed mass protest and resistant against industrial pollution, displacement and loss of water sources by farmers' spearheaded by activists and academicians. The movement was relatively successful in bringing some amount monetary compensation, yet could not resist the loss of livelihoods (SaciWAERs 2017). While in a different incident in Singur of West Bengal, farmers organized themselves to fight against acquisition of 32,000 acres of agricultural land around the districts of Kolkata. Under the leadership of Trinomul Congress Party and several left activists the local farmers could able to resist the transfer (Banerjee 2006).

What emerged in all these cases are (i) PU is an area of confrontation where people negotiate and bargain and thus confirms Friendmann's argument (ii) Political patronage plays out distinctly in these areas determining who is going to access what (Zeitoun 2013; Mehta *et al* 2014). Studying peri-urban areas are thus crucial as in due course multitude of actors of varying stakes generates several problems like, chaotic land use practices; falling water tables and diminishing groundwater supplies; growing income inequalities; and social fragmentation, that need to be addressed in public policy (Friedmann 2011).

Reflecting on the groundwater issues, PU challenges the logic of universal provisioning (Mehta *et al* 2014). Technically governed by village administrations (Gram Panchayats in India or Union Councils in Bangladesh), it lack financial provisions. There institutional void, in the sense of administrative and jurisdictional over laps and ambiguities further increases the challenges of universal provisioning of drinking and domestic water supply (Srinivasan *et al* 2013). Despite of its close proximity to large cities or metropolis, such space often remains outside the ambit of formal networked systems (Allen *et al* 2006). Insecurity of the land tenure and housing rights and dense housing create a very difficult condition for piped water network. Such differences in the in tenure systems creates more heterogeneity even within a particular income group. Access in such case is often a subject of ability and willingness to pay upfront, time spent in complaining to the zonal offices, waiting for the tankers, installing private submersibles (Malini *et al* 2009). Sometimes the state provision is so poor that both upper and lower income households are mistrustful of the quality of the supplied water. They both devise their own strategies to cope (Mehta *et al* 2014). However differences lie in the way elites (middle and upper income households) with their higher purchasing technologies, and political mileage able to bargain and access. Ranganathan *et al* (2009) critically discussed the accessed to different water sources by PU communities in Greater Bangalore. While master planned layouts and industrial estates in the periphery that typically cater to the corporate, middle class, and high-end residential sectors are equipped with water, electricity, road connectivity and other services poorer sections rely on informal access created through stealing and installing ones own submersible pumps. Since groundwater is practically free and unregulated, those with land and the proper documents can indiscriminately sink borewells/tubewells/handpumps, obtain electricity connections and pump water either for their own consumption or for sale (Ranganathan *et al* 2009). Millions of shallow and deep tube wells bears the testimony to the above fact that almost anyone can access groundwater of their own free will by "digging" or "drilling" wells, thus creating a ground for open competition in tapping a resource with a complex set of stock and flow characteristics (Kulkarni & Shankar 2014).

While groundwater has a major stake as consumptive asset for drinking and domestic use, its use as irrigational sources is largely seen in the PU regions surrounding the Delta cities. Although it largely remained in the domain of technical elites, having access to land, money and power. In the city like Kolkata rich agricultural land can be seen in its surrounding districts. Two factors have largely played; (i) understanding of having enough stock available (ii) concentration of economic activities only in the delta cities. Several writings on Ganga delta shows that though such agro climatic regions receives water from two largest river systems and recipient of several meters of rainfall annually, faces unparalleled water problems, particularly groundwater. High concentrations of dissolved arsenic, released from sediments into groundwater, present risk of severe health effects for the estimated 85 million people drinking shallow groundwater in affected parts of this region (Michael & Voss 2007).

Under such circumstances, increase urbanization has caused a normative shift in the way the ground water resources have been used. It has become the most dependable source of drinking water for millions of peri-urban community, being evicted from centrally networked system (Alen *et al* 2006a, 2006b, 2007, 2008). There are enough evidences to show that extensive cultivation of summer or boro paddy, a typical groundwater based crop, in the gangetic deltaic tract has been responsible for its massive depletion (Ray & Ghosh 2007). Pumping by industrial units and emerging drinking and domestic water market further adds to its woes (Basu 2015; Water-Excreta Survey 2005-06).

Such change processes are more visibly observed in the adjoining areas of the large delta cities like Kolkata or Khulna. Technology and business in ground water raised a new breed of peri-urban community with renewed social and political consciousness, in turn, affecting its use and access, which forms the subject of the Shifting grounds research. The following thematic report tries to analyse the impact of urban processes as expressed through industrialization, real estate boom, livelihood shifts on the groundwater use. This thematic report is the first report in a series of reports that focuses on the socio-economic dimension of these shifts in peri-urban groundwater management. It reports the first results of a survey among water users in peri-urban villages near Khulna and Kolkata. The report gives a descriptive understanding of the plurality of ground water use by different socio-economic groups. While doing this several elements like groundwater as drinking and domestic sources have been analysed. Its use and management under different irrigational systems (deep tube well and shallow tube well as well as aquaculture) have been assessed. How urban processes have altered the interrelations between actors within these systems has been probed. The report continues first with a further introduction of periurbanization and groundwater use in the study area, followed by a description of research questions and survey design, after which the main part of the report is devoted to a description and interpretation of survey results.

1.2 Periurbanization processes and groundwater resource use in two delta cities: Kolkata and Khulna

The city of Kolkata is often described as 'triple-blessed': possessing a river for drinking water, another to dispose of waste and the wetlands in between to treat its sewage and produce its food; yet significant disparities exists between the populations of the urban core and the neighbourhoods. Two agencies are jointly responsible for water supply and sanitation: Kolkata Municipal Corporation (KMC) and Kolkata Municipal Water and Sanitation Agency (KMWSA). While KMC is in charge of water supply to all the wards within KMC, KMWSA covers the rest of the metropolitan area. For the last 15 years the city has shown its expansion more towards the south and southeastern sections with more number of wards being brought under Kolkata Metropolitan Authority's jurisdiction. Such physical expansion has not been matched with the public utility services in these fast growing areas. The surface water sources coming from ganga river treated in Palta, Garden Reach, Jorabagan and Watgaunge Water Treatment Plants are often not sufficient. Provision of drinking and domestic water through public shallow and deep tube wells are common. However in many of such cases the provisions falls short of the demand forcing the peri-urban community to depend on host of private sources, like informal water vendors or private filtration plants. However such dependence does not always ensures access to safe drinking water as most of the cases they are unsealed bottles without confirming to any standard certification mark. Inadequate and poor water quality followed by renewed urban consciousness of convenience and purity played a very critical role in household's choice of drinking water needs in Kolkata.

Khulna although affected by similar deltaic and urban processes produces less pronounced impact particularly in the private drinking water sector. Unlike peri-urban Kolkata, villages in the fringes of the city are completely dependent on groundwater, through public and private deep tube wells and shallow handpums. Department of Public health and Engineering and Union Parishad jointly provide drinking and domestic water. However, supply is insufficient and of poor quality. Private and illegally constructed deep tubewells and shallow hand pumps often meet the deficit.

Groundwater irrigation constitutes the major water use in gangetic delta. Adjoining districts of Kolkata and Khulna have been the traditional tubewell irrigation belt. Copious availability of groundwater, suitable soil substrata, liberal import policy, cheaper boring technologies, financial assistance in form of bank loans and subsidy in electricity consumption, favourable economic returns and the compelling need to boast agricultural production has made groundwater based boro or summer paddy cultivation, the principal crop of the villages adjoining the city of Kolkata (Hariss 1993; Ray & Ghosh 2007). Three kinds of groundwater irrigation system: deep tube well, Shallow tube well and commercial aquaculture are commonly seen with distinct ownerships and mode of allocation of irrigational water, labour exchange and other social norms. Groundwater market emerged crucial particularly for the small and medium boro paddy farmers. Such increase in the boro cultivation has made tremendous impact on the groundwater status of this region. Goswami *et al* (2004) claimed that fluctuation in the groundwater table has been a consequence of indiscriminate extraction of boro paddy cultivation without considering the topo-sequence and soil types. Several pizometric observations in the deltaic districts of west Bengal revealed that the water table depleted at a faster level in the pre monsoon period due to tapping of the ground water for boro cultivation. Excessive withdrawn of groundwater also has led to widespread arsenic contamination beyond the permissible limit in the underground sources of ground water (Ray & Ghosh 2007).

Although critical, for the last 15 years urban expansion in form of agricultural land conversion, spreading of and small and medium manufacturing units, awareness and consciousness on one hand and heavy input cost has made tremendous impact on the groundwater based boro paddy irrigation particularly in the peri-urban villages. Tenancy farming in boro paddy irrigation has increased while in many cases farmers have moved out to fisheries and other vegetable and fruits cultivation. Similar trend can be seen in case of Khulna. Inspite of the ecological degradation and poor economic returns that boro paddy is currently fetching to the farmers, many of them still continues to cultivate out of compliance. In absence of tangible alternatives it still dominates the cropping pattern of vast majority of farmers in north and south 24 parganas, Nadia, Hugli and Howrah. However with the advent of urbanization a parallel for diversified livelihood options became popular in the areas along Kolkata. Aquaculture, particularly wastewater aquaculture in south 24 parganas and dying and other small-scale industries in parts of north 24 paragnas emerged significantly. The popularity of boro paddy is also been seen in

Bangladesh, where it is accompanied with aquaculture. Compared to aman or kharif rice, boro paddy is highly preferred due to its higher and assured yield.

1.3 Objectives and research questions

The overall objective of the study is to have an improved understanding of the impact of the urbanization processes on groundwater use and subsequently on the livelihood shifts of the peri-urban communities. Specific research objectives and questions are as follows –

1. To analyze the impact of urban processes (industrialization, real estate boom, waste water disposal) on household's access to drinking and domestic water sources?

    i. To what extent processes of urbanization has affected household's choice of drinking and domestic water sources?

    ii. Does social differentiations (caste, class and religion) has any significant bearing on access to drinking and domestic water sources of the peri-urban communities? If yes, what are the ways in which this is visible? Does urbanization processes further widens the social differentiations impacting the drinking and domestic water choices of the peri-urban communities?

2. To analyze impact of urban processes (industrialization, real estate boom, waste water disposal) on groundwater irrigation systems

    i. Does urbanization process have changed the cropping pattern, area irrigated and tenancy structures in the villages? If yes then how its gets reflected in the groundwater irrigation system?

    ii. How does urbanization influence the degree of groundwater trade in the shallow and deep tube well irrigation systems?

1.4 Methodology

1.4.1 Survey design: Information gathered through qualitative surveys has been used to determine the desired sampling frames in the four study villages for in-depth small-scale sample survey based on structured questionnaires. A *stratified systematic random* sampling technique has been adopted for the survey. In the sampling design, the initial units are, Tihuria, Bodai, Matomdanga and Hogladanga; four villages in peri-urban Kolkata and Khulna. The ultimate unit is a household. A combination of selection criteria was adopted to select the sample household in each of the study villages. Sample size for each of the villages is determined by using below formula[1] (see figure 1 and table 1 for sample design and sample size taken) –

$$n = \frac{N}{1 + Ne^2}$$

Where, n – is the sample size N – is the population size e – is the level of precision (95%; e = 0.08). Major sources of livelihoods in the village as well as migration status of the households have been considered as the primary criteria for stratification. Sample size has been kept to the exact proportion of all identified groups in actual total population. However, attempt are done to keep the sample size representative enough across these strata to maintain the statistical robustness for comparison between these groups.

[1] Cochran W. G. (1963). Sampling techniques. New York: John Wiley & Sons.

Figure 1.1 – Major livelihood groups in the sampling frame

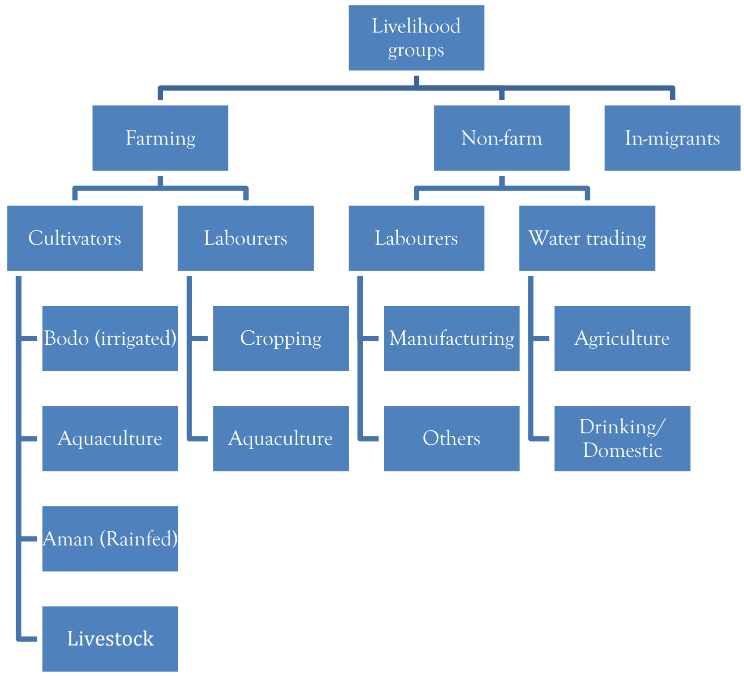


Table 1.1 – Sample design and size across livelihood categories*

Sector	Occupation	Sub-sector	Kolkata		Khulna	
			Tihuria	Badai	Hogladanga	Matamdanga
Farm	Cultivators	Bodo (Irrigated)	18	42	11	13
		Aquaculture	35	0	29	23
		Aman (Rainfed)	23	0	27	18
		Livestock	0	0	1	0
	Labourers	Cropping	23	15	4	8
		Aquaculture	23	0	4	4
Non-farm	Labourers	Manufacturing	0	17	0	2
		Other	0	34	2	3
	Water Trading	Agriculture	0	0	3	3
		Drinking	0	0	0	0
	Others		6	17	4	8
In-migrants			3	6	16	17
Total sample size with 8 % margin of error			126	130	99	93
Total number of households (actual)			770	920	282	240
Final sample size taken (Number of households)			128	130	100	93
Total population in the sampled households			563	641	461	421

*In calculation of sample size: 8 % margin of error, 95 % confidence level.

1.4.2 Determination of class: Level of dependency upon ground water resources is measured across different axes of inequality e.g. caste, religion, and class. To examine it class wise, the sample households are classified into three groups viz. groups enjoying lower, middle and upper economics statuses. The basis of classification is the average weighted scores of indicators of basic amenities across all the households. The valuations provided in the MPAT framework are adopted to weight all the variables from 1 to 10 scale. Then, these weights are averaged separately for six sub-components (table 1.2) of index of basic amenities.

Table 1.2 – Indicators and variables used for determining household's class

Sub-indices		Description
A. Housing amenities		3 variables: primary construction material of the housing unit's exterior walls; capacity of the housing unit to withstand against natural hazards; per capita availability of permanent bedding areas in the dwelling
B. Food security	a. Consumption	4 variables related to in-sufficiency of food and hunger
	b. Nutrition quality	7 variables related to consumption of Grains (cereals, bread, rice, pasta), Roots &/or tubers (potatoes, cassava, etc.), Vegetables/greens, Fruits, Dairy &/or eggs, Meat &/or fish/seafood, Nuts &/or legumes (and/or derivatives, tofu, etc.)
C. Water security	a. Availability	3 variables: insufficiency of water for drinking and domestic purpose; number of months with sufficient water supply
	b. Quality	3 variables: quality of drinking and non-potable water; treatment of drinking water at household
D. Energy sources		3 variables: primary source of energy for cooking, maintaining heat, and at the time of dark

1.4.3 Diversification Index: Extent of diversification across livelihood groups has been examined using household level sample data in the four study villages. The Herfindahl-Hirschman index (HHI) has been adopted to analyse diversification of peri-rural livelihoods. Mathematically, it could be written as-

$$HHI = \sum_{i=1}^{n} P_i^2$$

where, *HHI* stands for the Herfindahl-Hirschman index, n is for total number of production sectors, P_i is the employment proportion of the i^{th} sector in total. The index is calculated by taking sum of squares of these proportions. This index takes a value one when there is an absolute concentration and approaches zero when diversification is perfect (Szpiro 1987).

1.4.4 Logistic Regression: A binary logistic regression has been attempted to explain factors that influence the probability of a household's involvement in secondary economic activity. Peri-urban deltaic region of Khulna and Kolkata has considerable number of households which are involved in multiple economic activities for their livelihoods. This can be seen either as a distress phenomenon or as an influence of urban process with immense opportunities to work in various production sectors. The purpose of applying the logistic regression to the household level sample data is to link the participation of rural households in the second most important economic activity carried by them with these two the above said two outcomes.

Table 1.3 – Predictors in the logistic model

Categorical	Continuous
Region (village)	Household size
Economic status (class of the household)	Highest educational level among household members
Religion	Total cropped area under tenancy
Migration status	Total cropped area
Gender of household's head	
Location of workplace for primary economic activity	
Sector of production for primary economic activity	
Access to shallow/ deep tubewell	
Access to political capital (membership)	
Access to institutional capital (membership)	
Access to credit (ability to borrow money)	

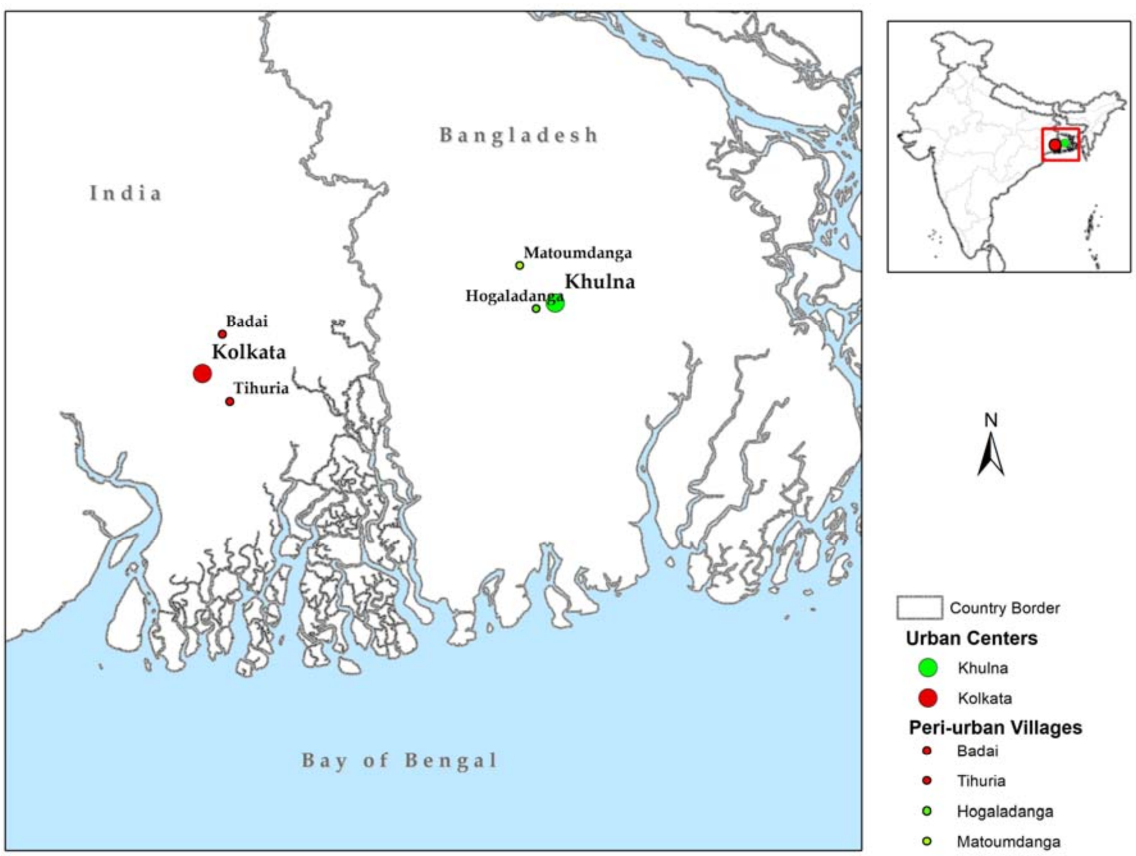
In the regression exercise, households are coded into two groups viz. 0 if there is no involvement in secondary activity irrespective of the production sector (the control group) and 1 if otherwise (i.e. the outcome variable). The predictors in the model are primarily categorical followed by few continuous variables. These predictors are not only the indicators related to socio-economic and demographic characteristics of the households, also depicting the prevailing urban process which supposed to influence the rural economy (table 1.3).

2 Description of the study villages

2.1 The Study Villages

In this section, a background for each of the four villages (figure 2.1) will be given, along with some preliminary findings based on observations and discussion with some of the key persons from the village. Successive sections will be essentially drawn from household survey. The information will provide an understanding of the degree of urban influence, economic activities and groundwater irrigation status of the selected villages.

Figure 2.1 – Location of study villages in peri-urban deltai region of Khulna and Kolkata



Source: Map constructed by SaciWATERs.

2.1.1 Tihuria—Background

Tihuria of Kheyadaha gram panchayat is a part of Sonarpur in South 24-Pargana district of West Bengal. It is situated 10.2 km away from sub-district headquarter Rajpur and 31.5 km away from district headquarter Alipore. Tihuria has witnessed many rapid commercial developments over last few years (figure 2.2). Agriculture has been shrinking over the days, but is still practiced in different form. The village has showed considerable rise in the land prices within the last 10 years particularly after the coming of Netaji Subash Chandra Bose Road, Garia main road and the Eastern Metropolitan Bypass roads, about 5 kms from the village. In conjunction with these transport networks, there has also been a construction boom with new middle to upper class colonies proliferating. Marshy tract and lowlying agricultural lands are getting rapidly converted into residential plots. Small mud huts that dotted the village scape 10 years back now changed into well build double stored structures surrounded by substantial compound wall. Luxurious living apartments, big real estate projects, gated communities and mini townships, very close to the village came up. Such colonies are often surrounded by many informal colonies inhabited by migrants from Bangladesh and other districts in West Bengal who came to take advantage from the increasing livelihood opportunities in the area. These changes have given clues to the significant changes of the socio-economic character and occupational profile of the households, probably making poorest village families better off. It would be important to tease out an explanation from the skein of factors responsible of such change and how it relates to groundwater management of the village.

Tihuria village, or mauza, as it is still commonly identified as, has three constituencies, Tihuria proper, Shahebderabad and Maulati. Essentially dominated by scheduled castes the village provides interesting narratives of changing land ownerships, redistribution and resettlements of marginal social groups under left regime.

The word Rajpur (Rajpur-Sonarpur), where Tihuria village was a part, has come from the Bengali word Rajar Puri meaning 'King's land'. Being located at the bank of Adi Ganga/ Gobindapur Creek/Surman's Nullah, an offshoot of Hooghly River, the area was one of the important commercial points during old Bengal rule and subsequently during British time. In fact Shahebderabad, the Bengali meaning 'the land where foreigners/British dwell', signifies the historical prominence of the village/area. Since colonial times Adi Ganga served dual purpose of trade–transportation and drainage–sewerage–sanitation (Mukherjee 2015b) between the village and the Kolkata city.

Tihuria, has been historically owned by '*Naskars*', a Bengali Zamindar (landlord) family. The landlord of this village was Hemchandra Naskar, who possessed more than 2000 bighas of land of the village. However 1980s under historical land reform initiative, 'Operation Barga' of left government (CPIM), made tremendous change on the landuse, village composition and occupation types of Rajpur-Sonarpur in general and Tihuria in particular. With the abolition of Zamindari system, Operation Barga ceased the excess land from the Nashkars and redistributed them among the marginal and small farmers and landless labourers of Scheduled caste groups. By giving 'pattas' (ownership rights) to the landless and bargas (cultivating rights) to the farmers, though popularized left's initiatives among the rural poor, created the problem of extremely fragmented land holdings, which eventually decreases the agrarian investments. Operation barga was accompanied by yet another agrarian reforms of left government, groundwater based intensive cultivation of summer or boro paddy. Smallholdings with longer established agricultural labour class and more substantial rich peasantry resulted in greater access to inputs and marketing facilities in Tihuria. Boro paddy along with freshwater fishing dominated the cropping pattern in 1980s and early 90s.

The economic activities, landuse pattern and shallow tubewell irrigation went on massive transformation since 2007-08 due to couple of factors, (i) urban spread in form of residential complexes (ii) decline in boro paddy productivity due to higher input cost (iii) moving out of the agricultural labour to more lucrative non –agricultural options (construction and other sectors) (iv) improved road network with Kolkata and (v) popularization of wastewater fish cultivation using sewerage from the tolly's nullah. Tolly's nullah is a 16 km-long water channel, which starts from Kidderpore and ends at Sonarpur carries Kolkata city's sewerage, serves as the principal surface water drainage channel for a large part of southern Kolkata and its suburbs. Tihuria receives several distributary channels of the Nullah, which changed the cropping pattern and the irrigation system in the village. The Considerable proportion of the farming groups started taking up wastewater fisheries by lifting waste water manually or low horse power motor. High demand of fishes in the Kolkata market and low input cost has made wastewater fisheries a dominant livelihood source for majority of the cultivators of Tihuria. The findings matches to the larger literature on aquaculture and wastewater fisheries of East Kolkata wetlands. In the writings of Allen et al 2017 '…around 25% (150 tonnes) of the total vegetables and 20% (22 tonnes) of total fish traded daily in the Kolkata market originate from EKW. The synergy between the livelihoods strategies of communities living in the EKW and the ecological sustainability of the city represents a key mode of co-production at work in peri-urban Kolkata'.

Figure 2.2 – Growth of settlements and industries in Tihuria village, 2005 – 2017

Source: Google Map.

Although economic activities and occupational shifts are glaring, village has been largely bypassed by the planning processes and become subject of flawed decisions. Apathy from both rural and urban authorities and political marginality, is reflected through poor public water delivery system. The unequal distribution of services is perhaps nowhere more evident as Tihuria, which also forms part of the East Kolkata Wetland (EKW). Lack of policy driven municipal water services has promoted households of Tihuria to develop a range of co-produced water management solutions to meet their quotidian needs.

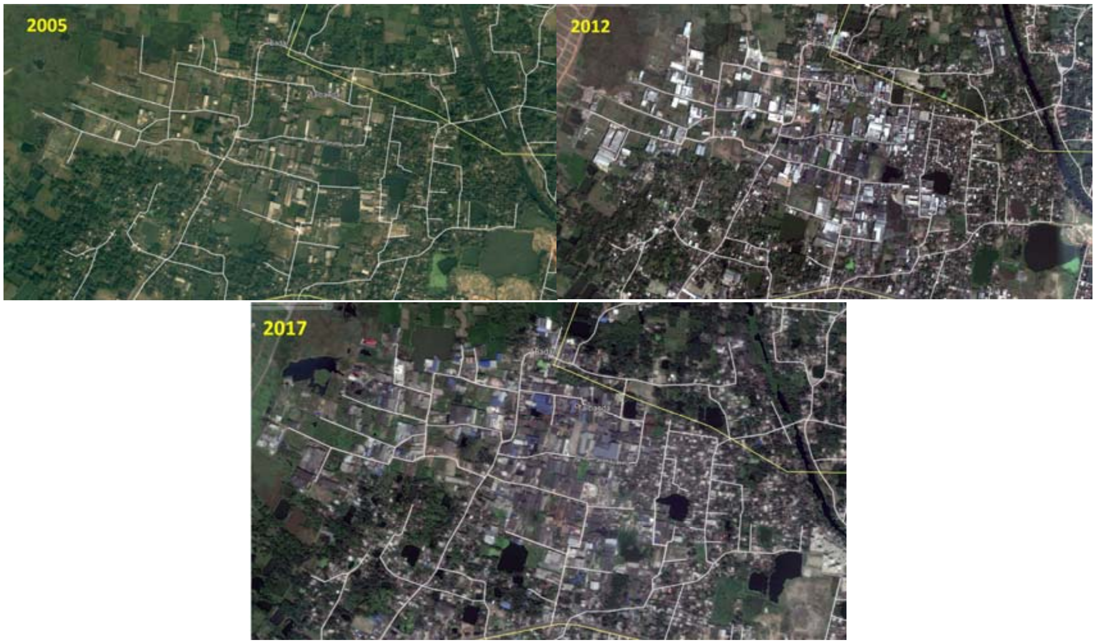
Although the village has been part of the east Kolkata wetlands, with strict restriction on land conversion and property transaction, illegal buying and selling of land is rampant. Even the wastewater irrigation is majorly controlled by group of rich small farmers either in leased in land or own land. Balance of forces between wastewater fish cultivators, local musclemen and political leaders determines who controls resources like land and water in the village.

2.1.2 Bodai – Background

Bodai village of Barrackpore 2 in North 24 Pargana district is one of the most industrialized villages located in the periphery of Kolkata. Bodai depicts a story of slowly disappearing village and of the desperate but ultimately losing struggles of the farmers to preserve its autonomy and its agricultural lands (figure 2.3).

Unlike Tihuria, Bodai has more heterogeneous social structure with two dominant religious groups, Hindus and Muslims having distinct spatial spread within the village. The village is dotted with several ponds, khals and bills and has copious groundwater resource. Easy access to rich groundwater, land reforms, agrarian and industrial policy of the left government in post 1990s has considerably shaped the economic and social spaces of the village.

Figure 2.3 – Growth of settlements and industries in Bodai village, 2005 – 2017



Source: Google Map.

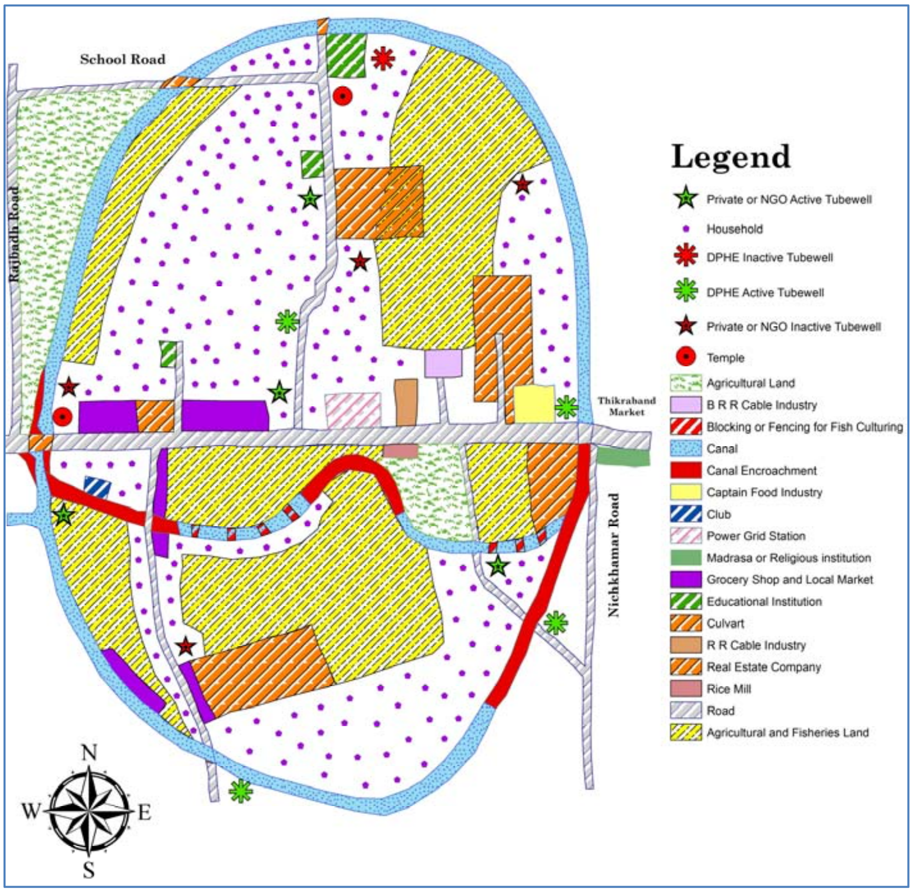
Traditionally agriculture in Bodai has been rainfed, with Aman paddy as the main crop. Irrigation started about 20 years ago with an installation of a deep tube well under World Bank and Government of West Bengal's initiative. The system is still collectively managed by the beneficiaries through water user association. Waterman, responsible for allocation of water across the head and tail users are democratically elected from the village. The elected member along with staff from the irrigation department jointly manages its operation and maintenance. Periodic user charges are taken from the beneficiaries. The initial command area was about 200 bigha, which over the years reduced to around 120 bighas. About 100 farmers were part of this irrigation system cultivating vegetables and boro paddy. Today around 80 farming households are involved in the deep tube well irrigation mostly cultivating boro in low-lying areas (*locally called Dhan Jomi*) and vegetables in the upland (*locally called Danga Jomi*). The agricultural landscapes of Bodai started changing post 2004 with rapid industrialization, particularly with the mushrooming of small-scale dye factories. It marked huge shift in the labour force from agriculture, in migration of population from surrounding districts, development in transport network. What signifies is most of these are small scale unorganized and informal manufacturing units producing dyes, textiles and soaps, glycerines etc. Easy permit from Gram Panchayat, unlimited access to groundwater, cheap availability of casual workers, political patronage, muscle power resulted a strong and powerful industrial lobby. While talking to one of the dying factory manager, most of these units consume excessive groundwater. Recycling, rainwater harvesting or some of such sustainable practices are hardly taken up by these units. These are mostly hazardous and informal, not complying with the BIS safety standards and waste management norms. The untreated industrial waste are either disposed off to the open drain that eventually meet ponds, khals or goes to the paddy farms destroying the land and the crops. Over the years the land becomes unsuitable for any kind of agricultural use, either remains fallow or being sold off to the factory owners.

Dumping of industrial pollutants has caused loss of fertile agricultural land, decay of surface water bodies, and contamination of the shallow aquifer in Bodai. Bodai gives interesting narratives of land degradation due to industrial pollution and subsequent grabbing and displacement of farmers by the powerful industrial lobbies. A farmer protest spearheaded by several Trinomool congress (TMC) members along with affected farmers initiated in 2012. However with the change in the political regime and coming of the Trinomool congress in power the movement got diluted.

2.1.3 Hogladanga – Background

Hogladanga, part of Jalma Union and Batiaghata Upazila narrates the story of urbanization processes distinctly playing out in the peripheries of the Khulna city corporation. The village has 260 households with sizable number of migrants from Koyra, Shyamnagar, Dumuria, Morolgonj Barisal, Shyamnagar, Dumuria and Terokhada. Since 2005 the migrant population increased considerably changing the nature and characteristics of the village. Hogladanga became the favourite destination for real estate investments and rampant conversion of agricultural lands. Several real estate projects like Maa Mati Abasik Prokolpo, Rajdeep Abasik Prokolpo, Shikdar Abasik Prokolpo, Swapno Puron Abasik Prokolpo, Sonar Bangla Abasik Prokolpo etc started mushrooming in the close vicinity of the village. Public provision for drinking and domestic supply has been deep tube wells not adequate to the increasing households. The village has three DPH installed active tubewells. The story of poor operation and maintenance of the community-installed tubewells are common. Collective sharing of the deep tube wells are copying strategies for the local households.

Figure 2.4 – Social map of Hogladanga village, 2016



Source: Field survey conducted by JJS; Map constructed by JJS.

These projects lacking the public supply of drinking and domestic water is largely dependent on groundwater as their only sources. Illegal drilling of private deep tube wells for domestic and drinking use are rampant in the village. With the declining groundwater trend such massive growth of deep tubewell can be a potential threat to the aquifer.

The village is predominantly agrarian with diversification of the secondary livelihood sources (figure 2.4). Agriculutral land and khals are often encroached by the industrial groups or real estate giants. Degradation of agricultural land due to waste dumping, land grabbing, pollution of the surface water sources mainly khals has created agrarian distress. Pollution and illegal encroachments of the khals have compelled farmers to depend more on the groundwater-based irrigation system. Hogladanga has created competing space for local farmers and fishermen and the urban elites, more powerful and having illegal stakes on the khals, ponds and land.

3 The Urban process: Livelihoods and basic amenities

3.1 Patterns of Livelihood

All the four study villages exhibit varying degree of urban influences. The historical processes underpinning Khulna and Kolkata have made all the changes in their neighbourhoods. Although there are considerable differences in the degree of urbanization in both the cities certain commonality can be observed. All the four villages have experienced changes in the livelihood choices, moving from agriculture to non- agriculture based ones. Table 3.1 shows percentage distribution of households across primary production sectors in all the four villages.

Table 3.1 – Percentage distribution of households by primary source of income, 2016

Sector	Tihuria	Badai	Hogaladanga	Matamdanga	Total
Cropping (Paddy, Vegetables etc.)	35.2	38.3	65.0	55.9	47.0
Commercial shrimp farming	0.0	0.0	3.0	5.4	1.8
Freshwater aquaculture	20.3	0.0	0.0	2.2	6.2
Waste water aquaculture	17.2	0.0	0.0	0.0	4.9
Other allied agriculture	1.6	0.8	9.0	3.3	3.3
Manufacturing and repairing	4.7	25.0	5.0	5.4	10.7
Construction	10.9	18.0	2.0	5.4	9.8
Trade (wholesale and retail)	7.1	4.7	6.0	10.8	6.9
Transport, Storage and Communication	1.6	8.6	3.0	5.4	4.7
Real estate, renting and business activities	0.0	0.8	1.0	0.0	0.4
Other services	1.6	4.0	6.0	6.5	4.1
Total	100	100	100	100	100
Herfindahl-Hirschman index (HHI)*	**0.21**	**0.25**	**0.44**	**0.34**	**0.26**
Number of households	128	128	100	93	449

Source: Primary survey. * Index takes a value one when there is an absolute concentration and approaches zero when diversification is perfect. *Note*: Other allied agriculture includes animal husbandry, mixed cropping, forestry, logging and related services; Other services include public administration and defense; education, health, social work; community, social and personal services; hotels and restaurants etc.

Table 3.2 – Secondary source of income, 2016

	Sector	Tihuria	Badai	Hogaladanga	Matamdanga	Total
Households having secondary income source	Bodo and Aman paddy	46.1	18.7	3.3	21.7	29.1
	Commercial shrimp farming	0.0	0.0	6.7	4.3	1.3
	Freshwater aquaculture	3.9	0.0	40.0	52.2	12.2
	Waste water aquaculture	7.8	0.0	6.7	0.0	4.3
	Other allied agriculture	0.0	1.3	6.7	0.0	1.3
	Manufacturing and repairing	5.9	30.7	6.7	8.7	14.3
	Construction	13.7	12.0	16.7	4.3	12.6
	Transport, storage and communication	2.0	8.0	6.7	0.0	4.3
	Trade (wholesale and retail)	14.7	24.0	6.6	0.0	15.2
	Real estate, renting and business activities	1.0	0.0	0.0	0.0	0.4
	Other services	5.0	5.3	0.0	8.7	4.7
	Total %	100	100	100	100	100
	Total households	102	75	30	23	230
% of households not having secondary source of income		**20.3**	**41.4**	**70**	**75.3**	**48.8**
Total households		128	128	100	93	449

Source: Primary survey. Note: Other allied agriculture includes animal husbandry, mixed cropping, forestry, logging and related services; Other services include public administration and defense; education, health, social work; community, social and personal services; hotels and restaurants etc.

Table 3.3 – Convergence between primary and secondary economic activity of the household (%), 2016

Primary sector	Secondary sector: Cropping (paddy, vegetables etc.)	Aquaculture	Other allied agriculture	Manufacturing and repairing	Construction	Others (non-agriculture)	Total
Cropping (paddy, vegetables etc.)	23.9	78.0	66.7	27.3	65.5	50.9	46.5
Commercial shrimp farming	3.0	0.0	0.0	0.0	0.0	0.0	0.9
Freshwater aquaculture	19.4	0.0	0.0	6.1	6.9	7.0	9.1
Waste water aquaculture	10.4	2.4	0.0	3.0	13.8	10.5	8.3
Other allied agriculture	3.0	2.4	33.3	0.0	3.4	3.5	3.0
Manufacturing and repairing	9.0	4.9	0.0	21.2	0.0	19.3	11.3
Construction	14.9	0.0	0.0	18.2	3.4	3.5	8.3
Others (non-agriculture)	16.4	12.2	0.0	24.2	6.9	5.3	12.6
Total (%)	100	100	100	100	100	100	100
Total household engaged in secondary economic activity	67	41	3	33	29	57	230

Source: Primary survey. *Note*: Other allied agriculture includes animal husbandry, mixed cropping, forestry, logging and related services.

Tihuria has the larger share of households involved in multiple income sources (table 3.2 & 3.3). If we see the percentage of households not having any subsidiary income sources, Hogladanga and Matomdanga stand out significant. Out of total households reported to have subsidiary occupational sources 46 percent is involved in agricultural sector in Tihuria, followed by Matomdanga, Bodai and Hogladanga. Freshwater fisheries and wastewater aquaculture are other allied activities emerged significantly in Hogladanga and matomdanga.

Logistic regression estimates (table 3.4) from household level sample data also suggest that the probability to being engaged in secondary economic activity is significantly higher among households in Tihuria followed by Badai compared to that in the study villages of Khulna. In the four study villages, such probability is significantly higher among Hindu households. Similarly, the male headed households follow a same pattern.

Table 3.4 – Logistic Regression: Engagement of rural household in secondary economic activity

Co-variate	Exp(B)
Household size	1.176**
Hindu^	
Muslim	0.393**
Tihuria^	
Badai	0.881
Hogaladanga	0.100***
Matamdanga	0.125***
Migrant^	
Non-migrant	1.415
Male headed^	
Female headed	0.260**
Educational level^	0.977
Lower economic status^	
Middle economic status	1.080
Upper economic status	1.056
Primary economic activity: Cropping, animal farming, mixed farming, forestry, logging etc. ^	
Primary economic activity: Aquaculture	0.795
Primary economic activity: Secondary sector (Manufacturing, construction, electricity-gas-water supply as well as mining and quarrying)	0.513*
Primary economic activity: Services	0.459**
Location of workplace for primary economic activity: Rural/ peri-urban^	
Location of workplace for primary economic activity: Urban	2.502*
Location of workplace for primary economic activity: No fixed location	0.635
Access to shallow/ deep tubewell: No^	
Either shallow or deep tubewell: Yes	1.612
Both shallow and deep tubewell: Yes	2.597
Institutional membership: Yes^	
Institutional membership: No	1.478
Political membership: Yes^	
Political Membership: No	0.672
Ability to borrow money: Yes^	
Ability to borrow money: No	0.479
Ability to borrow money: Do not know	0.839
Total operated land under Bodo, Aman, and Aquaculture	1.293
Total operated land under tenancy in Bodo, Aman, and Aquaculture	0.883
Constant	2.228
-2 Log likelihood	459.8
Cox & Snell R Square	0.297
Nagelkerke R Square	0.396
Chi-square	156.8
Source: Primary survey. Dependent variable 0 if the household is not involved in secondary economic activity and 1 if otherwise.	
*** Significant at 0.01 level, **Significant at 0.05 level, *Significant at 0.10 level; ^ is the reference category in case of categorical predictors.	
Exp (b) – labels for the odds ratio of the row independent with the dependent (engagement in secondary economic activity). It is the predicted change in odds or likelihood for a unit increase in the corresponding independent variable. Odds ratios less than 1 correspond to a decrease and odds ratios more than 1 correspond to an increase in probabilities.	

Demographic factor, the household size also depicts a significant positive association with the probability of being engaged in secondary activity. Apart from this, the primary economic activity of the household also determines the household's decision to earn livelihoods from secondary sources. The households which are primarily engaged in the farm sector, other than aquaculture, are more likely to have a secondary income source than the households primarily engaged in non-farm sectors. It loosely denotes that the households which primarily engaged in the farm-sector also earn their substitute income from other sources, hence the multiplicity factor is more prominent among them. Location of workplace for the primary economic activity also throws out some significant results. The households which are having their primary workplace located in nearby urban areas are more likely to engage in the secondary income activity as compared the households which have workplace withinn the rural/peri urban area as well as those not having any fixed workplace. It denotes that the households which are probably having one or more economically active out-migrants tend to be involved in the secondary economic activity (table 3.4).

Other predictors viz. the migration status, economic status, access to ground water resources such as shallow or deep tubewell, institutional membership such as village panchayat, village committees, NGOs and other civil society organisations, association with any political party, access to credit (ability to borrow money), size of operational land holding and land tenancy, do not show any significant association with household's decision to be engaged in secondary economic activity (table 3.4).

3.2 Housing, education and sources of fuel wood

To understand the degree of urbanization processes operating in the villages we have taken some proxy indicators like construction material used for housing, exterior walls, main roof, food preparation area, ability to read newspaper, girls education etc. If we look into the kind of housing, Matamdanga reported more concretized houses compared to Hogladanga. Particularly in terms of material used for roofing and exterior walls, Matamdanga has reported the use of concrete bricks, while Hogladanga more of metal sheets, asbestos, thin bamboo and wood. For Tihuria and Bodai the houses are concrete in nature and thus shows the greater influence of urban processes (see annexure tables A3.1 & 3.2). Such differences in the kind of housing material show the economic prosperity across four villages.

However if we look into the place of cooking, which to a great extent reflects the socio-cultural dynamics of the households, Hogladanga performs far better with 61 percent of the households reported kitchen area within the premise (see annexure table A3.3).

Other parameters for instance hand washing before meals, use of soaps for cleaning, which are hygienic practices, and probably developed as part of the urban consciousness, are reportedly higher in Hogladanga than Matamdanga (see annexure tables A3.3 & 3.5). Interesting differences can be seen with regard to household head's reading capacity (see annexure table A3.6). Tihuria and Bodai has reported greater awareness and education level compared to Hogladanga and Matamdanga. Although there are no significant differences in secondary education for girls, Hogladanga reported significantly higher high level degree for women compared to the other (see annexure table A3.7). The gap significantly reduces in case of male education between the two villages.

4 Sources of drinking and domestic water supply

4.1 Distribution of drinking and domestic water sources across villages: Influencing factors and processes

Figure 3 – 6 provide distribution of drinking and domestic water sources for four villages seasonally and annually. In all the four villages of West Bengal and Bangladesh Public Health Engineering Department (PHED) is responsible for installation and supplying of drinking and domestic water, while Gram Panchayat and community for its operation and maintenance. Pubic supply is mainly done through households direct pipe connections; common stand posts and public deep tube wells. Among these three major sources used for both drinking and domestic use in peri-urban Kolkata, piped connections and community stand posts are treated, while deep tube wells are untreated. Private shallow wells are untreated water sources, essentially catering the domestic needs of the majority of households. Community open wells, ponds and small dams have both public and private property interface, with distinct features of its own. Ponds are privately owned, but are commonly shared among households through verbal agreement and understanding.

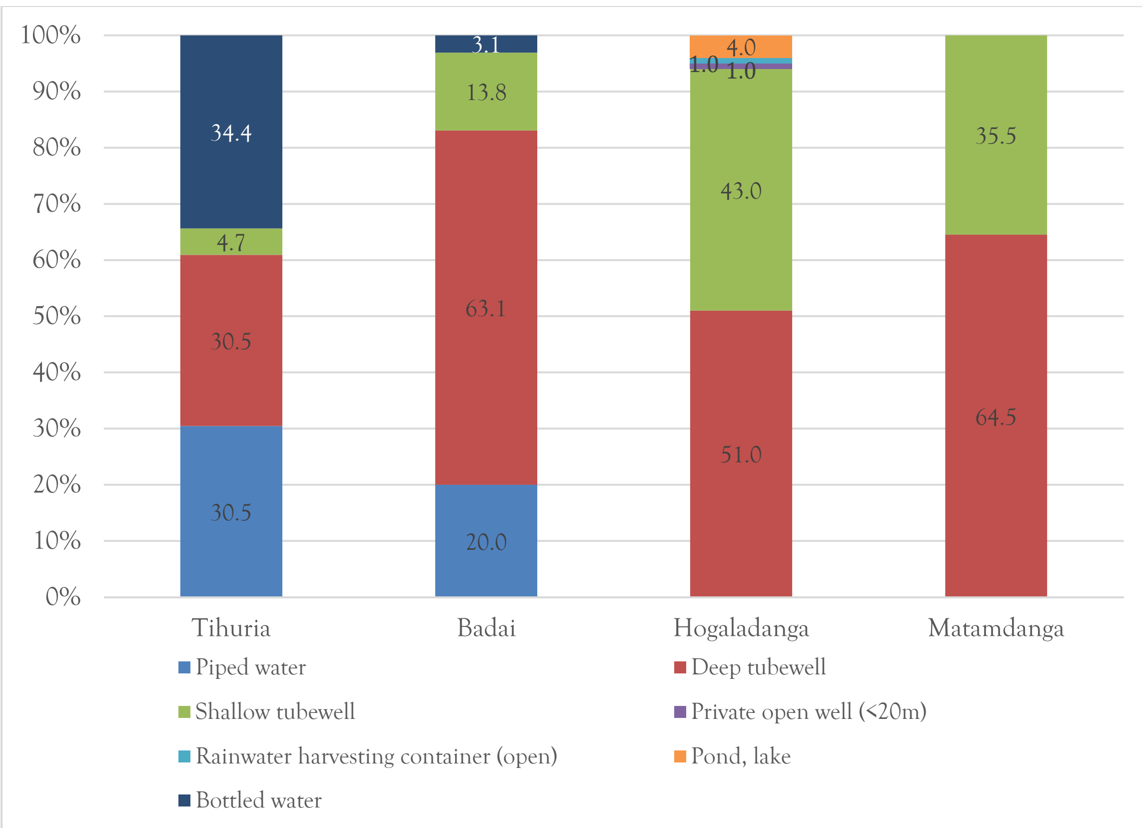
Table 4.1 – Public water sources of Tihuria

S. No.	Source name	Depth (for TW) in Feet	Locality/Landmark
1	Panchayet TW	600	South Tihuria
2	PHED tap water	–	Meet point of Tihuria and Saheberabad (At the east end of the village)
3	Panchayet TW	1000	Saheberabad
4	PHED tap water	–	Tihuria
5	Panchayet TW	1000	Bholapara
6	Panchayet TW	250	Majherpara
7	PHED tap water	–	Majherpara
8	PHED tap water	–	Tihuria School
9	Panchayet TW	1000	Bot tola
10	PHED tap water	–	Tihuria Play Ground (At the west end of the village)

Source: Collected by The Researcher from the field. TW – Tubewell.

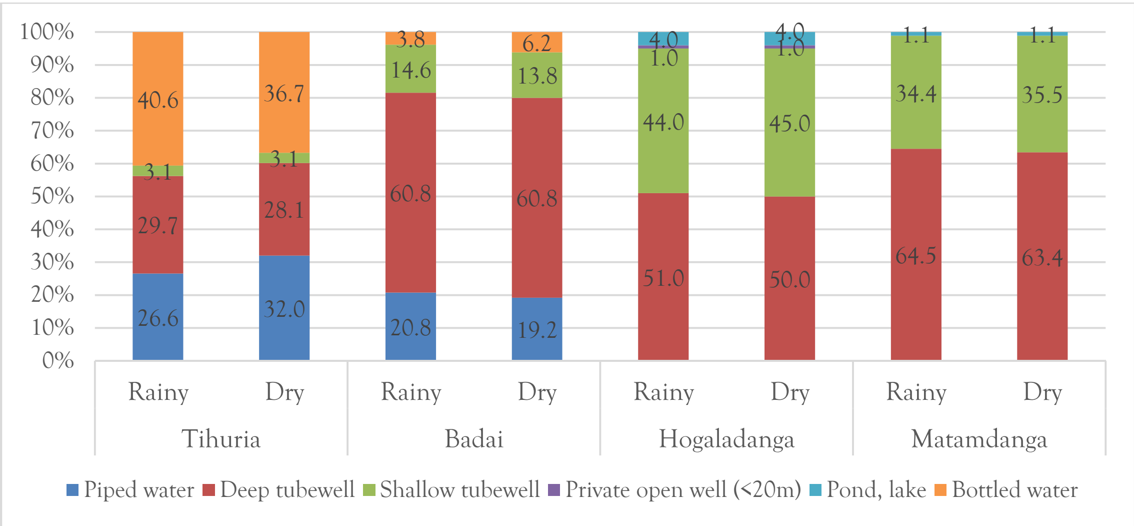
If we look into village wise distribution, in Tihuria piped water supply essentially comes from Ganga River, through a filtration plant located outside the village. The water gets stored in the PHED overhead tank where it gets mixed with groundwater and supplied through drainage network to common stand posts. Village does not have any direct household connections. Table 4.1 shows PHED and Panchayat sources of tube wells and common tap connections in Tihuria used for drinking and domestic purposes.

Figure 4.1 – Percentage distribution of sample households by primary source of water for drinking purpose during most of the year, 2016



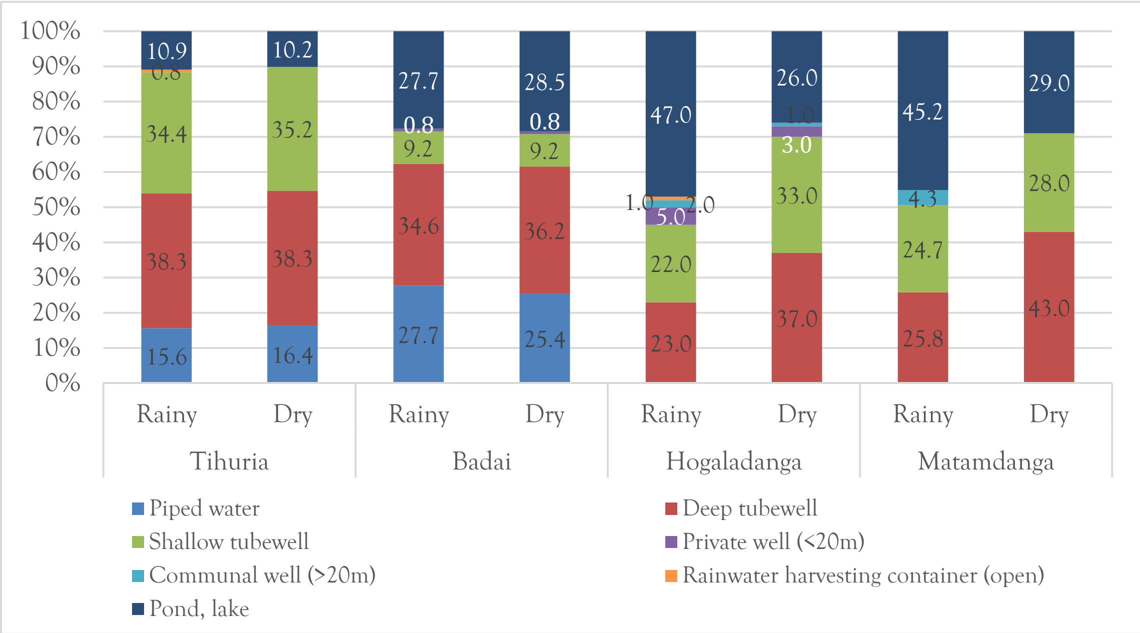
Source: Primary survey.

Figure 4.2 – Percentage distribution of sample households by primary source of water for drinking purpose during rainy and dry seasons, 2016



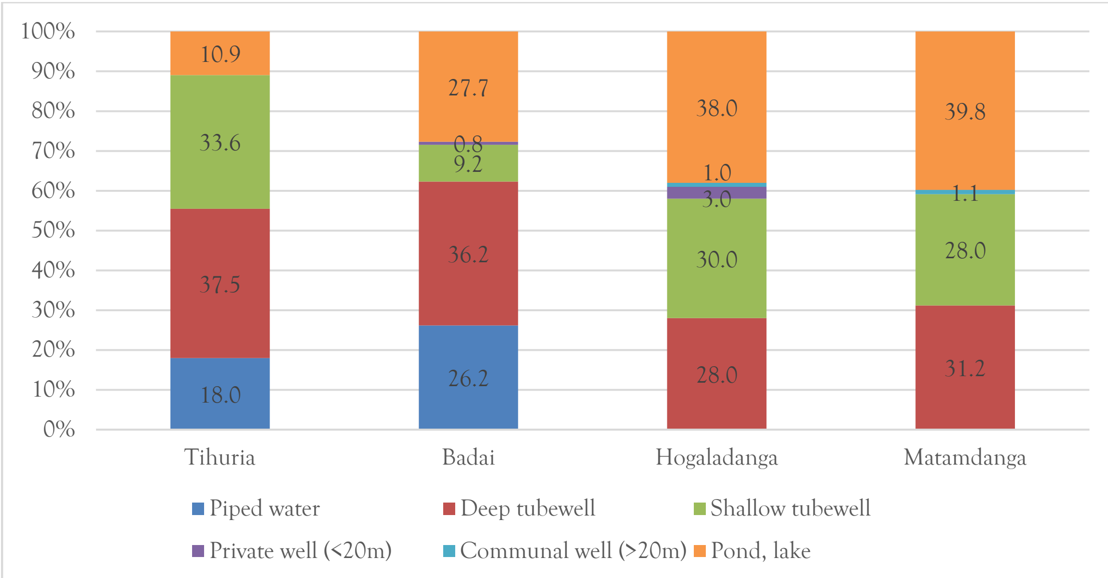
Source: Primary survey.

Figure 4.3 – Percentage distribution of sample households by primary source of water for domestic purpose during most of the year, 2016



Source: Primary survey.

Figure 4.4 – Percentage distribution of sample households by primary source of water for domestic purpose during rainy and dry seasons, 2016



Source: Primary survey.

For Bodai piped water is only from Ganga filtration unit and restricted to few households having direct pipelines. Deep tubewells forms the major drinking and domestic water sources for the village. For domestic use along with deep and shallow tube wells Bodai also depends ponds. The dependence increases during crisis period. Shallow tube wells are privately owned and untreated. Sizable proportions of households are dependent on paid sources in Tihuria. While in Bodai paid sources are relatively lesser, but increases during crisis period. While for Tihuria privately owned shallow tubewells serves the domestic water needs of the larger population. The trend towards paid water sources for both the villages reflects the mounting water crisis and wilful apathy of the public utility services. Narratives of the vulnerable groups particularly women in Tihuria shows mistrust in public supply particularly the quality of water and growing consciousness about paid water as more reliable.

Similar trend can be seen for Hogladanga and Matamdanga with an exception of having no direct pipe water network system. Greater dependence on private groundwater sources with no seasonal variations can be commonly observed. Matamdanga reported relatively greater dependence on deep tube wells, which could be either DPHE managed, community managed, NGO managed or individual in nature. DPHE managed tube wells although safe and does not require treatment, often fall short of the demand and suffer from poor maintenance.

Since 2004 both the villages have experienced unprecedented growth in the shallow tube wells particularly with the coming up of National Policy of Arsenic mitigation (NPAM). Shallow tubewells have two kinds of ownership rights, individual and community. Community tubewells could be either installed and managed by group of households or installed by private organizations (national and international NGOs) and maintained by the beneficiary households. Table 7 shows the percentage share of the shallow tubewell ownerships in four villages.

Table 4.2 – Type of shallow tubewell (%), 2016

Village	Individual	Shared	Total
Tihuria (103)	98.1	01.9	100
Badai (60)	86.7	13.3	100
Hogladanga (25)	84.0	16.0	100
Matamdanga (39)	84.6	15.4	100
Total (227)	91.2	8.8	100

Source: Primary survey. Number of households given in parentheses.

Other sources like open wells which tap shallowest of the aquifers has its marginal presence in Hogladanga. Ponds formed either by creating artificial earthen damming of the *khals* (connecting river channels), natural ponds, and small-scale rainwater-harvesting structures are other drinking water sources for marginal number of households in Hogladanga. In terms of treated and untreated sources, significant number of households depends on untreated sources for drinking,

For domestic water sources we can see differences across villages of Khulna and Kolkata. Shallow hand pumps and deep tube wells are major sources for Tihuria and Bodai while khals, earthen embankments across khals are significant sources for Matamdanga and Hogladanga. Dependency from surface water sources shifts to shallow tubewells during the crisis period

In terms of diversity of water sources for domestic purposes Hogladanga has diversified sources, more of public and communal in nature. Where as in Matamdanga deep and shallow tubewells are major sources. Seasonality exists in domestic water sector where in crisis or dry period dependency on other sources like wells are significantly lowers down in Matamdanga than in Hogladanga. Interesting point of observation is operation of collective action through sharing of the community wells, ponds and dams in Hogladanga particularly in the crisis period. Matomdanaga has comparatively greater availability of treated drinking water sources. Unlike Kolkata there is no drinking or domestic water market present in the villages.

Table 4.3 – Insufficiency of drinking water from primary source (%), 2016

Household's response	Tihuria	Badai	Hogaladanga	Matamdanga
Never to rarely	41	41	42	56
Very often	30	39.2	54	39.8
Always	18	14.6	2	4.3
No response	10.9	5.4	2	0
Total (%)	100	100	100	100
Total households	128	130	100	93

Source: Primary survey.

Insufficiency in drinking water supply is persistently high in all the four villages (table 4.3). Several factors have been attributed to such insufficiency (table 4.4). Infrastructural challenges in terms of poor maintenance of the network, erratic supply of the public stand posts /household pipelines have been reported in Tihuria and Bodai. Depleting groundwater level has emerged as most significant factor affecting the drinking water supply for Matamdanga and Hogladanga. Since the villages remains outside the ambit of the surface water network, with heavy dependence on tube wells (both deep and shallow) such insufficiencies not only depict the distress of the peri-urban communities but considerable stress on the already falling aquifer level.

Table 4.4 – Reason for insufficiency in drinking water source (%), 2016

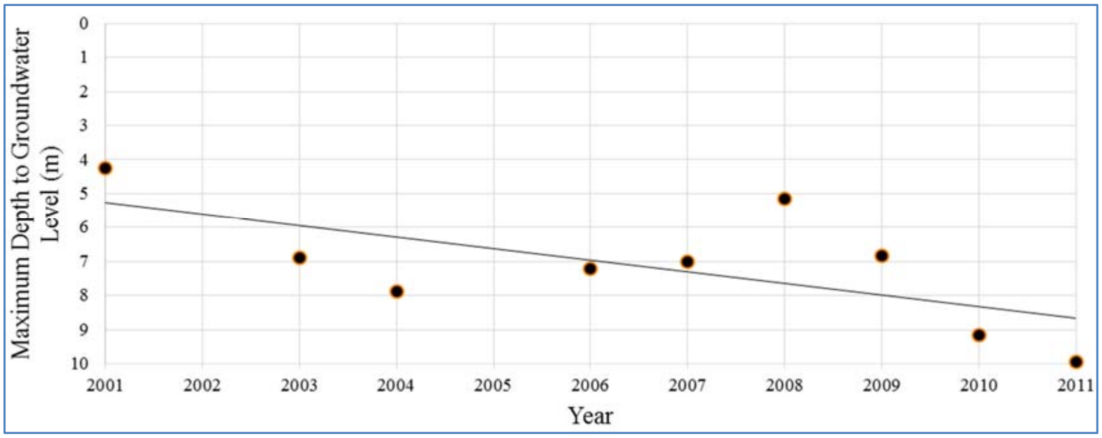
Reason	Tihuria	Badai	Hogaladanga	Matamdanga
Erratic supply from public	19.5	10	11	10.8
Location of the house on an elevated terrain	0	2.3	1	0
House situated in the rear side of the village where the water does not reach	5.5	0	10	0
Excess usage/ consumption by other households	0.8	1.5	8	2.2
Leakages in the pipe	10.2	3.1	1	0
Other	0.8	3.1	0	0
Do not know	36.7	44.6	6	6.5
No response	1.6	2.3	1	5.4
Depletion of ground water table	0	0	60	49.5
Not applicable	25	33.1	2	25.8
Total (%)	100	100	100	100
Total households	128	130	100	93

Source: Primary survey.

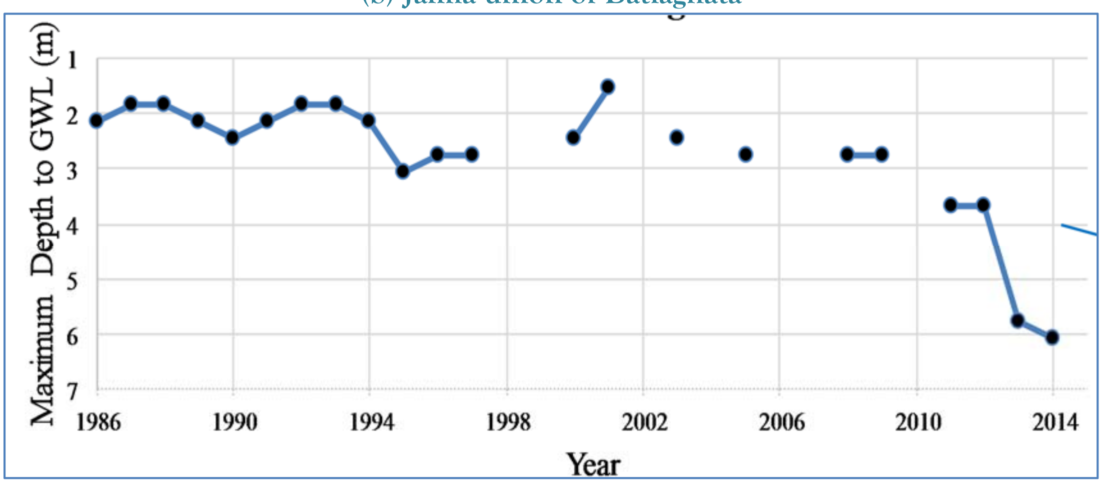
Insufficiency in domestic water supply been reported in Tihuria and Bodai where almost 20 percent of the households have informed acute crisis. This probably because of large scale falling of shallow tubewells/handpumps or contamination with iron and hazardous waste water. For deep tube wells it is essentially the matter of poor maintenance. This largely points out to the groundwater stress for Tihuria and Bodai where deep and shallow tube wells forms the predominant choices. The findings largely confirms to the scientific data on groundwater trend for Barrackpore II and Sonarpur blocks where our study villages are located (e.g. see figure 4.5a & b).

Figure 4.5 – Declining ground water trend, 2011 – 2011

(a) Sonarpur block



(b) Jalma union of Batiaghata



Source: prepared by BUET using pre-monsoon data of SWID. Well depth is unknown.

Insufficiencies in groundwater supply for domestic use have also been reported in Hogladanga and Matamdanga where depleting aquifer has been essentially attributed. The findings also confirms to the groundwater data trend for Jalma union (figure 4.5b). However the supplementary surface water sources like khals, ponds and rainwater harvesting structures has caused greater accessibility to water sources even though they are unsafe. Thus 40 percent of the households have reported to have sufficiency of the surface water sources. However such sufficiency does not confirm to the safe water quality as reported by 78 percent of the households (table 4.5). While looking into the water quality as perceived by the households, Matamdanga and Hogladanga has significantly reported poor water quality of the drinking water sources, attributed to industrial solid and liquid waste dumping, flooding of the waste water canal and salinity intrusion due to shrimp farming. In case of Tihuria iron contamination, salinity intrusion and overflowing of the wastewater canal forms the causal factors. For Bodai dumping of the industrial wastages through khals and canals forms the major source of contamination of the shallow aquifer used for drinking and domestic use.

Table 4.5 – Insufficiency of domestic water from primary source (%), 2016

Household's response	Tihuria	Badai	Hogaladanga	Matamdanga
Never to rarely	47.7	43.1	42	56
Very Often	31.2	30.8	55	41
Always	17.2	19.2	1	3.2
No response	3.9	6.9	2	0
Total (%)	100	100	100	100
Total households	128	130	100	93

Source: Primary survey.

Table 4.6 – Quality of household's drinking and cooking water before treatment (%), 2016

Quality	Tihuria	Badai	Hogaladanga	Matamdanga
No response	0.8	0	1	0
Do not know	3.9	0	5	1.1
Very bad	6.3	0	0	8.6
Poor	9.4	7.7	12	8.6
Satisfactory	35.2	17.7	49	47.3
Good	44.5	73.8	26	28
Very good	0	0.8	7	6.5
Total (%)	100	100	100	100
Total households	128	130	100	93

Source: Primary survey.

Interesting observation derives while investigating the causes of such distress across four villages. While Hogladanga and Matamdanga attributed to falling groundwater table as the major cause of insufficiency of the deep and shallow tubewells used for domestic use, sizable proportion of the households of Tihuria and Bodai has reported to be unaware of any distinct factors responsible. Insufficiency is accompanied with poor water quality that was reported to be increasingly observed for the past 5 years in all he four villages. All these points out to the urbanization forces operating in the villages.

4.2 Accessing the drinking and domestic water sources: Who gets what water

Mix arrangements of formal supply and informal coping mechanisms including tapping from the formal piped network to, extracting groundwater through submersible pumps or borrowing drinking water from middle class colonies operates in all our study villages. There are upcoming informal providers who provide water in tankers, packages and bottles. There are few privately operated water quality treatment plants. Who is going to access what kind of water depends much on their political and cultural realities.

As seen in the previous section majority of the households remains evicted of the surface networked system in Tihuria and Bodai while in Hogladanga and Matamdanga government supply stands as scattered deep tube wells shared by large number of households. Local norms and informal agreements determine the sharing of the private deep and shallow tube wells across households. It is also evident from the literature that access to decentralized water infrastructure is not uniform among the peri-urban community (Allen, Davila & Hofmann 2006; Srinivasan *et al* 2013). Which particular socio-economic and religious group will access what kind of water depends on their daily struggle to collect water from distance, certain 'need driven practices' based on collective action and community sharing or water bought from small independent providers, informal or licensed water vendors. For majority of the households all these options co-exist but uncertainties are endless and more critically felt by the poorest households.

For drinking and domestic use, economically vulnerable groups have reported to be dependent on untreated public water sources (table 4.7 & 4.8). The trend remained persistent across seasons for Tihuria. High degree of insufficiency of the public sources pushes the vulnerable poor into acute distress. If we look into the middle to upper income groups, greater dependence on shallow private tubewells further points out to the increasing inequalities across peri-urban communities. This can be further substantiated with distribution of primary drinking water sources across economic groups in Tihuria. Table 4.7 shows significant dependence on paid water sources across all the economic groups. This is quite distinct for Tihuria that not only reflects lack of public coverage but also the growing urban consciousness among the middle and lower middle-income groups. Focus group discussions with women in Tihuria gives an interesting narratives of such change. Frequent inundation during monsoon and overflowing of the wastewater canal makes ponds, public standposts completely unsafe and inaccessible to large section of the households of Tihuria proper and Shaberabad. Households of South Tihuria had to travel to far off Eastern corner of the village to collect water, while Shaberabad depends on panchayat well or bottled water from the local Filtration plants, purchased at 5-20 Indian rupees for 20 liters jar. Packaged water even if they are not sealed and does not carry standardization certificate forms the major drinking water source for both rich and poor.

Bodai reported slow but steady operation of informal water vendors for the last 5 years. Deep tube wells, mostly government installed forms the significant drinking water source, richer households started relying on the packaged water brought by the vendors in 20 litre jars from the adjoining villages. Religion wise classification shows greater prominence of Hindu households mostly working in the nearby town of Barrackpore or Kolkata metropolitan inclines to package water (table 4.9). While consistent dependence of Muslims to bottled water all the year indicates lack of public utility services. There is no significant difference between classes or religion with access to public utility sources or commonly managed private sources like ponds.

Table 4.7 – Economic status wise percentage distribution of sample households by primary source of drinking water, Tihuria, 2016

Source	Most of the year				Rainy season				Dry season			
	Lower	Middle	Upper	Total	Lower	Middle	Upper	Total	Lower	Middle	Upper	Total
PHED water supply (Common stand-post)	24.4	35.9	26.1	30.5	22	31.3	21.7	26.6	24.4	39.1	26.1	32
Deep tubewell	34.1	26.6	34.8	30.5	34.1	25	34.8	29.7	34.1	23.4	30.4	28.1
Shallow tubewell	4.9	4.7	4.3	4.7	2.4	3.1	4.3	3.1	2.4	3.1	4.3	3.1
Bottled water	36.6	32.8	34.8	34.4	41.5	40.6	39.1	40.6	39	34.4	39.1	36.7
Total (%)	100	100	100	100	100	100	100	100	100	100	100	100
Total households	41	64	23	128	41	64	23	128	41	64	23	128

Source: Primary survey.

Table 4.8 – Economic status wise percentage distribution of sample households by primary source of domestic water, Tihuria, 2016

Source	Most of the year				Rainy season				Dry season			
	Lower	Middle	Upper	Total	Lower	Middle	Upper	Total	Lower	Middle	Upper	Total
PHED Common stand-post	24.4	20.3	0	18	19.5	18.8	0	15.6	22	18.8	0	16.4
Deep tubewell	34.1	39.1	39.1	37.5	34.1	40.6	39.1	38.3	34.1	40.6	39.1	38.3
Shallow tubewell	22	32.8	56.5	33.6	24.4	32.8	56.5	34.4	24.4	32.8	60.9	35.2
Private Ponds	19.5	7.8	4.3	10.9	19.5	7.8	4.3	10.9	19.5	7.8	0	10.2
Total (%)	100	100	100	100	100	100	100	100	100	100	100	100
Total households	41	64	23	128	41	64	23	128	41	64	23	128

Source: Primary survey.

Table 4.9 – Religion wise percentage distribution of sample households by primary source of drinking water, Badai, 2016

Source	Most of the year			Rainy season			Dry season		
	Hindu	Muslim	Total	Hindu	Muslim	Total	Hindu	Muslim	Total
PHED water supply (household connection)	13	14	13.8	13	15	14.6	13	13.1	13.1
PHED water supply (Common stand-post)	0	7.5	6.2	0	7.5	6.2	0	7.5	6.2
Deep tubewell	65.2	62.6	63.1	65.2	59.8	60.8	60.9	60.7	60.8
Shallow tubewell	17.4	13.1	13.8	17.4	14	14.6	13	14	13.8
Bottled water	4.3	2.8	3.1	4.3	3.7	3.8	13	4.7	6.2
Total (%)	100	100	100	100	100	100	100	100	100
Total households	23	107	130	23	107	130	23	107	130

Source: Primary survey.

Increase dependence on private shallow tube wells for domestic use can be observed among richer households of Bodai. This confirms to the larger understanding that shallow tube wells in west Bengal has been the product of high installation costs, political connection, fulfilment of complex permits and greater bribes to the local government officials. Sharing of the private ponds are some of the daily need based choices adopted by group of poor households in the village. The dependency is no seasonal variations and forms important surface source for poor households.

Interesting insights emerges from the distribution of households reporting inefficiency of drinking water from primary sources in four villages across class. Earlier insight (table 4.3) already informed about the persistent insufficiency of drinking water sources for all the study villages. However such insufficiency if distributed across economic class gives a different picture (table 4.10). There is consistent decrease of the degree of insufficiency with economic standards in both Tihuria and Bodai. However vulnerability is more severe in case of lower income groups of Bodai where 64 percent have reported critical compared to 24 percent in Tihuria. Occasional insufficiency has been reported for both the villages of Khulna across class group. Greater insufficiency been reported by the poorest and richest sections in Hogladanga. While Matomdanga has perpetual insufficiency reported by the poorest section.

Table 4.10 – Class wise insufficiency of drinking water from primary source (%), 2016

Class	Village	Never	Rarely	Very Often	Often	Always	No response	Total
Lower class	Tihuria (41)		2.4	43.9		24.4	12.2	100
	Badai (13)		0	38.5		61.5	0	100
	Hogaladanga (41)		7.3	70.7		2.4	2.4	100
	Matamdanga (32)		9.4	56.3		9.4	0	100
Middle class	Tihuria (64)		20.3	26.6	3.1	18.8	9.4	100
	Badai (72)		6.9	38.9	4.2	15.3	2.8	100
	Hogaladanga (50)		20	38	4	2	0	100
	Matamdanga (40)		15	27.5	10	2.5	0	100
Upper class	Tihuria (23)	47.8		4.3	0	4.3	13	100
	Badai (45)	44.4		33.3	0	0	11.1	100
	Hogaladanga (9)	11.1		33.3	11.1	0	11.1	100
	Matamdanga (21)	76.2		19	0	0	0	100

Source: Primary survey. Number of sample households in parentheses.

Table 4.11 – Class wise insufficiency of domestic source (%), 2016

Class	Village	Never	Very often	Always
Lower class	Tihuria (41)	19.5	42	29.3
	Badai (13)	0	40	61.5
	Hogaladanga (41)	14.6	68.3	2.4
	Matamdanga (32)	44.4	56.3	9.4
Middle class	Tihuria (64)	46.8	34.4	15.6
	Badai (72)	34.8	31.9	23.6
	Hogaladanga (50)	56	36	0
	Matamdanga (40)	62.5	32.5	0
Upper class	Tihuria (23)	95.7	0	0
	Badai (45)	68.3	22.2	0
	Hogaladanga (9)	33.3	55.6	0
	Matamdanga (21)	77.2	23.8	0

Source: Primary survey. Number of sample households in parentheses.

Perpetual insufficiency in the domestic water sector been reported by the poorest sections in Tihuria and Bodai (table 4.11). Hogladanga has frequent insufficiency reported by the poorest and the middle-income groups.

5 Impact of urbanization on agrarian structures and groundwater irrigation

To understand how urbanization (in form of industrial pollution, real estate boom, land grabbing, waste dumping) has played out significantly in the peri-urban villages for the last 15 years, influencing groundwater irrigation in particular, it is critical to have a historical account of the agrarian structures of the state of West Bengal and Bangladesh. Since 1980s till present the agricultural trajectories of West Bengal and Bangladesh not only showed changes in the productivity and cropping pattern, but land ownerships, labour relations, tenancy structures and most importantly control of water.

West Bengal, is characterized by smallholdings, larger established agriculture labour class and more substantial rich peasantry (Rogaly *et al* 1995). However, unlike many other states in India, where neo liberal developments reshapes the socio-economic space of the peri-urban villages, West Bengal's rich peasantry class movements rooted in the policies of the CPI (M) government historically determined its land use change. The pattern of land size distributions in the state shows predominance of small and marginal holdings. Most of these farmers are previously landless agricultural labourers, got ownership under land reforms, and thus it confirms to the larger literature that states the land redistribution of the Left Front Government have been in favour of poor and marginal.

1980s and 90s was the era of massive land reforms and intensification of groundwater irrigation in the state. 'Operation Barga', the prominent tenancy reform of communist government, has given land ownerships to landless and marginal farmers, where the names of the sharecroppers were registered in the land records. These ensured security of tenure, prevented evictions of tenants by non-cultivating landlords, provided access to credit, and made many tenurial contracts more transparent. The nature of agricultural labourer contracts also changed from bonded to more casual with labour wages being more structured.

During this phase state government invested heavily on groundwater development particularly by creating irrigation facilities for small and medium farmers through World Bank supported massive shallow, low, medium and heavy-duty tube well schemes. Shallow tubewells were largely under private investments and initiatives while government took care of the deep tubewells.

Boro (summer: from March to June) paddy cultivation emerged as the most promising crops, reaping higher profits, and entirely feeding on such irrigation system. As Ray & Ghosh (2007) writes, availability of copious groundwater, a suitable soil substrata, favourable economic return and political stability of the left government has resulted in Boro paddy boom in West Bengal, particularly in the gangetic delta districts of north and south 24 Parganas, Hooghly, Nadia, Murshidabad etc. 90 percent of the Boro paddy area of north 24 paragna is under groundwater irrigation (Ray & Ghosh 2007). While stating the agricultural trajectories Rawal & Swaminathan (1998) further writes 75 percent of the gross area and productivity in 1980s can be attributed to the groundwater based Boro paddy cultivation. Such boom is heightened by subsidization of electricity and fertilizers and greater access to rural credits.

The phase of land reforms saw the emergence of new middle class peasantry, economically and politically powerful. They are generally middle or upper castes, and even scheduled castes and/or tribes, commonality of having strong political patronage of the ruling party. They have able to reap greater benefits of the tube well irrigation either by private investments or through irrigation water market. Informal sharing, consolidation of the large plot of lands around small, medium and deep tubewells are some of the common practices observed. Second, Panchayat became more powerful as the operation and management of public tubewells were devolved to it. Panchayat Samities were made responsible for collection of water rates and maintaining the infrastructures.

End of communist rule, around 2000, West Bengal witnessed another phase of urbanization reflected in its industrial and land development policies. Adjoining districts particularly north and south 24 Parganas, Hoogly and Howrah saw massive industrial growth particularly small scale manufacturing intensively groundwater dependent. Real estate boom in terms upscale residential complexes made considerable change in the agriculture and control of water. Intensive groundwater based boro cultivation already started showing signs of aquifer distress, got further accentuated with illegally extracting groundwater by industries.

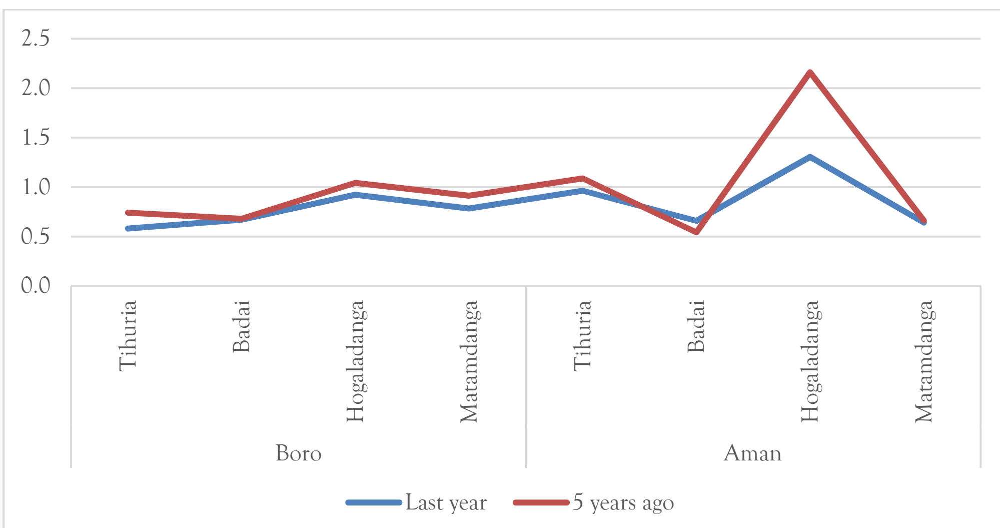
Like West Bengal, smallholdings characterize the agricultural trajectory of Bangladesh. The difference however lies in longer established agricultural labour class and a more substantial rich peasantry enabling the farmers of West Bengal to maintain a wider range of economic activity and greater access to higher prices for their produce (Bose 1993). Bangladesh has shown preponderance of family labour and with leverage of foreign aid traditionally has given richer small holders greater access and power over resources (Rogali *et al* 1995). Irrigation has been groundwater dependent and controlled by balance of forces between water lords and richer peasantry. Irrigation essentially comprises of privately owned and operated minor irrigation schemes, and non-mechanised and traditional indigenous systems. Minor irrigation systems comprise of deep tubewells, shallow tubewells and low lift pumps. Both deep and shallow sometimes pump from the same aquifer, but have different operational guidelines and management options. Unlike West Bengal they can be privately owned and shared by group of households (Mondal & Saleh 2003). Policy shifts towards deregulation of agricultural market in 1980s, the role of liberalization providing incentives for industrial and infrastructural development made tremendous impact in the way contest of classes over resources and control of water shaped up (Rogali *et al* 1995).

Falling groundwater tables (as much as 1.2 metres per year) due to excessive withdrawal by tubewells, low recharge, and poor management have frequently been reported in literature (Mondal & Saleh 2003, Mirjahan 1984; Akteruzzaman *et al* 1993; DAE 1994; IIMI 1996; Rashid & Mridha 1997). While there are questions of sustainability of these deep tubewell

(DTW) and shallow tubewell (STW) irrigation projects urban processes have further increased the distressed level depicted by large number of failed tubewells in the periphery of the large metros. New breed of urban elites illegally accessing the resources replaces the traditional power dynamics between the water lords and rich peasantry.

The above insights from the literature holds true in most of our study villages. Over last five years the agrarian structure of all the villages have undergone drastic changes. Although the cropping pattern has more or less remained same, there has been a substantial decrease in area cultivated, irrigational sources, productivity, intensity of groundwater use and tenancy structures. Average sizes of the landholdings in all the study villages are small and marginal in nature as shown in figure 5.1.

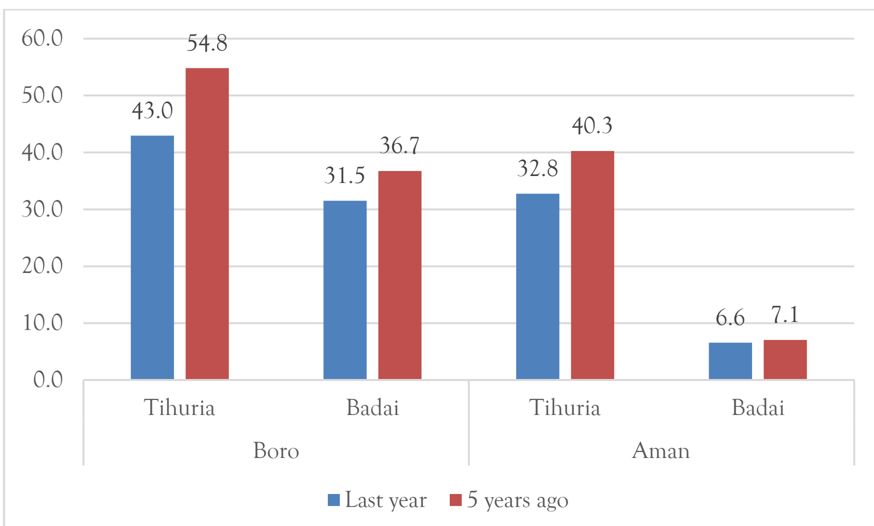
Figure 5.1 – Change in average operated land (acre) per cultivator household under Boro and Aman paddy, 2011 – 2016



Source: Primary survey.

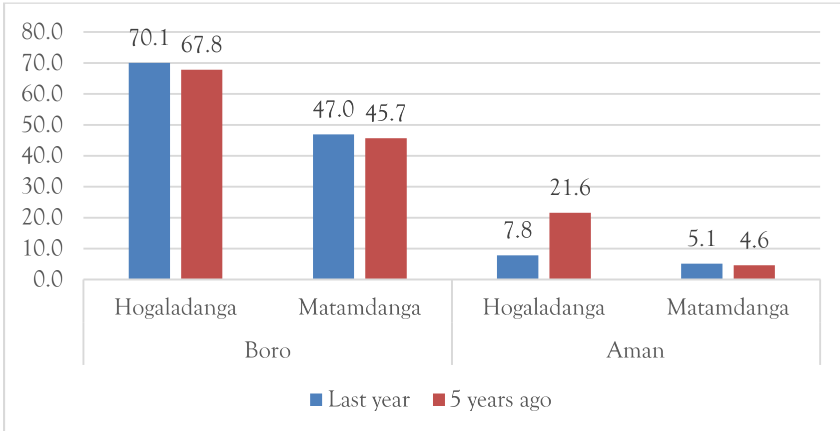
Three principal cropping patterns can be seen in all the four study sites; Boro, consisting of boro paddy and vegetables, Aman with rainfed paddy and Aquaculture. Different types of aquaculture are practiced, reflecting varying degree of urban demands. *Waste water fisheries*, a distinct practice of Tihuria is more in response to decrease productivity and rising cost of boro paddy and increasing local demand for fishes in Kolkata. Low input cost and wastewater source from Tollys nalla has provided adequate impetus for the monoculture of 'hybrid magur', a particular fishing variety in Tihuria. *Freshwater shrimp* cultivation is a distinct aquaculture practice commonly seen in Hogladanga and Matamdanga. Essentially surface water based, practiced along khals, has been the traditional livelihood options for farmers. Encroachments and waste dumping in khals often reduces the water flow impacting the water use patter of this system. Groundwater extracted through diesel pump sets substantiates low water flow in khals. Freshwater boro and fishes is an indigenous aquaculture ported in Hogladanga and Matamdanga, while freshwater fishing for both commercial and subsistence purposes being reported in all the four villages (figure 5.4).

Figure 5.2 – Change in total operated area (in acre) under Bodo and Aman Paddy, Kolkata, 2016



Source: Primary survey.

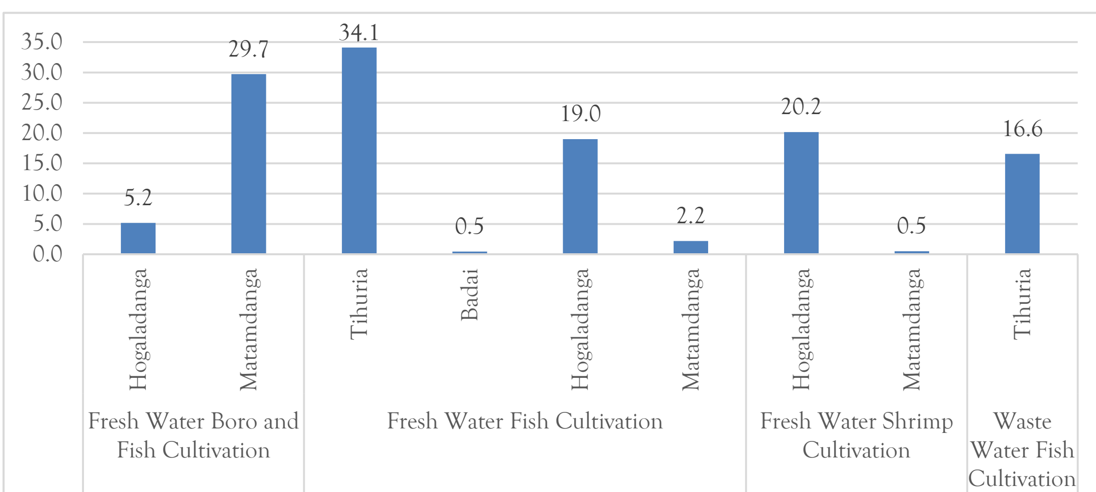
Figure 5.3 – Change in total operated area (in acre) under Bodo and Aman Paddy, Khulna, 2016



Source: Primary survey.

Between 2011 and 2016 area operated under two principal crops; boro and aman shows a relative decline in Tihuria and Bodai (figure 5.2). While for Hogladanga and Matamdanga the operated area more or less remained constant with insignificant rise in Hogladanga (figure 5.3). Aman shows significant and persistent decline in all the four cases. Since boro paddy is an irrigated (tubewells) and popular crop in the study villages, such a decrease in the operated area has a significant bearing on the intensity of groundwater usage.

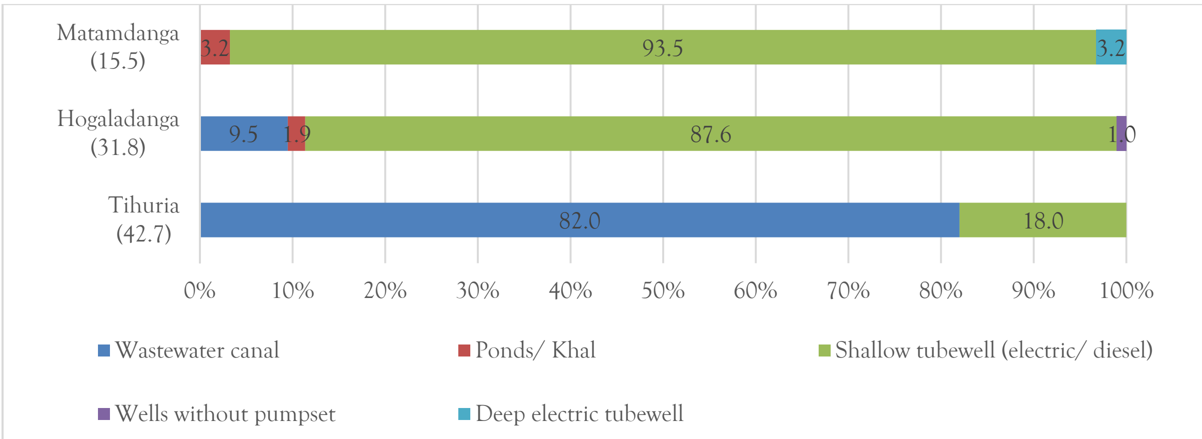
Figure 5.4 – Area (in acre) under various types of aquaculture, 2016



Source: Primary survey.

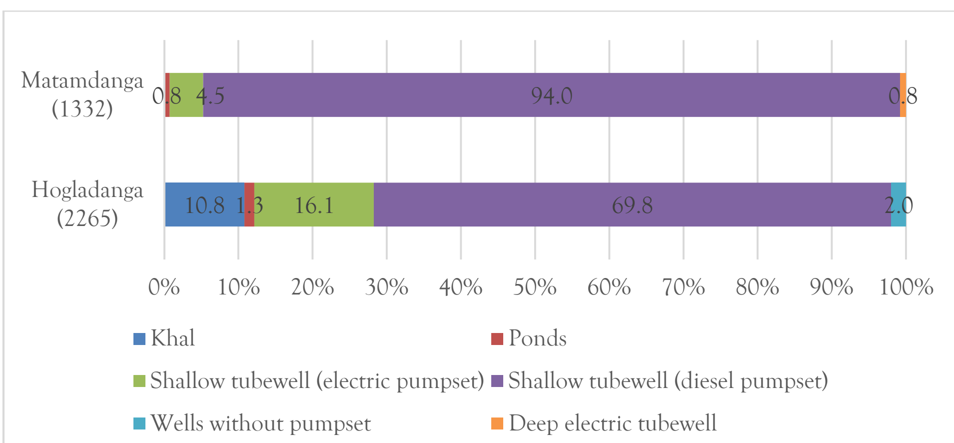
While figure 5.4 shows two distinct aquaculture practices, commercial fresh and waste water fishing and shrimp cultivation. The role of groundwater in each of these systems can be seen in figure 5.5 & 5.6.

Figure 5.5 – Percentage distribution of irrigated area under aquaculture by primary source of irrigation, 2016



Source: Primary survey. Total irrigated area (in acre) in parentheses.

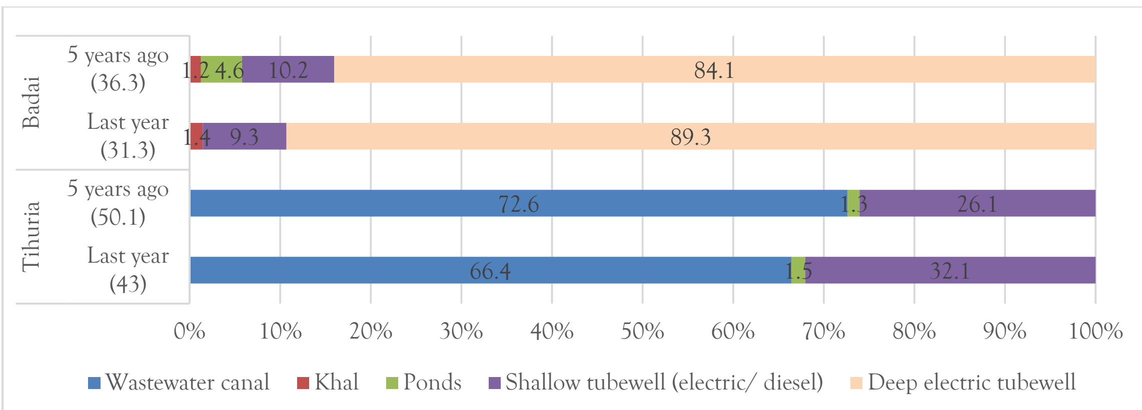
Figure 5.6 – Pumping hours (%) in aquaculture by primary source of irrigation, Khulna, 2016



Source: Primary survey.

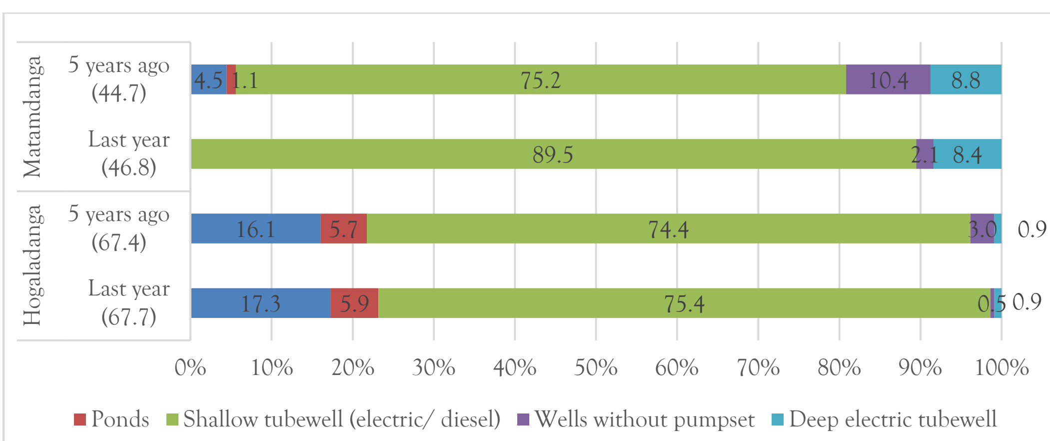
Shallow tubewells forms the major irrigation sources for aquaculture. Considering the fact aquaculture forms significant livelihood choices for the peri-urban households, particularly with its high local demand in the nearby cities, such dependence points out to greater groundwater usage and probable stress. The stress on groundwater can be further explained by distribution of irrigation in boro season cultivation. The trend significantly remained constant with greater predominance of deep tubewells in bodai while Matamdanga shows significant rise in shallow tube well irrigation within last 5 years (figure 5.7 & 5.8).

Figure 5.7 – Percentage change in distribution of irrigated area under Boro cultivation by primary source of irrigation, Kolkata, 2016



Source: Primary survey. Total irrigated area (in acre) in parentheses.

Figure 5.8 – Percentage change in distribution of irrigated area under Boro cultivation by primary source of irrigation, Khulna, 2016



Source: Primary survey. Total irrigated area (in acre) in parentheses.

Table 5.1 shows change in the pumping hours in boro cultivation. There is a significant shift in the pumping hours from surface sources like khals and ponds to subsurface sources (tubwells) in all the villages. Tihuria depicts increase in pumping for the diesel tubewells. Similar trend can be seen for Hogladanga and Matamdanga.

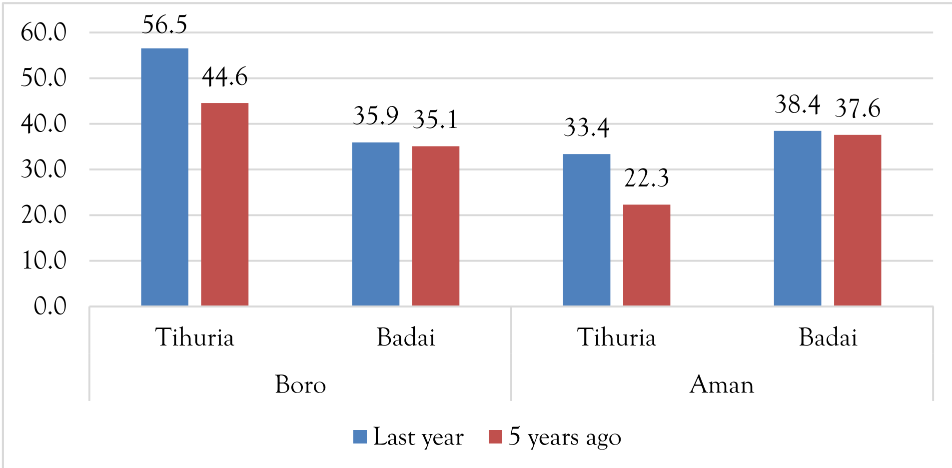
Table 5.1 – Pumping hours (%) in Boro cultivation by source of irrigation, 2016

Source	Tihuria		Badai		Hogaladanga		Matamdanga	
	Last year	5 years ago	Last year	5 years ago	Last year	5 years ago	Last year	5 years ago
Khal	3.3	16.6	0.0	0.0	20.5	20.8	0.0	0.0
Ponds	0.0	0.0	0.0	1.0	5.8	6.8	0.0	0.6
Shallow tubewells with electric pumpset	0.0	0.0	27.3	15.4	21.5	22.7	5.4	5.1
Shallow tubewells with diesel pumpset	91.2	74.2	0.6	0.0	48.7	42.1	83.7	76.1
Wells without pumpset	0.0	0.0	0.0	0.0	0.8	5.3	3.5	11.2
Deep electric tubewell	0.0	0.0	72.1	83.6	2.7	2.4	7.4	6.9
Wastewater	5.5	9.2	0.0	0.0	0.0	0.0	0.0	0.0
Total pumping hours (%)	100	100	100	100	100	100	100	100
Total pumping hours (numbers)	1095	566	5029	4135	5511	3325	4295	3113

Source: Primary source.

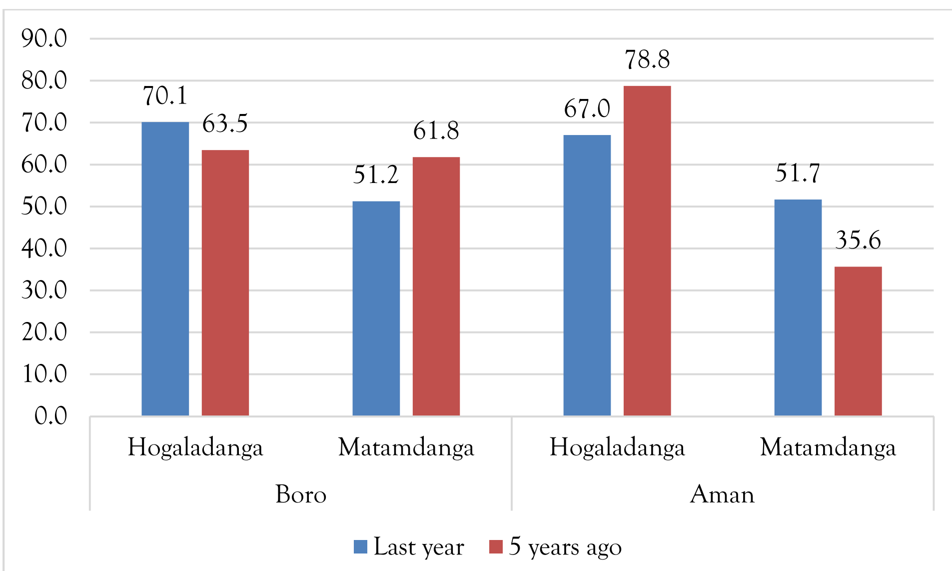
Crop wise area breakup in figure 5.9 shows the incidence of tenancy farming in Boro and Aman paddy cultivation has increased in Tihuria since last 5 years, while Bodai showed no substantial change. There is a transition from long-term tenancy to more short term one, with contract expanding for a year. This is essentially to avoid loss due to land degradation, groundwater failure and decrease in crop productivity. Such increase in tenancy farming also shows influence of urban processes. Discussion with the farmers in Bodai and Tihuria showed that majority of the land that has been leased out are either belongs to zamindars, absentee owners, cultivators of the nearby villages. Tenancy varies between 60:40 sharing along with cost of water and other inputs. Many a times the tenancy farmers either pay no rents and forcefully occupy the lands or bargain for small fixed kind of payments.

Figure 5.9 – Percentage of total operated (Bodo and Aman Paddy) area under tenancy, Kolkata, 2016



Source: Primary survey.

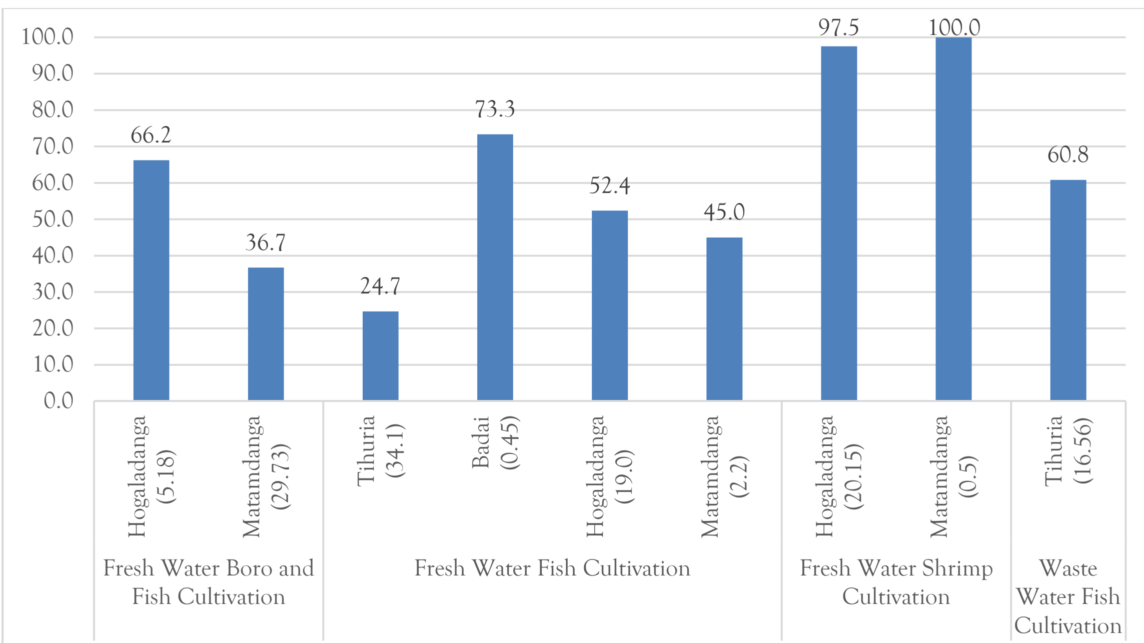
Figure 5.10 – Percentage of total operated area (Bodo and Aman Paddy) under tenancy, Khulna, 2016



Source: Primary survey.

For Boro paddy since last 5 years tenancy has increased in Hogladanga, while lowered down in Matomdanga (figure 5.10). For Aman opposite trend can be seen. Such trend is a probable effect of the agricultural land conversion rampant in Matomdanga. Boro, a groundwater based summer paddy has higher input cost with complex tenancy agreement. Aman on the other hand being a rainfed crop generally incurs less input cost. Matomdanga has seen major land acquisition by government and private enterprises for non-agricultural use. This further increases land fragmentation making it unprofitable for groundwater intensive boro cultivation.

Figure 5.11 – Percentage of total operated area (aquaculture) under tenancy, 2016



Source: Primary source. Total land (acre) in parantheses.

Among aquaculture practices, the highest tenancy is seen in the freshwater shrimp followed by freshwater fisheries and freshwater fish and boro. Such diversity in the tenancy to a great extent emphasize influence of urban demands, changing landuse, opportunities and access to groundwater resources. Matamdanga shows maximum incidence of freshwater shrimp as subsidiary occupation.

6 Conclusions

(i) Groundwater forms the most critical consumptive source for the peri-urban communities and the trend is quite similar for both Khulna and Kolkata. The surface water through piped network caters to very few households in Kolkata, with complete absence in Khulna. Even such surface water network has elements of groundwater where aquifer is pumped to compensate the supply by the authorities.

(ii) Groundwater ownership domain largely remained private and informal giving scope for its unregulated extraction. The stress in the aquifer is both observed through declining trend of the water level data as well as household's perception particularly in case of peri-urban Khulna. Yet, the causal factors for such decline can be more attributed to the groundwater intensive agricultural practices happening outside the village boundary and within larger hydrogeological setting of Bangladesh. Declining trend of the groundwater level as explained by the scientific data for Kolkata has not been complimented by people's perception.

(iii) Insufficiency of the public sources (deep tubewells, common stand posts, hand pumps) have been reported in all the four cases which points out to the institutional neglect that these peri-urban areas are facing. Infrastructural challenges, erratic supply, poor operation and maintenance of the public water supply is commonly reported as factors responsible for such insufficiency of the public sources.

(iv) Insufficiency of the public drinking and domestic water sources are managed through construction of private and often informal tube wells. Rich aquifer, lack of public sources and regulatory fluidity to construct shallow tubewells has created opportunities for the rampant construction of hand pumps for drinking and domestic consumption in all the cases. Construction of illegal deep tube wells for household consumption is more in Khulna pointing towards regulatory failure at large. Economic status of the households determines the access to these sources where poorest have reported to be dependent on untreated public water sources.

(v) Insufficiencies are often been compensated by vended water precariously observed in the villages of per-urban Kolkata. The trend has cut across economic and social groups. Such shift has not only created an informal groundwater market where informality and lack of regulation impacted already strenuous shallow aquifer.

(vi) Insufficiency managed through collective sharing of the deep and shallow tubewells is more of a function of social identities particularly caste and religion observed in cases of Khulna.

(vii) Impact of urbanization is more critically played out in terms of groundwater quality. All the four villages have become the sink for hazardous waste. Dumping of urban and industrial wastes, overflowing of pollute water from shrimp farms has causes land degradation and pollution of surface channels and shallow aquifer. While poorest of the peri-urban groups are dependent on the polluted shallow tubewells richer sections moved towards deep private tubewells particularly observed in case of Khulna. Households of Bodai and Tihuria depend more on the paid sources.

(viii) Agriculture forms the primary livelihood options for majority of the households across four cases. Diversified non-agricultural choices are also high among households particularly for peri-urban Kolkata. Agriculture with boro paddy continues to be intensively irrigated in nature with groundwater as the primary source. Urbanization has influenced the traditional cropping system where shift towards commercial monoculture of fisheries can be seen in Tihuria, Matamdanga and Hogladanga. Such a shift has diversified the irrigational sources with greater dependence on surface water (Khals of Hogladanga and Matamdanga and waste water canal of Tihuria). However in each of the aquaculture systems practiced (fresh water fish and boro paddy, fresh water fisheries, shrimp culture and wastewater fishing) in the study sites, groundwater is pumped into to maintain the water level. Such pumping is unregulated and illegal and points towards diversification of groundwater use.

(ix) Degree of inequalities is sharper in shrimp and wastewater aquaculture system. Controlled by few urban elites and economic powerful locals in shrimp and waste water fisheries not only reflects power play but greater control of the aquifer in a different and diffused manner. The degree of extraction on groundwater as reflected in the pumping hours in boro cultivation has increased over last 5 years.

References

Akteruzzaman, M, Mandal, MAS, & Miah, MTH. 1993. Productivity and equity performance of deep tubewell irrigation under different management systems in Chandina Thana of Comilla District. *Bangladesh J. Agric. Eco.*, Vol. 16, Issue 1, 77–88.

Basu, Jayanta. 2015. *Kolkata, a water-rich city turning water-poor*. The third pole, November 11. Available at: https://www.thethirdpole.net/2015/11/11/kolkata-a-water-rich-city-turning-water-poor/

Ranganathan, Malini, Kamath, Lalitha & Baindur Vinay. 2009. Piped Water Supply to Greater Bangalore: Putting the Cart before the Horse? *Economic & Political Weekly*, Vol. 44, No. 33, pp. 53-62.

Allen, A, Dávila, JD, & Hofmann, P. 2006a. *Governance of water and sanitation for the peri- urban poor: a framework for understanding and action in metropolitan regions*. London: University College London, Development Planning Unit.

Allen, A, Dávila, JD, & Hofmann, P. 2006b. *So close the city, so far from the pipes*. London: University College London, Development Planning Unit.

Allen, A, Hofmann, P, & Griffiths, H. 2007. *Rural–urban linkages for poverty reduction*. Report commissioned by IDRC/UPE and UN-Habitat for the State of the World's Cities Report 2008: Creating Harmonious Cities.

Allen, A, Hofmann, P, & Griffiths, H. 2008. *Moving down the ladder: governance and sanitation that works for the urban poor*. Discussion paper commissioned by IRC for the Symposium: Sanitation for the Urban Poor.

Banerjee, Parthasarathi. 2006. Land Acquisition and Peasant Resistance at Singur. *Economic & Political Weekly*, Vol. 41, No. 46, pp. 4718-20.

Bose, Sugata. 1993. *The New Cambridge History of India: Peasant Labour and Colonial Capital*. Cambridge University Press, Cambridge.

Cochran, WG. 1963. *Sampling techniques*. New York: John Wiley & Sons.

DAE, 1994. *National survey on performance of irrigated agriculture 1992–93*. Department of Agriculture Extension, Ministry of Agriculture, Government of the People's Republic of Bangladesh, Dhaka.

Dasgupta, Biplab. 1984. Agricultural Labour under Colonial, Semi-Capitalist and Capitalist Conditions: A Case Study of West Bengal. *Economic & Political Weekly*, Vol. 19, No. 39, pp. A129-A133+A136- A148.

Friedmann, John. 2011. Becoming Urban: Periurban Dynamics in Vietnam and China — Introduction. *Pacific Affairs*, Vol. 84, No. 3, pp. 425-34.

Harriss-White, Barbara, Rogaly, Ben, & Bose, Sugata. 1995. Sonar Bangla- Agricultural Growth and Agrarian Change in West Bengal and Bangladesh. *Economic & Political Weekly*, Vol. 30, No. 29, pp. 1862-1868.

Harvey, D. 2003. The right to the city. *International Journal of Urban and Regional Research*, Vol. 27, Issue 4, pp. 939–941.

Heynen, N, Kaika, M, & Swyngedouw, E. 2006. *Urban political ecology: politicizing the production of urban natures*. In: Heynen et al. (Eds.), In the nature of cities: Urban political ecology and the politics of urban metabolism. Routledge.

IIMI, 1996. *A study on privatization of minor irrigation in Bangladesh, Final Report.* International Irrigation Management Institute (IIMI) with the Bureau of Socioeconomic Research and Training of the Bangladesh Agricultural University, Bangladesh.

Kalyan, Rudra. 2014. Changing river courses in the western part of the Ganga–Brahmaputra delta. *Geomorphology*, Vol. 227, pp. 87-100.

Kulkarni, Himanshu & Shankar, PS Vijay. 2014. Groundwater resources in India: an arena for diverse competition. *Local Environment*, Vol. 19, Issue 9, pp. 990 – 1011.

Lefebvre, H. 1996. *The right to the city*. Writings on cities, 63-181.

Mallik, Chinmoyee. 2014. Land Dispossession and Rural Transformation: The case of Fringe Villages of Kolkata. *Journal of Rural Development*, Vol. 33, No. 1, pp. 51-71.

Mehta, L. 2003. *Struggles around "Publicness" and the right to access: perspec- tives from the water domain*. In I. Kaul (Ed.), Global public Goods: Making Globalisation work for all. New York: Oxford University Press.

Mehta, Lyl & Karpouzoglou, Timothy. 2015. Limits of policy and planning in peri-urban waterscapes: The case of Ghaziabad, Delhi, India. *Habitat International*, Vol. 48, pp. 159-68.

Mehta, Lyla *et al*. 2014. Global environmental justice and the right to water: The case of peri-urban Cochabamba and Delhi. *Geoforum*, Vol. 54, pp. 158–166.

Michael, A Holly & Voss, I Clifford. 2009. Controls on groundwater flow in the Bengal Basin of India and Bangladesh: regional modeling analysis. Hydrogeology Journal, Vol. 17, No. 7, p. 1561.

Michael, Holly A. & Voss, Clifford. 2008. *Evaluation of the sustainability of deep groundwater as an arsenic-safe resource in the Bengal Basin*. Proceedings of the National Academy of Sciences of the United States of America, Vol. 105, No.25, pp. 8531-6. Available at: http://www.jstor.org/stable/25462820

Mirjahan, M. 1984. *Evaluation of some selected deep tubewell irrigation systems in Bangladesh.* Water Resources Engineering Department, Bangladesh University of Engineering and Technology, Dhaka, Bangladesh J. Water Resources Res. 5 (1), 25–35.

Mondal, M. Shahjahan, Saleh, Abul Fazal M. 2003. Evaluation of some deep and shallow tubewell irrigated schemes in Bangladesh using performance indicators. *Agricultural Water Management*, Vol. 58, Issue 3, pp. 193–207.

Naraian, Vishal. 2016. Peri-Urbanization, Land Use Change and Water Security: A New Trigger for Water Conflicts? *IIM Kozhikode Society and Management Review*. Available at: http://journals.sagepub.com/doi/full/10.1177/2277975215617267

Narain, Vishal *et al.* 2013. Urbanization, peri-urban water (in) security and human well-being: A perspective from four South Asian cities. *Water International*, Vol. 38, Issue 7. Available at: http://www.tandfonline.com/doi/abs/10.1080/02508060.2013.851930?journalCode=rwin20

Purcell, M. 2003. Citizenship and the right to the global city: reimagining the capitalist world order. *International journal of urban and regional research*, Vol. 27, Issue 3, pp. 564-90.

Rao, Ursula. 2010. Making the Global City: Urban Citizenship at the Margins of Delhi. Ethnos: *Journal of Anthropology*, Vol. 75, Issue 4, pp. 402-24.

Rashid, M.H., Mridha, MAK. 1997. *Command area development of deep tubewell schemes*. In: Proceedings of the Joint International Conference on Agricultural Engineering and Technology, Vol. 3, Bangladesh Society of Agricultural Engineers, pp. 800–6.

Rawal, Vikas & Swaminathan, Madhura. 1998. Changing Trajectories: Agricultural Growth in West Bengal, 1950 to 1996. *Economic & Political Weekly*, Vol. 33, No. 40, pp. 2595-602.

Ray, Sreerupa & Ghosh, Dhrubajyoti. 2007. Modern Agriculture and the Ecologically Handicapped: Fading Glory of Boro Paddy Cultivation in West Bengal. *Economic & Political Weekly*, Vol. 42, No. 26, pp. 2534- 42.

Reddy, V Ratna, Reddy, B Suresh. 2007. Land Alienation and Local Communities Case Studies in Hyderabad-Secunderabad. *Economic & Political Weekly*, Vol. 42, No. 31, pp. 3233-40.

Srinivasan Veena et al. 2013. The impact of urbanization on water vulnerability: A coupled human– environment system approach for Chennai, India. *Global Environmental Change*, Vol. 23, Issue 1, pp. 229–239.

Steinberg, NC. 2013. Losing water in a fight for land: examining water access amidst land acquisition in Northwest India. *Contemporary South Asia*, Vol. 21, Issue 2, pp. 148-68.

STEPS and Sarai. 2010. *Contesting Sustainabilies in the Peri Urban Interface*. Research Report, STEPS Centre, Brighton.

Swyngedouw, E. 1999. Modernity and hybridity: nature, regeneracionismo, and the production of the Spanish waterscape, 1890 – 1930. *Annals of the Association of American Geographers*, Vol. 89, No. 3, pp. 443-65.

Szpiro, George G. 1987. Hirshman versus Herfindahl: Some topological properties for the use of concentration indexes. *Mathematical Social Sciences*, Vol. 14, Issue 3, pp. 299-302.

Water-Excreta Survey. 2005-06. *Centre for Science and Environment*, New Delhi.

Zeitoun, M. 2013. Global environmental justice and international transboundary waters: an initial exploration. *The Geographical Journal*, Vol. 179, pp. 141–49.

Annexure tables

A3.1 – Percentage distribution of sample households by primary construction material of the housing unit's exterior walls, 2016

Material	Tihuria	Badai	Hogaladanga	Matamdanga	Total
Reinforced concrete	0	0	3	7.5	2.2
Stone & mortar	1.6	0	0	0	0.4
Cement blocks	0.8	0	4	10.8	3.3
Brick (fired/ burnt)	72.7	96.9	31	50.5	65.9
Metal sheeting	1.6	0	20	4.3	5.8
Logs or thick wood	0	0	5	0	1.1
Thin wood	0.8	0	11	1.1	2.9
Bamboo	7.8	0.8	11	5.4	6
Brick (mud or earth)	3.9	2.3	6	11.8	5.5
Earth or adobe	10.9	0	8	6.5	6.2
Reeds/ thatch	0	0	1	2.2	0.7
Total (%)	100	100	100	100	100
Total households	128	130	100	93	451

Source: Primary survey.

A3.2 – Percentage distribution of sample households by primary construction material of the housing unit's main roof, 2016

Material	Tihuria	Badai	Hogaladanga	Matamdanga	Total
Roofing shingles	1.6	0.8	7	10.8	4.4
Ceramic tiles	36.7	29.2	0	2.2	19.3
Synthetic roofing/ asbestos	35.2	13.1	22	24.7	23.7
Metal sheeting	0.8	1.5	61	46.2	23.7
Metal or concrete	25.8	55.4	2	12.9	26.4
Bamboo	0	0	0	1.1	0.2
Straw or reeds	0	0	8	2.2	2.2
Total (%)	100	100	100	100	100
Total households	128	130	100	93	451

Source: Primary survey.

A3.3 – Kind of food preparation area in the household (%), 2016

Area	During winters					During rest of the year				
	Tihuria	Badai	Hogaladanga	Matamdanga	Total	Tihuria	Badai	Hogaladanga	Matamdanga	Total
No food preparation area	4.7	3.1	3	1.1	3.1	4.7	3.1	3	1.1	3.1
Food preparation area outsite the house	51.6	21.5	67	90.3	54.3	49.2	20.8	52	73.1	46.6
Food preparation area inside the home with minimal facility	13.3	21.5	24	8.6	17.1	13.3	22.3	37	25.8	23.7
Food preparation area inside the home with a stove (at least one burner and a fuel source)	7.8	31.5	1	0	11.5	8.6	30.8	2	0	11.8
Food preparation area inside the home with a stove and an oven (any size any fuel source)	20.3	15.4	3	0	10.9	22.7	16.2	4	0	12
Food preparation area inside the home with a refrigerator or freezer (any size)	1.6	5.4	2	0	2.4	1.6	5.4	2	0	2.4
Food preparation area inside the home with stove, oven, refrigerator, freezer	0	1.5	0	0	0.4	0	1.5	0	0	0.4
Other	0.8	0	0	0	0.2	0	0	0	0	0
Total (%)	100	100	100	100	100	100	100	100	100	100
Total households	128	130	100	93	451	128	130	100	93	451

Source: Primary survey.

A3.4 – Hand washing practice before eating a meal among sample households (%), 2016

Hand washed	Tihuria	Badai	Hogaladanga	Matamdanga	Total
Never	0.0	0.0	0.0	1.1	0.2
Rarely	0.0	0.0	6.0	4.3	2.2
Sometimes	0.8	1.5	10.0	11.8	5.3
Often	3.9	14.6	23.0	17.2	14.0
Always	95.3	83.8	61.0	65.6	78.3
Total (%)	100	100	100	100	100
Total households	128	130	100	93	451

Source: Primary survey.

A3.5 – Use of soap by adult members of the household while cleaning hands (%), 2016

Soap used	Tihuria	Badai	Hogaladanga	Matamdanga	Total
No	3.9	1.5	2.0	0.0	2.0
Yes, but very rarely	4.7	0.0	19.0	7.5	7.1
Yes, but only when guest visit	0.8	0.0	2.0	1.1	0.9
Yes, after defecating	69.5	74.6	41.0	50.5	60.8
Yes, before meals	2.3	3.8	4.0	2.2	3.1
Yes, after defecating and before meals	18.0	19.2	32.0	38.7	25.7
Other	0.8	0.8	0.0	0.0	0.4
Total (%)	100	100	100	100	100
Total households	128	130	100	93	451

Source: Primary survey.

A3.6 – Household head's ability to read newspaper (%), 2016

Ability	Tihuria	Badai	Hogaladanga	Matamdanga	Total
No	53.1	52.3	81	83.9	65.4
Yes, with difficulty	7.8	14.6	14	10.8	11.8
Yes, without difficulty	39.1	30	5	4.3	21.7
Do not know	0	0	0	1.1	0.2
No response	0	3.1	0	0	0.9
Total (%)	100	100	100	100	100
Total households	128	130	100	93	451

Source: Primary survey.

A3.7 – Highest level of schooling that female children in the household are likely achieve (%), 2016

Level	Tihuria	Badai	Hogaladanga	Matamdanga	Total
No response	0	0.8	1	1.1	0.7
Don't know	10.2	4.6	4	3.2	5.8
No female children	60.9	58.5	31	23.7	45.9
No formal education	0	0	0	2.2	0.4
Primary School (age 5/6 untill age 11/12)	0	0	6	5.4	2.4
Junior school (age 11/12 until age 14/15)	0.8	0.8	3	7.5	2.7
High school (age 14/15 until age 18/19)	9.4	7.7	12	23.7	12.4
Technical/ vocational school (post junior or high school usually for 2 years)	0.8	0.8	1	0	0.7
College or university (post high school 3-5 years)	14.8	25.4	26	25.8	22.6
Advanced degree (master/ PhD)	3.1	1.5	16	7.5	6.4
Total (%)	100	100	100	100	100
Total households	128	130	100	93	451

Source: Primary survey.

Shifting Grounds: Institutional transformation, enhancing knowledge and capacity to manage groundwater security in peri-urban Ganges delta systems

The project aims to build knowledge and capacity among local actors to support a transformation process in peri-urban delta communities in Bangladesh and India for a pro-poor, sustainable and equitable management of groundwater resources across caste/class and gender. This will be based on an improved understanding of the dynamic interplay between local livelihoods, the groundwater resource base, formal and informal institutions and links with nearby urban centres in Khulna and Kolkata. These two cities provide a good basis for an institutional comparison, being part of the same Ganges delta system, yet located in different countries.

Funded by the Netherlands Organisation for Scientific Research (NWO), the Shifting Grounds project is executed by a group of academicians, researchers and civil society organisations. Delft University of Technology (TU Delft) leads the consortium and SaciWATERs is the regional coordinator for the project. Other project partners are Jagrata Juba Shangha (JJS), The Researcher, Bangladesh University of Engineering and Technology (BUET) and Both ENDS.

TU Delft · SaciWATERs SOUTH ASIA CONSORTIUM FOR INTERDISCIPLINARY WATER RESOURCES STUDIES · Both ENDS Connecting people for change · JJS Jagrata Juba Shangha

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