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Mapping Institutions for Assessing Groundwater Scenario in West Bengal, India

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MAPPING INSTITUTIONS FOR ASSESSING GROUNDWATER SCENARIO IN WEST BENGAL, INDIA

Madhavi Marwah*

Abstract

With the growing realisation that the policies towards 'getting property rights right' and 'getting prices right' do not work well in natural resource management, increasing focus is being given to 'getting institutions right'. The current study assesses and analyses West Bengal's groundwater management from an institutional perspective. The case of West Bengal proves interesting since it is dealing with a major environmental issue of arsenic contamination in groundwater, while the formal institutional set-up is aimed at liberalising groundwater extraction for agriculture. Based on the analysis of relevant secondary data and primary survey data from sample villages, the study brings forth the linkages between various institutional factors and their implications for sustainable groundwater use in West Bengal. The concluding section summarises the findings and draws out lessons for policy.

Key words: groundwater, institutions, quality, arsenic, West Bengal

Introduction

Examining the relevant institutions and the dynamics within and across these institutions proves insightful with regard to understanding the scenario of a particular resource and the state of resource management. The significant role of institutions in natural resource management is emphasised with Williamson's recognition of the present era being the era of "getting institutions right" as opposed to effective and efficient pricing and/or establishing property rights (Williamson 1994).

While defining the term 'institution' in tandem with Douglass North's understanding of the term as the 'set of working rules' in society or 'humanly devised constraints that shape human interaction' implies that organizational and administrative set-up, laws and legislations being followed, norms, traditions and customs in society are all classified as 'institution' (North, 1990).

Taking the specific case of groundwater management as an irrigation source for the state of West Bengal, this paper aims to decipher the status of groundwater management – both quantity and quality aspects – by decomposing the role of relevant institutions and linkages between them. By highlighting the significance of institutional aspects in groundwater management, the analysis carried out in the paper through the lens of institutional economics shows the pathways for effectively addressing the twin concerns of quantity depletion and quality degradation of groundwater, and the implications thereof for agricultural production.

An analytical framework is developed for understanding the role of institutions in managing groundwater use for irrigation in West Bengal. West Bengal is a distinct case in terms of groundwater as it faces a major environmental concern of arsenic contamination in the aquifer. To analyse the role of institutions in managing the groundwater situation in West Bengal, the paper develops an analytical

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framework after a thorough review of the already existing frameworks on institutional analysis. These are the Institutions for Sustainability (IoS) framework, the Institutional Analysis and Development (IAD) framework, and the Institutional Decomposition and Analysis (IDA) framework. Several institutions are identified based on a review of relevant literature as well as primary survey in some selected villages of West Bengal. The analytical framework provides the basis for exploring the linkages between various institutions and how these in turn feed into the dynamics of West Bengal's current groundwater scenario.

Statement of the Problem

Much of eastern India is underlain by alluvial aquifers not susceptible to quantity depletion of groundwater, but rather quality problems. Being a high rainfall region, its highly porous alluvial soils ensure good recharge of groundwater. What calls for attention, however, is the fact that the groundwater aquifers in some parts of this region, specifically West Bengal, are infested by geologically occurring arsenic (see Figure 1 – red areas have above permissible limit of 0.1 mg per litre of arsenic in groundwater).

Figure 1: Arsenic Map of India

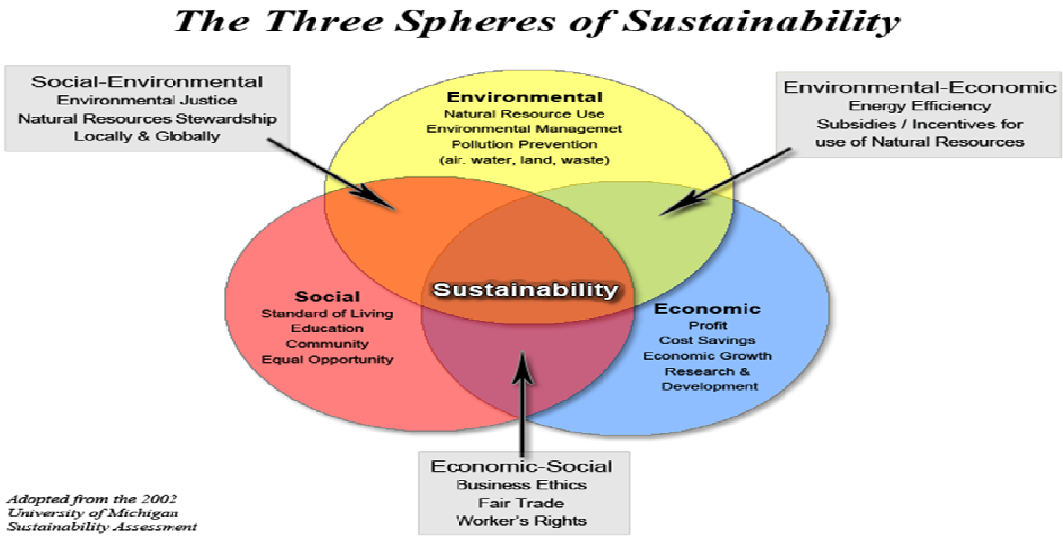
Source: Arsenic Knowledge and Action Network, http://www.arsenicnetwork.in/drinking-water/

Arsenic contamination in groundwater poses a serious threat to the sustainability of agriculture and human health in regions where this contaminated groundwater is the primary source of irrigation. There is abundant scientific evidence pointing towards the deterioration in soil fertility on account of arsenic accumulation in soil which results in a decline in the yields of several crops. Khan *et al* (2010) for instance, found that arsenic addition in water or soil resulted in yield reductions from 21 to 74 per cent in *boro* (summer) rice and 8 to 80 per cent in *aman* (winter) rice, the latter indicating the strong residual effect of arsenic on subsequent crops. In a controlled pot experiment study, Abedin *et al* (2002) found that arsenate contaminated irrigation water accounted for 26, 38, 56 and 65 per cent rice yield reduction by the addition of 1, 2, 4 and 8 mg arsenic, respectively.

The cause for concern emanates from the fact that the policy arena seems oblivious to the threatening impacts of using arsenic-contaminated water for irrigation. Given that the north-western states which were once known as the 'Food Bowl of India' have failed to meet India's growing food requirements, the government has turned its focus towards eastern India to harbour and harness a second 'Green Revolution'. In this regard, policies aimed at the liberalisation of groundwater use in agriculture have taken shape, since the resource is not over-exploited as such.

'Sustainability' as a concept in any given context can be identified as the intersection between three spheres or realms, i.e. economic, social and environmental. It encompasses economic considerations such as efficiency, net profit, growth and development, social considerations relating to equity, as well as environmental aspects focussing on management of quantity and quality of natural resources (see Figure 2).

Figure 2: Three Spheres of Sustainability



Source: Vanderbilt University, Center for Teaching https://wp0.vanderbilt.edu/cft/2010/08/new-cft-guide-on-sustainability-and-pedagogy/ven-sus/

Hence, sustainable agricultural production implies that agricultural production continues without any significant alterations to the economic characteristics, social aspects and the natural resources within the system. Our hypothesis is that in arsenic infested areas, sustainability of agricultural production is under threat, given the implications of declining soil fertility and consequent crop yield deterioration.

This paper aims to analyse the issue from the lens of institutional economics given the premise that institutions affect human behaviour and play an important role in natural resource management. Institutions like social norms and traditions, property rights and pricing policies affect people's behaviour. The design of economic and political institutions can be used to manage environmental degradation. Therefore, given West Bengal's vibrant set of formal and informal, economic, political and social institutions, we try to assess the role of these institutions in managing agricultural sustainability in the wake of arsenic contamination in the state.

Review of Literature

Relevant literature has been reviewed and presented in two sections; the first is a review of the theoretical studies dealing with an understanding of institutions and the frameworks on institutional analysis, whereas the second section focusses on empirical studies explaining the role and dynamics of institutions in the specific context of West Bengal's groundwater management.

• Theoretical review

The theoretical review is divided into two sub-sections; the first looks at the definition of the term 'institution' and the second delves into the important frameworks applied in the study of institutions.

o Understanding the term 'institution'

While the use of the term 'institution' dates back many centuries, there was no clarity of the interpretation of the term. It was often confused with 'organizations' (Bandaragoda, 2000). The understanding broadened with the advent of philosophers such as Ciriacy-Wantrup, who explained institutions as the "decision rules" which enable the adjustment of conflicting demands and interests across different groups in a society (Ciriacy-Wantrup and Bishop, 1975). This definition was still limited in its interpretation as it did not encompass all the different types of "rules" guiding peoples' decisions and actions such as norms, habits, traditions and customs.

The most concise definition was given by North (1990) in his book *Institutions, Institutional Change and Economic Performance* wherein he described institutions as "rules of the game in a society" or in other words, "humanly devised constraints that shape human interaction". Similarly, Ostrom (1990) defined institutions as the "set of working rules" which enable decision-making and determine the actions which can and cannot be undertaken in society. These rules also define who the decision-makers are, and what returns each individual or group of individuals must receive for his actions. This definition is in line with the "rules-in-use" interpretation of institutions given by Hodgson (2006). Hodgson explains the term "institutions" as "systems of established and prevalent social rules that structure social interactions" and these rules may either constrain or enable human actions. While rules in themselves act as constraints to behaviour, these constraints in turn allow for possibilities that would not otherwise exist. Here, he cites the example of traffic rules which constrain people's actions on the road, but the existence of these rules allows for smooth travel (ibid.). However, only those laws which have been enforced and in practice become classified as a rule. Laws which are largely neglected and do not influence people's behaviour are not rules (Hodgson, 2006).

The term 'institution' is a multi-dimensional concept, in the sense that it can be segmented at different levels: formal or informal (North, 1990), macro or micro (The World Bank, 2010), institutional environment or institutional arrangements (Saleth and Dinar, 2004). Williamson (2000) provides a four-level distinction of institutions: informal institutions, institutional environment, governance and resource allocation.

Codified rules, such as the Constitutional provisions and other laws, form part of the formal institutions. Informal institutions guide the course of action for formal institutions, in how they are used. The importance of informal institutions becomes clear when we compare two countries with the same

set of formal institutions in the context of a particular 'action arena'. Acemoglu (n.a.) notes that at the send of the World War II, North and South Korea were homogenous, but then followed two different paths of building economic and political institutions. North Korea went in for communism whereas South Korea became a capitalistic economy. Thus two countries which administered the same laws and formal rules have very different resultant outcomes and this can be explained on account of the disparities in their informal institutional setup. While GDP per capita of the two countries was similar in 1970, South Korea's GDP had multiplied five times by 1998, whereas North Korea's GDP was even lower than that of the 1970 level.

The macro and micro level distinction of institutions is not always consistent with the classification of formal versus informal institutions. In the Indian context, the classification can be further extended to include meso (middle) level institutions so that institutions at national level are considered as 'macro', those at state level as 'meso' and village or other community level institutions are classified as 'micro'.

Williamson (2000) explains four levels at which institutions exist. First is the level of informal institutions including customs, traditions, norms, religion and so on. The second level is the institutional environment comprising formal rules, regulations and laws. The third level in his framework is governance which consists of contracts and agreements between groups of people in a society. The fourth level is that of resource allocation and it deals with the production function.

Understanding the term 'institution' requires thinking deeper about the functioning of society and cannot be analysed through simple logical constructs. Why a person does what he does, i.e. his actions and why he chooses what he chooses, i.e. his choices, provide insights into society's functioning. Similarly, interactions between people result in certain decisions and actions in society which are undertaken jointly by different groups of people in society. These actions and decisions may be one-time events or informal agreements or arrangements that sustain over a period of time, until some other event causes the arrangement to dissolve or fall apart. Therefore, decisions and actions as well as the trigger for the decision or action can be an 'institution'. In other words, the concept of 'institution' extends far beyond the realm of formal rules, laws, policies and organisations within which the society functions. Rules and norms which govern the behaviour of people as well as patterns of behaviour themselves classify as institutions. These rules and norms may be formal or informal arrangements between people or groups of people.

o Frameworks on institutional analysis

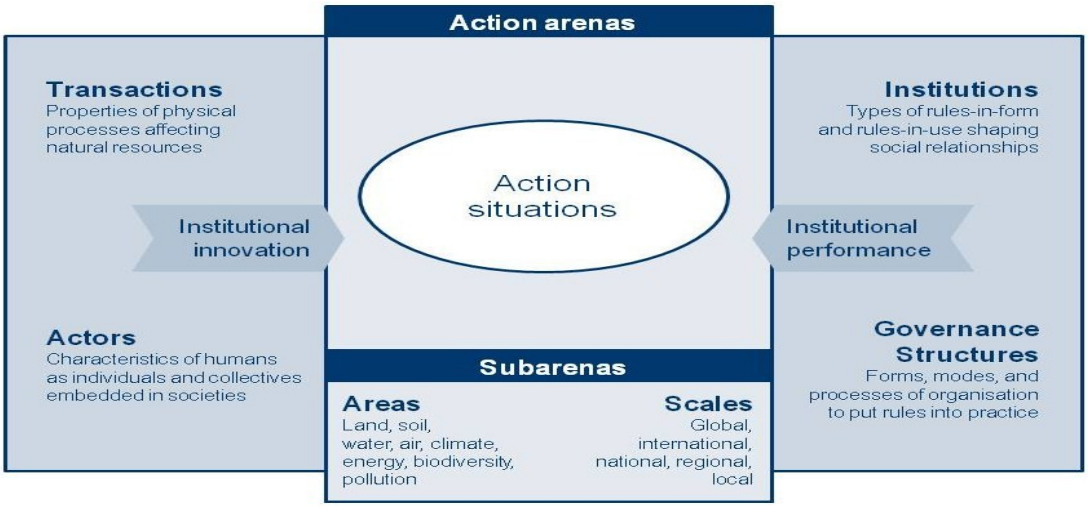
This section provides a detailed review of the existing frameworks on institutional analysis, which enables us to build our own framework suitable to the current study.

(i) Institutions of Sustainability (IoS) framework

'Institutions of sustainability' are defined as institutions which arise for the purpose of coordination of the co-evolution of social-ecological systems (SES). There are four key elements which form the basis for interactions in a SES. These are: Transactions, actors, institutions and governance structures (see Figure 3).

The IoS framework basically suggests that the properties of the respective transactions and the characteristics of the involved actors determine which institutions (sets of rules) develop and through which governance structures (organisational forms) these institutions will in practice be implemented. The framework explains how institutional innovation and institutional performance affect the 'action arenas'.

Figure 3: IoS Framework



Source: Humboldt Universitat zu Berlin, Albrecht Daniel Thaer – Institute of Agricultural and Horticultural Sciences, https://www.agrar.hu-berlin.de/en/institut-en/departments/daoe/ress-en/forschungskonzep-en/IoS-en

Developing countries often lack the institutional capacity to tackle developmental problems such as poverty, hunger and malnutrition and degradation of natural resources. It may be understood that these problems do not exist in isolation and it is likely that resource degradation consequently results in poverty and insufficient food supply. Hence, the institutionalisation of sustainable use of natural resources is particularly relevant in a developing country context.

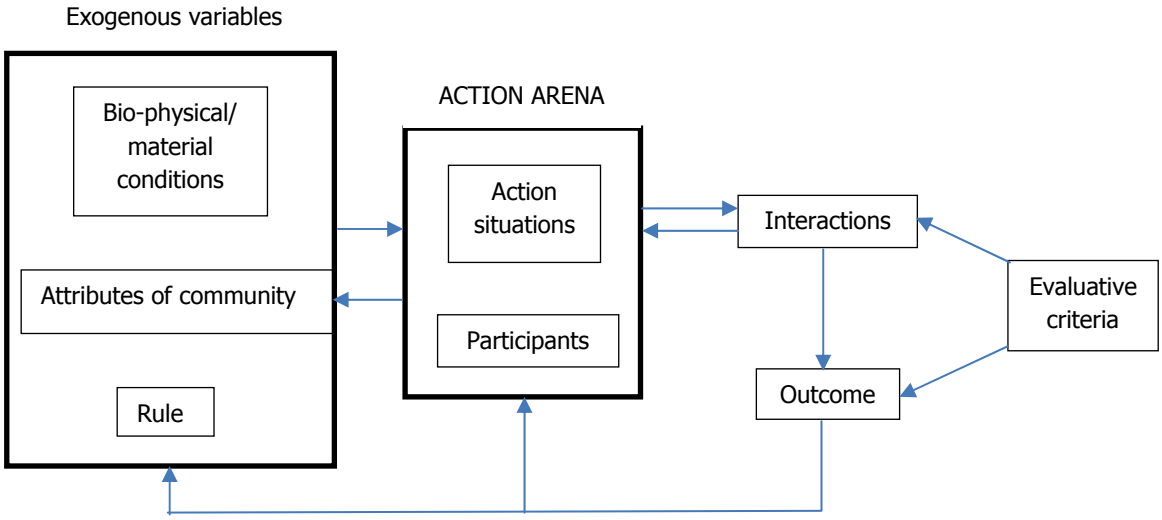
(ii) Institutional Analysis and Development (IAD) framework

This framework has useful application in analysing and understanding different kinds of institutional arrangements in both developed and developing countries. Such applicability in turn facilitates the comparison of performance of various institutions in a given context, since it makes no prior assumption about the preference or superiority of one institution over another. IAD is unique in the sense that it incorporates the role of exogenous or context-specific factors other than institutions and also the entire gamut of transaction costs.

It begins by defining the 'action arena' under consideration. The 'action arena' is a social space where individuals interact, exchange goods and services, solve problems and so on. After understanding the structure of the 'action arena', the framework then allows an inquiry into the factors which affect the 'action arena' (see Figure 4). It further assesses how a shared understanding of rules, states of the world and nature of the community alter parts of the 'action arena' (Ostrom, 1990).

However, the IAD framework has certain drawbacks. The framework is limited in its scope for exploring and understanding the inter-connections between formal institutions and the 'rules-in-use' in society. While at times those two categories of rules seem to overlap, in other cases, they seem to differ significantly or to bear little relation to one another.

Figure 4: IAD Framework



Source: Ostrom (1990)

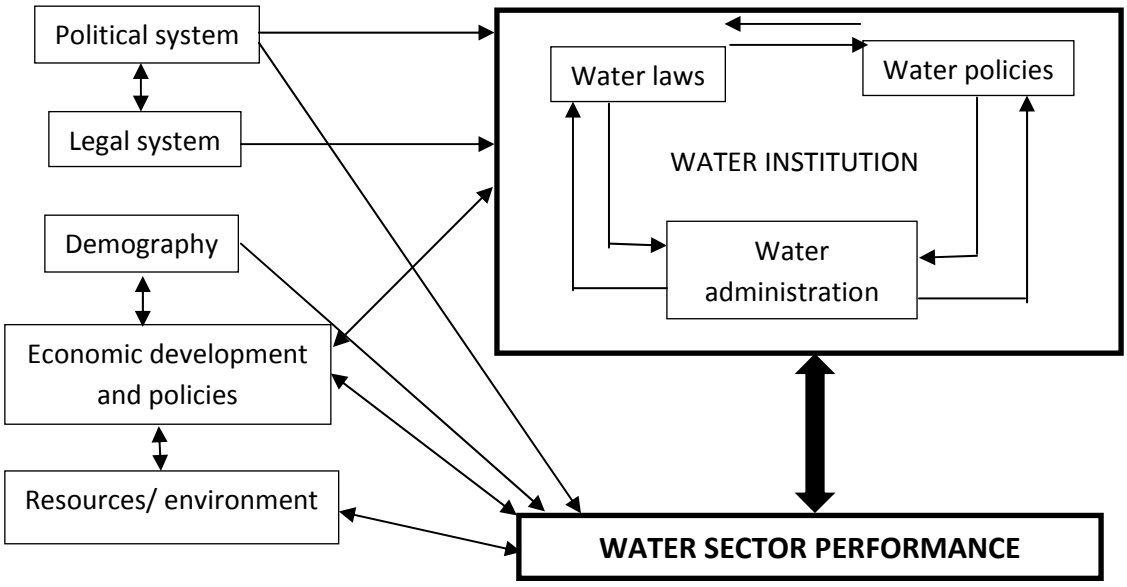
Another problem is that the variables preceding the action arena which have been referred to as "exogenous" are actually endogenised to the framework by virtue of the feedback loops from the 'outcomes'. This is primarily because patterns of interaction can and do affect biophysical conditions, community attributes and rules (Ostrom 1990).

(iii) Institutional Decomposition and Analysis (IDA) framework

Institutions are known to function as a system that consists of a complex set of relationships. Given the difficulty in evaluating the impacts of various institutional components in isolation from the inter-connected components, decomposition as an analytical approach becomes relevant. Saleth and Dinar (2004) observe that this approach of institutional decomposition was popularised by earlier thinkers - North (1990) mentioned 'components of institutions' and Williamson (1994) came up with four levels of institutions. In sum, the common recognition among those subscribing to the institutional decomposition approach is that institutions are not a single entity, but rather evidently composed of 'analytically and functionally distinguishable elements'.

IDA framework is a useful methodology for unbundling institutions, which by analysing linkages between institutional components facilitates the evaluation of the role of institutions in the performance of a particular sector. Saleth and Dinar (2004) applied the IDA framework for a macro level cross country analysis for the water sector in totality, covering all water sources and uses.

Figure 5: IDA Framework



Source: Saleth and Dinar (2004), p.104

The variables/factors on the left-hand side in Figure 5 are termed as 'exogenous factors', such that they are exogenous to the water sector. The components of 'water institution' i.e. water laws, water policies and water administration are further decomposed into specific sub-components and the linkages between each of them are identified[†].

Since the methodology for analysis is based on the perceptions of various stakeholders, the performance of the water sector is evaluated on subjective criteria: Physical performance, financial performance, economic performance, equity performance and overall performance.

Identifying objectively defined criteria for performance evaluation is a challenging task. Segregation of the impacts of institutional components and various exogenous factors on the sectors' performance is also difficult and can only be theoretically explained. The nature of 'institutions' is such that it would be difficult to estimate the extent of impact on performance with a given change in any of the institutional factors.

- **Empirical review**

There exists a plethora of studies analysing equity, efficiency and sustainability implications of groundwater markets in different states (Mukherji 2004; Manjunatha *et al* 2009; Chandrakanth 2015), the dynamics within such markets under diverse scenarios of metered electricity versus flat tariff system (Mukherji and Das 2012) and characteristics of the market where there is a predominance of diesel pump owners and so on. Furthermore, the importance of the strength of farmer lobbying as an institution is elucidated from a political ecology perspective by comparing two distinct cases – water scarce Gujarat and water abundant West Bengal (Mukherji 2006).

† These components are explained in a separate diagram by Saleth and Dinar, 2004 in their book *Institutional Economics of Water*

Mukherji (2004) traces the emergence and evolution of groundwater markets as a crucial rural institution in the Ganga-Meghna-Brahmaputra basin through a review of 13 studies on groundwater markets between 1974 and 2003. In the early phases of groundwater development, the act of selling water by pump owners was considered as a social taboo. Over time, however, economic logic dominated non-economic considerations and by the late 1990s, water selling became the norm rather than an exception. In addition, the concentration of pump ownership in the hands of dominant social and economic groups such as the large landowners and high caste families has become more diffused over a period of time. The changing terms of transaction in water markets with the installation of meters and implementation of time-of-day tariffs has been analysed by Mukherji and Das (2012). Therefore, by agricultural metering policy, a formal institution alters the internal functioning of an informal institution such as water market. The main finding of this study is that Bengali farmers i.e. water sellers did not object to the introduction of metered tariffs due to the fact that the previously administered flat tariff was higher than the bill received after metering, although the marginal cost of selling water became positive from zero. From the sustainability point of view, the progressive metering policy was aimed at curtailing wasteful groundwater extraction.

There are also certain non-market water sharing arrangements which exist in West Bengal's rural economy. Like farmer cooperative societies, there are tubewell cooperatives which provide pumps on custom-hiring basis at a rental cost (Rawal 2002). Such an institution possibly exists as a cheaper alternative to owning a pump individually and is likely to flourish in a community familiar with the system of cooperatives.

Rawal (2002) also observed joint tubewell ownership arrangements wherein a group of two or more farmers jointly invest in the capital cost of a water extraction mechanism (WEM), sharing the costs in equal proportion or proportionate to the land-holding sizes. Such arrangement is often observed when the WEM has been inherited by two or more brothers from the previous generation. Cost sharing in such circumstances differs from case to case; it may happen equally or proportionately to the land size.

Gram Panchayats (GP) in West Bengal are highly politicised and their role in the rural economy is inevitably critical. In lieu of the requirement of a permit from the State Water Investigation Directorate (SWID) prior to filing an application for electricity connection for extracting groundwater as per the West Bengal Ground Water Resources (Management, Control and Regulation) Act, 2005, Mukherji (2004) notes that "those who support the right party are given access to groundwater". In other words, the GP, at its discretion, has the power to have the permit granted or denied to any individual farmer depending on whether he supports the ruling party or not.

Meso level or state level institutional changes and their implications have also been analysed. Mukherji, Banerjee and Shah (2012) highlighted the major changes in formal institutions with a common view towards liberalising the extraction of groundwater for irrigation. In 2011, the government of West Bengal passed an amendment for one of the provisions in the West Bengal Ground Water Resources (Management, Control and Regulation) Act, pertaining to the mandatory requirement of a permit before installing a machine for extracting groundwater anywhere in the state. As per the amended provision, those operating a pump of 5 Horse Power (HP) or less with a discharge of up to 30

cubic metres per hour in the 301 'safe' blocks were exempted from the requirement of permit. This categorisation of blocks into 'safe', 'semi-critical', 'critical' and 'over-exploited' is undertaken at the national level by the Central Ground Water Board (CGWB), Government of India through the assessment of pre-monsoon and post-monsoon water levels in designated 'monitoring wells' (refer to Table A1). In the same year, 2011, the West Bengal State Electricity Distribution Company Limited (WBSEDCL) passed a policy resolution stating that it would provide electricity connections to users of groundwater for irrigation at a fixed fee ranging between Rs 1,000 and Rs 30,000 depending on the connected load. This aimed to overcome the previously stringent process and extra costs of wires, poles, etc. which had to be borne by users. Given that the state receives very high rainfall annually, implying a good rate of groundwater recharge, Mukherji, Shah and Banerjee (2012) foresee these policy changes as stepping stones towards "kick-starting a second Green Revolution in Bengal".

Study Area and Sampling Method

For substantiating with additional first-hand observations of institutional factors interwoven into the West Bengal rural economy and factoring in the utilisation and management of groundwater resources, a primary survey was undertaken in a few selected blocks of West Bengal during March and April 2017.

The main purpose of the sampling method was to undertake a comparative analysis of the agricultural scenario, with a focus on groundwater, across four types of regions – differentiated based on groundwater characteristics – encompassing broadly the determinants of groundwater use including the role of institutions.

Since there is no established relationship between groundwater depletion and the level of arsenic contamination, four blocks were chosen based on variation in groundwater quantity and quality parameters. Quantity depletion of groundwater is based on the 2013 CGWB assessment of long-term changes in the pre- and post-monsoon water level below the ground (CGWB, 2013), and groundwater quality dimension is confined to the extent of arsenic contamination. The arsenic level is averaged at block level based on testing from all drinking water wells in each block obtained by the Public Health Engineering Department, government of West Bengal, for the year 2015-16.

Table 1: Criteria for Selection of Blocks

	High arsenic level in groundwater	**No arsenic in groundwater**
Groundwater depletion	I	II
No groundwater depletion	III	IV

In other words, the blocks were chosen as follows:

- Block with highest average arsenic contamination among the groundwater depleted blocks. Raninagar-II block in Murshidabad district was the chosen block.
- Block with highest average arsenic contamination among the non-groundwater depleted blocks. Basirhat-I block in North 24-Parganas district was the block chosen in this category.

- Block with high groundwater depletion but no arsenic contamination. Goghat-II block in Hooghly district was selected since it is the only block in the state marked as 'critical'.
- Randomly selected block with neither depletion nor arsenic contamination. Here, Ausgram-I block in Bardhaman district was selected from the blocks in this category.

A sample of 55 to 60 households from each block, covering two villages in each block, were surveyed using an interview schedule, such that the total sample size was 230 households. The sample was purposively selected with at least 15 WEM owners selected in each block, so as to ensure a mix of both WEM owners and non-owners. Table 2 gives a general overview of the villages where the survey was conducted.

Table 2: General Profile of Sample Villages (As of 2011)

Block	RANINAGAR-II		BASIRHAT-I		GOGHAT-II		AUSGRAM-I	
Village	**Rakhaldaspur**	**Godhanpara**	**Sankchura**	**Panitar**	**Satberia**	**Agai**	**Alefnagar**	**Warishpur**
Gram Panchayat	Malibari-I	Raninagar-I	Sankchura Bagundi	Itinda Panitar	Kamarpukur	Bengai	Ausgram	Ausgram
Population	-	14,173	2548	13,947	1378	2090	2278	2223
Households	-	3352	596	3177	290	448	593	579
SC / ST	-	0.8%	11.2%	42.5%	61.7%	55%	40%	39%
Literacy	-	59.2%	69.8%	74.2%	77.8%	75.1%	71.7%	69.4%

Source: Census of India 2011, Ministry of Home Affairs, Government of India

Analytical Framework

An analytical framework aiming to put together the various pieces of documentation of institutional aspects and their implications in understanding the groundwater management scenario in West Bengal is presented in this section. The purpose of the framework is to make explicit the role of various institutional factors in managing groundwater quality and dealing with its impacts on agriculture, with particular reference to arsenic contamination of groundwater in West Bengal.

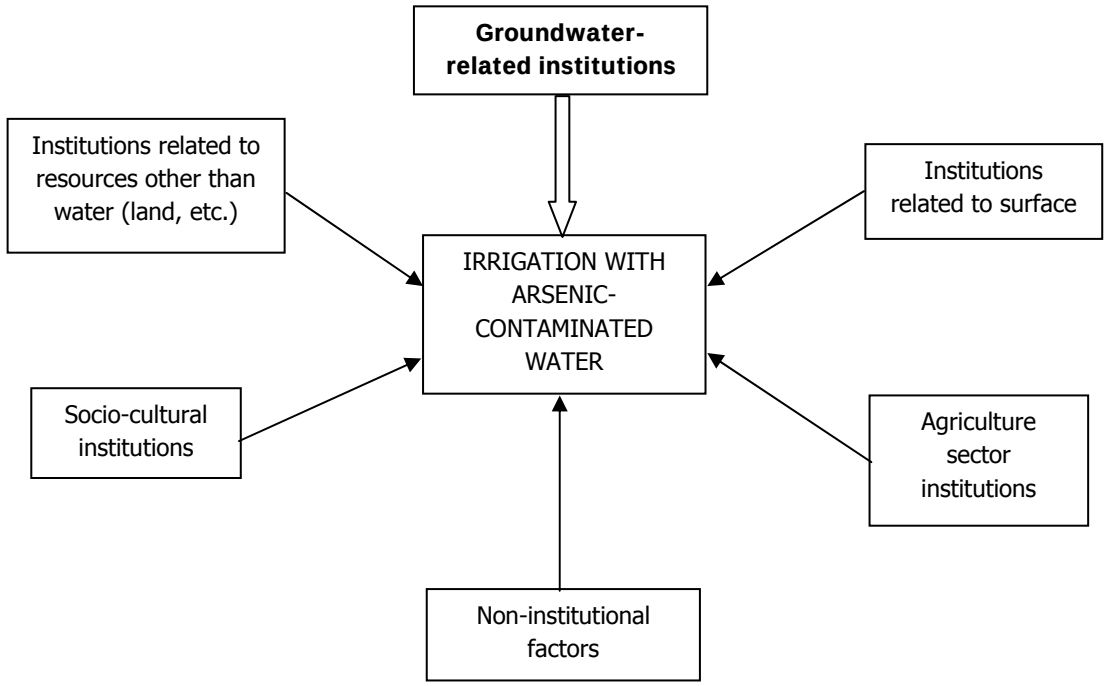
Since the issue at hand is very specific in nature, the framework is centred around the main issue / theme as opposed to the 'action arena' in the IAD framework or 'action situations' as in the case of the IoS framework. In part one, the institutional factors which play a role are mentioned and then distinguished on the basis of various possible types of categorisation. In the second part, the specific linkages between different institutions and their individual or combined influence on the central theme are illustrated and explained subsequently.

Although the focus is on institutional analysis, the impact of relevant non-institutional variables must also be identified. Both the IDA and IAD frameworks consider the role of some external factors which they term as 'exogenous factors or variables'. However, we recognise that these factors may not be exogenous but rather endogenised within the system.

In the IDA framework, only the role of water related institutions is analysed with respect to the performance of the water sector. The other institutional factors are considered as exogenous to the system. Our study is different, in that we analyse the role of all institutional factors and distinguish these based on the domain of influence, i.e. whether related to ground water, surface water, other

resources like land, environment and socio-cultural factors. These are further classified into formal or informal, type of institution such as policy, law/legislation, administrative organisation, micro-level arrangement, societal norm, etc. The other external variables which influence the 'action arena' are then considered as part of the 'non-institutional factors' and maybe exogenous or endogenous to the system.

Figure 6: Analytical Framework – Institutional and Non-institutional Factors Affecting Groundwater Management



Source: Authors' construction

Table 3 presents the components within each category of institutions identified in Figure 6. It further distinguishes them as formal versus informal, national, state or local level, type of institution as in policy, legal, societal norm, etc. and whether it defines the institutional environment or is an institutional arrangement.

Table 3: Identification, Categorisation of Institutions Concerning Use of Arsenic-Contaminated Groundwater in Agriculture in West Bengal

Sl. No.	Institution	*Related to*	Formal / Informal	Macro, meso, micro	Category		Institutional environment (IE) / Institutional arrangement (IA)	Objective of the institution
					Level	Type		
1	National Water Policy, 2012	Ground and surface water	Formal	Macro	National	Policy	IE	Comprehensive policy on managing water resources in India
2	Indian Easements Act, 1882	Groundwater	Formal	Macro	National	Law/ legislation	IE	Suggests that water below the ground is owned by landowner.
3	West Bengal Ground Water Resources Act, 2005; 2011 amendment	Groundwater	Formal	Meso	State	Law/ legislation	IE	Aimed at managing water resources related problems in West Bengal
4	WBSEDCL 2011- policy resolution	Groundwater	Formal	Meso	State	Policy	IE	Reduction of cost for setting up electricity connection for irrigation
5	Bringing Green Revolution to Eastern India (BGREI) scheme, 2011	Groundwater; agriculture	Formal	Macro	Administered at national level; applicable to Eastern states	Government programme	IE	Facilitate agricultural activities in Eastern States, through asset building subsidies, etc.
6	Group scheme for pumps	Groundwater; agriculture	Formal	Meso	State	Government programme	IE	Joint ownership of irrigation pumps
7	SWID	Groundwater	Formal	Meso	State	Administration	IA	
8	CGWB	Groundwater	Formal	Macro	National	Administration	IA	
9	Public Health Engineering Department (PHED)	Groundwater	Formal	Meso	State	Administration	IA	
10	Directorate of Agriculture	Groundwater; agriculture	Formal	Meso	State	Administration	IA	
11	Arsenic Taskforce	Groundwater	Formal	Meso	State	Administration	IA	
12	Electricity pricing for agricultural consumers	Groundwater	Formal	Meso	State	Policy	IE	
13	Formal market and black market for diesel	Groundwater	Formal	Meso, micro	State	Policy, arrangement	IE, IA	

14	Groundwater markets	Groundwater	Informal	Micro	Local	Arrangement	IA	
15	Tubewell cooperatives	Groundwater	Informal	Micro	Local	Arrangement	IA	
16	Joint ownership	Groundwater	Informal	Micro	Local	Arrangement	IA	
17	Contract among water sellers	Groundwater	Informal	Micro	Local	Arrangement	IA	
18	Non-monetary exchange	Groundwater	Informal	Micro	Local	Arrangement	IA	
19	Electricity theft	Electricity	Informal	Micro	Local	Arrangement	IA	
20	Kerosene instead of diesel	Groundwater	Informal	Micro	Local	Arrangement	IA	
21	Land reforms and 'Operation Barga'	Land	Formal	Meso	State	Law/ legislation	IE	Redistribution of land holdings
22	Food habit/ pattern / preference (for rice)	Socio-cultural	Informal	Meso	State	Habit	IE	
23	Education	Social	Informal	Micro	Local	-	IE	
24	Caste	Social	Informal	Micro	Local	-	IE	

Source: Author

Understanding Institutional Linkages

The management of groundwater involves several different domains of institutions including economic, social, political, cultural and so on, some of which are macro level and others micro level institutions; they may be either formal or informal. These institutions may be nesting out from one another as well as be embedded into each other. Understanding the role of institutions in affecting groundwater utilisation requires us to get a grasp on the several interconnections between all the relevant institutions. When analysing the role of one institution we may miss out on the interlinkages between different institutions. Identification of these linkages between the different institutions and the implications thereof will enable us to understand the groundwater situation in West Bengal.

The institutional environment constituting the formal laws, legislations and policies is inherently linked with the institutional arrangements, both formal and informal. Informal institutions may emerge to fulfil societal goals which remain out of the purview of formal institutions. The institutional factors, and their linkages, in the context of groundwater management in West Bengal are explained under three categories – State-formal, national, and local-informal.

1) State, formal

The most important formal institution governing groundwater management in West Bengal is the West Bengal Ground Water Resources (Management, Control and Regulation) Act of 2005. Its mandate is to manage, control and regulate the extraction of groundwater as well as control the contamination of groundwater with arsenic, fluoride, other heavy metals, organic and inorganic pesticides, fungicides and rodenticides in West Bengal (India Water Portal, n.a.). As per the Act, anyone who sinks a well or tubewell which uses a mechanical or electrical device for groundwater extraction for domestic or irrigation purposes should apply to the District Level Ground Water Authority (DLGWA) established under the Act for permission. The DLGWA, after scrutinising every application on the basis of the groundwater balance, quantity and quality of groundwater available in that area according to the assessment by State Water Investigation Directorate (SWID), would grant or reject the permit.

SWID is responsible for undertaking periodical assessment of the groundwater quantity and quality in the state and provide such data to the district level authorities for evaluating applications for setting up of wells and tubewells, among other uses. The purview of SWID is largely limited to managing groundwater extraction and monitoring resource quality in irrigation wells. It is the PHED which undertakes wide scale monitoring of water quality since it is the authority responsible for providing safe drinking water across the state. PHED monitors all drinking water wells in the state and publishes the data on various quality parameters – arsenic, fluoride, iron, chloride, salinity, electrical conductivity.

Furthermore, the two significant developments in 2011, viz. the amendment of the West Bengal Ground Water Resources (Management, Control and Regulation) Act, limiting the requirement of a permit for extracting groundwater to only the 'critical' and 'semi-critical' blocks, as well as the resolution passed by WBSEDCL regarding cost reduction for farmers to set up electricity connection for agricultural use of groundwater, have already been highlighted.

With the mandate to all states coming from the Electricity Act of 2003 passed by the Government of India to enforce and implement metering of agricultural electricity supply and charge accordingly, by 2007 in West Bengal, 90 per cent of electric tubewells had been metered. Until then, the flat tariff system was in place which was attacked on several grounds such as the lack of energy accounting in utilities and inefficient use of power as well as water, and the fact that it had become a political tool because of which the tariff rates remained stagnant for years together. The metered tariff was structured as a time-of-day tariff such that there were three different rates depending on the time of the day when electricity was used – peak hours (5 pm to 11 pm), off-peak hours (11 pm to 6 pm) and normal hours (6 am to 5 pm) (Mukherji and Das 2012). This type of tariff structure was aimed at easing the load of electricity consumption in peak hours, rather than efficient use of electricity and groundwater.

A large majority of farmers rely significantly on diesel operated water extraction mechanisms (WEMs). The recent market rate for diesel is Rs 63 per litre with which a 5 HP pump machine, on average, can be operated for 1 hour. Given such high costs, studies have shown that the cost of cultivation for *boro* paddy for diesel pump owners is twice that for electric pump owners and higher even as compared to water buyers of electric pump owners (Evans *et al* 2012). However, there are two sets of farmers who depend on diesel for groundwater extraction. There are those who by compulsion have to rely on diesel pumps, and those who by choice stick to diesel pumps. In the first case, they lack electrification in the village, or belong to backward class and have no political connections and are unable to secure a connection. The other set of farmers reported that they were not interested in switching to electric pumps, although they were aware of the cost implications, and reasoned out that the electricity supply for pump operation was intermittent and inadequate to allow sufficient irrigation of their farmland.

The structure of landholdings in the state, i.e. high concentration of small and marginal farm holdings, can be attributed to the historical role of 'Operation Barga' (land reforms, which began in 1978) which ensured a significant redistribution of agricultural land. The land size is one of the main determinants of investment in a WEM, since small cultivable land holding means a lower incentive to own a WEM, unless there is enough potential to sell water.

With regard to dealing with arsenic contamination in the aquifer, the Arsenic Taskforce was constituted by the government of West Bengal to tackle the menace of arsenic contamination in groundwater and manage the adverse impacts of using this resource. This high-level committee in its report of 2005 explains the occurrence of arsenic in the Indo-Gangetic Plain and provides various possible options – technological measures like arsenic treatment plants, and non-technological ones such as tapping the deeper aquifer – to tackle arsenic for different uses (Government of India, 2007).

2) National level

Reeling under the concerns of food security for the country, the central government has been pushing for a second Green Revolution by improving agricultural production and productivity in the eastern states. In lieu of such goals, the BGREI scheme was instituted in 2011 under the Rashtriya Krishi Vikas Yojana (RKVY) wherein one of the main components was asset building for farmers. It offers subsidies

on farm equipment including pumpsets, wherein the subsidy amount covers 50 per cent of the cost or Rs 10,000, whichever is less, to farmers in need (RKVY, n.a.).

An important national level institution governing the water sector in India is the National Water Policy. The first one was published in 1987, with several revisions in subsequent years and the latest one was brought out in 2012 by the Ministry of Water Resources, Government of India. The objective of this policy is "to take cognizance of the existing situation, to propose a framework for the creation of a system of laws and institutions and for a plan of action with a unified national perspective" (Government of India, 2012).

The Indian Easement Act 1882 laid out that groundwater rights be based on land ownership. As per the Act, water below the land is assigned to the landowner. Administering and monitoring such a law is practically impossible for the obvious reason that controlling the flow of water below the ground is infeasible. It has been observed that anyone who can afford to set up a water extraction mechanism such as tubewell, borewell, etc can extract much groundwater from the aquifer. Furthermore, there are also cases when a farmer only owns a pump which he attaches to some other farmers' borewell/ tubewell to extract groundwater.

In terms of the national water administration, there are two government bodies relevant to groundwater management. The primary one is CGWB which through its monitoring wells collects water level and water quality data for the entire country. Based on periodical assessment of changes in water levels, it categorises 'assessment units' (which are usually blocks or taluks) into four categories: over-exploited, critical, semi-critical and safe. The second is the Directorate of Agriculture which manages the subsidies for farm mechanisation including pump sets, which are rolled out under different centrally-sponsored schemes such as the BGREI.

3) Local, informal institutions

In West Bengal, there is an extensive market for groundwater wherein tubewell owners allow other farmers to use their well for irrigation at a cost, which may be charged either on the basis of hours of pump operation or the area irrigated.

The dynamics within this institution of buying and selling pumping services for groundwater irrigation are in turn dictated by other informal institutions. The type of cost which the WEM owner faces often dictates the marginal cost of pumping to him, i.e. whether positive or zero, which in turn determines the type of charge at which he sells water to other farmers. For instance, in case of diesel machine as well as metered electricity supply, the owner faces a positive marginal cost of pumping each unit of groundwater. In such cases, the owner often charges an hourly rate for selling water from his pump. On the other hand, when the electric pump owner pays a lumpsum electricity bill, it is observed that he charges an area-based water tariff to the buyer for one entire cropping season. Since the amount of groundwater required for irrigation differs across the three seasons and depending on the crop cultivated, the area-based water charge also tends to differ across seasons and crops grown – higher in summer season as compared to winter (*rabi*) and monsoon (*kharif*); higher for paddy cultivation as compared to that for potato or mustard (Meenakshi *et al* 2013). One important dimension

to groundwater markets is that it not only allows non-WEM owners to access irrigation water but also some WEM owners who are required to buy water given the fragmentation of landholdings.

In areas where there are many WEM owners willing to sell the service of pumping groundwater, they sometimes collude and make an informal agreement for demarcating the boundaries of landholdings to which each will sell, thus functioning as a 'contested oligopoly'. They fix the water charge as well as who each buyer can buy from. The buyer is only allowed to switch the seller in the rare event that his seller's machine becomes dysfunctional or he is unable to sell for some reason. Such an institution emerged as it guarantees a certain amount of profits from water sale for all owners in the area. It functions based on competition versus cooperation criteria. It is in the interest of all the WEM owners involved to cooperate and not to go against the group members. If one tries to compete by charging a lower price and selling beyond his designated area, the other group members can group together against him and he may be at an all-time loss, losing all his customers.

Certain non-market water sharing arrangements also exist in West Bengal's rural economy. Like farmers' cooperative societies, there are tubewell cooperatives which provide pumps on custom-hiring basis at a rental cost (Rawal, 2000). Rawal also observed that there were joint tubewell ownership arrangements wherein a group of two or more farmers jointly invest in the capital cost of WEM, sharing the costs in equal proportion or proportionate to the land holding sizes. Such an arrangement often exists when the WEM has been inherited by two or more brothers from the previous generation. Cost sharing in such circumstances differs from case to case; it may happen equally or proportionately to the land size.

During my field visit to Warishpur village (Ausgram-I block, Bardhaman district), farmers reported non-monetary exchange of WEM services. *I let you use my machine for five days and in return I am allowed to use your machine for five days*. Such an institution or mechanism exists mainly due to land fragmentation; in most cases, one person cannot use his machine for irrigating all his landholdings because of large distances. Instead of buying and selling pumping services for money, they engage in a barter type of arrangement wherein neither makes a profit or loss, but manages to irrigate his far-off land, which might be difficult using his own machine. The institution sustains itself due to mutual dependence, and would most likely fall apart when one does not need the other.

There is widespread illegal hooking of electricity across villages in the state. In Shankchura village (Basirhat-I block), people reported that WEM owners who compete with each other for selling water often file complaints against one another so that their opponent gets fined to the tune of Rs 1 lakh. The one filing the complaint gains by being able to increase profits from water selling as the customers of his competitor shift to buying from him. This system of competitive power theft and reporting is classified as an informal institution which reflects certain individual and community characteristics.

Similarly, the widespread use by some diesel pump owners of kerosene, whose market price is one-third that of diesel, is an institution in the sense that it has persisted over a period of time and sheds light on individual and community characteristics. Diesel costs Rs 63 per litre, whereas kerosene costs Rs 22.50 per litre. Due to high demand of kerosene in areas where diesel machines are high in number, there exists a black market for the sale of kerosene which is sold at Rs 45 per litre. Since it is

still much lower compared to the price of diesel, poor farmers at times buy kerosene from the black market. Over the years, the spread of a black market for kerosene has resulted in an increasing number of diesel pump owners switching to kerosene. This is environmentally degrading. Such a mechanism was observed during a field visit to Ausgram-I block, Bardhaman district.

The cropping pattern is often determined by the agro-climatic zone, soil conditions and water availability as well as the demand for the crops. Rice is the staple food grain in the Bengali diet and therefore consumed by the masses. A high demand for rice for self-consumption is one of the main reasons for the rice-based cropping pattern in West Bengal wherein there are three rice growing seasons, locally known as *aus*, *aman* and *boro.*

Caste politics is known to be vital in the rural West Bengal economy. From being a major factor in determining access to water extraction mechanisms, such as the permission for electricity connection for shallow machine, to accessing water in the groundwater market, by way of who a certain caste farmer can buy from, caste dynamics is important among farmers in West Bengal (Mukherji, 2006).

Analysing the Role of Institutional Factors for Groundwater Management

At the national level, there is a lack of acknowledgement of degradation of water quality and its impacts on different sectors. National Water Policy, 2012, makes no mention of arsenic contamination or its causes and resultant impacts or how to manage the resource in the face of such contamination. The policy document which is deemed to be the most comprehensive and inclusive of all water sector challenges in the country fails to detail the major water-related crisis faced by eastern states.

Instead, the BGREI scheme under RKVY promotes the use of groundwater through subsidising the capital investment in pump sets and shallow tubewells, given that there is a vast potential for the replenishable resource to be tapped. Data obtained from the Directorate of Agriculture shows that pump subsidies given across the state each year over the last four years have been in the tune of 30,000. District-wise data shows that a large number of these subsidies have gone to the highly arsenic affected districts (refer to Table A2). This shows a blatant lack of coordination across different government departments working towards groundwater management in the state.

However, its effectiveness remains under question since no policy comes without loopholes. During a field visit to Shankchura village (Basirhat-I block), a farmer reported that he along with five others had been granted this subsidy individually for purchasing a pump. But upon going to the Panchayat office, they were each asked to pay Rs 3,000 as transaction cost if they wanted to claim the subsidy. Not able to afford this amount, the farmers refrained from utilising the subsidy.

Boro rice cultivation, which has been blamed for the adverse groundwater situation in the state, depends entirely on irrigation water since it is grown in summer. Table 4 shows the average water requirement of a few crops grown in West Bengal. Since the yield of *boro* rice is significantly higher as compared to *aus* and *aman* rice, farmers feel incentivised to grow rice in summers. There are also several social factors which drive *boro* cultivation. Rice being the staple food in the Bengali diet, there is a substantial demand for the crop in the market. And since it is non-perishable, farmers can

store it until they get a good price. The marginal farmers often grow the crop to meet their own food requirements.

Table 4: Water Requirement for Different Crops in India

Crop	Growing days	Total water requirement (in cm)	Total water requirement (in inches)	Daily water requirement (in cm)	Daily water requirement (in inches)
Rice	93	104.5	41.80	1.075	0.43
Potato	88	30.0	12.00	0.750	0.30
Mustard	88	25.2	10.08	0.300	0.12
Wheat	88	37.0	14.80	0.425	0.17

Source: http://www.agriinfo.in/default.aspx?page=topic&superid=7&topicid=16

Education as an institution is likely to be correlated with awareness about arsenic contamination in groundwater and hence, its impacts on agriculture. During my survey in Godhanpara village (Raninagar-II block, Murshidabad district), it was found that the less educated households, being unaware of the existence of an arsenic removal plant situated in the village, continued to use their shallow well water for drinking and domestic purposes. It was found that in villages of Basirhat-I block, where arsenic and iron were present together, the colour of well water was red and in these villages people tended to raise the issue of water quality in Panchayat meetings. Furthermore, a system of piped water supply had been set up by the government in Rakhaldaspur village (Raninagar-II) on the recommendation of the Panchayat since cases of skin lesions were very common.

Furthermore, at the state level, there is a lack of political will to constrain or restrict use of groundwater for agriculture and increase awareness on the impacts of using arsenic affected water on agriculture and people's livelihoods. This unwillingness stems from the fact that such actions would be like building a political deathbed that would lead to pressure on the government to take the necessary measures, while it is still unable to supply safe drinking water in arsenic affected areas.

The state government, having recognised arsenic contamination as a health hazard, has been focussing on providing access to safe drinking water to the population in affected areas. PHED, being the authority handling this work, is discouraging the use of groundwater for all purposes in view of the fact that extraction further mobilises arsenic. However, there is a clear lack of coordination between the centre and the state in this regard, with BGREI subsidising pump sets. There is an absence of coordinated action even among state departments, PHED on the one hand and WBSEDCL and SWID on the other. WBSEDCL and SWID have eased access to electricity connections as well as made it more affordable for farmers. While the state seems to have made some progress in ensuring the supply of clean drinking water to the rural population, the declining crop yields and higher cultivation costs (higher fertiliser dosage) on account of arsenic-rich irrigation water is taking a toll on agriculture-based livelihoods of this population.

Conclusion

The underground (hydro-geological) and above ground (socio-economic) settings shape the dynamics of groundwater resource use. The dynamics above ground are to a large extent shaped by institutional factors – formal, informal, and macro-micro level – and the linkages between them and with the non-institutional factors.

With policies of liberalising groundwater for agriculture by the state supported by the central government, it can be inferred that arsenic contamination is not taken to be a serious threat to agriculture in the state. The government seems to have only understood the human health implications through drinking arsenic-rich water. Even though there exist a large number of studies pointing towards the adverse implications of arsenic contaminated irrigation water for sustainable agricultural production, these have not been taken seriously by the policymakers.

While the Arsenic Taskforce was specifically constituted by the state government to deal with the problem, and although it came up with comprehensive solutions both technological and otherwise, there seems to be little progress on the ground. Many of the arsenic treatment plants which were installed by PHED have fallen into disuse after few initial years of operation.

There have been no concerted efforts to check arsenic contamination in groundwater by the central government over the last three and a half decades when the issue first became prominent with cases reported from West Bengal. This is reflected in the clear negligence of the issue in the National Water Policy, 2002 and its later revision in 2012. Instead, the central government, in view of food security, initiated the BGREI scheme with a provision to subsidise and therefore encourage groundwater use for agricultural purposes in eastern states including West Bengal. This negligence at macro level feeds into the micro level with the farming community being unaware of the adverse implications of arsenic contamination on their livelihood. Despite measures such as awareness campaigns in the affected rural areas, the social institution of *boro* cultivation has continued unhampered, with dependence on groundwater irrigation being on the rise.

To conclude, this study highlights that the institutional environment defining the groundwater scenario in the state of West Bengal is liberal with respect to groundwater utilisation, in view of the fact that the state receives high rainfall annually which recharges the water levels to nearly pre-monsoon levels. In terms of arsenic contamination, the view seems to be narrow, limited and focussed on dealing with only the direct and immediate implication of drinking contaminated water on human health as well as the food chain implications through arsenic uptake by crops. However, the long-term impact on sustainability of agriculture due to continuous irrigation with arsenic-rich water has not received due attention in the policy arena, and needs concerted efforts through targeting the interlinked institutions – formal and informal, and macro, meso and micro.

The sustainability aspect needs to be considered in all spheres – economic, social and environmental – when looking into the management of groundwater resources. This requires the building of a conductive institutional base at macro level through policies targeted at limiting the use of shallow groundwater in arsenic rich areas and instead providing alternative sustainable sources of irrigation water. These may be developed through community participation – such as through providing

resources for building rainwater harvesting structures, and thus facilitating the emergence of a system of effective micro-level institutions.

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Appendix

Table A1: CGWB's Categorization of Assessment Units

Stage of groundwater development	Significant long-term decline		Categorization
	Pre-monsoon	Post-monsoon	
≤ 70 %	No	No	Safe
>70 % and ≤ 90 %	No	No	Safe
	Yes/No	No/Yes	Semi-critical
>90 % and ≤ 100 %	Yes/No	No/Yes	Semi-critical
	Yes	Yes	Critical
>100%	Yes/No	No/Yes	Over-exploited
	Yes	Yes	Over-exploited

Source: CGWB (2013)

Table A2: District-wise Number of Subsidies on Pumpsets in Each Given Year

District	2015-16	2014-15	2012-13
Alipurduar	2,241	1,716	3,007
Jalpaiguri	2,548		
Cooch Behar	1,570	1,382	3,087
Uttar Dinajpur	2,090	1,244	661
Dakshin Dinajpur	975	465	174
Malda	1,805	2,063	3,923
Murshidabad	1,524	2,967	342
Nadia	2,012	3,195	1,527
North 24-Parganas	1,752	4,251	2,195
South 24-Parganas	2,183	1,700	3,471
Howrah	1,030	1,032	10
Hooghly	2,569	2,921	3,879
Burdwan	1,769	384	1,682
Birbhum	956	2,253	1,514
Bankura	701	1,577	210
Purulia	2,355	4,011	2,113
Paschim Medinipur	2,687	2,220	2,721
Purba Medinipur	2,371	2,355	4,021
TOTAL	**33,138**	**35,736**	**34,537**

Arsenic affected districts

Source: Directorate of Agriculture, Government of West Bengal (unpublished)

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