FRAMEWORK FOR PUBLIC PARTICIPATION IN WATER SUPPLY PROJECTS: THE CASE OF SOUTH-WEST GUWAHATI WATER SUPPLY PROJECT

A THESIS

submitted by

RAKHEE DAS

for the award of the degree

of

DOCTOR OF PHILOSOPHY

DEPARTMENT OF CIVIL ENGINEERING
INDIAN INSTITUTE OF TECHNOLOGY GUWAHATI
GUWAHATI – 781039 (INDIA)

APRIL 2019

Dedication

To my Family and Well-wishers

Indian Institute of Technology Guwahati

Department of Civil Engineering

Statement

*I, hereby declare that the content embodied in this thesis entitled "**Framework for Public Participation in Water Supply Projects: The Case of South-West Guwahati Water Supply Project**" is the result of investigations carried out by me at the Department of Civil Engineering, Indian Institute of Technology Guwahati, Guwahati, India.*

In keeping with the general practice of reporting scientific observations, due acknowledgements have been made wherever the work described is based on the findings of other investigators.

Date: Rakhee Das

Indian Institute of Technology Guwahati

Department of Civil Engineering

CERTIFICATE

*This is to certify that the thesis entitled "**Framework for Public Participation in Water Supply Projects: The Case of South-West Guwahati Water Supply Project**", being submitted by **Rakhee Das (126104026)**, to the Indian Institute of Technology Guwahati, India, for the award of Doctor of Philosophy, is a record of bonafide research work carried out by her under our guidance and supervision. The work embodied in this thesis has not been submitted for any other degree or diploma. In my opinion, the thesis is up to the standard of fulfilling the requirements of the doctoral degree as prescribed by the regulations of this Institute.*

Date:

Prof. Mohammad Jawed
Department of Civil Engineering
Indian Institute of Technology Guwahati,
Guwahati-781039. India

Dr. Laishram Boeing Singh
Department of Civil Engineering
Indian Institute of Technology Guwahati,
Guwahati-781039. India

Acknowledgments

I am indebted to many people who had helped me during my research work and it is my privilege to acknowledge them.

At first I express my deepest sense of gratitude and reverence to my thesis supervisors Prof. Mohammad Jawed and Dr. Laishram Boeing Singh for believing in me. Without their guidance, persistent help, comments, and valuable suggestions, I would not have reached my destination. I thank Prof. Mohammad Jawed for his dedication, concern, constant encouragement, and being a thrust whenever I was downcast with my Ph.D. I also thank him for instilling in me a craving for perfection. I believe, it will always remain with me in my future life. It has really been a notable working experience with him. Many thanks must go to Dr. Laishram Boeing Singh for initiating and shaping the work of my Ph.D. and constantly shepherding throughout.

I express my sincere thanks to the members of my Doctoral Committee Prof. Sharad Gokhale, Dr. Bulu Pradhan and Prof. Mrinal Kanti Dutta, for their valuable suggestions, encouragement, and timely help provided at various stages of the research work.

I thank the head of the civil engineering department (former and present), faculty in-charge of environmental engineering laboratory (former and present) and staff members viz. scientific officer Jonali Saikia, junior technical superintendent Chittaranjan Medhi, and Pathak Da for providing uninterrupted help accomplishing the Ph.D. work.

I would like to thank Prof. Bhisma Kumar Patel (former Dean of Student Affairs) for considering my case of keeping a vehicle for sample collection. Further, I thank Mrs. Puspanjali Sonowal, Assistant Professor, Assam Engineering College and Mr. S. Venkatesan, Former Managing Director, Guwahati Jal Board for their help in suggesting and arranging experts for interview. I thank all the experts from various departments/institutes/companies for their participation in framework development and validation with invaluable inputs, practical difficulties and current legal/administrative trends on public participation.

I am very thankful to Mr. Mrinal Adhyapak, Mr. Dengkhw Brahma and Mr. Trimukhanand

Kulkarni for helping me in collecting groundwater samples from different households in South-West Guwahati.

I would like to thank my senior Dr. Ravindra Patil, for his help and encouragement during the early stage of my PhD. Special thanks to my friend Dr. Kulkarni V. V for his support and help in achieving my work. Words would be less to thank my friends Ms. Mitali Sahu, Dr. Raj Kumar Das, Mr. Subrat Kr. Mallick, for their constant encouragement, communication, love and respect throughout my stay and during my research work.

At last I would also like to thank to my parents, my brother and sister-in-law for their patience and unconditional support during my PhD.

Indian Institute of Technology Guwahati
Guwahati
December, 2018

Rakhee Das

Abstract

The domestic water sufficiency of urban population is looked after by urban local bodies (ULBs). As of today this is voided by differential rates of infrastructural expansions and increase of urban population creating acute problem of infrastructure bottleneck e.g. water supply facility. In events of inadequate water supply, groundwater is being used due to its non-turbid and bacteria free nature, and its use is also endorsed by governmental policies. However, considering possible groundwater contaminations and associated treatment costs, India has made policy shift to use surface waters and has initiated various surface water supply schemes. Viability of such projects is greatly influenced by the public willingness to procure (WtP) for and its acceptance, which subsequently is a function of various critical success factors (CSFs). The studies undermining CSFs are plenty, however, limited studies have considered framework development for public participation particularly in water supply projects. Hence, the study has been taken up with an objective to develop and propose a framework for integrating people in water supply projects. It has been worked out considering a standing case of South-West Guwahati water supply project, which is a fully government owned turnkey based project, but facing public opposition. A mixed research approach methodology has been adopted and executed in 4 phases. Phase 1 has been designed to understand the reasons for public opposition. In phase 2, quantitative method has been employed for groundwater quality assessment in the study area. In phase 3, groundwater quality awareness has been carried out through door to door interaction and in phase 4, semi-structured questionnaire is designed to generate primary data in conjunction with secondary data, and finally a framework is formulated in accordance with the identified CSFs.

The study of public opposition and perception on groundwater quality reveals casual public approach towards groundwater quality irrespective of profession, education and financial status of household. The document analysis on public opposition reveals that the project fails to encourage public participation and maintain transparency in project related issues. The public completely lack information on funding sources, executing agency, and contract/sub-contracts. As the information on the tariff was not properly circulated, it failed to convince and build public trust, resulting in lower (58%) public WtP. The survey also reveals that a greater proportion (98%) of

the people have never tested groundwater quality. Only 4% are aware of groundwater contaminations and 30% use household filters, thereby indicating a high level of ignorance and lack of knowledge on groundwater quality. The people are aware of iron contamination and use filters, however are completely unaware of fluoride contamination and its health effects. The public is suffering from discoloration of skin or pigmentation (2.93%), yellowish teeth (56.51%) and children teeth cavities (4.72%) but no report of superficial growth/patch of skin (keratosis) is seen. Hence the study shows the need for carrying out water analysis and undertaking awareness program in the study area.

Study of groundwater quality (1568 groundwater samples) using eleven water quality parameters has revealed that iron, fluoride and arsenic as the critical parameters, exceeding Bureau of Indian Standards (BIS) permissible limits and World Health Organization (WHO) guidelines. The study highlights the unsuitability of groundwater in the study area for direct consumption with highest concentrations of iron, fluoride and arsenic as 21 mg/L, 7.93 mg/L and 35.7 µg/L, respectively. The percentage samples exceeding WHO guideline/BIS permissible limit for iron, fluoride and arsenic are observed to be 55%, 12% and 9% respectively. An interesting pattern of groundwater contamination has also been uncovered - the contamination is higher at the foothills and decreases radially outward in the study area. Furthermore, the study illustrates the need of water quality monitoring as well as awareness programs to publicize health hazards of contaminated groundwater.

A questionnaire survey and door to door awareness uncovers insightful factors affecting public WtP such as education level of respondent, source of drinking water, groundwater taste and within household. Comparative study of public WtP categorizes groundwater quality awareness and its adverse health effects as one of the most influencing factors that improves public WtP from 58 to 74%. Public WtP increases dramatically (35 to 78%) after information sharing on visible health hazards such as skin discoloration. Income is also found to be one of the most influencing factors; public disclosing their income are found to be sensible as well as concerns towards water quality and show higher WtP even with greater water sufficiency (SUFF). The findings of public WtP through simple percentage form are fortified by logistic regression model which uncovers interesting trend of public hesitation and explicitly throw light upon sensibility of people who disclose their income during survey.

In framework development, extensive literature review (secondary data collection) has identified 9 CSFs. Primary data evolves three additional thematic codes (themes) apart from those closely matching eight CSFs from secondary data. Study of theories of public participation such as Arnstein's, Connors and the International Association for Public Participation (IAP2) depict a ladder for public participation. Finally, a framework is conceptualized on the basis of CSFs from secondary (literature review) and primary (expert interviews) data, entrenched on fundamental theories of public participation encircling lifecycle of a water supply project. The developed framework achieves effective public participation in five levels viz. inform, educate, consult, involve, and collaborate. Each level satisfies different set of CSFs and ultimately all CSFs addresses to deemphasize the effects of disincentives in water supply projects. The framework is envisaged to enhance public acceptance, timely completion and successful comprehensive management of a project through various levels of public participation. Further, framework validation from 16 experts receives satisfactory rating for all six validation aspects with highest score (4.13/5) obtained for 'degree of practicability'. Satisfactory ratings from expert demonstrates that the newly developed public participation framework is appropriate, objective, replicable, practical, reliable, and suitable for water supply projects.

Keyword: Piped water supply, Public protest/opposition, South-West Guwahati, Groundwater, Groundwater abundancy, Groundwater quality, Public perception, Willingness to procure, Water supply scheme, Groundwater quality awareness, Framework, Public participation, Questionnaire survey, Expert interview, Thematic analysis, Critical success factor, Urban local bodies.

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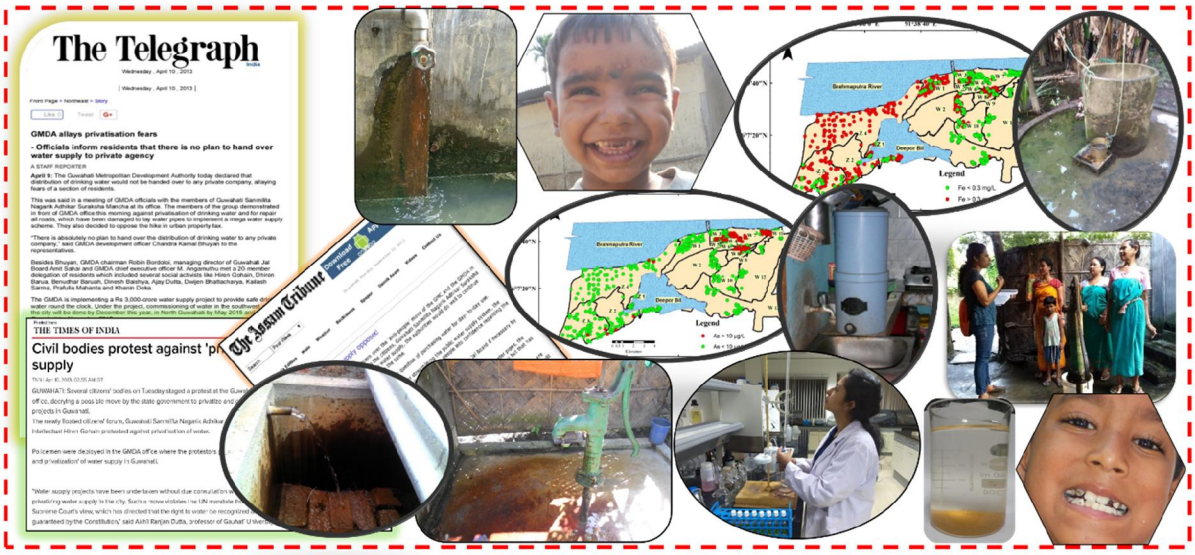
Chapter–1

Introduction



This chapter outlines the background of the present study and familiarizes reader with the need of public participation in water supply projects.

1.1 Introduction

Freshwater is a limited resource and an essential element for survival. It is sufficient and usable as long as well managed. The beneficial uses of water are in domestic, commercial, industrial, agricultural, recreational and environmental sectors. The domestic needs of treated water in urban areas are looked after by urban local bodies (ULBs). The treatment of raw water to meet drinking water quality standards depends upon the quality of raw water and the subsistence of infrastructure. The sufficiency of infrastructure required is solely dependent upon the population to be served. The rapid urbanization has created a void or deficiency because of differential rates of infrastructure expansion and increase in the rate of population growth. As a result, the ULBs are finding it difficult to meet the growing demand of safe and hygienic drinking water in and around ULBs city limits. In addition to insufficient infrastructure, ULBs are facing inadequate finance, low investments and low skillsets of operators which are the major causes of not producing potable quality drinking water (Aijaz, 2010; Devkar et al., 2013; Dutta et al., 2005). The inadequacy/imbalance in finance of State Governments/ULBs is primarily due to the highly subsidized water services, very low water tariff and reluctance of ULBs to review and increase the rates periodically. However, insufficient revenue income prevents keeping pace with rising capital and operation & maintenance costs and prevents authorities from investing in services, leaving existing and future needs unfulfilled (PCGI, 2002). In addition, lack of knowledge, skills and training to plant operators may lead to production of treated water not meeting the required quality standards. Lack of the right skills at the right time has posed as a major reason for failure of water supply schemes (Nelson & Joshi, 1995). There is a need to clearly define the operators' skill sets required before taking any staffing actions for efficient maintenance of the water treatment scheme (Nelson & Joshi, 1995). These shortfalls of ULBs are usually associated with huge handling costs causing financial unsustainability. The degrading water quality further leads to poor customer satisfaction, resulting in low willingness to pay for the water supplied (Dutta et al., 2005).

At many instances, people in developing and underdeveloped countries are mostly dependent on groundwater for domestic purposes, rather than the ULBs (Sujatha et al., 2012). The reason could be abundance of groundwater at shallow depths and/or incompetence of ULBs to supply treated water. In such contexts, groundwater is indeed considered safer than surface water

because of its less turbid and bacteria free nature (Mitchell et al., 2011). The governments in developing and underdeveloped countries has constantly encouraged installation of hand pumps and deep tube-wells (personal or public) to utilize groundwater in such scenarios (Narain, 2004; Sharma et al., 2005). Though groundwater usage has certain advantages, there is higher contamination risk of several dissolved contaminants such as iron, fluoride, arsenic, nitrate causing acute or chronic health effects (Chakraborti et al., 2009; Dar et al., 2010; Singh et al., 2013; Singh & Singh, 2011). The sources of groundwater contamination could be natural or anthropogenic, the former occurs due to weathering and leaching of fluoride-bearing minerals from rocks and sediments, whereas latter might be due to release or spills from stored industrial wastes, septic tank, land fill leachates, and leaky petroleum storage systems (Aller et al., 1987; Egboka et al., 1989; Jha et al., 2013). Moreover, water exploitation without proper recharging and leaching of pollutants from pesticides and fertilizers into the aquifers has contaminated groundwater (Gupta, 2011; Taylor et al., 2013). Eventually, this contamination results in degraded drinking water quality that could cause severe health hazards if used for drinking and cooking purposes. As part of mitigation measures, awareness programs have been undertaken by governmental and non-governmental organizations (NGOs) to educate people on exigency of groundwater preservation and adverse health hazards of contaminated groundwater. In this view, India has made a policy to use only surface water as raw water source for domestic purpose in place of groundwater sources. This policy shift could also be attributed to higher treatment and distribution costs of groundwater when compared to surface water (Nas & Berktay, 2010). Hence, the Indian Government have initiated several governmental, internationally funded and private sector involved surface water based water supply schemes across the country (DoEA, 2001).

Infrastructure projects involve either setting up new projects or expansion of existing ones. The viability of these infrastructure projects is greatly influenced by the public willingness to procure for and its acceptance. Public participation is considered as a key factor improving success rate of projects enhancing public acceptance. Numerous studies have been undertaken to identify principles and critical success factors (CSFs) of public participation in infrastructure project to increase their acceptance (Frefer et al., 2018; Müller & Jugdev, 2012; Rehesaar & Rose, 1995). However, limited studies have considered developing a framework for public participation particularly in water supply project. Integrating public through a guideline or a framework ensures better and easy implementation of decisions, those reflects public interests and requirements,

values and are apprehensible. The framework can serve as an early warning system for public concerns, a means through which accurate and timely information can be distributed, and can contribute to acceptable decision-making (IAP2, 2014). A framework captures and builds on theories of public involvement and the experiences of practitioners would offer guidance for integrating, analysis and deliberation with public in different water supply project decision context (Garnett et al., 2017). Hence, the study has been taken up with an objective to develop and propose a framework for integrating people in water supply projects considering theories and CSFs of public participation in water supply projects around the world.

1.2 Problem Definition

Guwahati is the largest city of Assam and commercial hub of North-Eastern India. It is one of the fastest developing cities in India with rapidly growing population. As a result, ULBs are unable to cope up with the increasing water demands due to lack of finance and sufficient infrastructure. The Ministry of Urban Development, Government of India has considered supporting State Government for the construction of four greenfield water supply projects in the city through international financial support in terms of loans. Greenfield projects with private sector involvement are becoming significant in volume worldwide mainly for investment required in acquisition of new assets. Considering the success cases in other infrastructure projects, countries like Brazil, China, Chile, Mexico and Colombia have initiated greenfield water supply projects since 1995 (Easterly & Serven, 2003).

To streamline greenfield water supply to Guwahati city, the city area has been divided into four zones: North, South-East, South Central and South-West (Figure 1.1). At present, the water supply facility at the South-West zone is contracted to a private enterprise for its construction on turnkey basis. In turnkey contract, a contractor purchases and assembles all the installations, equipment and supplies to put the plant into an operational condition and the owner just 'turns the key' to start using the new plant. Sometimes, the contractor continues to operate the plant until the owner undertakes operational control. In these contracts, the owner repays all the contractor's construction-related costs plus an amount to cover overheads and the contractor's profit (Ferreira & Rogerson, 1999). However, local residents of the upcoming water supply schemes are holding protest against the State Government/ULBs. They blamed the State Government/ULBs of

privatizing water supply in the city and are demanding for greater public participation. The people feel that the private companies would levy high water tariffs to deal with capital cost of the project and its operation and maintenance.

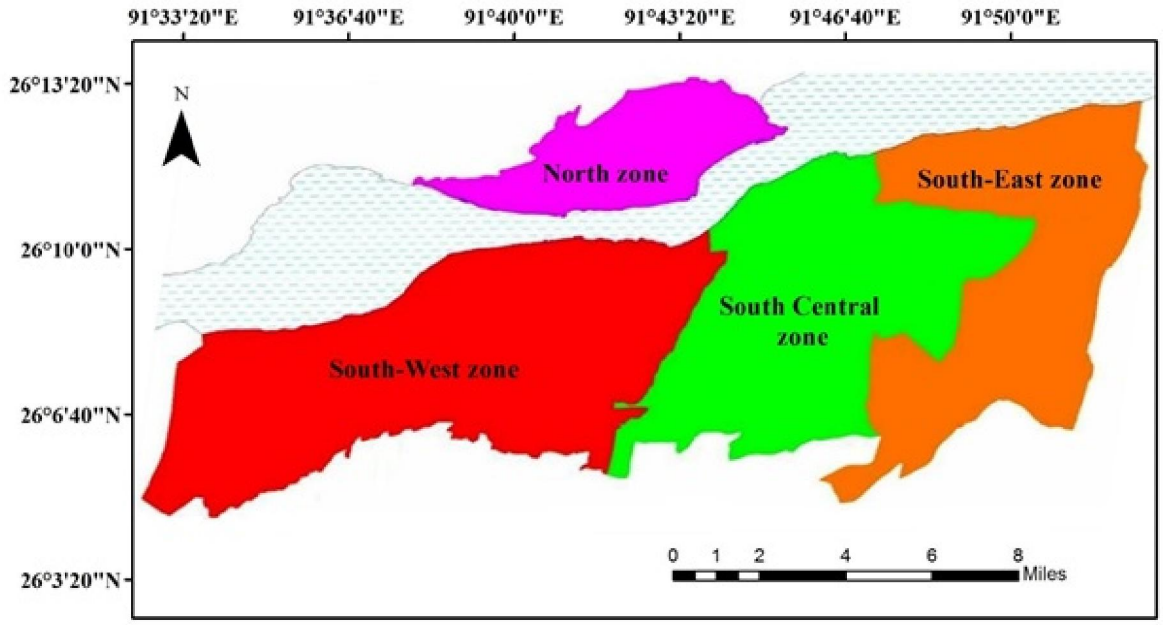


Figure 1.1: Zone-wise location map of Guwahati city (GMDA, 2019).

In the present investigation, the water supply projects at South-West Guwahati has been taken as the study area. The public perception about the groundwater in the study area as well as the upcoming water supply project was assessed through document review and a questionnaire survey with an objective to investigate rationale of public dissatisfaction and to assess public needs and demands from the water supply project.

1.3 Scope of the Work

The present investigation involves understanding of public perception on current drinking water (groundwater in most cases). The study revealed that public perception on groundwater quality was far away from reality and only 4% people were aware of groundwater contaminations. Misconception and lack of knowledge about water supply project were found to be most prominent rationale for public dissatisfaction and 42% people were found to be reluctant towards procuring water from the project. The results of the study necessitated assessment of groundwater quality and its health impacts, if any in the study area. The groundwater quality assessment involved

collection of 1568 number of household groundwater samples and subsequent laboratory testing. Public health hazards if any were also recorded during survey. The study indicated unsuitability of groundwater for direct consumption with concentrations of iron, arsenic and fluoride beyond permissible limits. The study also demonstrated need of water quality monitoring as well as awareness programs to publicize health hazards of contaminated groundwater. Further, door to door awareness programs on household groundwater quality were taken up and public willingness to procure (WtP) was assessed. This uncovered the influencing parameter on WtP to be income, level of education, water availability, taste of water and groundwater contaminations. The study also indicated that awareness on health hazards enhanced public WtP dramatically.

This whole exercise gave an impression that for successful implementation of the project there should be a guideline that mandates to fulfill CSFs for water supply projects. And, this triggered the idea of framework development for water supply projects. For this, primary and secondary data were collected from present case and literature, respectively and used as a source for research inquiry. The primary data was analyzed using a data management software NVivo that revealed themes for public participation. On the other hand, review of literature helped in identification of 9 CSFs relevant to water supply projects. Finally, the framework was formulated in accordance with the identified CSFs from primary and secondary data and the review of various theories on public participation. Investigation into the Guwahati case highlights that identified CSFs have been found to be relevant in the present project and failure to take this into account properly has an adverse effect on the project success. The framework was so developed to address all of the flaws and inclusion of additional CSFs if any. It is of the opinion that the proposed framework could become a better tool for the public and private sector to assess and enhance the acceptance of water supply projects in this region. This could also help in formulating policies and restructuring the public participation process so as to ensure greater public acceptance and enable timely completion and successful comprehensive management of water supply projects.

1.4 Organization of Thesis

The thesis is organized into ten chapters. **Chapter 1** focuses on the background of the study. **Chapter 2** presents a general overview of the relevant literature relating to water supply, various water policies, five year plans, legislative provisions, urban water supply conditions and existing

groundwater contamination in India. This chapter also discusses the shift in Indian government policies on water supply schemes from groundwater to surface water along with the dicussion on the various success and failure stories of water supply projects in India and abroad. The critical factors affecting success of water supply projects have also been explored with detailed discussion on how to enhance public paraticipaton in such projects through review of theories of public participation, and principles of public participation. **Chapter 3** focuses on the aim and objectives of the study and the manner in which the thesis has been organised. The research methodology adopted for the study along with the need and justification for adopting the current research methodology is the focus of **Chapter 4. Chapter 5** presents the investigation on the rationale of public opposition to the Guwahati city water supply project. The public perception on household groundwater source and their willingness to procure water obtained through a questionnaire survey is presented in this chapter along with the statistical basis for estimation of sample size to ensure true representation. **Chapter 6** focuses on the study that had been conducted to explore the existing groundwater quality in the study area and document the health hazards among the common public through collection of total of 1568 number of samples. **Chapter 7** presents the findings on how public willingness to procure changes when they are made aware about the quality of their groundwater. Furthermore, extension of this analysis with respect to various factors such as age, gender, level of education, usage of filter, source of drinking water and ownership in study area is also disccused in detail in this chapter. Finally, the discussion on the logistic regression model that has been developed to identify the influencing factors on willingness to procure water is presented in the latter part of this chapter. **Chapter 8** focuses on development of framework for public participation in water supply project by considering various critical success factors obtained from primary and secondary data. The development of this framework has been influenced by various theories and principles of public participation. And, the chapter discusses their theoretical framework along with the viewpoints of the expert on the relevancy of this framework. **Chapter 9** focuses on the validation of the developed framework. The developed framework was validated through face to face survey approach using six validation aspects i.e., degree of appropriateness, objectivity, replicability, practicability, reliability, and suitability for water supply projects/schemes. Finally, **Chapter 10** outlines the major findings, limitations, and recommendations for further research directions.

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Chapter–2

Literature Review

This chapter presents the review of literature on public access to drinking water in respect of global and Indian scenario. It extensively reviews water policies, planning and legislative provisions in India. The groundwater contaminations in various parts of country are reviewed with its health hazards. Further, policy shift to surface water based water supply projects is brought into consideration. It digs further into possible solutions to overcome public opposition to such projects. Public consultation principles and procedures followed worldwide are comprehensively studied and reported. Finally, the theories of public participation are examined thoroughly to develop better understanding.

2.1 Public Access to Safe Drinking Water: Global Scenario

As per World Health Organization and United Nations Children's Fund report (WHO & UNICEF, 2017), 650 crore people availed improved sources of drinking water within 30 minutes reach (basic drinking water services) and 26.3 crore people (4 per cent of the world population) availed the same with more than 30 minutes collection time (limited drinking water services). The percentage of the population with at least basic drinking water services has increased by an average of 0.49 percentage points per year between 2000 and 2015 (WHO & UNICEF, 2017). The 84.4 crore people lacking basic drinking water service in 2015 either used limited services, unprotected wells and springs (unimproved sources), or took water directly from surface water sources. Between 2000 and 2015, the population using piped supplies increased from 350 to 470 crore, while the population using non-piped supplies increased from 170 to 210 crore (WHO & UNICEF, 2017). It is estimated that half of the world's population will live under conditions of severe water stress in 2025, with conditions particularly severe in Africa, the Middle East and South Asia (WWC, 2000a). In many parts of the world, mostly in developing countries, available water quantity is decreasing and quality is worsening (Karavoltsos et al., 2008; WWAP, 2006).With rapid growth in population and increase in industrialization, groundwater and surface water quality is being increasingly threatened. Agricultural chemicals and disposals of urban and industrial wastes into water bodies are some of the major causes of water quality degradation. Moreover, it has been estimated that after contamination enters the subsurface, it remains concealed within the ground surface for many years and is dispersed over wide areas of groundwater aquifer thus making groundwater unsafe. The rate of depletion of groundwater levels and deterioration of ground and surface waters quality is of great concern worldwide that adds to lack of public access to safe drinking water (Jain et al., 2010; Krishnakumar et al., 2013; Riley et al., 2011). Most of the countries in the globe are affected by water scarcity caused by groundwater depletion and insufficient surface water availability. About 70 crore people in 43 countries are under water stress, led by Ethiopia, Haiti, and Niger with the least amount of water available for drinking purpose. Efforts have also been undertaken by various international organizations like United Nations to improve the supply of safe water and its equitable distribution by defining various goals. By 2015, it was aimed to reduce one half of people without access to adequate quantities of affordable and safe water by the Second World Water Forum (Rijsberman, 2000) and United Nations Millennium

Declaration (MDG, 2013). The United Nations evaluates that even if the Millennium Development Goals for clean water supply are achieved, 80 crore people still lack access to safe drinking water in 2015. In 2015, member states of the United Nations met again and adopted the 2030 Agenda for Sustainable Development. The Sustainable Development Goal 2030 aims at achieving universal and equitable access to safe and affordable drinking water for all. Water has also been a major focal area for World Bank for lending financial support to developing countries. Almost a third of all Bank projects approved since 1997 have been water related, including irrigation, groundwater, hydropower, floods and drought, water supply and sanitation, watershed management, rivers, lakes, coastal zones, inland waterways and fisheries. Loan commitments under the bank sponsored projects grew 55 percent during 1997 to end of 2007 (World Bank, 2010). However, country-wise access to safe drinking differs drastically and some of the country scenario is given below -

USA: Availability of water is one of the critical resource issues United States is facing recently. With increase in water use every year, nearly 36 states are anticipating local, regional, or statewide water shortages even under non-drought conditions. The demand for freshwater is likely to increase further with increase in human population and declining rate of precipitation due to climate change (GAO, 2014).

Europe: Water shortages is regarded as an urgent problem facing some of the European countries. Around one third of European countries has relatively low availability of water, heavily populated northern and southern countries like Malta, Belgium, Denmark and the UK come within the low water availability country group (EEA, 2019). Residents in the towns and cities of Europe are generally well supplied with connections to water. In many countries, 100% of the urban population has a home connection to mains drinking water but the rural populations lack connection to mains water supplies. The outlying suburban areas of Albania, Romania has intermittent water supplied for 1-3 hours per day and sometimes the discontinuity and interruptions exceed 12 hours per day of no water supply (Lack, 1999).

Japan: In Japan, water is safe to drink from the tap anywhere in the country. Water quality andfacility standards are cautiously monitored by operators ensuring that public health is not compromised. Japan achieved 97.8% water supply coverage in 2014 and almost all citizens of

Japan enjoy safe drinking water. Use of groundwater is restricted in urban areas because of excessive extraction in the past and thus use of surface water is encouraged (70% of water sources in Japan is surface water and 30% is groundwater). Japan also had made intensive efforts on leakage prevention and this has resulted in reducing leakage rates from 80 to 3% in large cities of Tokyo and Osaka after World war II (JICA, 2017).

Singapore: Singapore is a city state covering an area of about 700 km^2 with approximately 1.36 billion litres of water consumption per day. It is a water-scarce country and thus imports its water from the neighboring state of Johor, Malaysia. Apart from importing water from Malaysia, Singapore has made persistent attempt to protect its water sources both in terms of quantity and quality. It augments its available sources by desalination and reuse of wastewater and storm water, and use technological developments to increase water availability. The water sources are further augmented by reducing unaccounted for water caused due to leaks, and apparent water loss arising from meter inaccuracies. Singapore does not have any illegal connections to its water supply systems unlike other South and South-east Asian countries (Tortajada, 2006)."

2.2 Public Access to Safe Drinking Water: Indian Scenario

India has 16 percent of the world's population and its population has increased from 23.8 crore in 1901 to 36.1 crore in 1951 and further to 102.8 crore in 2001. It reveals that during the first 50 years from 1901 to 1951, population grew by 12.3 crore while during the next 50 years from 1951 to 2001, it increased by more than 5 times, that is, by 66.7 crore (Census, 2019). However, India has access to only four percent of its fresh water resources. The per capita availability of freshwater in the country thus has decreased from 5,177 m^3 in 1951 to an alarming 1,820 m^3 in 2001 (Ray, 2008). It has been predicted that the per capita availability of water would drop further to 1,341 m^3 by 2025; this is alarming as the threshold per capita value water is 1,000 m^3 (Ray, 2008). In addition to this, the availability of fresh water is distributed in an uneven manner over time and space (Bansil, 2004). One mechanism for managing the implications of the decreasing availability of water and uneven distribution is through proper water demand and water supply management. To deal with the demand and supply management, Government of India had introduced various schemes for equitable and safe water distribution like Accelerated Urban Water Supply Programme, Low Cost Sanitation Programme, Mega City Scheme, National Slum

Development Prorgramme, Swarna Jayanthi Shahari Rozgar Yojana, Valmiki Ambedkar Awas Yojna and Scheme for Integrated Development of Small and Medium Towns. Schemes like Jawaharlal Nehru National Urban Renewal Mission (JNNURM) were launched to bridge up the investments/resource gap required for infrastructure development. However, in spite of these initiatives, no Indian city has received piped water supply 24 × 7, as water supply is limited to a few hours per day only (WHO, 2011). The gravity of this problem is further aggravated by the fact that less than 50% of urban population has access to piped water supply (WHO, 2011).

2.3 Indian Water Policies and Five Year Plans

Over a period of time, the government of India has come up with various National Water Policies and Five Year Plans to achieve the objective of water to all. A National Water Policy is formulated to govern planning and development of water resources and its optimum utilization. Whereas, a Five Year Plan is a continuing series of programs designed to achieve usually specified goals in a planned and coordinated manner over a period of five years.

2.3.1 Water Policies

Water policies of the country are prepared by the Ministry of Water Resources (MoWR), Government of India presently renamed as Ministry of Water Resources, River Development and Ganga Rejuvenation (MoWR, RD & GR). The first National Water Policy was adopted in September, 1987 with emphasis on planning and management of water resources. The policy considered optimal, economical and equitable use of water of utmost importance to overcome growing scarcity and degrading water quality. The policy encouraged introduction of new strategies and use of new innovated techniques to eliminate pollution of surface and groundwater resources, to improve water quality and to step up the recycling and reuse of water (MoWR, 1987). National Water Policy (2002) focused mainly on the development and management of the water resources in an integrated manner (MoWR, 2012). The major provisions under the policy were related to potable water. It emphasized on creating adequate safe drinking water facilities for the entire population both in urban and in rural areas. In addition to establishment of new water resources facilities, adequate emphasis was given on physical and financial sustainability of existing water facilities. The idea to levy water charges for various users was proposed to sustain operation and maintenance of water facility in the beginning and to recover capital costs

subsequently. Further, management of the water resources was encouraged through a participatory approach. This resulted in involvement of various governmental agencies, the users and other stakeholders in an effective and decisive manner. This participatory approach was set to safeguard smooth functioning of project in various aspects of planning, design, development and management of the water resources schemes. It was mandatory to make necessary legal and institutional changes at various levels duly ensuring appropriate role for women. Decentralization (bottom-up approach) of water facility management was planned and deliberated. The Central Government cedes power to actors and institutions at lower levels in a political-administrative and territorial hierarchy. As such water users' associations, urban local bodies such as municipalities and gram panchayats were to be involved in the operation, maintenance and management of water infrastructures/facilities at appropriate levels wherever possible. This was planned with a view to eventually transfer the management to the user groups/local bodies. It also encouraged private sector participation to seek financial needs and to meet the demand for infrastructure facilities of the people with improved efficient services (MoWR, 2002). The emphasis on private sector participation was dropped from the 2012 draft. Instead, the current policy seeks to develop a public-private partnership model to effectively manage water resources. This is a result of public concern and opposition to the possibility that the private sector may own water assets (Meena et al., 2015).

The National Water Policy (2012) had emphasized to treat water as an economic good and to promote its conservation and efficient use (MoWR, 2012). Some of the major provisions under the policy include pricing of water to ensure its efficient use and reward conservation as well as equitable public access to water and its fair pricing. The involvement of local governing bodies like Panchayats, Municipalities, Corporations, and Water Users Associations made mandatory in planning of the projects, encouraging the concept of decentralization in water supply facilities. The unique needs and aspirations of the scheduled caste (SC) and scheduled tribe (ST), women and other weaker sections of the society were given due consideration. As per this policy, water resources projects and services should be managed with community participation. For improved service on sustainable basis, the State Governments/urban local bodies may associate private sector in public private partnership mode with penalties for failure, under regulatory control on prices charged and service standards with full accountability to democratically elected local bodies (MoWR, 2012). Though the National Water Policies have been adopted in India since 1987, but

practically nothing much was done to ensure sensible use of water and to prevent violation of water bodies or growing exploitation of groundwater resources (Bansil, 2004; Ray, 2008). The policies favor incentives to recycling of resources but lack strict laws to prevent the organization/industries that pollute water. Thus, various water audit reports reflect contamination by industrial leakages and pilferages, which are to be reduced by taking into account strict amendments (MoWR, 2012). Moreover, the policies specify that the tariff should be based on quality of water but does not specify any regulatory governance for authority to check the quality of water. The policies have not set any criteria or standard for framing tariff structure. Hence, there is imperative need of proper implementation of tariff structure so that cost of production and supply of water could be recovered (Bansil, 2004; Iyer, 2003).

2.3.2 Five Year Plans

Since independence, Indian economy has been based on the concept of planning in terms of five-year plans, which were developed, executed, and monitored by the Planning Commission of India. The initial five-year plans gave stress on eradicating poverty, development of public sector, improving agriculture and employment opportunities. The water sector became one of the key areas for development from the Fourth Five-Year Plan onwards. Until the end of the Fourth Five Year Plan, i.e. during the period 1951 - 1974, the total investment made by the Central and State Governments for providing water supply facilities was of the order of Rs 323 crores (PCGI, 1980). Though budgetary allocation has been made, but water supply was not accorded as high priority sector in the national planning process. The constraint of resources in the states and the competing demands for programs in other sectors compelled the state and local governments to give relatively lower priority to water supply sector in the allocation of funds. The importance of providing safe water supply and sanitation as a basic minimum need without improvement in the living standards of the people was reiterated in the Fifth Five-Year Plan. It has been declared that adequate resources would be allocated for the program irrespective of the resource constraints of individual states and a total investment allocated for the water sector was Rs 505 crores. A Minimum Needs Program was introduced in the first year of the Fifth Five-Year Plan. The objective of this Program was to provide the facility to all villages suffering from chronic water scarcity or having unsafe sources of water. The Integrated Development of Small and Medium Towns program, Accelerated Rural Water Supply Scheme and Minimum Needs Program launched in the Sixth Five-Year Plan

intended to provide at least one source of drinking water in every village that was identified as a water scarcity village. During this plan, there was a provision of an outlay of Rs. 2425 crores under Centre and State government fund. Still, the water supply program was not given enough high priority in the national planning process (PCGI, 1980).

After 1980s, the State Governments and local bodies were directed to explore the possibility of raising funds for water supply schemes through suitable levies (capital charges) on the potential beneficiaries, exempting poorer section to pay for water. However, it was encouraged to raise little funds through local village initiative, which would cover at least a part of the maintenance expenses. It was also proposed to cover all those villages which do not have an assured water supply within a distance of 0.5 km. The per capita water norms in litres per capita per day (lpcd) were increased from 40 to 70 during the Seventh Five-Year Plan, as recommended by the Estimates Committee, while the international per capita norms at that period assumed in North America as 400 lpcd, Europe as 200 lpcd and Sub-Saharan countries as 10–20 lpcd (WWC, 2000b). An outlay of Rs 4377 crores was provided for water sector under this Seventh Five-Year Plan (PCGI, 1985).

The objective of the Eighth Five-Year Plan was to achieve 10% increment in the coverage of access to safe drinking water from 84% at the end of the Seventh Five-Year Plan. To achieve this, investment of Rs 9224 was allotted to meet the requirements of incremental population for drinking water services. Whereas, the participation of financial institutions and the private sector was not significant, particularly due to the absence of cost recovery, appropriate tariff rate policies and lack of fiscal and monetary incentives. In this perspective, a new program was launched in the Eighth Five-Year Plan for urban water supply, namely the Accelerated Urban Water Supply Programme (AUWSP), which was targeted to small towns (population less than 20,000 based on 1991 census) as these towns had been excluded earlier in spite of having encountered severe water scarcity problems. AUWSP aimed at providing safe and adequate water supply facilities to the entire population of the towns having population less than 20,000 (PCGI, 1992).

The Ninth Five-Year Plan prioritized 100% coverage of all habitats with safe water supply, adequacy in terms of minimum per capita consumption norms, quality, distance from source as well as regularity of supply, bringing in the policy and operational issues of drying and inaccessible sources of water, recycling of waste water and sewage for non-domestic use, and water harvesting.

The strategies to promote and strengthen decentralization of production and distribution systems, privatization and participation of the community in management and maintenance are expected not only to induct higher efficiency levels but also to have less leakages and wastages. Exploitation of groundwater is to be avoided to maintain quality and to control water pumping cost. The Central and State funding for water sector in the Ninth Five-Year plan was estimated to be Rs 19228 crores (PCGI, 1998).

The Planning Commission (PCGI, 2002) in its Tenth Five-Year Plan aimed to achieve the specific objectives related to drinking water supply with an outlay of Rs 31356 crores. The priority was given to ensure that the 'not covered', 'partially covered', scheduled caste/scheduled tribe (SC/ST) population and other poor and weaker sections and those habitations facing a severe water quality problem are fully covered with safe drinking water facilities on a sustainable basis. The three major and widely prevalent problems identified in sustainable supply of drinking water were scarcity, brackishness and excess fluoride content. These problems were mainly found in the low rainfall and high potential evaporation areas. An integrated water management approach that included water harvesting, conservation and direct or indirect artificial recharge of aquifers was sought for simultaneous mitigation of all the three problems. It was also sought to adopt block/district wise technology depending upon contaminant present e.g. iron, fluoride, arsenic shall be district/block specific. It was also proposed to carry out research to develop new, and improve existing technologies in terms of their simplification and cost effectiveness. The Government of India introduced an 'Arsenic Sub-mission' in 1994 under the Rajiv Gandhi National Drinking Water Mission to tackle the arsenic problem in West Bengal on a 3:1 cost sharing basis between the Centre and the State. In view of the increasing problem of water quality and the resultant health hazards, water quality monitoring and surveillance systems were institutionalized. Water quality surveillance was carried out by an independent organization, more appropriately by the Public Health Engineering Department (PHED) which should be provided with adequate funds for the task (PCGI, 2002).

The objective of the Eleventh Five-Year Plan was to provide clean drinking water to all by 2009. The first two years of the eleventh plan targeted to achieve proper water coverage to 55,067 'not covered' habitations (average supply of drinking water less than 10 lpcd), 2.17 lakh 'quality-affected' habitations {habitations where water samples tested in laboratories have indicated levels

of chemical contamination (limited to arsenic, fluoride, iron, nitrate and salinity) higher than the permissible limits of Bureau of Indian Standards} and 2.8 lakh 'slipped back' habitations. 'Slipped back' habitations are habitations having 'fully covered' (average supply of drinking water equal to or more than 40 lpcd) status at one point of time but which is 'partially covered' (average supply of drinking water is less than 40 lpcd and equal to or more than 10 lpcd) or 'quality-affected' presently. The States have done well in covering the 'slipped back' habitations (1.63 lakh habitations covered) and 'not covered' habitations (23,000 habitations covered). However, achievement in the quality-affected habitations was way below the target. Against 2.17 lakh habitations, as on 2005, about 70,000 habitations have since been addressed. The reason behind such shortfalls was found to be unavailability of alternate source in vicinity or lack of efficient technology for contaminant removal. However, due to rapid increase in urban population the situation has become much grim to meet the water demand in urban areas. To cope up with this huge progressively increasing gap between the demand and supply of water in urban areas, government sought of introducing certain reforms through Public Private Partnership (PPP). Through PPP, the Government is making efforts to attract finance for water supply projects/services from private sector and to access management efficiencies (PCGI, 2008). With a view to provide reform-linked infrastructure facilities in the urban areas, the Government of India has launched two new programs namely: (i) Jawaharlal Nehru National Urban Renewal Mission (JNNURM) covering 63 cities with population above one million as per 2001 census, including 35 metro cities and other State capitals and culturally important towns, (ii) Urban Infrastructure Development Scheme for Small & Medium Towns (UIDSSMT) for the remaining 5098 towns having population less than one million to cover all the towns as per 2001 census, irrespective of the population criteria. The Eleventh Five-Plan provided an outlay of Rs. 88211 crores of which Rs. 49000 crores were under States/UT Plan and Rs. 39211 crores under Central Plan for water supply programme (PCGI, 2008).

Desired outcome of the current five-year plan (Twelfth Five-Year Plan) with respect to water supply are (i) Universal access to water and sanitation, (ii) 100 % metering of water supply, (iii) Provision of 24 × 7 water supply wherever possible and feasible, (iv) Provide step by step improvement in the operations of the water utility, (v) Steadily bring down distribution inefficiencies by bringing down wastage of water closer to international best practice, and (vi) Improve the quality of water to be supplied (PCGI, 2013). The tentative gross budgetary support

for drinking water supply and sanitation in the Twelfth Five-Year Plan is Rs 2,30,408 crores. 100 percent of this outlay is for flagship programmes, namely National Rural Drinking Water Programme and Nirmal Bharat Abhiyan, administered by Ministry of Drinking Water and Sanitation (PCGI, 2013).

2.4 Urban Water Supply in India: Flaws and Issues

In India, ULBs are delegated the responsibilities of supplying safe/treated water for domestic use purpose within the municipal/city limits. This makes it mandatory for ULBs to develop the necessary technical expertise for treatment and distribution of quality water to its residents. On the other hand, the state and the Central Government have their important stakes in financing the activities of the ULBs. However, no municipal limit exists now-a-days as the city is growing in all directions due to migration of people from rural parts. The growth of population in municipal limits and suburban areas is faster than the expansion of existing or institution of new water treatment facilities for supply of treated drinking water as well as provision of good sanitary systems. Therefore, the municipal agencies are finding it difficult to meet the growing water demands of urban and suburban population, creating huge gap between demand and supply of water (Devkar et al., 2013). In addition, lack of expertise within ULBs have led to compromise the desirable deliverables from water facilities. There are evidences of poor maintenance of water supply systems, huge water losses, large number of non-functional meters, inadequate supply of safe drinking water, insufficient water quantities, intermittent water supply, poor quality of water, depleting groundwater levels, lower tariff than the expected, lower cost recovery, poor financial management, lack of reliable data/information, numerous technical problems, lack of dedicated service connections, insufficient treatment capacity, frequent pipe bursts and poor maintenance of reservoirs (Aijaz, 2010; Ananda, 2011; Kashaigili et al., 2003; Lee, 2010; Lobina & Hall, 2007; Makungo et al., 2011; Motte, 2007; Ndokosho et al., 2007). All these shortcomings lead to outbreak of diseases through supply of contaminated water. The major reason for this could be the negligence and lack of skillsets of operators for water tests/analysis as well as routine treatment and maintenance. The supply water from water treatment plants at Bhagirathi, Sonia Vihar, Wazirabad, Nangloi, Okhla, and Haiderpur in Delhi were found to contain trihalomethane and pesticide contamination (Hasan et al., 2010; Thacker et al., 2008). Water supply from Pawnar water treatment plant situated in Wardha, Maharashtra have been revealed to contain high levels

of turbidity and total coliform in tap water (Mankar & Nagarnaik, 2011). The maximum limits of physico-chemical parameters observed for turbidity and bacterial contamination in supply water were above WHO guidelines limits in the water treatment plant at Dewas, Madhaya Pradesh, which is being maintained by state Public Health Engineering Department (PHED) (CPCB, 2003). Similarly, in Guwahati, it was observed that water supplied from water treatment plants maintained and operated by Guwahati Municipal Corporation, Public Health Engineering Department had exceeded the World Health Organization (WHO) (WHO, 2008) as well as Bureau of Indian Standards (BIS) standard specifications for potable water (BIS 10500, 2012) for turbidity, lead, arsenic, chlorine and *Escherichia coli (E-coli)* (JICA, 2008; The Assam Tribune, 2017).

2.5 Groundwater Quality and its Contamination in India

Groundwater is the dominant resource in developing countries like India to meet the drinking water needs. Groundwater has been considered as the source of safe drinking water especially in rural population in many developing and under-developed countries. In fact, millions of hand pumps and deep tube-wells have been installed in India since the last few decades to provide bacteria-free safe water (Garode et al., 1998; Mitchell et al., 2011). It is usually accounted as safe drinking water in disperse populated rural areas with no availability of water treatment facility. Though groundwater is free from bacterial contamination, it is usually contaminated by numerous dissolved chemical constituents that may cause chronic health effects, taste and aesthetic problems (Jain et al., 2010; Sankararamakrishnan et al., 2008). The contamination of groundwater depends upon geology of the region and the climatic conditions. In arid waterless or limited water recharge regions, slow percolation of water through soil results in mineralized poor-quality groundwater high in sodium chloride. In humid climates, leaching and weathering of sedimentary rock takes place releasing iron, calcium, magnesium and producing excessive hardness in water. Fluorite mineral found in sedimentary, igneous, and metamorphic rocks can cause fluoride contamination. Arsenic is found significantly in aquifers of volcanic depositions (Krishna et al., 2017).

Different regions in India face a number of problems regarding the quality of groundwater. Arsenic contamination is prevalent in the Ganga–Brahmaputra–Meghna Basin, high levels of fluoride, salinity (electrical conductivity), nitrate, chloride, iron and microbial contaminations at shallow aquifers are encountered in several areas of Uttar Pradesh, Bihar, Jharkhand, West Bengal,

Tamil Nadu, Andhra Pradesh, Assam, Manipur and Mizoram (Chakraborti et al., 2009; Naram, 1981; Nickson et al., 2007; Rawat et al., 2012; Satpathy et al., 2014; Singh et al., 2006; Singh et al., 2013; Singh & Singh, 2011; Suthar et al., 2009).

In a survey conducted in Bangladesh, consuming high saline concentrated water causes pre-eclampsia, eclampsia, and hypertension in pregnant women living in coastal areas (Khan et al., 2008). In addition, excessive intake of water containing sodium chloride at concentrations above 2500 mg/L has been reported to produce hypertension (WHO, 2008). In India an estimated 62 million population including 6 million children have dental, skeletal and non-skeletal forms of fluorosis due to consumption of fluoride contaminated water (Reichard et al., 2000; Susheela et al., 1993).

Assam, rural areas of Punjab, few areas in Andhra Pradesh, Dhenkenal district, Orissa were observed to have high levels of fluoride, turbidity, total dissolved solids (TDS) (Chakraborti et al., 2009; Das et al., 1998; Siddiqui, 1955). Health hazards such as premature greying of hair, hair fall, typhoid, yellowish teeth, joint pain, diarrhea, constipation were reported to be major diseases prevailing in the region (Singh & Singh, 2011). In southern and south-western Haryana, nitrate levels were observed to be extremely high at shallow depths in several places (Kakar, 1981). The nitrate pollution is likely to be caused by anthropogenic activities such as discharge of sewage and agricultural wastes in this region. High concentrations of nitrate in groundwater is hazardous for health and pollution abatement measures are necessitated to prevent further degradation of groundwater quality (Kakar, 1981). The World Health Organization (WHO) guideline limit (WHO, 2008) for nitrate in drinking water is 50 mg/L, exceeding this limit causes methemoglobinemia or blue baby syndrome in infants.

Studies have also focused on cases of cancer and adverse reproductive outcomes on exposure to drinking nitrate contaminated water (Ward et al., 2005). In Bihar, the state government tested water sources spread up in all districts of Bihar during 2002-2008. The test results revealed presence of fluoride, iron and arsenic in different parts of the state. The Government of Bihar has taken diversified steps to provide safe drinking water through identification of contaminated as well as safe water sources, infected hand-pumps and providing alternate safe drinking water source. The awareness programs on water related health issues caused by arsenic and fluoride were

organized at various levels. Advanced or innovative tools were implemented spreading awareness among the people by community volunteers, frontline functionaries both belonging to government and non-governmental organization (NGO) stream. It included distribution of hand-outs, frequently asked questions (FAQs) on myths and realities, posters on signs and symptoms for general awareness, wall paintings and relevant training materials for the field staff. Moreover, rain water harvesting system and aquifer recharging systems are being constructed in contaminant affected areas for safe drinking water. The state and districts laboratories are made functional for testing and mapping of water sources and safest aquifers were explored for piped water supply in Bihar (PHED, 2009).

In many parts of the world including India, naturally occurring high arsenic concentration is one among the recognized problems in groundwater (Kumar et al., 2013). Anthropogenic activities such as over-extraction of groundwater is adding to groundwater salinization and arsenic pollution in the coastal areas (Liu et al., 2003). High level of arsenic exposure is associated with chronic health effects including cancer of the bladder, lung, liver, kidney, and skin. The biological mechanisms of arsenic may relate to oxidative stress, altered deoxyribonucleic acid methylation and repair, cell proliferation, gene amplification, and chromosomal abnormalities (Han et al., 2009; Hughes, 2002). Hence, use of groundwater for drinking purpose cannot be encouraged in many parts of India until it meets the requirements of drinking water standards.

2.6 Drinking Water Quality Standards/Guidelines

Drinking water must comply with desirable quality standards set by regulatory authorities in a country. The Bureau of Indian Standards (BIS) provides the water quality standards for domestic consumption (BIS 10500, 2012) in India (Table 2.1) while World Health Organization provides guidelines to be adopted wherever national standards are not available (WHO, 2008). For drinking water, turbidity should be less than 5 NTU as per BIS 10500 (2012) but less than 1 NTU as per WHO (2008). For iron and fluoride, the BIS permissible/WHO guidelines limit are 0.3 mg/L and 1.5 mg/L respectively. Whereas arsenic concentration needs to be less than 0.05 mg/L as per BIS permissible limit but less than 0.01 mg/L as per WHO guidelines limit (Table 2.1). These standards/guidelines are applicable irrespective of source of water.

Table 2.1: Water quality standards/guidelines for drinking purpose (BIS 10500, 2012; WHO, 2008)

Characteristics	BIS Standards		WHO Guidelines
	Desirable limit	Permissible limit	Desirable limit
Colour, Hazen units	5	25	-
Odour	Agreeable	Agreeable	-
Turbidity, NTU	5	10	< 1
pH value	6.5 - 8.5	No relaxation	6.5 to 8.5
Total hardness (as $CaCO_3$), mg/L	300	600	500
Iron (Fe), mg/L	0.3	No relaxation	0.3
Chloride (Cl), mg/L	250	1000	250
Fluoride (F), mg/L	1.0	1.5	1.5
Dissolved solids, mg/L	500	2000	1000
Calcium (Ca), mg/L	75	200	75
Magnesium (Mg), mg/L	30	100	30
Copper (Cu), mg/L	0.05	1.5	0.05
Manganese (Mn), mg/L	0.1	0.3	0.1
Sulphate (SO_4), mg/L	200	400	200
Nitrate (NO_3), mg/L	45	No relaxation	45
Phenolic compounds (C_6H_5OH), mg/L	0.001	0.002	0.001
Mercury (Hg), mg/L	0.001	No relaxation	0.001
Cadmium (Cd), mg/L	0.003	No relaxation	0.01
Selenium (Se), mg/L	0.01	No relaxation	0.01
Arsenic (As), mg/L	0.01	0.05	0.01
Cyanide (CN), mg/L	0.05	No relaxation	0.05
Lead (Pb), mg/L	0.01	No relaxation	0.05
Zinc (Zn), mg/L	5	15	5
Total alkalinity (as $CaCO_3$), mg/L	200	600	-
Aluminium (Al), mg/L	0.03	0.2	0.03

2.7 Groundwater Awareness Programs

Awareness programs on groundwater conservation and its quality regarding presence of contaminants have been carried out by various organizations. The awareness programs are of great importance as the groundwater usually is aesthetically good but contains numerous contaminants e.g. iron, fluoride, nitrate, arsenic etc. There are examples of success stories of awareness campaign. For instance, Wells in Exeter, Canada had reached maximum fetching capacity due to over extraction and traces of chemical contaminants were detected in groundwater. The public was unaware of this fact and 90% of the population was dependent on groundwater supplied by ULB and on private wells. Awareness program was, then, organized by the ULBs through distribution

of brochure and newsletters, and broadcasting in local TV channel with the aim of educating citizens on importance of groundwater recharge and its existing contamination (Chevalking et al., 2008). This resulted in creating a basic understanding of aquifer systems and the actions required to use groundwater in a sustainable manner. Similarly, the Dutch government has also set up a campaign called 'Living with Water' to create wider understanding of the complexities of groundwater in the Netherlands through commercials on television, radio and magazines (Kazmierczak & Carter, 2010). The annual national groundwater awareness week is held in USA to encourage well owners to check their well water for contamination and limit of extraction (CDCP, 2016). In India, training programs were organized in Telangana (earlier part of undivided Andhra Pradesh) to familiarize users with scope and need for groundwater conservation. Such steps triggered no resistance from groundwater users when groundwater laws and regulations were introduced (Chevalking et al., 2008). Central Ground Water Board (CGWB) organizes various capacity building activities as well as mass awareness campaigns on the importance of water conservation and judicious ground water management in various parts of the country (CGWB, 2015).

2.8 Policy Shift from Groundwater to Surface Water Sources

Most of the developed nations rely on surface water as drinking water source (Falconer, 2004). Different developing and underdeveloped countries are also targeting shift from groundwater to surface water sources for safe and hygienic drinking water. For example, cities in Bangladesh such as Dhaka, Chittagong, Khulna, Rangpur and Rajshahi have prepared master plans to incorporate a gradual shift from groundwater to river water sources (BanDuDeltAS, 2015). The groundwater in most part of the Dhaka is contaminated by arsenic. Similarly, region of Ganga–Brahmaputra–Meghna basin in India is also contaminated by arsenic. Hence, for this reason, the Governments at Central and State levels have repeatedly expressed need to shift from groundwater to surface water for drinking purpose. The Mid-Term Appraisal of the Tenth Five-Year Plan of Government of India has already suggested shift from groundwater to surface water, to resolve twin problem of groundwater preservation and contamination (PCGI, 2002). Moreover, the Twelfth Five-Year Plan also recommended gradual shift from over dependence on groundwater to surface water sources (PCGI, 2013). West Bengal, an Indian state has severe arsenic, iron and fluoride contaminated groundwater and have emphasized on complete shift from hand pump, and

tube wells to piped water supply schemes for safe, sustainable and adequate water supply to its citizens (PHED, 2013). All the Indian states have some regions of groundwater contamination. Hence, the Central and State Governments have initiated several surface water based water supply schemes across the country. The financial investment wherever possible is provided either by the government or funding from international funding agencies and private sector (DoEA, 2001).

2.9 Public Opposition to Water Supply Projects

Provision of water supply, sanitation and wastewater services generate substantial benefits for public health, the economy and the environment (OECD, 2011), However, public opposition have been encountered by various water supply projects worldwide that have eventually led to its failure (McKenzie & Mookherjee, 2003). Water supply projects in Cochabamba had to terminate its contract with private entity due to huge rate of tariff hike of 35%, where low-income households' bills rose by about 10% and higher-income customers experienced double tariff (Davis, 2005; McKenzie & Mookherjee, 2003; Nickson & Vargas, 2002). The instances of public protest to water supply projects were also observed in countries like Ecuador, Lima, Rio de Janeiro and Paraguay (McKenzie & Mookherjee, 2003). Since the beginning of involvement of private sector in water supply projects as planned in PCGI (2002), India has also faced similar opposition from public against water supply projects. In Latur (Maharashtra) and Mysore (Karnataka) there were sententious protests against water supply project. Water tariff was increased and water meter and connection fees introduced without any improvement in service or delivery of water. This resulted in widespread non-payment, protests and, in some cases social instability (riots) (MAK, 2011). In case of water supply projects of Belgaum, Hubli-Dharwad, and Gulbarga in Karnataka, India the private enterprises were given responsibility of execution and operation & maintenance. This enrooted fear among the public that involvement of private sector will lead to increase in water tariffs (Chabra, 2014). Although the increment in tariff was not expected in this case the public were not taken into confidence during decision-making process of the project. They are being marginalized to an extent that they feel like they are outsiders during the development and management processes, liable of paying tariffs (El-Gohary et al., 2006; Henjewele et al., 2013). Besides the visible reasons of the failures of the water supply projects in India, very few studies have been conducted to systematically study the causes of failure of such projects that may include technical, social, economic and political reasons.

2.10 Public Participation in Water Supply Projects: A Key to Success

Effective public participation (PP) is one of the key factors for improving the efficiency of a project and to succeed in its comprehensive management. Many governments world-wide are increasingly encouraging the involvement of interested individuals, groups and organizations in various projects as a means of improving the openness, transparency and accountability of the decision-making process and help improve the projects' long-term viability and benefits to the community. Globally, PP in rural areas is found to be poor but in urban areas the participation rate is quite high (Franceys & Gerlach, 2011; Jingling et al., 2010; Li et al., 2012). PP is a key water management principle but its practical application is much complicated. The problems associated with implementation of PP are: (i) government unwillingness to listen to the public, (ii) response from the public is often limited and unrepresentative, and (iii) the quality of the response may be low. Government normally initiates PP only at a very late stage, when nothing can be changed or it may simply ignore the outcomes of PP. This results in disappointment, soured public relations and less public acceptance. Sometimes the public is seen as short-sighted, ill-informed, selfish and too emotional or lacking in democratic attitude (Mostert, 2003). Tang et. al. (2008) identified certain constraints in public participation such as (i) lack of legal and administrative back-up i.e. absence of a statutory framework and administrative procedures at the local level, (ii) lack of transparency, and (iii) low education level and awareness among public. These drawbacks together restrict the capacity/ability of public to participate in decision making processes (Tang et al., 2008). Ozerol & Newig (2008) identified five key constituents affecting success of public participation processes and used them as indicators. The indicators are: (i) Scope of the participants: it includes unclear definition of stakeholders and unequal opportunities for involvement of each of them. (ii) Communication with the public: it states that the authorities should not be inaccessible, unclear, insufficient, too much or too less technical information passing, there should not be delay or absence of response from the competent authorities, adopting opaque decision-making processes. (iii) Capacity building: it states that there should not be lack of knowledge on the part of the public and free from lack of institutional capacity. (iv) Timing of participation: this is the most important to avoid late involvement of the public or involvement at the end of the decision process. (v) Financing of participation: it refers to renumeration or reimbursement of money spent by public for public participation (Ozerol & Newig, 2008). Number of participants and public willingness to

take part in PP process depends upon set of rules, time as well as place of PP, and the participant's profession (Johnson, 1997). The eligibility criteria must be pre-informed publicly through a specific legal framework for involvement in decision making rather than the overall role of household participation (Prokopy, 2005). Moreover, failing to participate formally in a project, public try out alternate means of participation such as social mobilization, legal petition, public protest and agitation (Diduck et al., 2013).

2.11 Willingness to Pay for Treated Surface Water Supply

Considerable effort has been made in recent years in improving the quality and quantity of water supplied to the people in developing world but the results from those efforts are limited and insufficient (Saz-Salazar et al., 2015). One of the reasons for this could be attributed to the lack of maintenance of water supply schemes and slow extension of services to unserved populations (Whittington et al., 1990). Apart from these, another reason for the lack of improvement of these facilities is inadequate information sharing among the consumers and not considering public preferences while implementing new services (Whittington et al., 1990). In many areas, people to be served by new facility have chosen to continue with their traditional water use practices. Hence, if water supply projects are required to be sustainable and acceptable, an improved planning approach is required that includes accountability and transparency in project initiation, planning, execution and closure processes (Whittington et al., 1990). In addition, tariffs are to be designed so that capital costs or at least operation and maintenance costs can be recovered. Otherwise low cost-recovery rates of these services would lead to a huge gap between the finances required to operate and maintain the water supply facility and the revenue generated based on the existing tariff (Saz-Salazar et al., 2015). One important step in an improved planning approach is that of willingness to pay and procure services. A particular service is valued, if people are willing to pay for its services and that it will be possible to generate the funds required to sustain, operate and maintain the project. Attempts to incorporate willingness-to-pay of people into the project have mostly been impromptu (Whittington et al., 1990).

Numerous variables that have been used in past studies/investigations that are linked to household's willingness to pay and procure services have been identified by various researchers. It was observed from most of the studies that the households have commonly shown their willing

to pay for improved water quality and its services. It has also been revealed that the demographic characteristics of the households like age of the respondent, gender and size of household and characteristics of the existing or traditional sources of water play an important role in enhancing willingness to pay for water supply facilities (Fotue, 2013; Widiyati, 2011). Studies by Casey et. al. (2006) and Whittington et. al. (1990) at Manaus and Haiti revealed that, contrary to the conventional notion of income being an important parameter (Brox et al., 2003; Jayasundara et al., 1999; Kanayo et al., 2013), it was identified to be not a major determinant of the household decision regarding willingness to pay for improved water supply services. This implies that not only the rich but also the poorer households are willing to pay for the water supply facilities. Findings also revealed that the willingness to pay for water was sensitive to education and it increases with the education level of the household head (Brox et al., 2003; Mbata, 2006; Noor et al., 2010). Other studies revealed that respondent perception about quality of the existing water supply is significant and that explain willingness to pay (Khan et al., 2010; Vo & Huynh, 2017; Wendimu & Bekele, 2011). Again, a study in Nigeria revealed that occupation of the household head, prices charged by water vendors, amount of water consumed and type of water sources are the determining factors for willingness to pay for improved water services (Kanayo et al., 2013). Whereas, Whittington et al. (1990) in Haiti found that distance to existing sources has been a significant factor influencing the households' willingness to pay.

2.12 Stakeholder Management

Stakeholders are individuals or organizations those are either affected by or can influence the development of the project (El-Gohary et al., 2006; Freeman, 2010). Stakeholders may be anyone that can affect the development of the project at some stage. It would include the owners and users of facilities, project managers, facilities managers, designers, shareholders, regulatory authorities, employees, subcontractors, suppliers, process and service providers, competitors, banks, insurance companies, media, community representatives, neighbors, general public, government establishments, visitors, customers, regional development agencies, the natural environment, the press, pressure groups, civic institutions, etc. (Chinyio & Olomolaiye, 2010). The stakeholder influence could be positive or negative; they may support or obstruct an ongoing project. Chinyio & Olomolaiye (2010) identified two tactics for managing public stakeholders in a project: firstly, that each stakeholder should be managed based on their character/nature. That

way, the missions, strengths, weaknesses, strategies and behavior of the different stakeholders will be known to avoid any possible threats they may pose to the proposed water supply project. Secondly, each project-based set of stakeholders must be managed as a cohort like users of facilities, members of the public, etc. that may affect the project after the construction phase and so stakeholder management stretches in having a life-time agreement/compatibility of opinion and action.

2.13 Importance of Public Consultation

Apart from the willingness to pay and stakeholder management, public consultation is a key factor deciding the fate of the water supply projects. There are multiple studies that have already proved that public consultation enhances public acceptance of the project (Henjewele et al., 2013; Rowe & Frewer, 2000). However, public consultation is a complex process that needs reliable planning and in-depth knowledge of the society in almost all aspects. For the simplicity of the planning, many countries have adopted principles of public consultation. Public consultation principles are the set of guidance that government departments and ULBs adopt for engaging public/stakeholders when developing a policy or legislation. It is not a 'how to' guide but aims to help policy makers make the right judgements about when, with whom and how to consult. Effective consultation can bring valuable information to help design successful policy solutions and make informed decisions (EC, 2012). Moreover, effective consultation encourages greater public involvement and interest, deliver stronger community leadership, plan services and policies based on the needs/views of people, identify priorities and improve strategies, and to monitor the performance of services over time (Watkinson, 2011).

2.13.1 Public Consultation Principles Worldwide

For the purpose of public consultation, various lists of consultation principles are frequently developed by countries worldwide. These include official versions of governments and principles adopted by organizations. They usually consist of recommendations for specific changes that would be needed in order to achieve efficient public consultation. Development of policy for a country or particular project necessitates studying the policies, regulations and principles followed in different countries. The various sets of principles for public consultation established by different governments and organizations are discussed in this section. The summary of the public

consultation principles of different countries and organization are explained in Table 2.2 along with the implementation practices of the principles followed by different countries in Table 2.3.

The UK Government had drafted 11 principles as a goal to achieve effective public consultation in policy and legislation (Crown, 2012). It depicts that the consultations should be clear and concise, goal-oriented, informative, public-engaging, targeted and facilitate scrutiny. It should last for sufficient time to have true representation of society, take into account the views of the groups being consulted and should be agreed before publication. In addition, the government responses to consultations should be published in a timely fashion and the consultation exercises

Table 2.2: Description of principles to accomplish public consultation goal

Sl. No.	Principles of consultation	Description
1	Clear and concise	The consultation shall make clear its purpose, context and the process and should ensure that the information shared is relevant, complete and easily understandable to common people.
2	Purposeful	Public consultation should not be carried out for the sake of consultation. Consultation responses must be accounted framing the policy forward. Consult about policies or implementation of plans at a formative stage.
3	Informative	Adequate information needs to be shared to public to acquire helpful and informed inputs.
4	Last for proportionate time	Consulting for too long will unnecessarily delay policy development. Consulting too quickly, will offer short time to share adequate information and reduce the quality of responses.
5	Targeted	Targeted public groups (business, voluntary bodies and representative groups) are to be considered so that they are aware of and could access the consultation.
6	Take consulted group responses	Consult stakeholders in a way that suits them. Take into account the responses.
7	Agree before publication	Seek collective agreement before publishing a written consultation.
8	Facilitate scrutiny	State and explain number of public responses received and how these are incorporated in policymaking.
9	Timely response publication	Publish responses well in stipulated time or provide reason for delay.
10	Timing convenience	Public are to be given reasonable time to prepare and provide their responses and consultation activities should not be launched during local or national election periods.

Sl. No.	Principles of consultation	Description
11	Be well planned, managed and coordinated	Planned instructions to managers in carrying out consultations.
12	Be well communicated	Publicize consultations and keep people informed about what is happening.
13	Provide fair, accessible feedback	Publish responses as well as their consideration in policymaking.
14	Consultation at earliest possible stage	Consultation with key stakeholders should start as early as possible i.e. at planning stage so that there would be enough time for consultations in a meaningful manner. Lack of adequate consultation may create problems and local opposition, delaying the project and putting project planning and implementation aspect at risk.
15	Transparent	Various considerations in development of policy should be explained to public. The purpose, process, possible outcomes and utilization in policy revision should be made clear to public.
16	Knowledge and educational discussion	Organizing educational initiatives to ensure public awareness about project information and encourage fruitful discussions. However, public need to be receptive and responsive to these initiatives.
17	Privacy	The privacy of participants in public consultations shall be ensured.
18	Impartiality	When planning and carrying out a public consultation the impartiality of the process shall be guaranteed in order to pursue the general interest.
19	Inclusion	Public participation should be accessible, inclusive and open, offering equal opportunities to all stakeholders.
20	Continuous	It should continue through all stages of the regulatory cycle, including when detailed design features are being finalized. This will help to identify and understand potential problems.
21	Accessible	Consultation should ensure that stakeholders could readily contribute to policy development.
22	Consistent and flexible	Consistent consultation procedures can make it easier for stakeholders to participate. They can also permit better coordination of regulatory quality initiatives across a wide range of policy areas.
23	Subject to evaluation and review	Policy agencies should evaluate their consultation processes and continue to examine ways of making them more effective.

[Source: (BCC, 2011; Crown, 2012; MIKR, 2009; NAP, 2016; OBPR, 2016; OGP Team, 2017; SCC, 2017; Watkinson, 2011)]

Table 2.3: Mapping of public consultation principles of different countries

Sl.	Principles of Consultation	Countries						
		UK	UK[a]	EC	Canada	Italy	Aus.	NL
1	Clear and concise	✓	✓	✓	–	✓	–	✓
2	Purposeful	✓		–	–	–	–	–
3	Informative	✓	✓	–	–	✓	✓	✓
4	Last for proportionate time	✓	✓	–	–	✓	✓	–
5	Targeted	✓	✓	✓	–	–	✓	–
6	Take consulted group responses	✓	–	✓	–	–	–	–
7	Agree before publication	✓	–	––	–	–	–	–
8	Facilitate scrutiny	✓	–	–	–	–	–	–
9	Timely Response publication	✓	–	✓	✓	–	–	–
10	Timing convenience	✓	✓	–	–	✓	✓	–
11	Be well planned, managed and coordinated	–	✓	✓	–	✓	–	✓
12	Be well communicated	–	✓	–	–	–	✓	–
13	Provide fair, accessible feedback	–	✓	✓	✓	–	–	–
14	Consultation at earliest possible stage	–	–	–	✓	✓	✓	–
15	Transparent	–	–	✓	✓	✓	✓	–
16	Knowledge and educational discussion	–	–	–	✓	✓	–	–
17	Privacy	–	–	–	–	✓	–	–
18	Impartiality	–	–	–	–	✓	–	–
19	Inclusion	–	–	–	–	✓	–	–
20	Continuous	–	–	–	–	–	✓	✓
21	Accessible	–	–	–	–	–	✓	–
22	Consistent and flexible	–	–	–	–	–	✓	–
23	Subject to evaluation and review	–	–	–	–	–	✓	–

UK-United Kingdom, UK[a] - Bristol city, UK, EC - European Commission, Aus. - Australia, NL-Netherlands

[Source: (BCC, 2011; Crown, 2012; MIKR, 2009; NAP, 2016; OBPR, 2016; OGP Team, 2017; SCC, 2017; Watkinson, 2011)]

should not generally be launched during local or national election periods. Besides the UK Government's principles, Bristol and St Helen's City Council of UK had also proposed 7 principles to run a public consultation (BCC, 2011; Watkinson, 2011). They also recommended that the duration of consultation should be enough to clearly pass project information and encourage public for informed opinion. It should be well targeted and efforts should be made to reach out social

groups, offer genuine options and ask objective questions. It should be well planned, managed, coordinated, listed on official website and be well communicated to provide fair, and accessible feedback.

In addition, the European Commission for Health and Consumers Directorate-General had put forward a set of principles for public consultation and involvement that states that the consultation needs to be effective by considering it at the earliest possible stage in the decision-making process, when there is scope to influence the policy outcome. Consultation should be targeted to make sure that the relevant stakeholders are involved and should be transparent about its scope. Consultation exercises should be clear on what has taken place in the development of the policy prior to the consultation, how the consultation will be run and, as far as is possible, what can be expected after the consultation has formally closed. Moreover, the type of consultation should be proportionate to the scale and impact of the respective legislative initiative. It should be inclusive i.e., efforts should be made to involve a representative cross-section of stakeholders in policy development, since different sections or groups of stakeholders across the EU have different needs and views. Consultation needs to be accountable through timely feedback to stakeholders that improve the transparency and accountability of the overall policy development process, and helps make the connections between stakeholders' input and the result. Coherent consultation to be maintained through documents including the feedback report, should be presented in a common format and satisfy clear quality criteria (Crown, 2012).

Likewise, the Surrey City Government, Canada together with 38 community associations from across Surrey created standard principles to guide consultations. These principles make sure that the consultations are effective and responsible as the city grows and moves forward (SCC, 2017). The City of Surrey supports the open flow of timely information amongst government, the community groups and the community at large based on the following principles: 1. Early involvement 2. Transparency 3. Accountability 4. Knowledge and education 5. Information updates.

The Irish Government has set three key principles of consultation (NAP, 2016). The first principle states that consultation with the public must be genuine, meaningful, timely, balanced and with the ultimate objective of leading to better outcomes. It should result in greater

understanding of public about benefits and consequences of proceeding with particular policy or legislation proposals. Consultation should aim to achieve real engagement and 'real listening' rather than being a pro-forma exercise for bureaucratic purposes. A genuine consultation process must be carried out to ensure the real-world impact of policy. The second principle illustrates that consultation should be targeted and easily accessible to those with a clear interest question in the policy. It adds that there is no 'one size fits all' approach to consultation. The size, type and scope of the consultative process depends on the proposed policy, the type and/or scale of the potential impacts, the number of people or groups affected, and requirements of the marginalized or vulnerable public. The third principle is for the government departments and agencies to make systematic efforts ensuring that interested and affected parties have the opportunity to take part in open consultations at all stages of the policy process on significant policy, services and legislative matters: development, implementation, evaluation, and review.

Apart from these countries, Australia has 10 principles as guide to policy makers, two of them related to public consultation process (OBPR, 2016). The principles are: (i) Policy makers should consult in a genuine way and the consultation is to be carried at proper time (ii) Policy makers must consult with each other to avoid creating cumulative or overlapping regulatory burdens. This ensures the rights or expectations of public are taken care of in planning, execution and operational phase of the project. In the similar lines, the Netherlands has also published a list of seven principles for effective public consultation (MIKR, 2009). Similar types of principles have also been formulated by the Government of Italy for public consultation such as commitment, clarity, transparency, support to participation, privacy, impartiality, inclusion, timeliness and citizen oriented approach (OGP Team, 2017).

Many developed nations, though, have well established specific guidelines/principles for public consultation for infrastructure projects. Developing nations have started adopting public consultation for infrastructure projects but no standards/principles/guidelines have been formulated to carry out consultation process in case of water supply projects (Manowong & Ogunlana, 2006; Yang, 2008). With respect to water supply project in India, though generic consultation process has been developed for infrastructure project but no specific sector specific consultation principles or guidelines have been developed. In addition to this, the current consultation steps have limitations like these consultation steps are inadequate to cover all the

issues and may spread misleading information to the public. The currently adopted consultation procedure is unstructured and creates doubt among public over significant environmental and social issues that may lead to conflict among public. Moreover, the conflict resolution part posed to be ineffective due to lack of guidance on action plan to resolve these conflicts (MoEF, 2000). In addition, there is lack of representation or very limited public representation or involvement reported till date. The public opinion obtained from such process does not truly represent the opinion of the public and most of the times these are greatly influenced by emotions, money and power. Apart from this, implementation of any infrastructure project needs environmental impact assessment (EIA) clearance that involves public consultation. However, water supply projects have not been specifically classified amongst any of the category of infrastructure wherein public consultation process is made mandatory as part of the EIA process.

2.13.2 Public Consultation through EIA Process of Different Countries

Public consultation in EIA is mostly carried out before granting environmental approval of development projects in most developed countries. It is important to enhance the quality of EIA and acceptability of related decisions. Various techniques of public involvement during every stages of EIA process are in practice. However, in most of the regimes, it is discretionary at earlier stages of EIA like, scoping and detailed investigation/study of baseline environmental conditions. Its effectiveness in terms of influence on the final outcome also varies from country to country (Nadeem et al., 2016).

2.13.2.1 Public Consultation in EIA: Developed and Developing Nations

Public consultation in USA is carried out by informing or inviting public through notification on the internet, newspapers, direct communication and newsletters. Consultation techniques used during scoping generally include: telephonic conversation, community meetings and/or written comments from various stakeholder groups both online and on paper. Public hearings and community advisory groups are the most commonly used methods of consultation (Zavestoski et al., 2006). In UK, a variety of participation methods is used depending upon the proponent and nature of the issue. These include public exhibition, newsletters and notices in local newspapers, informal discussions, public meeting, community advisory committee and public inquiry (Petts, 2003). In Canada, method of consultation, like public hearing is at the discretion of the review

panel. Public consultations during initial stages of the EIA process are left at the discretion of responsible agency and the concerned minister. Since, the early opportunities for public involvement i.e. during screening and scoping are non-mandatory, project proponents are mainly responsible for designing and carrying out public participation activities. (Sinclair & Diduck, 2001). In the Netherlands, public consultations take place at two stages: firstly, public meetings arranged to develop scoping guidelines and secondly, public hearings during review of EIA report. (Morrison-Saunders & Early, 2008). Similar steps are also being adopted by the agencies of the developing countries. For example, in China, public participation is compulsory during scoping phase of EIA and is carried out through questionnaire survey, expert consultation and testimony hearings (Yang, 2008). Thailand had no provision of public consultation/participation in EIA till 1996. However, on request public hearing is conducted by a committee appointed by the concerned minister. Access to information about projects, environmental impacts and public consultation proceedings is extremely limited in Thailand due to paucity of sharing such information and cooperation between concerned agencies and the public (Manowong & Ogunlana, 2006). Philippine is one of the first countries in South East Asia pioneering the implementation of EIA in 1977. However, public consultation during scoping, EIA validation and review were made compulsory in 1996. In most of the cases, EIA related documents are not easily accessible to the public due to fear, uncertainty and lack of experience in handling controversial projects. Most of the public hearings are conducted haphazardly with inadequate and poor presentation due to time constraints and lack of skills within the government to handle social issues (Cooper & Elliott, 2000)

2.13.2.2 Public Consultation in EIA: Indian Case

In India, the Central Government issued a Notification under the Environment (Protection) Act 1986 on 14 September, 2006 requiring certain categories of projects to obtain an Environmental Clearance (EC) prior to commencing any project work. The categories of projects requiring EC includes thermal power projects, river valley power/irrigation projects, mining, industries, airports, highways and solid waste management projects. The draft EIA report containing loss and benefits to the public is prepared and is then made available in the public domain (offices of local and regional authorities and official websites) for public consultation.

Public consultation in India is essentially carried out through public hearings. Public hear-

ings are carried out at the project site(s) or in its close proximity by the concerned State Pollution Control Board (SPCB). In this process, the applicant requests the Member Secretary of SPCB to arrange for a public hearing with a request letter and a draft EIA report. The applicant further forwards copies of draft EIA along with the summary EIA to Ministry of Environment and Forests and to concerned authorities or offices, within whose jurisdiction the project falls. Further, on receiving the draft EIA, the authorities arrange to circulate the report and request interested persons to send their comments. The Member Secretary of SPCB finalize the date, time and exact venue for public hearing and advertise the same in one major national daily and one regional vernacular daily. A notice period of 30 (thirty) days is provided to the public for furnishing their responses. The District Magistrate of area assisted by a representative of SPCB supervise and preside over the entire public hearing process. The SPCB arrange to video record the entire proceedings, which is later forwarded along with the public hearing proceedings to the regulatory authority concerned. Moreover, attendance of all present at the venue are noted and annexed with the proceedings. The proceedings are displayed at the office and at the website for general information. Comments, if any, on the proceedings can directly be send to the applicant or concerned regulatory authorities (MoEF, 2006).

However, in reality, although EIA documents stipulated public consultation, these are often neglected and possess certain drawbacks. Some of the drawbacks of public consultation in EIA are: (1) There is lack of consultation with the public as it does not include representatives from all socioeconomic backgrounds. Also, the draft/documents prepared and shared during public consultation are often drafted in technical language, which are understandable to few well-educated persons, restraining proper understanding of the rest of the population. (2) Most of the infrastructure projects are formulated and constructed without any dissemination of information about the project to the public. These information spreading is necessary to curtail any misunderstanding of the project. Further, project authorities in EIA frequently makes promises that they rarely keep regarding compensation, employment to local public, and resettlement packages. (3) Many government organizations lack required experience to adopt public participation. Such organizations often display dominance or superiority that sets them apart from the public. (4) The EIA process lacks transparency in sharing informing to the public. More often documents are treated as confidential, preventing public dissemination. This lack of transparency fosters mistrust and misunderstanding between project authorities and the people. (5) The EIA public consultation

in projects very often takes place toward the end of the project and sometimes no information provided to the public leading to agitation and opposition by the public and failure of projects (Kakonge, 1996; Paliwal, 2006).

2.13.2.3 Water Supply Projects and EIA: Indian Context

Several developed and developing countries have defined certain infrastructure projects (e.g. highway construction, hydropower plants, etc.) that are considered to possess potential adversity to environment. To prevent this potential adversity, an infrastructure project needs to undergo EIA along with public consultation (as mandatory clause of EIA). Public consultation plays a vital role in building trust among public and increases projects' acceptability. These projects may have environmental adversities but public consultation will help in demonstration of the project's benefits to public, leading to increased acceptability.

Most of the infrastructure projects don't involve public directly. For instance, highway is not being used by every citizen on every day basis. Similarly, in case of hydroelectric projects, people do not get electricity from hydroelectric project but from state electricity boards. On the other hand, water supply projects deal directly with public i.e. water treated and supplied to households from water treatment plants on daily basis. In the case of water supply projects, every individual may have a different opinion on the water policies, likelihood of project and apprehension from the project. Hence, the water supply projects should be instituted after carrying public consultation. However, in India, projects of such importance are not included in the list of projects requiring environmental clearance under EIA. The possible reason for exempting water supply projects from EIA could be that the projects do not actuate adverse environmental impacts. Neither treatment of raw water nor waste generation poses threat to environment (water, air, and land/soil). The water supply projects differ from other infrastructure projects on very foundation line that the infrastructure projects are developed to serve as well as earn profit, whereas, the water supply projects are instituted to serve public on no profit no loss basis. The other infrastructure projects may aim or target particular group or class of population but water supply projects serve entire population as a whole. Being different from the projects the water supply projects obligates different demands such as water quality testing facility, satisfactory water supply service and cost economy.

2.14 Public Participation Processes and its Typologies

Until the end of 19th century, the decision making through public participation process was more of unilateral regulatory verdicts. The term public participation was coined by Arnstein (1969), according to him the public participation activities are at the rungs of and citizen power levels. Under these conditions at lower rung of non-participation and tokenism, the people lack the power to ensure that their views will be noted by the authorities. And further up the ladder in citizen power, there is increasing degrees of decision-making power. In further advancement, Howell (1987) derived sixteen citizen involvement principles from democratic, social mobilization and social exchange theories. Each offered encouraging idea for active participation of citizens in public affairs. Together, he constituted the theoretical basis for the citizen involvement program (Howell, 1987). The democratic theory weighted all citizens equally in public decision-making providing numerous opportunities to acquire the information and skills necessary to enact the citizen role. Without such opportunities, people remain ignorant of public issues and the political process, uninterested in and incapable of participating in public and political issues effectively. The social mobilization theory believed that training citizens for political involvement would spread awareness on issues seeking greater influence in decision-making process. The social exchange theory suggested about giving rewards to public so as to increase participation (MacNair, 1981). The theory achieved success to some extent, however the public was found to be non-existent with issue. In order to bring public closer to an issue, King et al. (1998) categorized public participation processes in four components: the issue or situation, the administrative structures, the administrators, and the citizens. They identified that administrator has no real power to redefine the issue for greater citizen involvement as he works under politically and socially constructed frameworks. For the greater inclusion of public, they developed a model involving public at the beginning with equal footings, where citizen placed next to the issue and the administrator bridges administrative structures and citizens (Figure 2.1). This highlighted need of changes in public participation process in various components viz. the role, and relationships of citizen, administrator, and administrative processes.

In another study, Beierle (1999) identified that lack of basic knowledge on project leads to negligence of public views as policymakers hardly communicate for conflict resolution, leading to mistrusts among public and eventually resulting in conflict. In order to mitigate the situation, he

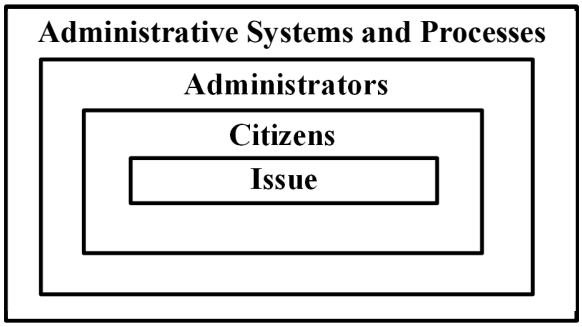

Figure 2.1: Context of authentic participation (King et al., 1998).

proposed goals that included informing and educating the public; incorporating public values, assumptions, and preferences into decision-making; increasing the substantive quality of decisions; fostering trust in institutions; and reducing conflict among stakeholders.

In recent years, the decision-making process has evolved to be more comprehensive compared to earlier that used to focus on unilateral regulatory verdicts only. In this context, Margerum (2002) used consensus building to reduce costly conflicts by identifying obstacles through research and interview of twenty stakeholder groups. This practice led to several key questions for stakeholders' involvement and its evaluation in a participation process (Margerum, 2002). This was later confirmed by Innes (2011) who found this as costly affair too but the costs of not using such methods can be even greater (Innes, 2011). However, the success of public participation is subject to various conditions such as nature of society, level of education, financial backgrounds, and availability of resources. Creighton (2005) encompassed few additional parameters such as who needs to be on the planning team, identifying potential issues and concerns, level of controversy, defining public participation objectives and method to be adopted, and most importantly identifying special considerations that could affect decision-making process (Creighton, 2005). Further Butler & Adamowski (2015) proposed level of stakeholder participation as function of methods chosen. They used Group Model Building (GMB) process and explored the common issues of public participation recommending improved practices. These improved practices engage diverse stakeholder communities in earliest stages to give them control over framing the project scope (Butler & Adamowski, 2015). The facilitation team was employed not only to highlight but also to address barriers that would prevent the marginalized stakeholder's inclusion in a project.

2.15 Summary

Water is a valuable resource for the survival of living beings. Water, may it be groundwater or surface water, is contaminated by anthropogenic activities and is becoming scarce due to exploitative use. Hence, it is imperative to conserve water and decontaminate before using it. Groundwater is widely used as source of drinking water in many parts of the country. But there have been reports on groundwater contamination and presence of various dissolved chemical constituents like iron, fluoride, nitrate, and arsenic beyond permissible drinking limits in India. These dissolved chemical constituents are rarely found in surface water unless contaminated by industrial pollutants and other external sources. Hence, treatment of surface water is easier and less expensive than the groundwater.

At present in India, the municipal agencies are entrusted with the responsibility of providing treated water to the households in and around municipal city limits. But due to rapid increase in city population the demand for the essential commodities has been increasing including the need for potable water. This has become a major concern for the governments as it has become an obstacle goals of providing safe and hygienic drinking water. In this regard, various Indian water policies have emphasized on introducing private entity in water sector to attract private financing and to access excellent managerial efficiencies. But there have been evidences of mass protest and strikes by the public due to inclusion of private sector in infrastructure service delivery. Moreover, public seek its involvement in the decision-making process of the project and demand to have transparent system of the processes involved in the project.

The public involvement through consultation has been a mandatory clause of the EIA in case of implementation of many kinds of infrastructure development projects in India. However, such a provision has not been made mandatory for development of water supply projects. This has led to implementation of water supply projects with limited or without public consultation, leading to the public opposition at many instances. In addition, the studies on various elements viz. public participation, stakeholder management, quality testing of existing water and willingness to pay for new water treatment facilities are available in a scattered manner. Although there are ample efforts to develop theories enhancing public participation for public acceptance and timely completion of infrastructure projects avoiding public opposition, studies on development of framework to

achieve the same are in nascent stage. Public involvement through a framework helps authorities to make acceptable decisions reflecting public interests and values, through accurate and timely information distribution and participatory decision-making. More often, public participation is understood as the contribution by public to the decision-making process. Whereas, public participation through a regulatory governance is of utmost importance especially in water sector to encourage public backed decisions and increased levels of project acceptance.

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Chapter–3

Objectives

This chapter covers the need of the study and bestowed with the research objectives of the present work and the organization of the thesis.

3.1 Need for the Study

The city of Guwahati has witnessed rapid population growth, particularly in last two decades. Despite being water abundant area, only 30% of the city population have access to safe drinking water through piped network (Das & Goswami, 2013). To improve the condition of piped water network, the Ministry of Urban Development, Government of India has financed construction of water treatment plants in four zones of Guwahati viz. North Zone, South-East Zone, South Central Zone and South-West Zone. Unfortunately, these water supply schemes have been facing wide public opposition/protests since the start of the construction works (The Sentinel, 2013; The Sentinel, 2014; The Telegraph, 2013). There were reports on social media as well as in newspaper regarding reasons for public dissatisfaction/protest, lack of public acceptance of the project and lack of public willingness to procure (WtP) water from the project. However, rationale of public dissatisfaction and public needs/requirements from the water supply project were not known or revealed. This was the preliminary reason to investigate case of Guwahati water supply project to explore public perception or opinion. On the other hand, major portion of the population in study area has been dependent on groundwater which was reported to be contaminated, however no official groundwater quality testing or awareness programs were being taken up by governmental and/or NGOs in public interest. This further triggered the need for a systematic study to investigate the multifaceted and delicate issues of water supply. Moreover, Guwahati Jal Board made an effort for successful public participation for the project by sharing information through their website. But, this whole exercise did not serve the purpose and the project have faced public opposition due to lack of any kind of guidelines from government over the conduct of public participation in water supply projects. This encouraged the need to develop or set up a policy/guidelines/framework for public participation in such projects.

3.2 Objectives of the Dissertation

Viability of new water supply projects or expansion of existing ones is greatly influenced by public acceptance and willingness to procure water from the facility. Public participation is considered as a key factor improving success rate of water supply projects, enhancing public acceptance. The review of published literature has highlighted numerous examples of public

opposition to implementation of water supply projects. The magnitude of public opposition to water supply projects is expected to increase in case of availability of alternative water sources such as groundwater to the potential users of the project. Consumption of groundwater has, however, been discouraged in view of the presence of various contaminants and the associated health hazards. In such a scenario, improving the public acceptance of water supply will require a systematic analysis of the public consultation process along with the concepts relating to stakeholder management and willingness to procure. Furthermore, the design of the public consultation process to include the perspective of the existing groundwater quality vis-à-vis the water to be provided through the new water supply projects will also need to be explored. On the other hand, lack of any existing regulatory governing guidelines in India has imperatively suggested the need for development of framework or guidelines to increase public acceptance and WtP from water supply facilities for cities with existing access to alternative water sources such as groundwater. Hence, the present study is designed to gain insights on the interrelationships between water supply projects and the concept of public participation in order to develop a framework for enhancing public participation in such water supply projects. Therefore, the present study aims to gather evidences to answer the research question "*How to enhance public participation in water supply projects?"*. The research objectives pursued in order to answer the research question are:

1. Identify reasons for public opposition and assess factors affecting public acceptance as well as willingness to procure (WtP) water from upcoming water supply project.
2. Assessment of the groundwater quality in study area and identification of critical water quality parameters.
3. Compare public WtP before and after creating groundwater quality awareness and identify the predominant factors influencing public WtP.
4. Development of a framework for public involvement and enhancement of public participation in the implementation of water projects.

The scope of the work is limited to the study area of the city of Guwahati where four water supply schemes have been taken by the Guwahati ULBs. This city provides the unique setting of public getting access to free groundwater at their households providing the choice to the people to opt for surface water supply from the proposed water supply projects against the freely available groundwater. However, the misnomer on using freely available water and ban on use of

groundwater is not applicable to Assam, as there is no ground water legislation enacted for the state as of now. So far the states of Andhra Pradesh, Goa, Tamil Nadu, Kerala, West Bengal, Himachal Pradesh and Union Territories of Lakshadweep and Pondicherry have enacted and implemented the ground water legislation (CGWB, 2015).

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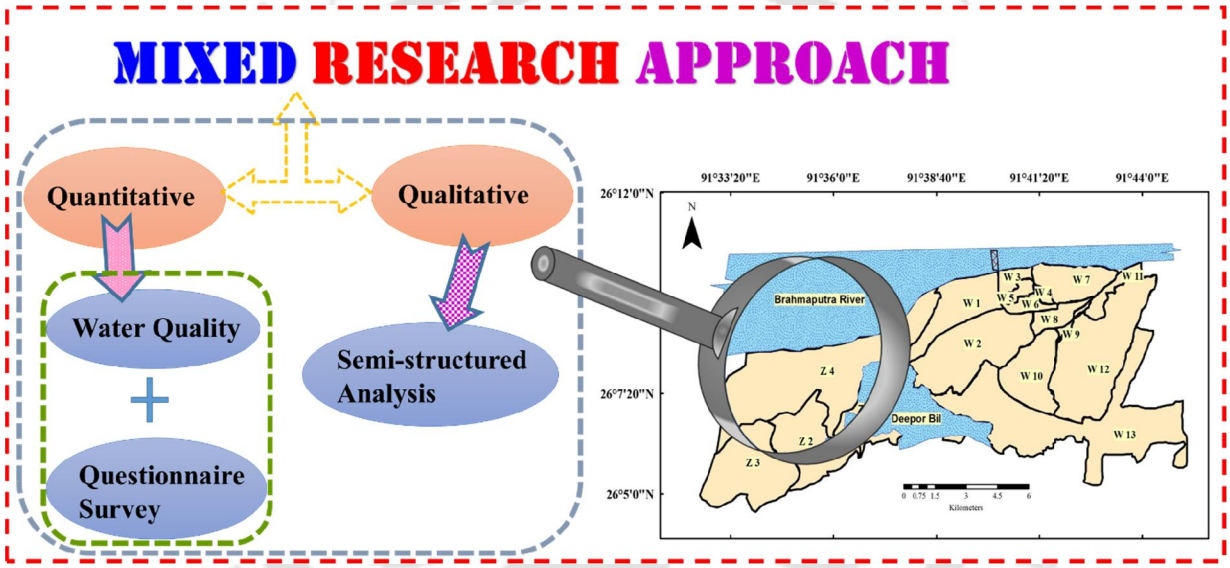
Chapter–4

Research Methodology



This chapter provides detail description of the research methodology adopted in this study to answer the research question ***'how to enhance public participation in water supply projects'****. The pros and cons of qualitative and quantitative research approach are presented to justify selection of mixed approach methodology.*

4.1 Research Methodology

According to Denzin and Lincoln (2005), a research methodology is designed by the nature of the research question and the subject under investigation. The research layout acts as a tool to investigate and answer the research question. The scope of the study is to explore and understand public participation process in water supply projects. As this study was initiated with the focus to answer the research question *"How to enhance public participation in water supply projects?* the same research question also guided the research inquiry. Such kind of research questions engaging public views, though, are easy to state but highly complex to analyze (Tariq & Woodman, 2013). This kind of research question may include collection and analysis of public opinions on particular issue and statistical analysis of numerical data (data collection is inevitable). Hence, the research question for the present study can be more comprehensively addressed by implementing a mixed method approach instead of either quantitative or qualitative approach alone. The mixed method approach, thus, has become extensively popular since the last two decades (Almalki, 2016). This approach is also referred to as the third research paradigm and is widely used and recognized by social science and management scholars. It can profoundly integrate thematic and statistical data following a divergent findings leading to greater depth and breadth in overall results. This provides more accurate implications with increased credibility in the research (Jogulu & Pansiri, 2011). Use of this methods permits a deeper understanding of a phenomenon of interest than the use of either a quantitative or qualitative approach alone (Tariq & Woodman, 2013).

Usually, quantitative research is associated with objective measurements and the statistical, mathematical, or numerical analysis of data collected. The tools for this research include polls, questionnaires, and surveys that could be analyzed using computational techniques. Quantitative research emphases on collecting numerical data and generalizing it based on samples that are both large enough and representative. This approach is extensively used in descriptive and experimental research. However, this approach has a limitation of not able to generate hypothesis that talks about how and why things are occurring, or explaining complex social or cultural phenomena (Tariq & Woodman, 2013). Qualitative research is believed to have multiple realities shaped by personal viewpoints, context and meaning. In-depth qualitative research aims to provide a rich description of views, beliefs and meaning. However, for research with qualitative method, it is needed to have

a large sample size for in-depth exploratory work or else it will lack consequence of generalizability. However, mixed methods research therefore has the potential to blend the strengths and counterbalance the weaknesses of both approaches and can be especially powerful when addressing complex, multifaceted issues (Almalki, 2016; Mills et al., 2009; Tariq & Woodman, 2013).

4.2 Methodology Adopted

This section discusses the adopted mixed approach research methodology to answer the research questions. A flow chart of the research design adopted is presented in Figure 4.1. The research design comprises of 4 phases. Phase 1 was designed to understand the reasons for public opposition and to assess the factors affecting public acceptance and willingness to procure (WtP) water from the upcoming water supply project. A secondary data source of documents review was carried out for the study area to identify the reasons for public opposition. Furthermore, public acceptance and WtP from upcoming water supply scheme was assessed through a questionnaire survey. For the questionnaire survey, representative number of samples were determined statistically. The data collected from primary and secondary sources were then analyzed using document and cross tabulation analysis. Document data was examined and interpreted to elicit meaning, gain knowledge, and finally used to develop an empirical understanding of the situation on public opposition. Whereas, questionnaire survey data was analyzed using cross tabulation analysis to detect/identify association/relation between WtP and surveyed parameters. In general, it is considered easier to interpret percentages than raw numbers in a table for identifying similarities (Vaus, 2002). Hence, the cell frequencies for various WtP variables in a table were converted into percentage form.

In phase 2, quantitative method was employed for groundwater quality assessment. A total of 1568 number of household groundwater samples were collected from the same households that had participated in the questionnaire survey. The samples were analysed in laboratory for 11 water quality parameters viz. pH, conductivity, sodium, potassium, calcium, iron, fluoride, arsenic, nitrate, alkalinity and hardness for identifying critical water quality parameters exceeding drinking water quality standards (BIS 10500, 2012; WHO, 2008). All analytical estimations were performed following methodology given in Standard Methods for Examination of Water and Wastewater

(APHA, 2012). The spatial variations in concentration of contaminants were mapped using ArcGIS 9.3.

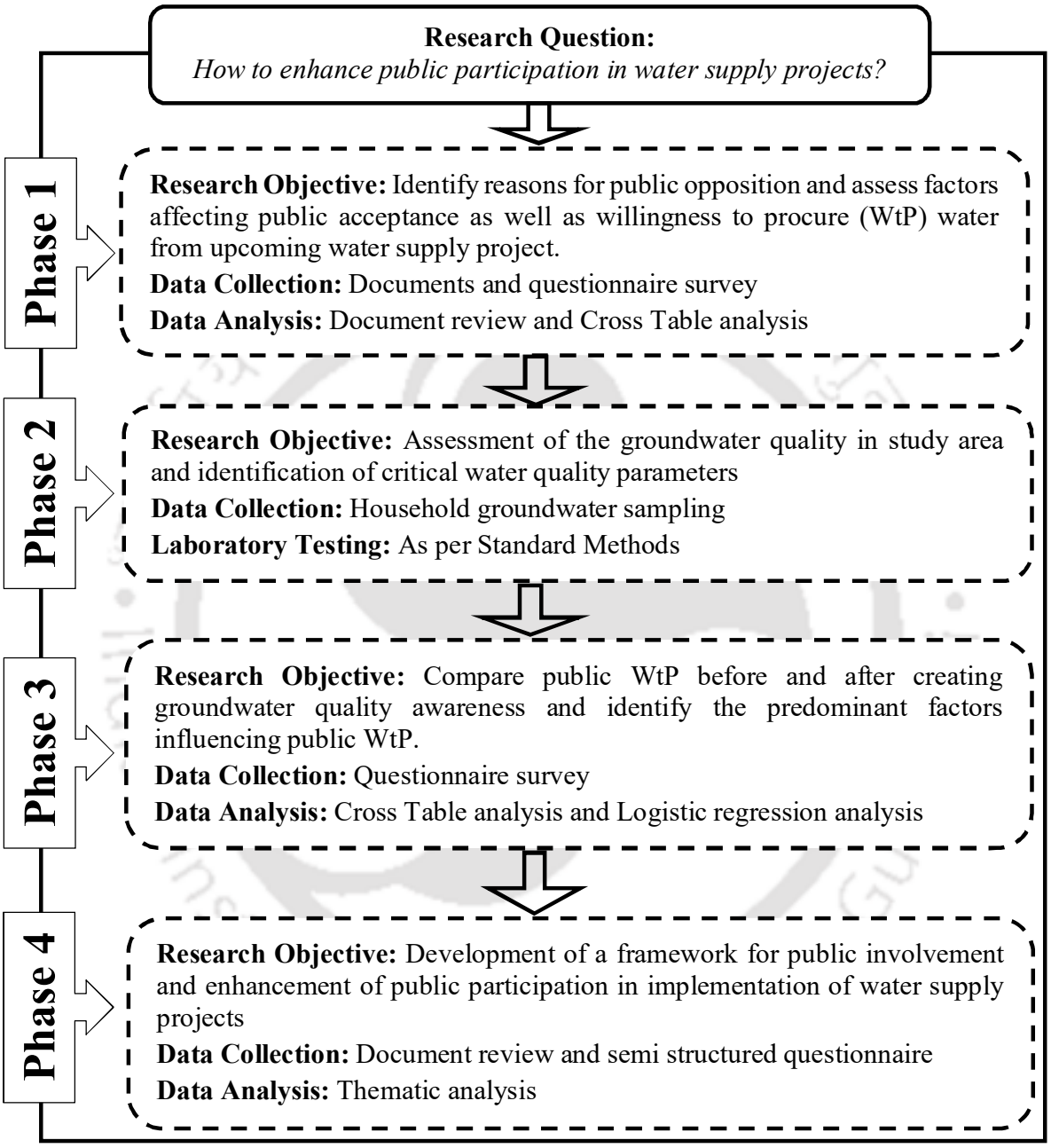


Figure 4.1: Research design for the present study.

In phase 3, groundwater quality awareness was carried out through door to door interaction followed by second round of questionnaire survey with the aim to compare WtP before (first round) and after creating awareness (second round). The data of both questionnaire surveys were

analyzed through cross table and logistic regression analysis. The cross-table analysis was performed to identify relation between WtP and surveyed parameters, whereas logistic regression analysis was employed to identify the parameters influencing WtP using STATA software version 9.0 (STATA 9.0 for Windows, StataCorp LP, College Station, USA).

In Phase 4, the fourth objective of the research was achieved using qualitative research approach. Secondary data was collected from studies on public participation in water supply projects in various countries and analyzed to identify critical success factors (CSFs) for public involvement in water supply projects. A semi-structured questionnaire was designed to generate primary data in conjunction with secondary data as supplement on public participation. Thematic analysis was employed to identify the CSFs from primary data influencing public participation in the project. Finally, a framework was formulated in accordance with the identified CSFs from primary and secondary data and the review of various theories on public participation to achieve the objective.

4.3 Background of Study Area

The city of Guwahati is located between 26°05' to 26°12' North latitude and 91°34' to 91°51' East longitudes in Kamrup district of Assam (India) on the bank of the mighty river Brahmaputra. The city has an undulating topography with varying altitudes from 49.500 to 55.500 m above the mean sea level with a number of hills and hillocks. There are several low-lying areas and bils (billabong or lake-like wetlands) within the city.

Guwahati city has a total area of approximately 262 km^2 under Guwahati Metropolitan Development Authority (GMDA) with a population of 9,68,549 as per 2011 census (Das & Goswami, 2013). The civic amenities in Guwahati are being looked after by two ULBs viz. Guwahati Municipal Corporation (GMC) and GMDA (JnNURM, 2006). However, the planning, construction and operation of water supply facilities, sewerage and drainage are the responsibility of multiple governmental organizations like Assam Urban Water Supply and Sewerage Board (AUWSSB), GMC, GMDA and Public Health Engineering Department (PHED), delegated to serve specific demarcated area in the city (Bhattacharya & Borah, 2014; Das & Goswami, 2013). Despite this delegation, only 30% of the population have access to piped-water supply (Das & Goswami, 2013). GMC supplies piped water to some parts of South-Central Guwahati and South-

West Guwahati, AUWSSB to some specific areas of South-Central Guwahati, whereas PHED is supplying piped-water to South-Central, North and South-West Guwahati. PHED's supply is, however, limited to government buildings and public establishments (JnNURM, 2006). All these governmental organizations run their water treatment plants independent of the ULB.

The water treatments plants maintained by GMC and AUWSSB at Panbazar, Satpukhri and Zoo Road are running below their designed capacity. However, water is supplied for all existing plants for approximately 2 to 3 hours daily either in the morning or evening. Further, there is no laboratory for testing of water samples and the chemicals required for treatment are added arbitrarily. Moreover, the distribution system had been laid in a haphazard way and low pressure problem is faced by the users. The wastage of water in distribution system is reported to be about 30 to 40%, but no systematic studies have been carried out so far. In Satpukhri treatment plant, one of its distribution reservoirs has no covering and this condition needs be improved. Most of these plants have exceeded their designed life and the expansion & renovation work are very difficult due to limited area (JICA, 2008).

On the other hand, groundwater in Guwahati city is available under confined to semiconfined conditions at a shallow depth of 2 - 4 m, thereby encouraging its public usage (through dug well, hand pumps or bore wells) (Das & Goswami, 2013). Several researchers, however, have expressed concerns towards groundwater quality about iron, fluoride, nitrate and arsenic contaminations in various regions of Assam (Chakrabarty & Sarma, 2011; Chetia et al., 2011). Guwahati is also not an exception and traces of fluoride and iron above the guideline values of WHO have been observed in the eastern and southern plains of the city (Chakrabarty & Sarma, 2011). Several researchers revealed that the concentration of fluoride is higher with depth and the deeper aquifers are more contaminated with fluoride (Lahkar, 2015; DGM, 2018). To minimize public usage of contaminated groundwater and improve the accessibility of potable water, the Ministry of Urban Development, Government of India has initiated implementation of four water treatment and supply schemes in Guwahati city using Brahmaputra river water as the source of surface water. These schemes are located in North Guwahati, South-Central Guwahati − both funded by Japan International Cooperation Agency (JICA), South-West Guwahati funded under Jawaharlal Nehru National Urban Renewal Mission (JnNURM), under Government of India and South-East Guwahati (funded by Asian Development Bank) (GJB, 2009). The upcoming water supply scheme

of South-West Guwahati is going to cover thirteen municipal wards and four undesignated peri-urban areas in Guwahati termed as zones. The present study is confined to this scheme only and the study area refers to the area served under the scheme. The project being taken up for investigation is the upcoming South-West Guwahati water supply scheme of 107 MLD capacity (GMDA, 2013). The project commenced in 2010 with scheduled completion in 2011 but has already missed a couple of revised deadlines till 2015 (The Telegraph, 2012). The reasons cited by authority for delay in completion of the projects are natural and various technical reasons (The Telegraph, 2017). This proposed scheme is also facing widespread public protests against its implementation.

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Chapter–5

Public Opposition to Upcoming Water Supply Scheme and Perception on Groundwater Quality and Health Effects

This chapter presents detailed investigation on the rationale of public opposition to the Guwahati city water supply project. The results of questionnaire survey on the public perception about groundwater quality and their willingness to procure water from upcoming water supply project are presented.

5.1 Introduction

The city of Guwahati has experienced a rapid growth in population particularly in last two decades (Census, 2011). Despite abundance of surface water in area and availability of different municipal water supply agencies, only 30% of the city population have access to safe drinking water through piped network (Das & Goswami, 2013). On the other hand, it is observed that many of the water supply facilities in Guwahati city are running below capacity and requires urgent attention in terms of technical inadequacy in operation and maintenance. Besides piped water supply system, population in the area is dependent on tanker truck service and groundwater. However, tanker service is intermittent, unreliable and costly, whereas the groundwater is contaminated with iron, nitrate, and fluoride along with traces of arsenic in certain areas (Chakrabarty & Sarma, 2011; Das et al., 2003). In order to improve the quality of public life, the Ministry of Urban Development, Government of India has proposed to extend financial support to construct new water treatment plants in four zones of Guwahati viz. North Zone, South-East Zone, South Central Zone and South-West Zone. The construction of these plants are in progress. Water supply scheme at South-East and South-West Zones are funded by Asian Development Bank (ADB) and JnNURM respectively. Whereas, Japan International Cooperation Agency (JICA) has funded North Zone and South Central Zone water supply projects (GJB, 2011). However, these water supply schemes have been facing wide public opposition/protests since the start of construction works (The Sentinel, 2013a; The Sentinel, 2014; The Telegraph, 2013a).

This chapter is framed with an objective to understand and investigate rationale of public dissatisfaction leading to opposition/protest and to assess public needs and demands from the water supply project. This is being achieved by observing/noting availability of public drinking water source in absence of piped water supply. After this, public perception on quality of existing groundwater i.e. alternate public drinking source has been acquired. Further, their familiarity and knowledge on the upcoming water supply scheme has been checked through a questionnaire survey. Finally, public willingness to procure (WtP) water from the scheme has been evaluated from the questionnaire surveyed data.

5.2 Methodology

In order to understand the rationale for public dissatisfaction/opposition/protest towards the water supply scheme, review of documents published for the study area has been carried out. Further, public knowledge and perception on quality of groundwater and WtP from water supply scheme has been assessed through a questionnaire survey and analyzed through cross table approach. The necessary and adequacy of representative samples to be collected from a locality has been determined statistically.

5.2.1 Questionnaire Development

The questionnaire survey method is an effective tool to assess characteristics and actions/opinions of a large group of people (Creswell, 2009). Hence, it was adopted for this study and questions were so developed that it should gather requisite information, should be quickly answerable and should be simple to understand. Apart from collecting demographic information (name, age, gender, etc.), the questionnaire survey primarily aimed to gather information on four parameters viz. public perception on household groundwater quality, knowledge on health effects of contaminated water consumption, knowledge/familiarity over upcoming water supply scheme and WtP. In development of questionnaire, a five level Likert scale was initially adopted for most of the question to allow the respondents to respond on the degree of agreement. The scale does not force the respondent to take a stand on a particular topic but had to indicate their level of agreement with a given statement (Croasmun & Ostrom, 2011). The preliminary questionnaire developed is presented in Table A.1, Appendix. A total of 15 households were selected randomly in the study area for the responses. However, it had been observed that most of the questions were pertaining to whether the respondents have observed the ill-effects of the contaminants or not. In such a case, the responses were expected to be either yes or no. Thus, the preliminary questionnaire was modified by replacing the questions with binary responses. Many researchers have claimed that binary answer formats were easier and quicker for respondents to respond than that of Likert scale formats (Dolnicar et al., 2011; Grassi et al., 2007; Hauser & Koppelman, 1979). The revised questionnaire was then used for the pilot study (Appendix, Table A.2).

5.2.2 Pilot Study with Questionnaire Survey

Pilot studies are the feasibility studies that are small in scale or trial run carried out in preparation for a major research (Polit et al., 2001). It helps to identify whether the study is aligned with the research question. And, the flaws, simplicity and clarity of the questionnaire could also be well understood and determined (Walker, 1997). While interviews were conducted in pilot study, questionnaire were checked for the design and format, its length and output, requisite data and its role in the analysis (Flowerdew & Martin, 2005) for a small sample of households before undertaking main data collection task (Hassan et al., 2006). Hill (1998) and Isaac & Michael (1995) suggested a sample size of 10 to 30 respondents for a pilot study in survey research. However, in medical field, Julious (2005) reiterated that a minimum of 12 subjects per group be considered for pilot studies. Treece and Treece (1977), referring to piloting an instrument, noted that for a project 10 respondents should be a reasonable number; while Creswell (1998) suggested 5 to 25 response as sufficient. As a part of the pilot study in our research, 20 households were selected randomly in the study area. The household respondents varied in age, gender, years of living in the area, educational level, and experience. This gave check and assurance over accurate collection and meaningful analysis of the data (Kometa et al., 1995). Furthermore, pilot study was to help improve questionnaire in aspects of gathering information, quick answerability and understandability with public feedback.

Using the questionnaire (Appendix, Table A.2), the household respondents were interviewed in face to face format and this questionnaire was further modified from time to time based on their feedback. Some of the important feedback were difficulty in understanding the questions and presence of repeated questions. Some participants even suggested on shortening the length of the questionnaire to shorten interview duration and become more appealing. These feedbacks were taken into consideration and most of the questions were rephrased/rewritten. The final questionnaire, thus, developed after the pilot study is shown in Table A.3, Appendix. The final questionnaire contained seven sub-parameters under three categories with 28 questions in total. The questions were either having multiple choices or dichotomous type (with yes/no response). The first category included 8 questions on demographic information. Rest of the 20 questions were related to household groundwater quality, WtP from the scheme, scenario of household water treatment, symptoms related to arsenic, fluoride, iron effect, and knowledge about the upcoming

water supply scheme. The focus and objectives of this perceptions about groundwater was conducted on household residents who were asked about their perceptions and concerns about drinking groundwater quality and groundwater related health issues. Understanding user perception of drinking water can contribute to improvements in water management and consumer satisfaction.

5.2.3 Sample Size Determination

The study area i.e. South-West Guwahati was divided into 13 municipal wards and 4 peri-urban zones. The wards were assigned by the municipality but the zones were newly included under the municipality and no ward number is assigned yet. The ward/zone of South-west Guwahati was plotted using ArcGIS 9.3 as shown in Figure 5.1. The population distribution in these wards/zones was found to be uneven due to presence of hills, marshy lands and irregular land use pattern as a result of migration/rapid increase of population. Based on the number of households in each of the wards/zones, the number of samples to be collected from each of the ward/zone for questionnaire survey and water sample collection were determined. The representative sample size for individual ward/zone was determined using Eq. 5.1 (Rammont &

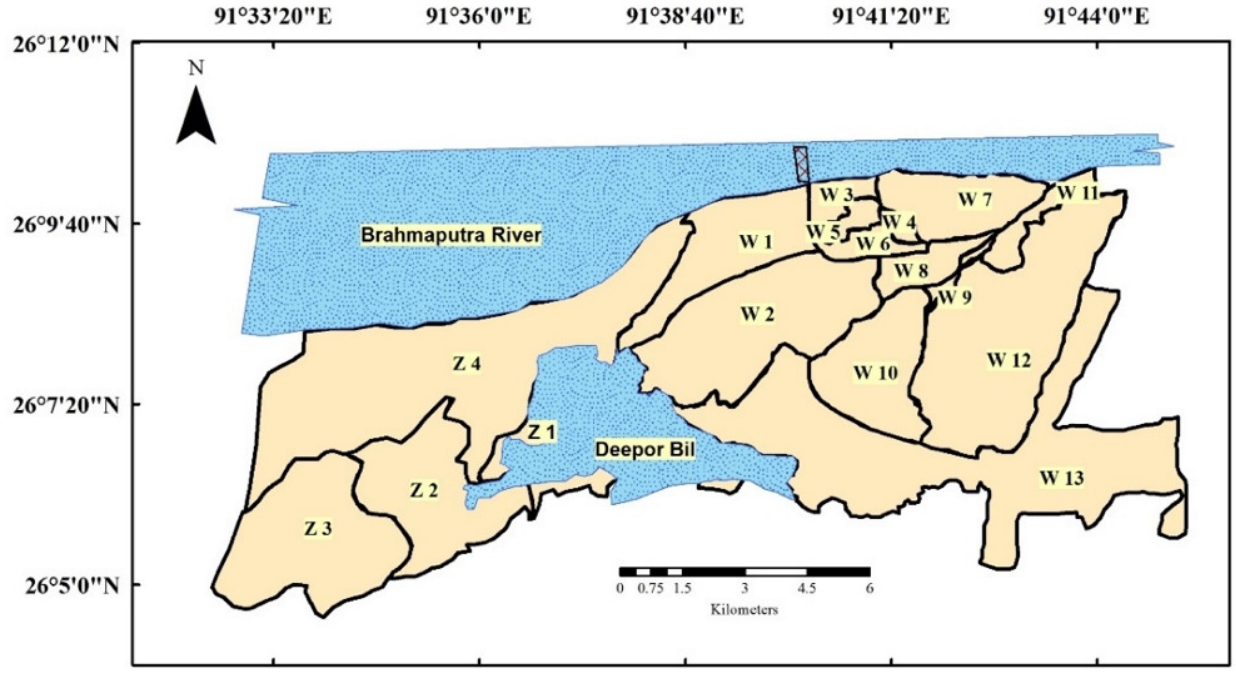

Figure 5.1: Location map of South-West Guwahati with its wards (W) and zones (Z).

Amin, 2010) and represented in Table 5.1.

$$n = \frac{\left[NZ^2p(1-p)\right]}{\left[Nd^2 + Z^2p(1-p)\right]} \quad (5.1)$$

where,

n = sample size of household for questionnaire survey and water sample collection

N = number of household

Z = value corresponding to confidence interval level (1.96 for 95% confidence level)

p = estimated population proportion (assuming to obtain the maximum value, p = 0.5) and

d = precision (assuming 10% precision).

However, the sample size is not directly proportional to the number of households and reaches plateau after certain household number. Various authors have also presented non-requirement of higher sample size with higher number of households (Bartlett et al., 2001; Walker & Almond, 2010). The variation of the sample size in present investigation is plotted in following figure for your kind reference and perusal. It changes gradually from 100 to 5000 but does not change much for households larger than 5000 (Table 5.2).

Table 5.1: Number of sample size of household for questionnaire survey and water sample collection for each ward/zone

Ward/Zones	No. of households	Sample size	Ward/Zones	No. of households	Sample size
W1	3598	94	W10	2336	92
W2	3671	94	W11	4251	94
W3	2609	93	W12	9055	95
W4	2617	93	W13	6663	95
W5	3076	93	Z1	609	83
W6	2372	92	Z2	1385	90
W7	4647	94	Z3	3174	93
W8	1715	91	Z4	1919	91
W9	1580	91			

Table 5.2: Change in sample size corresponding to number of households

Confidence level = 95%, Precision =10%			
No. of households	**Sample size**	**No. of households**	**Sample size**
100	49	1500	90
200	65	2000	92
300	73	3000	93
400	77	4000	94
500	81	5000	94
600	83	6000	95
700	84	7000	95
800	86	8000	95
900	87	9000	95
1000	88	10000	95

5.3 Results and Discussion

5.3.1 Rationale for Public Opposition in Study Area

The construction of South-West Guwahati water supply scheme commenced in 2010 and found to have missed a couple of revised deadlines till 2015 (The Telegraph, 2012). The reasons cited by the Project Manager for delay were natural (rain pattern, geography and topography) and technical difficulties (The Telegraph, 2017). This study uncovered that in 2013, there was a wave of public dissatisfaction about the water supply scheme. Public staged protest through rallies, hunger strike, and arranged citizen meetings. This was further backed up even by some political parties as conveyed through several national and local newspapers (Table 5.3). Table 5.3 gives a chronological order of public opposition events in the study area. The people in this protest demanded for greater public participation, transparency in project related issues and sharing information on funding, executing agency, contract/sub-contracts and tariff. (Joy et al., 2017; The Assam Tribune, 2013a; The Assam Tribune, 2013d; The Sentinel, 2014; The Telegraph, 2013b; The Times of India, 2013).

5.3.2 Demographic Characteristics

Demographic information describes survey respondents, allows comparisons among them and facilitates assessment of the generalizability of questionnaire results. In addition, demographic

Table 5.3: Chronological events for public opposition/protest for South-West Guwahati water supply scheme

Date	Event	Organizer	Reference
29/3/2013	Demonstration and protest march	CPI (M) stages demonstration over burning issues	The Assam Tribune (2013a)
9/4/2013	Group demonstration	Sanmilita Nagarik Adhikar Suraksha Mancha (GSNASM)	The Telegraph (2013a)
22/5/2013	Citizens meet	Sanmilita Nagarik Adhikar Suraksha Mancha (GSNASM)	The Sentinel (2013a)
21/9/2013	Hunger strike	Guwahati Sanmilita Nagarik Adhikar Suraksha Mancha (GSNASM)	The Sentinel (2013b); The Telegraph (2013b)
21/9/2013	Memorandum submission to GMDA	Sanmilita Nagarik Adhikar Suraksha Mancha (GSNASM)	The Assam Tribune (2013b)
22/9/2013	Citizens meet	Krishak Mukti Sangram Samiti (KMSS)	The Assam Tribune (2013c)
1/10/2013	Citizens meet	Sanmilita Nagarik Adhikar Suraksha Mancha (GSNASM)	The Assam Tribune (2013d)

data permit comparisons among important respondent subgroups and adjustment for differences among them. To study the demographic characteristics of the people in the study area, each household head was approached for the questionnaire response. The household heads were asked about their age, family size, gender, income, years living in the area. In the pilot study carried out with 20 households, the mean age was observed to be 48.40 years with standard deviation of 10.09 years (Table 5.4). The mean household size and years living in the neighborhood appeared to be 4 years and 12.3 years, respectively. And, the average monthly income of the household was observed to be Rs 16,700 (US$ 1 ≅ INR Rs 70.24 on 29th November, 2018). For the pilot study, it was observed that 80% of the respondents were male and 65% of the people lived in their own house while 35% stayed in rented houses (Table 5.4).

From the main study, it was observed that the mean age of the overall respondents was 49.01 years, with standard deviation of 11.28 years (Table 5.5). The lowest mean age of respondents was observed in Ward W3, W8, W11, W12 and Zone Z4 with 47.70 (±11.86), 47.22 (±12.38), 46.80 (±10.93), 46.40 (±10.35) and 47.88 (±11.21), respectively. For the household size of respondents in South-West Guwahati, the mean number of the household size (adults and children) was 5, with standard deviation of 2. The largest household size of 10 persons (mean

Table 5.4: Pilot study percentage/mean distribution of demographic, perception of people on current groundwater quality and procurement of water parameters from upcoming water supply scheme

Parameter		Percentage (%)	Parameter	Mean	Standard deviation
Gender	Male	80	Age	48.4	10.09
	Female	20	Household size	4.3	1.44
Ownership of house	Own house	65	Years living in neighborhood	12.3	6.23
	Rented house	35	Income (Indian Rupees, INR)#	16700	5594
Education level	Above Post Graduate	-	#(US$ 1 ≅ INR Rs 70.24 on 29th November, 2018).		
	Post Graduate	5			
	Graduate	15			
	12th	55			
	10th	25			
	Primary school	-			
	Illiterate	-			
Source	Tube well	25			
	Hand pump	65			
	Dug well	10			
Have access to desired water quality		95			
Have sufficient water throughout the year		40			
Purchase water from vendor		85			
Have contaminated groundwater		0			
Have checked groundwater quality		0			
Treat groundwater for all domestic choirs		50			
Treat water before drinking		40			
Treat water before cooking		50			
To treat groundwater household's used	Purifier	10			
	Candle filter	40			
	Sand filter	0			
	Boil	0			
	Direct	50			
Experienced skin discoloration		0			
Experienced superficial patch of skin		0			
Have yellowish colored teeth		40			
Children have teeth cavities		5			
Groundwater stains in clothes/utensils		95			
Groundwater has taste		10			
Aware of new water supply project		95			
Household is within the project domain		90			
Will procure water from water supply scheme		5			

value) was observed in Zone Z2 with standard deviation of 1. However, the overall average years of the households living in the neighborhood was 14.30 years with a standard deviation of 8.68 years. Ward W1 had the lowest average number of years living in the study area with 5.10 years, followed by Ward W3 and W10 with 12.99 and 12.98 years, respectively. Moreover, it was observed that out of the total respondents, 90% were male and only 10% were female. The lowest female respondents were recorded in Ward W2, W7, W13, Zone Z1 and Z4 with 6, 7, 7, 12 and 7% respectively (Table 5.5). As far as house ownership is concerned, overall 52% of the respon-

Table 5.5: Ward/Zone wise distribution of demographic characteristics of the study area

Wards /Zones	Sample size	Age	Household size	Years living	Gender (%)		Resides in own household (%)
					Male	Female	
W1	94	49.60 ± 11.29*	5 ± 2	5.10 ± 1.18	85	15	78
W2	94	48.04 ± 11.18	5 ± 1	13.00 ± 7.52	94	6	78
W3	93	47.70 ± 11.86	6 ± 2	12.99 ± 8.41	87	13	53
W4	93	49.66 ± 11.48	5 ± 2	13.13 ± 7.77	89	11	78
W5	93	50.70 ± 10.25	5 ± 1	13.15 ± 8.67	91	9	62
W6	92	49.59 ± 11.43	9 ± 7	15.23 ± 8.39	91	9	78
W7	94	48.04 ± 11.18	6 ± 2	13.00 ± 7.52	93	7	11
W8	91	47.22 ± 12.38	6 ± 1	14.93 ± 8.46	82	18	76
W9	91	50.01 ± 12.12	6 ± 2	14.21 ± 7.96	92	8	79
W10	92	51.05 ± 10.00	5 ± 1	12.98 ± 8.78	89	11	8
W11	94	46.80 ± 10.93	6 ± 2	17.72 ± 9.18	88	12	84
W12	95	46.40 ± 10.35	5 ± 2	17.83 ± 9.57	91	9	16
W13	95	50.37 ± 10.71	5 ± 1	18.83 ± 9.28	93	7	16
Z1	83	51.13 ± 10.40	6 ± 1	18.52 ± 9.07	93	7	37
Z2	90	49.10 ± 12.22	10 ± 1	30.41 ± 8.49	88	12	32
Z3	93	50.20 ± 11.79	5 ± 1	14.40 ± 7.67	86	14	33
Z4	91	47.88 ± 11.21	4 ± 2	13.19 ± 7.47	93	7	65
Overall	1568	49.01 ± 11.28	5 ± 2	14.30 ± 8.68	90	10	52

Note: *The data is presented in xx ± yy format where xx is the mean value for WtP and yy is the standard deviation

dents resided in own house while rest resided in rented house. With respect to the education level of the respondents, around 1.59% respondents were illiterate, 19.01% had education up to 10th class, and 29.15% were qualified up to 12th class, and 32.27% were graduates (Table 5.6). With respect to household groundwater source, it was observed that the respondents' household source differed from house to house. The majority of houses have hand pumps (51.15%) followed by tube well (39.22%) and dug well (9.63%) (Table 5.7). Also, it could be observed that people living in the plain areas and having groundwater table at shallow depth had dug well source, whereas people

Table 5.6: Ward/Zone wise percentage distribution of education level

Wards/ Zones	Sample size	Respondent education level (%)						
		Doctorate	Post Graduate	Graduate	12th	10th	Primary school	Illiterate
W1	94	4.26	37.23	6.38	44.68	7.45	-	-
W2	94	-	-	43.62	45.74	10.64	-	-
W3	93	-	11.83	45.16	5.38	17.20	-	20.43
W4	93	-	8.60	36.56	-	34.41	13.98	6.45
W5	93	22.58	7.53	30.11	33.33	6.45	-	-
W6	92	-	3.26	45.65	-	29.35	21.74	-
W7	94	1.06	3.19	11.70	46.81	36.17	1.06	-
W8	91	-	8.79	46.15	-	29.67	15.38	-
W9	91	-	4.40	56.04	-	16.48	23.08	-
W10	92	-	8.70	28.26	42.39	18.48	2.17	-
W11	94	-	-	54.26	30.85	13.83	1.06	-
W12	95	-	-	18.95	36.84	20.00	-	-
W13	95	-	-	25.26	55.79	18.95	-	-
Z1	83	-	-	36.14	48.19	14.46	1.20	-
Z2	90	10.00	25.56	21.11	34.44	6.67	2.22	-
Z3	93	11.83	12.90	20.43	33.33	17.20	4.30	-
Z4	91	7.69	4.40	24.18	37.36	25.27	1.10	-
Overall	1568	3.89	8.74	32.27	29.15	19.01	5.36	1.59

Table 5.7: Ward/Zone wise percentage distribution of household groundwater source

Wards/Zones	Sample size	Household groundwater source (%)		
		Dug well	Hand pump	Tube well
W1	94	4.26	30.85	64.89
W2	94	3.19	34.04	62.77
W3	93	5.38	73.12	21.51
W4	93	7.53	83.87	8.60
W5	93	11.83	67.74	20.43
W6	92	2.17	26.09	71.74
W7	94	31.91	17.02	51.06
W8	91	39.56	32.97	27.47
W9	91	-	81.32	18.68
W10	92	-	76.09	23.91
W11	94	3.19	88.30	8.51
W12	95	5.26	64.21	30.53
W13	95	8.42	41.05	50.53
Z1	83	7.23	42.17	50.60
Z2	90	7.78	24.44	67.78
Z3	93	13.98	32.26	53.76
Z4	91	12.09	52.75	35.16
Overall	1568	9.63	51.15	39.22

near the hilly areas and having groundwater table at a deeper depth preferred hand pump and tube well as a water source. Ward W8 and W9 falls under the hilly region with deeper depth of groundwater table, which could possibly be the reason for people preferring hand pump and tube well in place of dug wells (Table 5.7). Similar pattern of groundwater source is also reported by Khan et. al (2013). However, the choice of source (dug well, hand pump or tube well) depends upon the water requirement of the household as well as financial status (Khan et al., 2013; Singh et al., 2005).

5.3.3 Public Perception/Knowledge on Groundwater Quality, Health Effects and Project

The pilot study survey data presented in Table 5.4 revealed that 95% people feel that they have access to desired groundwater quality, while nobody feel that their groundwater is contaminated and 50% people consume groundwater directly without any sort of treatment. Furthermore, 95% people revealed that their groundwater stains clothes/utensils and 10% people reported to have bitter groundwater. However, on asking households about their WtP from the upcoming water supply scheme, only 5% showed their willingness.

The results of main study on water availability analysis and perception of households are tabulated ward/zone wise in Table 5.8. It could be observed that overall 90.43% households claimed to have access to desired drinking water from groundwater sources. On inquiring about conducting water quality tests in past, it was observed that only 1.72% households have checked their groundwater quality on their own and rest 98.28% households were unaware of it. The survey findings highlighted the casual public approach towards groundwater quality irrespective of profession, education and financial status of household. This observation was well supported by the fact that common people in many regions and even the educated ones are not bothered about the quality of water that they are drinking and are not aware of their source water contamination and/or its consequent health hazards (Boarh & Misra, 2010). The respondents' perception on household groundwater contamination revealed that only 3.32% households were aware of contamination while the rest (96.68% of the respondents) considered their groundwater to be safe to drink. They believed that iron is present but could be removed by aeration followed by sedimentation. The perception is partially true as aeration facilitates conversion of iron to iron oxides that remains as turbidity in water. Further removal of oxides can only be accomplished by

Table 5.8: Ward/Zone wise percentage distribution of perception of people on current groundwater quality, its health effect and procurement of water from upcoming water supply scheme

Ward/ Zone(s)	Ward wise percentage distribution of water quality perception and existing groundwater health effects															
	DSRWTR	SUFF	VENDOR	CONTAMI	CHECK QUA	DOMES	DRINKING	COOKIN	SKIN	PATCH SKIN	YELWTEETH	TEETHCAVITY	STAIN	TASTE	AWARE	WITHIN	WILLINGNESS TO PROCURE
Ward 1	94.68	62.77	84.04	14.89	8.51	38.30	51.06	46.81	20.21	0.00	64.89	3.19	32.98	5.32	94.68	52.13	12.77
ward 2	90.43	42.55	84.04	7.45	4.26	37.23	38.30	38.30	12.77	0.00	73.40	3.19	13.83	6.38	95.74	100.00	68.09
Ward 3	89.25	49.46	60.22	4.30	4.30	12.90	11.83	12.90	11.83	0.00	72.04	10.75	74.19	20.43	97.85	44.09	78.49
Ward 4	86.02	63.44	86.02	3.23	3.23	35.48	36.56	35.48	2.15	0.00	63.44	3.23	9.68	5.38	100.00	94.62	64.52
Ward 5	84.95	68.82	78.49	12.90	6.45	12.90	12.90	12.90	1.08	0.00	54.84	11.83	78.49	21.51	100.00	47.31	88.17
Ward 6	98.91	39.13	84.78	0.00	2.17	38.04	33.70	38.04	1.09	0.00	70.65	3.26	65.22	5.43	100.00	100.00	43.48
Ward 7	90.43	87.23	4.26	0.00	0.00	21.28	100.00	21.28	0.00	0.00	44.68	7.45	76.60	10.64	100.00	67.02	29.80
Ward 8	100.00	68.13	76.92	0.00	0.00	19.78	19.78	19.78	0.00	0.00	49.45	4.40	72.53	18.68	100.00	87.91	84.62
Ward 9	86.81	61.54	76.92	0.00	0.00	27.47	27.47	27.47	0.00	0.00	74.73	2.20	71.43	12.09	100.00	93.41	83.52
Ward 10	86.96	72.83	71.74	0.00	0.00	14.13	21.74	14.13	0.00	0.00	72.83	3.26	52.17	0.00	100.00	100.00	65.22
Ward 11	90.43	46.81	76.60	0.00	0.00	21.28	22.34	21.28	0.00	0.00	71.28	7.45	86.17	10.64	100.00	100.00	79.79
Ward 12	93.68	22.11	1.05	0.00	0.00	15.79	15.79	15.79	0.00	0.00	71.58	3.16	25.26	0.00	100.00	100.00	42.11
Ward 13	82.11	41.05	31.58	0.00	0.00	40.00	40.00	40.00	0.00	0.00	62.11	3.16	69.47	18.95	100.00	100.00	50.53
Zone 1	93.98	80.72	57.83	0.00	0.00	34.94	34.94	34.94	0.00	0.00	44.58	3.61	67.47	12.05	100.00	100.00	67.47
Zone 2	80.00	34.44	58.89	0.00	0.00	36.67	43.33	36.67	0.00	0.00	32.22	3.33	52.22	13.33	100.00	51.11	37.78
Zone 3	95.70	87.10	60.22	7.53	0.00	36.56	41.94	36.56	0.00	0.00	11.83	3.23	64.52	13.98	98.92	52.69	43.01
Zone 4	93.41	35.16	85.71	5.49	0.00	38.46	43.96	38.46	0.00	0.00	23.08	3.30	68.13	6.59	89.01	75.82	41.76
Overall	90.43	56.51	63.33	3.32	1.72	28.25	35.08	28.83	2.93	0.00	56.51	4.72	57.53	10.65	98.60	80.29	57.60

DSRWTR: Have access to desired water quality; SUFF: Have sufficient water throughout the year; VENDOR: Purchase water from vendor; CONTAMI: Have contaminated groundwater; CHECK QUA: Have checked groundwater quality; DOMES: Treat groundwater for all domestic choirs; DRINKING: Treat groundwater before drinking; COOKIN: Treat groundwater before cooking; SKIN: Experienced skin discoloration; PATCH SKIN: Experienced superficial growth/patch of skin; YELWTEETH: Have yellowish colored teeth; TEETHCAVITY: Children have teeth cavities; STAIN: Groundwater produces stains in clothes and utensils; TASTE: Groundwater has taste; AWARE: Aware of new water supply project; WITHIN: Household is within the project domain

filtration, if not filtered it results in iron depositions in washing machine and other domestic study area, several studies reported presence of fluoride along with iron but not arsenic (Chakrabarty & Sarma, 2011; Das et al., 2003).

Upon asking the survey respondents if groundwater is available throughout the year, there were mixed responses. As shown in Table 5.8, 56.51% responded that sufficient amount of groundwater is available throughout the year whilst 43.49% said that they do have groundwater shortage problem during the lean (dry) period of the year. The results are in line with the findings of Das & Goswami (2013) who showed concern on depleting groundwater in Guwahati city. It is reported that during pre-monsoon period the water in dug well is available at depth of 2 to 4 m and goes down to 10 m during lean period (Das & Goswami, 2013). This could be attributed to overexploitation of groundwater resources, concretization and changes in land use pattern due to rapid increase in population. Another reason for depleting groundwater could be that the study area comprises of sandy layers overlain by thick clay layer preventing the percolation of water into the aquifers (Das & Goswami, 2013).

About 63.33% of surveyed households claimed to purchase bottled water from vendor. The results on whether treatment/filtration of groundwater carried out before drinking and cooking are shown in Table 5.8. It was observed that overall 35.08% of the respondents treated groundwater before drinking and 28.83% treated groundwater before cooking. These people treated groundwater with the aim of removing iron, which stained clothes and imparted bitterness to water. The public have been unaware about one of the critical contaminations of ground water relating to fluoride contamination and its health effects. Many reports on fluoride contamination of groundwater in Guwahati have been published in various newspapers to create awareness amongst people (Das et al., 2003). On asking questions about health effects of contaminated groundwater, it was noticed that 2.93% households have experienced discoloration of skin (pigmentation) while none of the households claimed to have experienced superficial growth/patch of skin (keratosis) (Table 5.8). About 56.51% of household family members had yellowish teeth and 4.72% of households have children affected with teeth cavities. In addition, 57.53% of households have also reported to have issue of clothes and utensils staining, while 10.65% reported bitter taste of groundwater (Table 5.8).

It was observed that many people use different filtering system to treat the existing drinking water. Ward/Zone wise percentage distribution of treatment system used in the study area is shown in Table 5.9. In the study area, 6.31% respondents used full-fledged water purifiers (e.g. reverse osmosis filtration system), 20.85% respondents used candle filter (ceramic candle filters made out of clay), 2.87% people used sand filter and 0.32% adopted water boiling. However, majority of people i.e. 69.90% precisely were found to be consuming source groundwater directly without any kind of treatment. The analysis of public knowledge/familiarity about upcoming water supply scheme revealed that most of the people (98.60%) have noticed ongoing construction of upcoming water treatment plant (Table 5.8). However, people were found to be unaware about project information in terms of tariff structure, ownership of the project, public benefits and losses from project. The public was dissatisfied with the government for not informing details on the upcoming water supply scheme. The level of dissatisfaction among public was so high that they even doubted the government intentions and stated that the involvement of private sector would lead levy of high tariff on water to increase their margin of profit. Public also blamed government for not being

Table 5.9: Ward/Zone wise percentage distribution of groundwater treatment system used

Wards/ Zones	Sample size	Water treatment system used (%)				
		Purifier	Candle filter	Sand filter	Boil	Direct
W1	94	12.77	41.49	12.77	-	32.98
W2	94	12.77	20.21	5.32	-	61.70
W3	93	2.15	6.45	1.08	-	90.32
W4	93	4.30	19.35	8.60	3.23	64.52
W5	93	1.08	7.53	2.15	-	89.25
W6	92	15.22	19.57	3.26	-	61.96
W7	94	19.15	17.02	-	-	63.83
W8	91	6.59	15.38	-	-	79.12
W9	91	3.30	7.69	-	-	89.01
W10	92	8.70	9.78	-	-	81.52
W11	94	5.32	15.96	-	-	78.72
W12	95	2.11	15.79	3.16	-	77.89
W13	95	4.21	35.79	-	-	60.00
Z1	83	-	33.73	-	-	65.06
Z2	90	2.22	34.44	-	-	63.33
Z3	93	1.08	30.11	5.38	-	63.44
Z4	91	4.40	25.27	6.59	2.20	65.93
Overall	1568	6.31	20.85	2.87	0.32	69.90

transparent on this issue. The public also found to have prejudice about the scheme that they believed it is going to be a private water treatment facility with very high tariff. On asking question about household WtP for the water supplied from the upcoming water supply scheme, 57.60% households showed their willingness to procure (Table 5.8) while 42.40% households showed their reluctance to purchase water from the scheme. The reluctant households believed that their groundwater is safe to drink and mere visible contamination of iron could be removed by filtration.

5.4 Conclusions

Most of the people in the study area were found to be dependent upon groundwater (10% dug well, 51% hand pump and 39.22% tube well). 56.51% of the respondents had stated that they have sufficient amount of groundwater throughout the year whilst 43.49% faced shortage during lean (dry) period. However, the public perception on groundwater quality was far away from reality as such around 98% people have never checked their groundwater quality and that only 3-4% people were aware of contamination. Moreover, 30% people found using household filters to treat their groundwater. The survey also revealed that the rationale for public opposition were more of misconception and lack of knowledge about water supply scheme, wherein authorities failed in information sharing and building trust among public that lead to protest through public rallies, hunger strike and meetings. The people in study area were also found to be unaware of the facts and knowledge about upcoming water supply project, and the preconception found more prominent over facts. Furthermore, the public were found to be highly dissatisfied with authorities and demanded greater public participation, transparency and information sharing over the water supply scheme. In addition, a huge portion of society (42%) were found to be reluctant to pay for the water that is going to be supplied through the proposed water supply scheme. The major reason for this reluctance to procure water is observed to be casual, awful and ignorant public approach and lack of knowledge among the public about the scheme.

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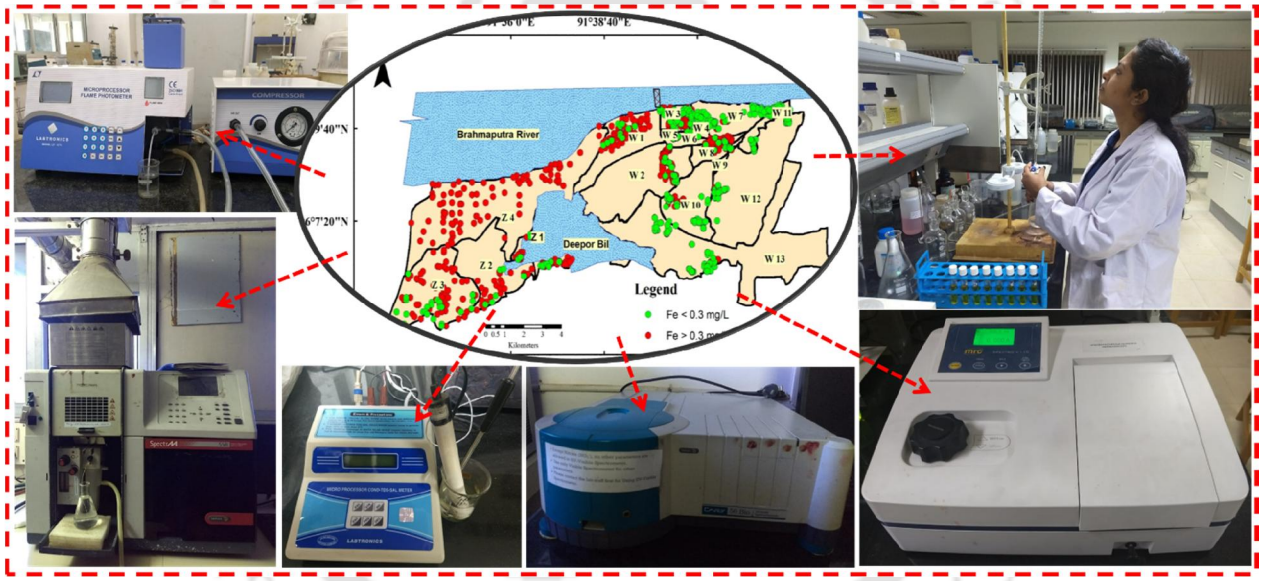
Chapter–6

Groundwater Quality Assessment and its Health Impacts in Study Area



This chapter presents results of laboratory testing for collected groundwater samples from the study area. The critical water quality parameters are identified with reference to WHO guidelines (WHO, 2008) and Indian standards (IS 10500, 2012). It also documents the existing public sufferings or health hazards of respective contaminants among people in the study area.

6.1 Background

People in developing and underdeveloped countries are mostly dependent on groundwater rather than piped drinking water supply from ULBs (Sujatha et al., 2012). It is the major source of drinking water in rural and peri-urban areas (Narain, 2004) and considered safer than untreated surface water. Hence, government has constantly encouraged installation of hand pumps and deep tube-wells in both public and private domain (Narain, 2004). However, groundwater is being contaminated by natural, agricultural, domestic, and anthropogenic sources (Pepper et al., 2011). In addition, groundwater overdraft for irrigation and industrial purpose leads to depletion of groundwater table leading to huge weathering of the metamorphic rocks causing groundwater contaminated with fluoride (Tularam & Krishna, 2009). In addition, overdraft of groundwater may also lead to excess dissolved oxygen that in turn oxidizes the original immobile minerals, releasing arsenic ions (Tularam & Krishna, 2009). In coastal areas, overdraft of groundwater has led to problem of saltwater ingress resulting in contamination of freshwater aquifers (Bansil, 2004). Many researchers have expressed concerns about groundwater contamination (iron, fluoride, nitrate and arsenic) and its suitability for drinking in various regions of Assam (Chakrabarty & Sarma, 2011a; Chetia et al., 2011). Despite numerous reports of groundwater contamination, a high percentage of population is drinking groundwater in Assam. Guwahati is not an exception to this and traces of fluoride and iron beyond WHO guideline values have been reported in the eastern and southern plains of the city (Chakrabarty & Sarma, 2011a). However, to the best of our knowledge, reports on groundwater contamination particularly in study area have not yet been reported. Therefore, there is a need of thorough investigation on groundwater quality of this area. Henceforth, the present chapter aims to fulfil second major objective of this study '*Assessment of the groundwater quality in study area and identification of critical water quality parameters*'.

In assessment of groundwater quality, a total of 1568 number of household groundwater samples were collected from the same households who had participated in the main survey for assessing the perception and WtP survey. The samples were analysed in laboratory for pH, conductivity, sodium, potassium, calcium, iron, fluoride, arsenic, nitrate, alkalinity and hardness. Critical water quality parameters {parameters exceeding Drinking Water Quality Standards (BIS 10500, 2012; WHO, 2008)} were identified. The ill effects of contaminated groundwater

consumption were recorded among the public in the study area. The spatial variations in concentration of contaminants were mapped using ArcGIS 9.3.

6.2 Material and Methods

6.2.1 Groundwater

In present study, samples were collected from household groundwater sources (dug well, hand-pump and tube-well) and analyzed in laboratory to identify critical parameters exceeding permissible drinking water quality standards. The present section includes procedures/methods adopted for groundwater sample collection and its laboratory testing.

6.2.2 Sample Collection

Spatial variation in groundwater quality of the case study area was studied by collecting groundwater samples from different location and sources (dug well, hand-pump and tube-well). For this purpose, each ward/zone was divided into grid pattern based on longitude and latitude encompassing an area of individual grid approximately 0.0311 km^2 prepared with ArcGIS 9.3 (ESRI, Redlands, CA, USA). The intersection points of longitude and latitude were used to demarcate the grid area in the field with the help of a handheld Global Positioning System (GPS) (Model: Montana-600, M/S Garmin Ltd., USA). The grid area either devoid of habitation or composed of marshy land (and of course absence of groundwater sources) were excluded from groundwater sampling. If a grid area is having habitations (and groundwater sources), less than required number of samples to be collected from the area, then the sampling was limited to available habitations only. The number of samples to be collected from the ward/zone (after taking into consideration grid area devoid of or less number of habitations) was uniformly distributed in the remaining grid area having sufficient habitations. While identifying groundwater sampling locations in a grid, efforts were made to spread the sampling locations covering the entire area of the grid. After sampling from a source, the exact location of the groundwater source was determined using the handheld GPS. The samples were collected by grab sampling from the groundwater source such as dug well, and hand pumps and then stored in poly-propylene bottles. The quantitative analysis of the collected samples was carried out in the laboratory. For determination of hardness, sodium (Na^+), potassium (K^+), calcium (Ca^{2+}), iron (Fe^{2+}) and arsenic (As^{3+}) concentrations, collected samples were added with 1 mL of concentrated HNO_3 to keep its

pH low (<2) and prevent precipitation of metal (APHA, 2012).

6.2.3 Analytical Methods and Instruments Used

All analytical estimations were performed following the methodology given in Standard Methods for Examination of Water and Wastewater (APHA, 2012). Fluoride (F^-) is determined by SPADNS reagent method whereas iron by 1, 10 phenanthroline method, hardness by EDTA titrimetric method, alkalinity by titration method, potassium, sodium and calcium ions determined by flame photometric method, nitrate in UV-visible spectrophotometer and pH measured by digital pH meter. The various instruments used in field work and for determination of the above physico-chemical parameters are presented in Table 6.1.

Table 6.1: List of important instruments and equipment used in the present study

Instrument	Purpose	Model & Manufacturer
Conductivity meter	Conductivity measure	VSI-04ATC & M/s VSI Electronics Pvt. Ltd., India
Digital spectrophotometer	Analyze iron and fluoride	166 & M/s Systronics India Ltd., India
Digital pH meter	pH measure	µpH System 361 & M/s Systronics India Ltd.,India
Flame photometer	Measure sodium, potassium and calcium	128 & M/s Systronics India Ltd., India
UV-Visible spectrophotometer	Measure nitrate	CARY 50 Bio & M/s Varian, Australia
Atomic Absorption Spectrometer (AAS)	Arsenic measurement	SpectrAA 55B & M/s Varian, Australia
De-mineralized water plant	Get de-mineralized water	Milli-Q Academic & M/s Millipore S.A.S., France
Global Positioning System (GPS)	Get location information	Montana-600 & M/s Garmin Ltd., USA

6.3 Results and Discussion

6.3.1 Overall Groundwater Quality

The household groundwater sample collection in the study area commenced in November 2013 and continued till September 2014. The samples were collected, brought to the laboratory and analyzed within 24 hours. The results of water quality analysis revealed that pH, conductivity,

sodium, potassium, calcium, alkalinity and hardness values were within WHO guidelines (Table 6.2) (WHO, 2008). It can be observed that iron was present in all the collected samples with least value of 0.02 mg/L in W12, whereas, concentration of iron exceeding WHO guidelines (WHO, 2008) was observed in all wards/zones. In case of fluoride, few samples found with no fluoride and instances of fluoride exceeding WHO guidelines (WHO, 2008) were observed in multiple wards except W1, W8, W9 and W14. Similarly, arsenic concentrations exceeded WHO guidelines (WHO, 2008) at many instances in wards W6, W7, W8, W9, W11, Z2, Z3 and Z4 (Table 6.2). Hence, these three contaminants were considered as critical parameters. The ward/zone wise number of samples exceeding WHO guidelines (WHO, 2008) are shown in Table 6.3. The collected groundwater samples showed ample variation in concentrations of iron, fluoride and arsenic. Basically, iron and arsenic contamination is reported to be high in Bengal Delta Plain formed by the Ganga-Padma-Meghna-Brahmaputra river basin and the contamination is reported to spread across West Bengal, Bangladesh and extends to Indian states viz. Jharkhand, Bihar, Uttar Pradesh, Assam, and other Northeastern states of India along with the neighboring Nepal (Chakraborti et al., 2013; Chetia et al., 2011; Sengupta et al., 2003). Analogously, the overall groundwater quality in the study area was found to be in line with these reports and was unfit for drinking in most of the households.

6.3.2 Iron

As per WHO guidelines and BIS permissible limits, iron in drinking water should be below 0.3 mg/L (BIS 10500, 2012; WHO, 2008). Most of the samples were observed to have exceeded the WHO guideline/BIS permissible limits. Figure 6.1 shows sample locations exceeding (> 0.3 mg/L) and within (< 0.3 mg/L) the permissible limit. It was observed that none of the wards/zones recorded 100% compliance with WHO guidelines on iron content (Table 6.3). The highest percentage of samples exceeding the guideline/permissible limit was observed in W9, followed by W8 and W2. The overall percentage exceeding required guideline/permissible limit for iron was observed to be 52%. The results of present study were in line with literature that reported similar results on concentration of iron exceeding guideline/permissible limit in Greater Guwahati, reflecting the water quality to be unsafe for drinking directly from the source (Jain et al., 2000; Singh et al., 2017). In another study carried out by Haloi & Sarma (2012) in Barpeta district, Assam, 65% of the sampling locations were found to be contaminated by iron exceeding WHO

Table 6.2: Variations in water quality parameter analysis carried out in wards/zones of the study area

Ward(W) / Zones(Z)	Sample size	pH	Conductivity (mmho/cm)	Sodium (mg/L)	Potassium (mg/L)	Calcium (mg/L)	Iron (mg/L)	Fluoride (mg/L)	Arsenic (µg/L)	Nitrate (mg/L as NO_3^--N)	Alkalinity (mg/L as $CaCO_3$)	Hardness (mg/L as $CaCO_3$)
W 1	94	6.54 ↔ 7.96	0.18 ↔ 1.59	8.25 ↔ 85.63	0.38 ↔ 8.29	4.03 ↔ 128.43	0.16 ↔ 2.03	0.02 ↔ 0.96	0.00 ↔ 9.79	0.00 ↔ 9.25	2.00 ↔ 18.00	14.00 ↔ 326.00
W 2	94	6.48 ↔ 8.43	0.12 ↔ 1.14	1.25 ↔ 71.26	0.25 ↔ 36.02	1.68 ↔ 118.13	0.12 ↔ 1.01	0.12 ↔ 2.76	0.00 ↔ 3.74	0.00 ↔ 8.51	2.00 ↔ 10.00	24 .00↔ 286.00
W 3	93	6.39 ↔ 7.77	0.06 ↔ 1.41	6.23 ↔ 61.63	0.37 ↔ 29.33	1.58 ↔ 119.56	0.12 ↔ 0.95	0.09 ↔ 1.51	0.00 ↔ 9.86	0.00 ↔ 7.16	2.00 ↔ 12.00	40.00 ↔ 294.00
W 4	93	6.68 ↔ 8.39	0.13 ↔ 5.57	2.30 ↔ 35.31	0.08 ↔ 7.58	0.61 ↔ 137.47	0.09 ↔ 0.49	0.03 ↔ 1.96	0.00 ↔ 8.33	0.00 ↔ 9.12	2.00 ↔ 20.00	28.00 ↔ 202.00
W 5	93	6.84 ↔ 8.50	0.13 ↔ 5.57	2.30 ↔ 35.31	0.08 ↔ 7.58	0.61 ↔ 137.47	0.05 ↔ 2.94	0.04 ↔ 7.93	0.00 ↔ 4.69	0.00 ↔ 34.00	0.00 ↔ 24.00	20.00 ↔ 202.00
W 6	92	6.34 ↔ 8.03	0.06 ↔ 1.65	6.23 ↔ 61.63	0.48 ↔ 11.33	0.66 ↔ 119.56	0.11 ↔ 1.19	0.01 ↔ 2.02	0.00 ↔ 28.36	0.00 ↔ 8.92	2.00 ↔ 10.00	54.00 ↔ 286.00
W 7	94	6.67 ↔ 8.27	0.15 ↔ 2.39	2.99 ↔ 42.53	0.25 ↔ 12.17	2.82 ↔ 75.53	0.09 ↔ 1.22	0.34 ↔ 1.84	0.00 ↔ 35.70	0.00 ↔ 10.29	2.00 ↔ 16.00	28.00 ↔ 262.00
W 8	91	6.56 ↔ 8.12	0.09 ↔ 1.78	6.23 ↔ 62.53	0.71 ↔ 30.23	8.74 ↔ 122.82	0.18 ↔ 0.93	0.57 ↔ 1.09	0.00 ↔ 28.36	0.00 ↔ 8.31	2.00 ↔ 10.00	28.00 ↔ 286.00
W 9	91	6.56 ↔ 8.12	0.09 ↔ 1.78	6.23 ↔ 62.53	0.71 ↔ 30.23	8.74 ↔ 122.82	0.18 ↔ 0.93	0.32 ↔ 1.09	0.00 ↔ 28.66	0.00 ↔ 8.31	2.00 ↔ 10.00	20.00 ↔ 286.00
W 10	92	6.77 ↔ 8.28	0.19 ↔ 1.41	7.73 ↔ 40.88	0.60 ↔ 52.51	0.23 ↔ 225.79	0.03 ↔ 0.69	0.48 ↔ 2.04	0.00 ↔ 2.40	0.00 ↔ 8.85	2.00 ↔ 10.00	16.00 ↔ 264.00
W 11	94	6.52 ↔ 8.51	0.12 ↔ 1.69	2.10 ↔ 60.28	0.60 ↔ 14.61	0.03 ↔ 103.24	0.03 ↔ 0.48	0.02 ↔ 2.21	0.09 ↔ 17.47	0.00 ↔ 8.52	0.00 ↔ 104.00	36.00 ↔ 374.00
W 12	95	7.04 ↔ 8.55	0.23 ↔ 1.17	10.46 ↔ 46.13	2.49 ↔ 63.52	0.83 ↔ 106.74	0.02 ↔ 0.78	0.16 ↔ 2.58	0.00 ↔ 4.57	0.00 ↔ 8.99	2.00 ↔ 12.00	20.00 ↔ 224.00
W 13	95	6.74 ↔ 8.4	0.20 ↔ 47.13	5.54 ↔ 38.28	0.60 ↔ 6.30	18.45 ↔ 101.31	0.06 ↔ 8.42	0.50 ↔ 3.06	0.00 ↔ 5.45	0.00 ↔ 8.79	0.00 ↔ 10.00	14.00 ↔ 210.00
Z 1	83	6.56 ↔ 8.37	0.29 ↔ 1.51	9.33 ↔ 42.48	1.27 ↔ 52.81	1.78 ↔ 227.95	0.13 ↔ 1.67	0.10 ↔ 2.10	0.30 ↔ 2.70	0.00 ↔ 8.67	2.00 ↔ 10.00	17.60 ↔ 379.20
Z 2	90	6.78 ↔ 8.09	0.3 ↔ 47.12	5.11 ↔ 33.09	0.61 ↔ 22.64	13.03 ↔ 92.53	0.11 ↔ 21.00	0.05 ↔ 1.95	0.50 ↔ 17.70	0.00 ↔ 9.64	0.00 ↔ 10.00	28.00 ↔ 124.00
Z 3	93	6.64 ↔ 6.99	0.11 ↔ 25	6.60 ↔ 23.58	0.86 ↔ 12.63	2.36 ↔ 32.67	0.06 ↔ 1.43	0.00 ↔ 2.00	0.10 ↔ 16.80	0.00 ↔ 8.90	2.00 ↔ 10.00	22.80 ↔ 374.80
Z 4	91	6.53 ↔ 7.12	0.12 ↔ 0.95	9.28 ↔ 22.56	0.48 ↔ 11.33	0.66 ↔ 44.55	0.11 ↔ 1.65	0.01 ↔ 2.02	0.00 ↔ 12.30	0.00 ↔ 9.42	2.00 ↔ 10.00	28.00 ↔ 124.00

Note: The data is presented in XX ↔ YY format where XX is the minimum value and YY is the maximum value

Table 6.3: Percentage of samples exceeding WHO guidelines in respective wards/zones

Wards(W)/ Zones(Z)	Sample size	% of samples exceeding WHO guidelines (WHO, 2008)		
		Iron	Fluoride	Arsenic
W 1	94	88	0	0
W 2	94	89	32	0
W 3	93	67	1	0
W 4	93	23	14	0
W 5	93	6	12	0
W 6	92	58	3	14
W 7	94	15	7	73
W 8	91	92	0	22
W 9	91	96	0	23
W 10	92	62	12	0
W 11	94	12	15	6
W 12	95	18	58	0
W 13	95	15	31	0
Z 1	83	65	18	0
Z 2	90	78	22	11
Z 3	93	55	3	1
Z 4	91	58	1	2
Total	1568	52	14	9

guideline value of 0.3 mg/L.

Iron effect

Consumption of iron contaminated water has no direct adverse health effect (Idoko, 2010; Naser et al., 2018). However, it imparts color to water, bitter taste to food and causes staining of clothes and utensils (Idoko, 2010). The thumb rule followed by researchers to recognize iron contamination is by physical observations i.e. taste, staining on containers, red coloration nearby hand pumps. It is reported that concentrations of iron >0.3 mg/L impart bitter taste and produces reddish-brown rust-colored stains on storage containers and utensils, further higher concentrations may also cause coloration of surroundings of water source (Naser et al., 2018). On the same line, household owners in the study area reported experiences of bitter taste and staining of water storage containers as well as surrounding of groundwater sources e.g. hand pump, water filters, etc. The percentage households reporting staining of water storage containers and hand pump surrounding areas was observed to be as high as 57.53% and households reporting bitter taste were

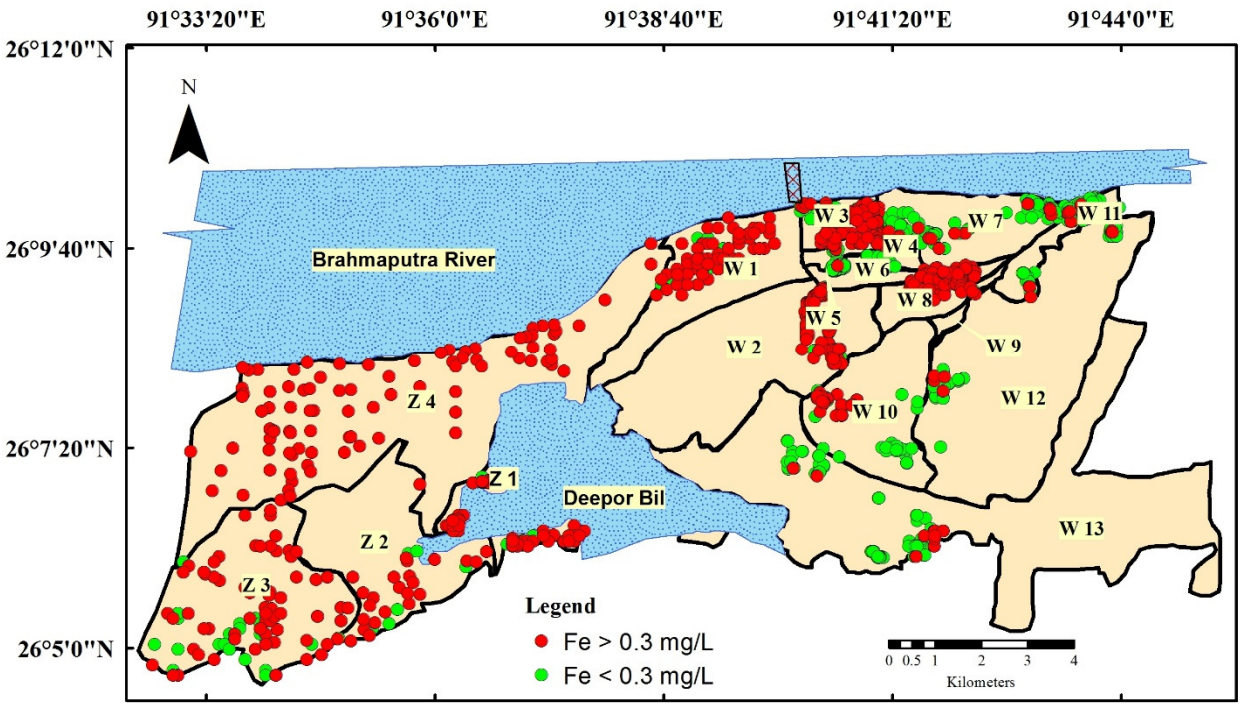


Figure 6.1: Location map of iron concentration in the study area with respect to WHO limit of 0.3 mg/L.

Figure 6.2: Precipitated iron besides groundwater sources.

10.65%. The photographs showing alarming levels of iron staining surrounding hand pumps and in filters were captured during sample collection and presented in Figure 6.2. Similar studies in Bangladesh (part of Ganga-Padma-Meghna-Brahmaputra river basin) have reported bitter iron

taste in 42% of household groundwater sources and staining of storage containers in 37% household groundwater sources (Naser et al., 2018).

6.3.3 Fluoride

As per WHO guidelines and BIS permissible limits, fluoride in drinking water should be below 1.5 mg/L, however, the desirable concentration of fluoride in drinking water is within 1-1.5 mg/L (BIS 10500, 2012; WHO, 2008). The collected groundwater samples showed variable levels of fluoride in different wards/zones. Wards W1, W8 and W9 did not show any fluoride contamination, whereas highest percentage of noncomplying fluoride concentration was observed in ward W12. In fact, 14% of the samples in the study area had exceeded stipulated WHO guideline/BIS permissible limits for fluoride as shown in Table 6.3. Figure 6.3 shows the sample locations considering 1.5 mg/L as threshold fluoride concentration in the study area. The results

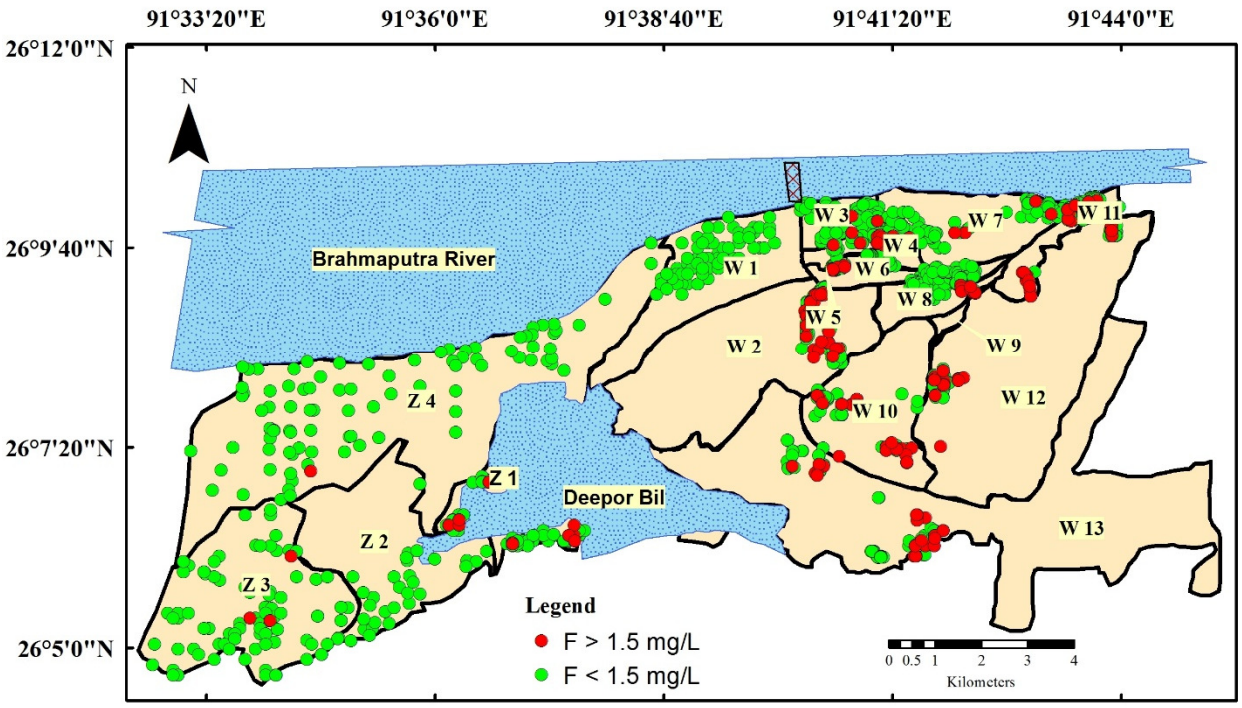


Figure 6.3: Location map of fluoride concentration in the study area considering 1.5 mg/L as threshold concentration.

from this study were analogous to those reported in literature and are in line with similar research findings on groundwater quality carried out for Central Guwahati, Nagaon and Karbi Anglong (Das et al., 2003; Haloi & Sarma, 2012; Singh et al., 2017). Although, concentration of fluoride <1.5 mg/L is acceptable for drinking purpose, minimum 1 mg/L of fluoride is essential for

preventing dental fluorosis, especially among children. The percentage of households with groundwater concentration less than desirable (1 mg/L) were 20.03%. The wards W1, W8 and W9 showed lowest fluoride concentrations.

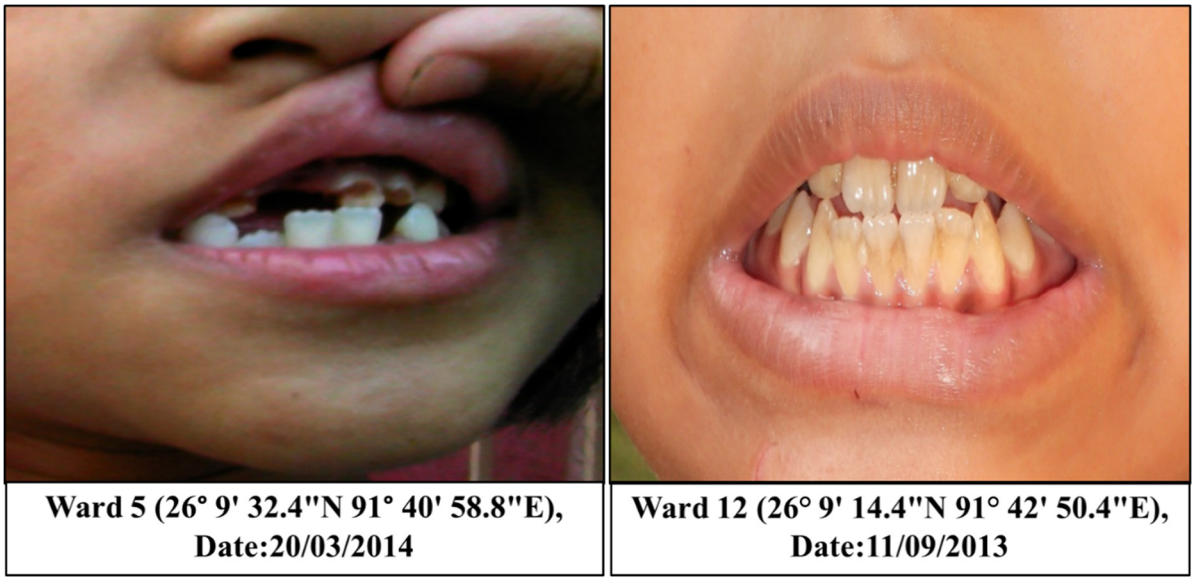


Figure 6.4: Effect of fluoride on children's teeth after consumption of fluoride contaminated water.

In the present study area, 56.51% households have reported that some of their family members were observed to have yellowish colored teeth whereas pits or cavity in the teeth of children were observed in 4.72% of the households. Figure 6.4 shows yellowish colored teeth among children in W5, and W12. Similar harmful effects have also been observed in other parts of the country where the fluoride content was more than permissible limit. For example, in Siddipet (Telangana), it has been reported that fluoride contamination had resulted in large scale dental fluorosis amongst the people of that area (Narsimha & Sudarshan, 2017). Susheela et al. (1993) in their study on health complaints of 1958 peoples in Faridabad (Haryana) revealed that 58, 27 and 41% of people were affected with dental fluorosis, skeletal fluorosis and non-skeletal manifestations, respectively. Though fluoride content was observed to be above permissible limit in the study area and cases of dental fluorosis are possibly present in the study area, however symptoms of skeletal fluorosis and non-skeletal manifestations were not observed among the people.

6.3.4 Arsenic

As per WHO guidelines, arsenic in drinking water should be below 10 µg/L (WHO, 2008) and as per the Indian standards the desirable limit is 10 µg/L and permissible limit is 50 µg/L (BIS

10500, 2012). It is well documented that high-levels of arsenic exposure causes chronic health effects which includes cancer, skin pigmentation, skin lesions, respiratory, neurological and hematological effects in human (Mukherjee et al., 2006; Yoshida et al., 2004). The results of arsenic analysis revealed that the highest concentration of arsenic was 35.7 µg/L, observed in W7. The results indicate that 9% of samples exceeded WHO guidelines limit but were well within BIS guidelines limit of 50 µg/L. Figure 6.5 shows groundwater locations in the study area exceeding (> 10 µg/L) and within (< 10 µg/L) WHO guidelines limits. The study results are in line with the findings of literature that reports that groundwater in vicinity of the Brahmaputra river is contaminated with high concentration of arsenic (Nickson et al., 2007; Singh, 2006). A study on groundwater analysis of 5,729 government hand pumps in 22 districts of Assam reported that overall 6.3% of groundwater sources contained arsenic in concentrations greater than 50 µg/L (Nickson et al., 2007). Another study reported presence of arsenic in Dhemaji and Karimganj districts of Assam exceeding WHO guidelines limit of 10 µg/L (Bhattacharya et al., 2008).In th study area, pigmentation was observed in 2.93% households (any member of the household), however there were no occurrences of keratosis noticed in surveyed samples. Keratosis prevalence is usually observed in areas with high arsenic concentration i.e. > 10 µg/L (Mazumder, 2003)

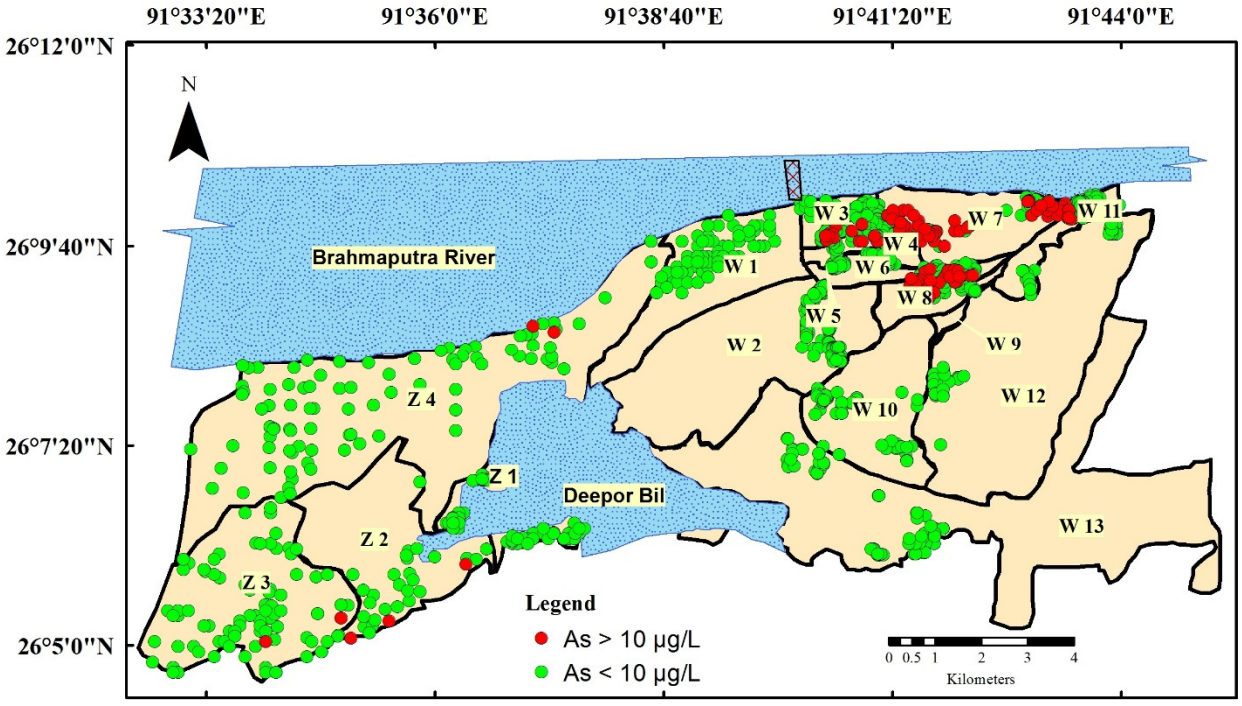


Figure 6.5: Location map of arsenic concentration in the study area considering 10 µg/L in study area.

which is not prevalent in our study area. Of the 1568 households, 44 males and 2 females have skin pigmentation whereas no symptoms of keratosis were observed.

6.3.5 Combined Presence of Iron, Fluoride and Arsenic

The severity of household groundwater contamination in simultaneous occurrences of iron, fluoride and arsenic was investigated, compared with WHO guidelines and results are shown in Table 6.4 (WHO, 2008). It can be observed that considering iron and fluoride contamination at the same time 7% i.e. 106 samples exceeded WHO limits. The samples locations showing the iron and fluoride concentrations considering 0.3 and 1.5 mg/L respectively as threshold values are shown in Figure 6.6. Altogether 63 samples showed simultaneous occurrence of iron and arsenic beyond prescribed limits. The sampling locations exceeding iron and fluoride beyond permissible limits were in W3, W5, W6, W7, W11, Z2 and Z4 as shown in Figure 6.7. However, only 12 samples reported simultaneous occurrence of fluoride and arsenic, which was found in W5, W7, W11 and Z2 as shown in Figure 6.8. Simultaneous occurrence of these three contaminants (iron, fluoride and arsenic) was observed only in 1% of the total samples (Figure 6.9) in W5, W7, W11 and Z2. Although simultaneous occurrence of the contaminants was not very severe in the study area, it is reported to be more often in other parts of the region. Groundwater quality analysis in Lakhimpur district of Assam reported that 6 out of 8 locations showed simultaneous occurrence of iron and arsenic, whereas fluoride was absent in all the samples (Hazarika & Bhuyan, 2013). A study carried out at Darrang district of Assam analyzed 25 samples at different locations and observed that 11 samples exceeded WHO guidelines limit for iron, whereas only one sample exceeded arsenic limit and reported no fluoride contamination (Borah et al., 2010). However, in our study fluoride contamination was detected with simultaneous occurrences of arsenic and iron at many instances as shown in Table 6.4.

Table 6.4: Number of samples contaminated by combined contaminants and its compilation with WHO guidelines

Combination of contaminants	Exceeding WHO guidelines limit (out of 1568 samples)	
	No of samples exceeding	Percentage of samples
Iron & Fluoride	106	7
Fluoride & Arsenic	12	1
Arsenic & Iron	63	4
Iron, Fluoride & Arsenic	9	1

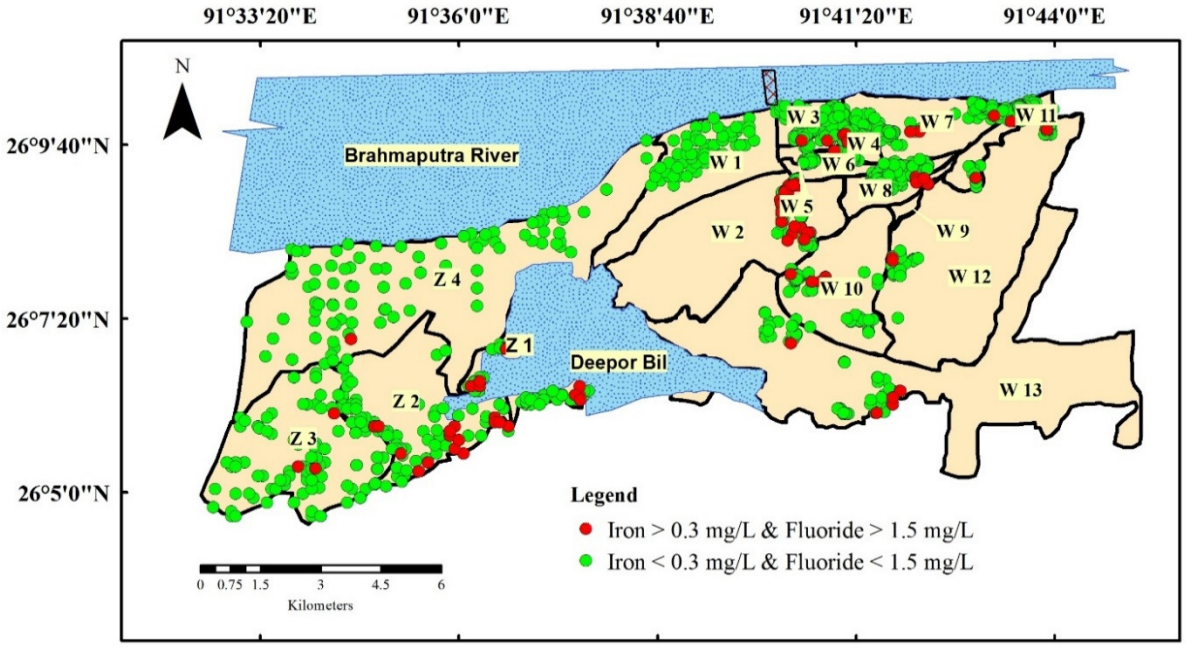


Figure 6.6: Simultaneous occurrences of iron and fluoride in study area considering 0.3 and 1.5 mg/L as threshold concentration, respectively.

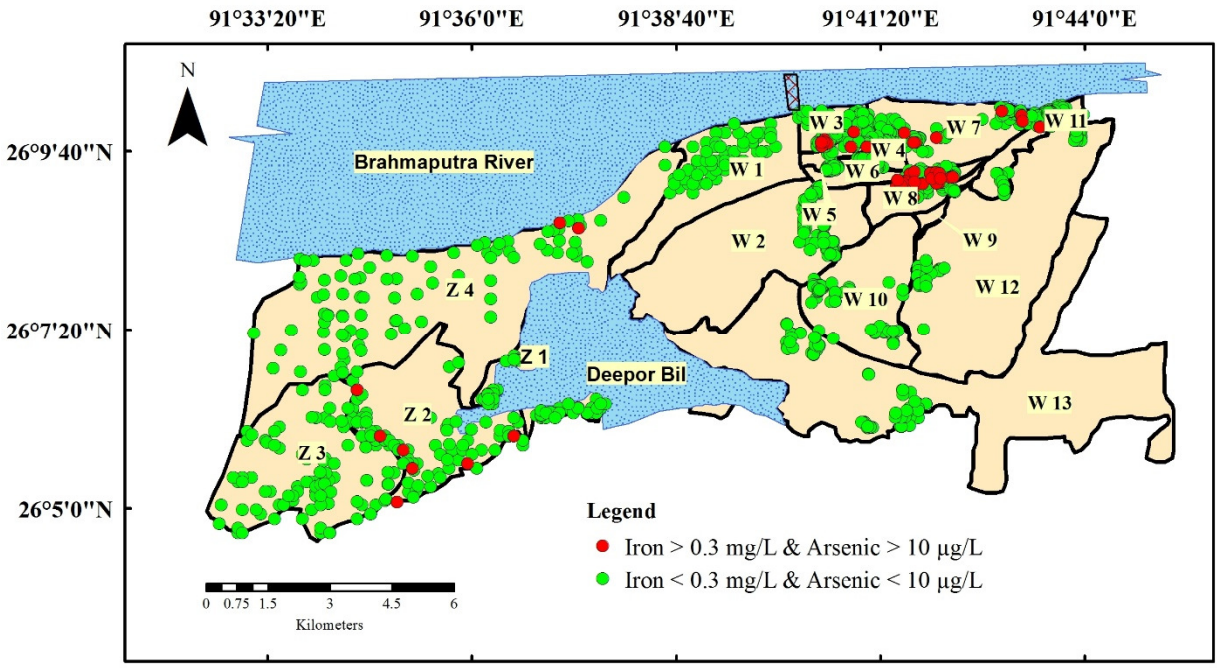


Figure 6.7: Simultaneous occurrences of iron and arsenic in study area considering 0.3 mg/L and 10 µg/L as threshold concentration, respectively.

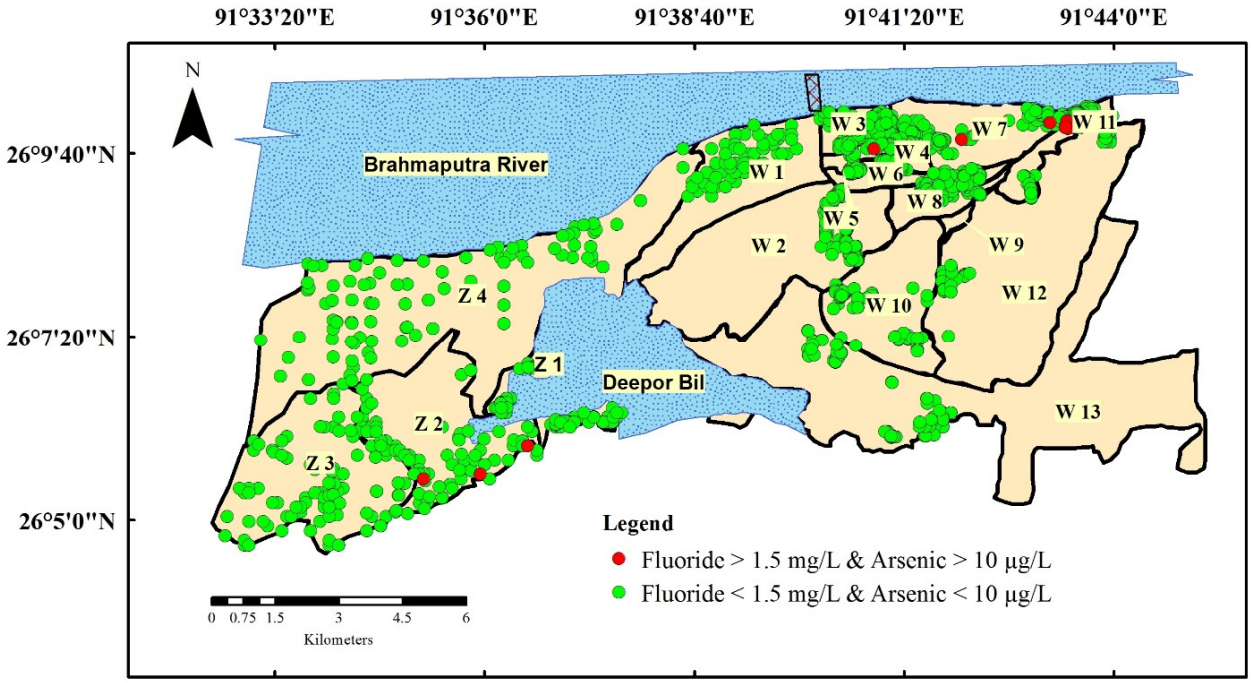


Figure 6.8: Simultaneous occurrences of fluoride and arsenic in study area considering 1.5 mg/L and 10 µg/L as threshold concentration, respectively.

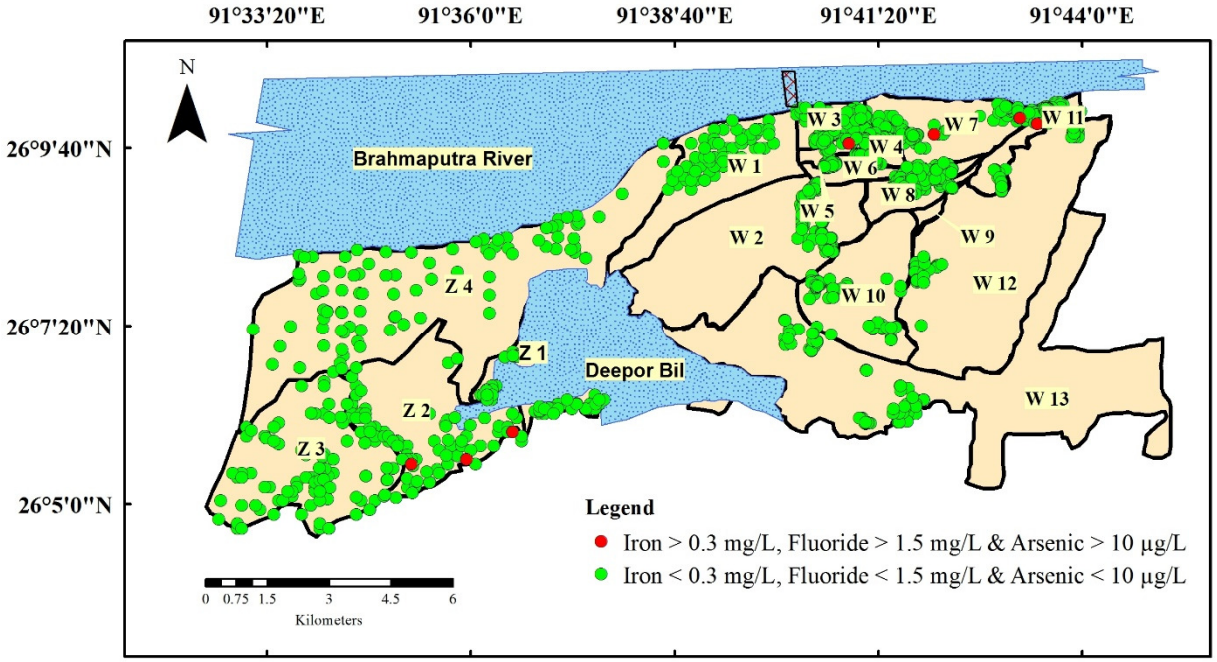


Figure 6.9: Simultaneous occurrences of iron, fluoride and arsenic in study area considering 0.3 mg/L, 1.5 mg/L and 10 µg/L as threshold concentration, respectively.

6.3.6 Groundwater Contamination and Topography/Geology of Region

The analogy in groundwater quality and topography/geology of the region was investigated. The parameters chosen were elevations of sampling locations and mineralogy of soil. The investigation revealed an interesting pattern of groundwater contamination showing higher contamination at foot hills and reducing radially outwards. The laboratory analysis of fluoride and arsenic gave higher values at foothills of Kamakhya, Ganeshpara hill (near Maligaon), and Assam Engineering College hill. It was further observed that the level of groundwater contamination reduced as one moves away from the hills. Similar observations for whole Northeast India including Assam were reported by Singh (2004) and Ramanathan et al. (2009) wherein the concentration of arsenic contaminant was reported to be prevalent near the foothills. The groundwater contamination in this region is reported to be due to dissolution of particular bedrock layer at a certain depth (Ramanathan et al., 2009). The dissolution is expected to be higher at foothills at certain depth contributing fluoride, arsenic and iron contamination of aquifers in its vicinity. In addition, the study region has two types of rocks viz. horneblende diorite and amphibolites that contributed to the contamination of groundwater (Chakrabarty & Sarma, 2011b; Sharma et al., 2012).

6.4 Conclusions

A total of 1568 groundwater samples were collected from the study area and analyzed for eleven water quality parameters (pH, electrical conductivity, total hardness, alkalinity, sodium, potassium, calcium, nitrate, iron, fluoride and arsenic). Of the analyzed parameters, iron, fluoride and arsenic were found to be critical parameters as these have exceeded the BIS permissible limits and WHO guidelines. Hence, unsuitability of groundwater for direct consumption were observed in households in the study area with highest concentrations of iron, fluoride and arsenic as 21 mg/L, 7.93 mg/L and 35.7 µg/L, respectively. The ward-wise order of iron, fluoride and arsenic contamination was W9 > W8 > W2 > W1 > Z2 > W3, W12 > W2 > W13 and W7 > W9 > W8 respectively. Moreover, the percentage samples exceeding WHO guideline/BIS permissible limit for iron, fluoride and arsenic was observed to be 55%, 12% and 9% respectively. An interesting pattern of groundwater contamination was identified, it was observed that contamination was higher at the foothills and decreases radially outward in the study area. Furthermore, the study

illustrated the need of water quality monitoring as well as awareness programs to publicize health hazards of contaminated groundwater.

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Chapter–7

Enhancing Public Awareness on Groundwater Quality and Willingness to Procure through Questionnaire Survey and Education

This chapter presents the findings on changes in public willingness to procure (WtP) after spreading groundwater quality awareness. The comparison of public WtP i.e. before and after awareness program is presented to find the factors affecting public WtP and identify specific ones in the study area.

7.1 Background

More often, public in developing countries is ignorant about quality of freely available groundwater and do not prefer to opt for nominally charged piped water supply (Egbinola & Amanambu, 2014). On the other hand, developed countries have public consciousness about groundwater contaminations and is trained to be attentive towards quality of services through timely organized awareness drives by governmental or nongovernmental organizations (NGOs) (Chatterjee et al., 2010; Nahar et al., 2008). Such awareness programs have proven to have increased public knowledge as well as acceptance of new water supply schemes.

In recent times, Indian government have passed laws limiting pumping of groundwater and endorsed surface water network by initiating various government and privately funded schemes (DoEA, 2001) due to lesser treatment cost (Nas & Berktay, 2010) and possible groundwater contaminations (PHED, 2013). Despite the governmental policies, Urban Local Bodies (ULBs) are unable to meet growing urban water demands and extend surface water network to reach every household. Insufficient funding and inadequate technical competency of ULBs have resulted in degradation of piped water quality, making safe water supply scenario worse (Aijaz, 2010; Devkar et al., 2013; Dutta et al., 2005). These shortfalls have affected consumer satisfaction and willingness to procure (WtP) for water supply schemes (Dutta et al., 2005). Such constraints and lack of water quality awareness have created circumstances that public prefer to continue using groundwater rather than to pay for piped water supply from ULBs (Sujatha et al., 2012). This ultimately affects viability of water supply schemes through lower acceptability and public WtP.

Various studies have reported necessary measures for enhancing public WtP such as awareness programs on health effects of contaminated water (Fotuè, 2013), public willingness surveys prior to project commencement (González-Gómez et al., 2012), high level of environmental awareness campaign, water conservation programs and information/problem sharing with the community. Positive effects of such measures could be observed in some of the Indian cities. For example, Mahalingam and Kapur (2009) have reported increased willingness to pay for Alandur sewerage scheme after door-to-door awareness program to convince public on project benefits. In case of Belgaum, Hubli-Dharwad and Gulbarga water supply projects, cases of public protest were observed due to fear of tariff hike. Mass door to door awareness campaign

launched by ULB officials successfully changed public minds in favor of project through information sharing and building trust (Chabra, 2014).

The awareness programs being carried out by the governmental agencies till date have been reporting qualitative improvement in WtP only. However, statistical quantification of enhancement in WtP before and after education/awareness programs is uniquely missing in literature. The present chapter aims to assess and study the enhancement in WtP and public acceptance of paid piped water supply scheme through the case of the Guwahati city study area. Third objective of the dissertation is '*Compare public WtP before and after creating groundwater quality awareness and identify the predominant factors influencing public WtP'*. This chapter, in turn, focuses on this objective. To understand public awareness on groundwater quality and their WtP, a questionnaire survey reported earlier in Section 5.3.3, Chapter 5, was taken up with the objective to identify the key factors influencing WtP. The groundwater quality awareness was carried out through door to door interaction followed by second round of questionnaire survey. The responses on WtP collected from the first round of the survey was then compared with the responses from the second round after the awareness program. Logistic regression model was, then, employed to identify the parameters influencing WtP using STATA software version 9.0 (STATA 9.0 for Windows, StataCorp LP, College Station, USA).

7.2 Methodology

7.2.1 Questionnaire Survey

A questionnaire survey was carried out to assess enhancement in WtP after groundwater quality awareness program. It aimed at assessing public groundwater quality awareness status and WtP apart from public demographic information (name, age, gender, etc.) as given in Appendix, Table A.3.

7.2.2 Data Analysis

Public opinion is considered as one of the easiest responses to take but complex to analyze in the field of statistics (Kelley et al., 2003). The opinion/decision of every individual is multidimensional and based on social, economic, technical and personal situations. Hence,

considering complexity of the data on public opinion i.e. WtP in our case, regression analysis technique was employed for the data analysis to achieve true representation (Sekaran & Bougie, 2010). The collected data was recorded in Microsoft Excel sheets and role data i.e. the inputs from respondents were analyzed using a software program to identify possible factors influencing public WtP. The possible effect of every individual factor e.g. age, gender, and household size on public WtP was estimated through cross table analysis (Table 7.1). Thereafter, combined effect of all factors (considering all factors simultaneously) on WtP was estimated in the same way. Finally, the logistic regression analysis was performed to identify specific factors influencing WtP for this case study. The regression analysis was performed considering two cases i.e. with and without including household income. Household income being the most crucial parameter for WtP water, in first case all data (total of 1568 household) taken into account, whereas in second case, only 493 households who disclosed/provided income was analyzed. It is common for people not to report their income (Casey et al., 2006) and in this case almost one-fourth of the households chose not to give their income. Finally, the results of both cases were compared.

7.2.3 Logistic Regression Model

The influence of several independent variables on one dependent outcome variable can be assessed using regression analysis. From literature, it is evident that the most widely used model in willingness to pay studies is based on logistic regression analysis (Raje et al., 2002; Sillano & Ortúzar, 2005). Logistic regression analysis is normally used if a categorical dichotomous outcome variable is used as a dependent variable, which is a type of probabilistic statistical classification model (Strickland, 2015). It is one of the most commonly adopted type of regression (Bhandari & Joensson, 2009). It measures the relationship between a categorical dependent variable and one or more continuous (but not necessarily) independent variable using probability scores as the predicted values for the dependent variable (Bhandari & Joensson, 2009; Strickland, 2015). In such analysis, the relationship between the independent variables and the probability of an outcome in the dependent variable is found using this model (Bhandari & Joensson, 2009).

In the present study, the categorical dependent variable i.e., WtP can assume only two classes (yes or no response). The response function is defined as in Eq. 7.1. (Viana et al., 2014)

$$E(y_i) = \frac{e^{x_i\beta}}{1 + e^{x_i\beta}} = \frac{1}{1 + e^{-x_i\beta}} \quad (7.1)$$

where, $E(y_i)$ is the expected value of the dependent variable y_i,

x_i is the independent variable,

β is the regression coefficient associated with the independent variable.

On adding multiple independent variables, Eq. 7.1 becomes (Viana et al., 2014)

$$E(y_i) = \frac{1}{1 + e^{-(\beta_0 + \beta_1 x_{i1} + \ldots + \beta_k x_{ik})}} \quad (7.2)$$

Based on the dependent and independent variables used in the questionnaire survey, a binary logistic regression was employed such that it is used in estimating empirical values of the parameters in a qualitative response model. Frequently, binary logistic regression is used where the dependent variable is binary (number of available categories is two). If it has more than two categories, then it is referred to as multinomial logistic regression or, when these multiple categories are in ordered form, it is referred to as ordered logistic regression.

7.2.4 Factors Affecting WtP

In the present study, values of dependent variable for respondents' positive WtP are assigned '1' and those unwilling i.e. negative WtP are assigned '0'. The available literature showed ample factors those adjudicate public WtP. However, subject to the availability of data and their relevance in the context of the present study, a number of independent variables have been identified from literature. The identified independent variables were studied for their probable influence on WtP decision and further coded as given in Table 7.1.

7.3 Results and Discussion

7.3.1 WtP After Groundwater Quality Awareness

A questionnaire survey on WtP water was carried out after households were informed about their groundwater quality. It can be seen from Table 7.2 that the awareness program and education on possible health hazards of iron, fluoride, and arsenic helped to change their mindsets on the WtP water from the upcoming water supply project. Table 7.2 shows ward/zone-wise WtP water before and after knowing groundwater quality. Higher WtP water from the project was observed for W1, W6, W7, W12, W13 and Z1, Z3, Z2 and Z4. The overall percentage of users WtP was

increased from 58 to 74%. The rest 26% users were not willing to procure water and were interested to use candle filter, sand filter, and water purifiers available in the local market.

Table 7.1: Description of independent variables

Variable code	Variable
AGE	Age of the respondent
GENDER	Gender of the respondent
HSIZE	Persons living in the household
YRSLIVING	Years living in the neighborhood
OWN	Whether living in own house or rented
INCOME	Amount of monthly income
EDU	Education level of respondent
SOURCE	Source of drinking water
DSRWTR	Have access to desired water quality
SUFF	Water sufficiency (sufficient availability of water round the year)
VENDOR	Purchase water from vendor
CONTAMI	Have contaminated groundwater
CHECK QUA	Have checked groundwater quality
DOMES	Treat groundwater for all domestic choirs
DRINKING	Treat water before drinking
COOKIN	Treat water before drinking as well as cooking
TREAT	Type of water treatment filter used
SKIN	Experienced skin discoloration
PATCH SKIN	Experienced superficial growth/patch of skin
YELWTEETH	Have yellowish colored teeth
TEETHCAVITY	Children have teeth cavities
STAIN	Groundwater produces stains in clothes and utensils
TASTE	Groundwater has taste
AWARE	Aware of new water supply project
WITHIN	Household is within the project domain

7.3.2 Effect of Demographic Factors on WtP Before Awareness Program

WtP is dependent upon many of the demographic factors. And, in the current study, the demographic factors selected for the analysis include age, gender, family size, years living in neighborhood, ownership of house, income (in rupees) and educational qualification of respondent. The effect of demographic factors on WtP in study area are presented in Table 7.3. Respondent's age is considered as an important factor highlighting the understanding of his/her views on issue and indicate level of maturity of an individual. In general, elderly people are expected to have low preference and less WtP than their younger counterparts (Liu et al., 2013). However, the effect of age on WtP was found to be insignificant in present study, and only ±3%

Table 7.2: Ward/Zone-wise distribution of willingness to procure (WtP) water from the upcoming water supply project before and after knowing groundwater quality

Wards(W)/ Zones(Z)	Sample size	Percentage WtP water from the project		Percentage increase in WtP
		Before knowing groundwater quality	After knowing groundwater quality	
W 1	94	13 (12)*	85 (80)	554
W 2	94	68 (64)	70 (66)	003
W 3	93	78 (73)	70 (65)	010 (negative)
W 4	93	65 (60)	67 (62)	003
W 5	93	88 (82)	77 (72)	013 (negative)
W 6	92	43 (40)	79 (73)	084
W 7	94	30 (28)	65 (61)	117
W 8	91	85 (77)	85 (77)	000
W 9	91	84 (76)	85 (77)	001
W 10	92	65 (60)	63 (58)	003 (negative)
W 11	94	80 (75)	69 (65)	014 (negative)
W 12	95	42 (40)	80 (76)	090
W 13	95	51 (48)	75 (71)	047
Z 1	83	67 (56)	81 (67)	021
Z 2	90	38 (34)	84 (76)	121
Z 3	93	43 (40)	58 (54)	035
Z 4	91	42 (38)	66 (60)	057
OVERALL	1568	58 (903)	74 (1160)	028

*The data is presented in xx (yy) format where xx is the percentage value for WtP and yy is the number of data points considered for estimating the percentage value.

variation was found in WtP (first round i.e. before groundwater quality awareness programs) among people age of 20-75 years. Gender is being used as a determinant factor for WtP by various researchers (Bogale & Urgessa, 2012; Jayasundara et al., 1999). However, studies have reported contradictory results of WtP for both men and women. Some studies showed higher WtP for men than women (Jayasundara et al., 1999), whereas some reported that women showed more WtP than men (Bogale & Urgessa, 2012). The results of present study also did not find any significant effect of gender on WtP, and it was 57% and 59% respectively for male and female respondents (first round i.e. before groundwater quality awareness). The effect of household size (HSIZE) on WtP is ambiguous and inconclusive in literature. A few researchers reported influence of household size on WtP but few others found no relation in WtP and household size (Widiyati, 2011). In present study, the HSIZE of a household was assumed on the basis of ownership i.e. the families

Table 7.3: Public WtP before and after groundwater quality awareness in the study area

Code (Variable)		WtP (%)		Percentage increase in WtP
		Before knowing groundwater quality	After knowing groundwater quality	
AGE (Age)	20-29	57.14	73.81	29
	30-39	54.96	74.38	35
	40-49	56.78	73.87	30
	50-59	58.60	75.16	28
	≥ 60	59.54	72.04	21
GENDER (Gender)	Male	57.43	74.06	29
	Female	59.01	73.29	24
HSIZE (Household size)	< 5	55.74	75.77	36
	= 5	55.31	73.13	32
	> 5	60.57	72.66	20
YRSLIVING (Years living in neighborhood)	< 5	51.23	77.05	50
	> 5	58.76	73.41	25
OWN (Ownership of house)	Own house	63.56	74.23	17
	Rented house	51.13	73.71	44
INCOME [Income (Rupees)]*	> 15001	76.27	91.53	20
	10001-15000	58.25	72.39	24
	5001-10000	43.59	73.08	68
	< 5000	54.24	59.32	09
EDU (Educational qualification)	Illiterate	40.00	52.73	32
	10th	44.94	47.62	06
	12th	43.41	70.66	63
	Graduate	79.84	97.43	22
	Post graduate	48.80	70.33	44
	PhD	78.08	90.41	16

* US$ 1 ≅ INR Rs 70.24 on 29th November, 2018

living together (either as joint family or rented guest families) and using the same source of drinking water were counted as single household. The effect of HSIZE was found to be insignificant in the present study, it was 55% and 60% respectively for HSIZE < 5 and HSIZE > 5 (first round i.e. before groundwater quality awareness). It is expected that number of years living

in neighborhood (YRSLIVING) to have significant positive effect on WtP (Casey et al., 2006). The results of the study found it to be inline with the literature and WtP increased from 51% (YRSLIVING < 5) to 59% (YRSLIVING > 5). The reason for increasing WtP could be that over period of years people in Guwahati have witnessed iron effects such as staining of clothes and utensils (Chakrabarty & Sarma, 2011). Such prolonged suffering from the problem is supposed to be the reason for enhanced public WtP for iron free water. House ownership is considered to have influence on public WtP in the present study, the house owners are expected to show higher WtP than the rented households (Pattanayak et al., 2006). It can be seen from Table 7.3 that house owners showed higher WtP (64%) than that of rented households (51%). The reason could be that owners see procuring water as permanent solution and are eligible for the supply water connection, subject to fulfilling necessary documents. Whereas, the rented households may see this as additional burden to arrange necessary documents for connection and may explore alternative solution rather getting supply water connection.

Education level of the respondent was considered as an influencing parameter on public WtP. It was considered that public knowledge and concern towards contaminated water would be higher with higher level of education. It is being reported in literature that highly educated individuals are more concerned towards contaminated water and see this as greater motive of solving the community problem (Bilgic, 2010). More educated individuals tend to be more aware about the necessity of solving the quality problem and have higher willingness to support improved facilities (Bilgic, 2010; Wahid & Hooi, 2014). However, in the present study the results obtained were mixed. The WtP shown by illiterate public was lower (40%) and comparable to 10th (45%), 12th (43%) and postgraduates level of education (49%). Whereas, the people with graduate and doctorate level of education showed the highest WtP (78%). The household income is one of the most important factors influencing WtP (Moffat et al., 2011). The public willingness to spend money on procuring water was apparently dissimilar depending upon their income. The expected trend of WtP was that it increases with increase in household income (Moffat et al., 2011; Parveen et al., 2016). However, in the present study only 31.38% households disclosed their monthly income during survey. Table 7.3 shows that WtP enhances with the increase in income, however the low-income public (< Rs 5000) also showed significant WtP (54%). The WtP increased from 44 to 76% when income of household increased from Rs 5000 per month to more than Rs 15000 per month. The results were in line with those reported in literature that states that WtP increases

with income (Moffat et al., 2011; Parveen et al., 2016) and high income group (HIG) people show more WtP for treated and reliable water supply (Moffat et al., 2011).

7.3.3 Effect of Demographic Factors on WtP After Groundwater Quality Awareness Program

The effect of groundwater quality awareness programs on enhancement of public WtP on the basis of the demographic profile of the respondents was investigated and results are presented in Table 7.3. It can be seen that substantial enhancement in WtP after awareness programs could be observed with the public WtP increasing by 12-15%. In case of HSIZE, the enhancement in public WtP was higher i.e. up to 20%, irrespective of HSIZE the WtP increased for all. The results of the present study were consistent with the findings of public WtP survey carried out for safe and reliable drinking water in Leon, Nicaragua (Vásquez & Franceschi, 2013). WtP could also be observed to increase when examined with respect to other demographic factors such as YRSLIVING, OWN, INCOME and EDU. This highlights that the awareness programs enhances public WtP for all. The public WtP in first round of survey i.e. before awareness was lesser for rented households (51%) when compared to owners (64%). However, after the awareness programs, the owners as well as rented households WtP improved to approximately 74%. Similarly, the WtP also enhanced with income. It was found that WtP has increased by more than 10% after awareness programs. However, enhancement in WtP for households with income < 5000 was only 5%. With respect to educational qualification of the respondent, the WtP has improved for all categories of respondents, including even the illiterate people. The highest enhancement was observed to be 28% in case of people educated up to 12th class, with overall enhancement of 16%.

7.3.4 Effect of Groundwater Quality Awareness Program on WtP

WtP of the respondents after making them aware about the groundwater quality has been studied vis-à-vis the respondents' different sources of groundwater, access to quality water, water availability, extent of contamination, quality check, and domestic treatment options. The sources of groundwater in the study area were found to be dug-wells, tube-wells and hand pumps. It can be observed from Table 7.4 that public WtP has improved for all three sources of groundwater dependent population. The WtP for tube well users were the highest (82%) and lowest for dug well (60%). The possible reason could be the order of groundwater contamination for the sources. Tube-

Table 7.4: Public WtP before and after awareness programs based on groundwater source awareness

Groundwater source awareness		WtP (%)	
		Before knowing groundwater quality	After knowing groundwater quality
SOURCE	Dug well	58.28	59.98
	Hand pump	62.97	71.32
	Tube well	50.41	82.60
DSRWTR	Have desired quality water	56.91	72.92
	Do not have desired quality water	64.00	84.00
SUFF	Have sufficient water	58.80	71.33
	Do not have sufficient water	56.01	77.42
VENDOR	Purchase vendor water	62.34	74.92
	Do not purchase vendor water	49.39	72.35
CONTAMIN	Have contaminated water	57.69	73.08
	Do not have contaminated water	57.59	74.01
CHECKQUA	Have checked groundwater	48.15	70.37
	Have not checked groundwater	57.75	74.04
DOMES	Treat water before domestic choir	51.92	73.14
	Do not treat water before domestic choir	59.82	74.31
DRINKING	Treat water before drinking	53.09	72.91
	Do not treat water before drinking	60.02	74.56
COOKING	Treat water before cooking	51.33	73.45
	Do not treat water before cooking	60.13	74.19
FILTER	Water purifier	50.52	87.63
	Candle filter	48.15	77.10
	Sand filter	32.26	40.32
	Boil	57.89	63.16
	Direct	62.21	74.02

well being the highest contaminated source, it showed highest increase in WtP, whereas, dug well is reported to be least contaminated and showed least increase in WtP. Similar results for enhanced WtP after awareness on water quality was reported from Cameroon (Fotuè, 2013).

With respect to the access to desired water quality, the public WtP improved for all categories of respondents i.e. people with and without access to desired water quality. Access to

desired quality of water can influence public WtP i.e. if public have access to desired water quality then the WtP will be lesser and vice versa (Majumdar & Gupta, 2009). In the present study also, the WtP enhancement was 16 and 20% for people with and without access to desired water quality. The desired water quality here refers to that recommended by WHO for drinking purpose.

With regard to water sufficiency, the public WtP enhanced by 12 and 21% for people with and without sufficient water availability. The reason for higher WtP by people having insufficient water could be that people face scarcity of water during dry season when groundwater table goes down (Biswas & Venkatachalam, 2015). A study carried out in Chennai City (India) revealed that poor people incur a sizeable expenditure in purchasing water from vendor and were willing to procure even at higher tariff for piped water supplies (Venkatachalam, 2015). WtP of such people in the present study was 62% before awareness program which increased to 75% afterwards. These results were similar to a study carried out in Nigeria, where public showed 88% WtP and chosen treated water supply over vendor supplied water (Ahmad, 2017).

Public perception on groundwater contamination was considered as a decisive factor for public WtP. A study reported that if an individual feels his/her source water is contaminated, the WtP will be dramatically higher (Vo & Huynh, 2017). In the present study, public WtP enhanced for everyone by 15%, irrespective of groundwater contamination. Knowledge of groundwater contamination depends upon whether quality testing of groundwater is carried out or not. The public WtP based on this factor was compared before and after awareness program and found that irrespective of whether people have checked groundwater quality or not the WtP increased for everyone. The reason for this could be that several researchers have reported groundwater contamination in Guwahati and several newspapers have reported for the same (Chakrabarty & Sarma, 2011; Das et al., 2003; Hindustan Times, 2013; The Pioneer, 2017). The cases of contaminated groundwater are published in various newspapers and journals, hence public chose to treat their source groundwater either only for drinking or for drinking as well as cooking or for all purposes. It is evident from literature that households treating water either by filters or any other means have positive WtP (Majumdar & Gupta, 2009; Parveen et al., 2016). Different types of household water treatments techniques found in the study area were water purifiers, candle filters and sand filters. People using expensive water purification system were expected to have lesser WtP compared to ones using relatively a cheap filters (Parveen et al., 2016). It can be seen from

Table 7.4 that the enhancement in public WtP was highest (37%) for people using water purifiers which are expensive, whereas it was lowest i.e. 5% for people who adopt cheaper technique i.e. water boiling for disinfection only.

7.3.5 Effect of Health Hazards and Groundwater Aesthetics on WtP

In India, significant contamination of arsenic was traced in 1983 when a few villagers in West Bengal were diagnosed with arsenicosis. Till date, arsenic contaminated groundwater in India is reported from Bihar, Jharkhand, Chhattisgarh, Uttar Pradesh and Assam. Apart from arsenic, fluoride contamination is reported in 19 states of India including Assam. The major sufferers of these contamination being children under 14 years of age. The study explored the possibility of relation between arsenic contaminations and public WtP in terms of keratosis and/or hyperpigmentation. The effect of fluoride contamination on WtP was also measured through observations on teeth discoloration and dental cavities. The results of health effects on enhancement of public WtP are shown in Table 7.5. It can be observed that the WtP for people suffering from health effects like skin discoloration and superficial skin growth, yellowish color teeth or having teeth cavity among children have increased to a large extent after sharing information about their groundwater quality. The visible health effect may change the public minds, hence the highest enhancement in WtP was 44% observed for skin discoloration. Another reason for higher WtP could be that the cost of curing/treating visible health effects is higher, hence these two were found to be reasons for enhancement in WtP (Parveen et al., 2016).

The aesthetic appearance and/or physical characteristics of groundwater contaminations such as bitter or metallic taste, staining of clothes or utensils and increased growth of iron bacteria is supposed to encourage public to pay for treated water. Presence of iron bacteria in groundwater forms slimy gelatinous colonies that looks like oil suspended in water (Saha et al., 2014). The public in the study area were found to encounter these problems and this may pose as a strong determinant for changing perception of people to procure water (Haq et al., 2007). It was observed that public who experienced staining of the clothes and gelatinous formations in water showed more WtP compared to others. Therefore, the present study considered the effects of aesthetic problems (staining of clothes/utensils and taste) have a positive effect leading to enhancement of public WtP.

Table 7.5: Public WtP before and after awareness programs based on health hazards and aesthetic groundwater effects

Effect of groundwater usage		WtP (%)	
		Before knowing groundwater quality	After knowing groundwater quality
SKIN	Have skin discoloration	34.78	78.26
	Do not have skin discoloration	57.59	73.98
SKINPATCH	Have skin superficial growth	-	-
	Do not have skin superficial growth	57.59	73.98
YELWTEETH	Have yellowish color teeth	60.27	75.17
	Do not have yellowish color teeth	54.11	72.43
CAVITY	Have teeth cavities	66.22	74.32
	Do not have teeth cavities	57.16	73.96
STAIN	Produces stains in clothes and utensils	59.87	73.06
	Do not produces stains in clothes and utensils	54.50	75.23
TASTE	Have bitter taste	62.87	78.44
	Do not have bitter taste	56.96	73.45

7.3.6 Effect of Knowledge About Upcoming Water Supply Project on WtP

The public awareness on upcoming project i.e. AWARE is reported to be an influential factor on WtP and is expected that more the public is aware more will be WtP (Parveen et al., 2016). The public was tested for knowledge and awareness on upcoming scheme and asked whether their household location was within the service area of the scheme. This was considered as independent factor influencing WtP and assumed that greater awareness will lead to higher public WtP. The more people would know about the project and understand that their household is within the project domain i.e. WITHIN, the higher will be the WtP. The awareness on availability of alternative safe drinking water source is also necessary to enhance public WtP (Parveen et al., 2016). The results of the WtP survey on the basis of AWARE and WITHIN are presented in Table 7.6. In first round of survey, i.e. before the awareness program, the WtP was 58% and 52% for parameters aware and unaware (about upcoming scheme). After sharing the information, these figures increased to 74% and 60%, respectively. The improvement in WtP was higher (16%) for public possessing knowledge on upcoming project, whereas it was only 8% for people unaware about upcoming

project. Several studies have reported awareness as a significant parameter that impacts the household decision and demand for safe drinking water (Ahmad & Sattar, 2010; Parveen et al., 2016). Further, the WtP for public considering them within the service area was found to be increased by 19%, whereas it increased by only 8% for public considering their household do not fall within the service area. Similar kind of findings have also been reported from a study in Greece that WtP have improved in anticipation of better services after knowing that the household falls in service areas of the project (Filippidis, 2005).

Table 7.6: Public WtP before and after awareness on the basis of AWARE and WITHIN

Water supply scheme awareness		WtP (%)	
		Before knowing groundwater quality	After knowing groundwater quality
AWARE	Aware of upcoming water supply scheme	57.89%	73.93%
	Not aware of upcoming water supply scheme	52.10%	59.55%
WITHIN	Within water supply scheme jurisdiction	58.94%	77.52%
	Not within water supply scheme jurisdiction	52.10%	59.55%

7.3.7 Factors Influencing WtP by Logistic Regression Analysis

The possible factors that can influence public WtP were identified from literature (Table 7.1). The regression analysis considering these factors was performed to recognize influence of every individual factor. In this study one of the important factors i.e. INCOME was, however, disclosed by 493 households out of total 1568 household surveyed. Hence, the regression analysis was performed considering two cases. The first case (Case 1) considered all 1568 households and 23 independent variables (excluding income variable) and the second case (Case 1) considered 493 households who disclosed income and 24 independent variables (including income variable). In order to identify the influence/effect of the independent variables, the output of the analysis i.e. public WtP was considered as dependent variable in both the cases. The independent variable (PATCHSKIN) was omitted from the logistic regression analysis as a consequence of collinearity. Collinearity or multi-collinearity is when the independent variables are correlated to one another and do not provide a unique relationship with the dependent variable. As a consequence of

collinearity, the standard errors tend to be large and model estimates becomes inefficient, inaccurate and biased. Kennedy (2003) suggested that collinearity or multi-collinearity in a model can be detected by measuring variance inflation factor (VIF) and this was estimated using Eq. 7.3. VIF estimates the inflation in the variance of a regression coefficient due to collinearity or multi-collinearity. It was computed as follows

$$VIF = \frac{1}{1 - R_i^2} \tag{7.3}$$

where, R_i is the i^{th} R-squared value of 'x' obtained from regression of each independent variable, against every independent variable.

The results of the model fitting in present study are presented in Table 7.7. It can be observed that the model fitted well as per the expectations and hypothesis. The model fit parameters for Case 1 as well as case 2 are tabulated in Table 7.7. In Likelihood Ratio Test, chi-square provides the usual significance test for Likelihood Ratio. It is a difference between $-2\log_e L$ (L=likelihood) for the full model and $-2 \log_e L_0$ for the null model in which all the coefficients are set to 0, and measures the improvement in fit of regression brought by the independent variables. In our case, the high value for chi-square indicates that the WtP is less likely under the null hypothesis (without WtP influencing parameters) than the full regression model (where the parameters are included) (Ayalew & Yamagishi, 2005). The overall pseudo R^2 was observed to be 0.37 and 0.46. Although a high values of pseudo R^2 are desirable in ordinary least square (OLS), it does not represent the same in logistic regression (Tamuli & Dutta, 2015).

Table 7.7: Model fitting results

Particulars	Estimation	
	Case 1 (without income)	Case 2 (with income)
Log-likelihood of full model	-563.63	-155.39
Log-likelihood of null model	-898.89	-286.44
LR Chi^2	670.51	262.10
Over all pseudo R^2	0.37	0.46
Degrees of freedom	23	24
Total observation	1568	493

LR: Likehood ratio, Chi^2: Chi-square, Dependent variable: WtP, Variables significant at 95% confidence level

Further, for detection of collinearity or multi-collinearity VIF was estimated using Eq. 7.3 and presented in Table 7.8. The mean values of VIF are observed to be 1.74 and 1.78 for Case 1

and Case 2, respectively. The most commonly accepted level of VIF is 10 (Kennedy, 2003) and indicated as harmful collinearity if VIF is greater than 10 (Marquaridt, 1970). It can be observed from Table 7.8 that VIF for all factors was between 1.01 and 8.02. This indicates the absence of multi-collinearity problem in the model.

Table 7.8: Collinearity diagnostics for independent variables

Variable	Variance Inflation Factor	
	Case 1 (without income)	Case 2 (with income)
AGE	1.01	1.05
GENDER	1.01	1.01
HSIZE	1.03	1.07
YRSLIVING	1.06	1.07
OWN	1.14	1.18
EDU	1.12	1.27
SOURCE	1.07	1.10
IMPWATER	1.01	1.05
SUFF	1.03	1.05
VENDOR	1.20	1.22
CONTAMI	1.07	1.12
CHECK QUA	1.04	1.11
DOMES	5.63	6.07
DRINKING	1.88	2.23
COOKIN	8.02	7.91
TREAT	4.23	4.31
SKIN	1.07	1.14
PATCH SKIN	-	-
YELWTEETH	1.04	1.09
TEETHCAVITY	1.03	1.06
STAIN	1.05	1.09
TASTE	1.06	1.09
AWARE	1.05	1.08
WITHIN	1.13	1.23
INCOME	-	1.17
Mean VIF	1.74	1.78

Finally, the results of regression analysis in terms of predicted probability of WtP (probability value/p-value) and coefficient are presented for both the cases in Table 7.9. Logistic coefficients are the probability that an event will occur divided by the probability that it fails to do so (Ayalew & Yamagishi, 2005). They represent the odds of y = 1 when x increases by 1 unit. The coefficients are the power to the natural log(e). If a coefficient is positive, its transformed log value will be > 1, denoting that the event is more likely to occur and if a coefficient is negative, the

transformed log value would be < 1 and the odds of the event occurring decreases (Ayalew & Yamagishi, 2005). Whereas, *p*-values are the probability of occurrence of an event and use to decide whether to accept or reject the null hypothesis. In our case, the null hypothesis would be

Table 7.9 Overall logit estimates for the likelihood of WtP decision of the respondents

Independent variables	Case 1 (without income)		Case 2 (with income)	
	Coefficient	*p*-value	Coefficient	*p*-value
AGE	0.005	0.482	0.015	0.280
GENDER	0.136	0.582	-0.119	0.851
HSIZE	-0.009	0.852	-0.174	0.057
OWN	0.245	0.126	0.237	0.455
YRSLIVING	-0.013	0.129	-0.010	0.571
EDU	1.523	0.000	2.143	0.000
SOURCE	0.686	0.000	0.592	0.019
IMPWATER	-0.613	0.054	-0.327	0.550
SUFF	-0.316	0.045	-0.232	0.443
VENDOR	-0.245	0.154	-0.396	0.232
CONTAMI	-0.498	0.244	0.216	0.799
CHECK QUA	0.043	0.946	3.148	0.016
DOMES	-0.166	0.677	-0.232	0.752
DRINKING	-0.407	0.061	0.231	0.633
COOKIN	-0.480	0.318	-0.460	0.587
TREAT	0.286	0.012	0.092	0.674
SKIN	0.610	0.255	0.467	0.556
PATCH SKIN	-	-	-	-
YELWTEETH	0.140	0.366	-0.226	0.463
TEETHCAVITY	0.300	0.415	1.252	0.144
STAIN	0.199	0.202	-0.497	0.111
TASTE	1.446	0.000	1.878	0.000
AWARE	0.182	0.774	-0.858	0.494
WITHIN	2.363	0.000	4.158	0.000
INCOME	-	-	0.001	0.203
CONSTANT	-8.527	0.000	-11.193	0.000

'independent variables have no effect on WtP'. The *p*-value is appropriately considered as statistic interpretable across a range of values in contemporary experimental studies. In most of the studies, "statistical significance" is conventionally set at a *p*-value of < 0.05. This means that the null hypothesis is appropriately rejected if the probability is < 5% (Flechner & Tseng, 2011).

From Table 7.9, it can be observed that the significant factors in both cases (case 1 and 2) that influence WtP were EDU, SOURCE, TASTE and WITHIN. Education of respondent (EDU) was found to positively influence the public WtP. These findings were in line with our earlier

results obtained from cross table analysis (Table 7.3) and also with the other studies that reports information and understanding acquired while having higher level of education increases people interest and concerns about the drinking water quality (Bilgic, 2010; Wahid & Hooi, 2014). The source of groundwater (SOURCE) was also found to positively influence the public WtP as indicated by positive sign of the coefficient value for case 1 and 2, respectively in Table 7.9. Similarly, earlier results showed positive sign of the coefficients indicating positive influence of TASTE on public WtP, which is also fortified by logistic regression analysis. Lastly, when people came to know that their houses are within the service area (WITHIN) of the water supply scheme, their WtP increased in both the cases. Water sufficiency (SUFF) was found to be a negative significant factor when income was not considered ($p < 0.05$), whereas it was not significant considering income ($p > 0.05$). This result implies that people who disclosed their income were more concerned towards water quality and willing to procure water irrespective of groundwater sufficiency. The negative values obtained for coefficient implies that water sufficiency have a negative influence on WtP i.e. it decreases with increase in water sufficiency. However, as per the results of cross table analysis of WtP calculations from Table 7.4, public WtP was found to increase irrespective of water sufficiency after awareness. Case 1 also showed TREAT as a significant factor ($p < 0.05$) and positive values of coefficient indicated its positive influence on WtP. However, the factor CHECKQUA was found to be significant only in Case 2 indicating sensibility of the public who disclosed their income. CHECKQUA was found to be positively influencing public WtP. The results were in line with Casey et. al., (2006) who reported increased WtP for treated water and water supply services.

7.4 Conclusions

A questionnaire survey and door to door awareness amongst 1568 households was carried out that uncovered insightful factors affecting public WtP. Factors such as EDU, SOURCE, TASTE and WITHIN were found to be significant for the study area. Public awareness on groundwater quality and its adverse health effects were found to be one of the most influencing factors on public WtP and it improved from 58 to 74% after creating awareness. Sharing groundwater quality information and creating awareness about its potential health hazards had a significant on public WtP. Public WtP increased dramatically (35-78%) after information sharing on visible health hazards such as skin discoloration. Income was also found to be one of the most

influencing factors and comparison of WtP with and without income discovered common factors influencing WtP were EDU, SOURCE, TASTE and WITHIN. The public who had disclosed their income was found to be sensible and more concerned towards water quality and showed higher WtP even with greater water sufficiency (SUFF). The findings of public WtP through simple percentage form were fortified by logistic regression model which uncovered interesting trend of public hesitation and explicitly thrown light upon sensibility of people who disclosed their income during survey.

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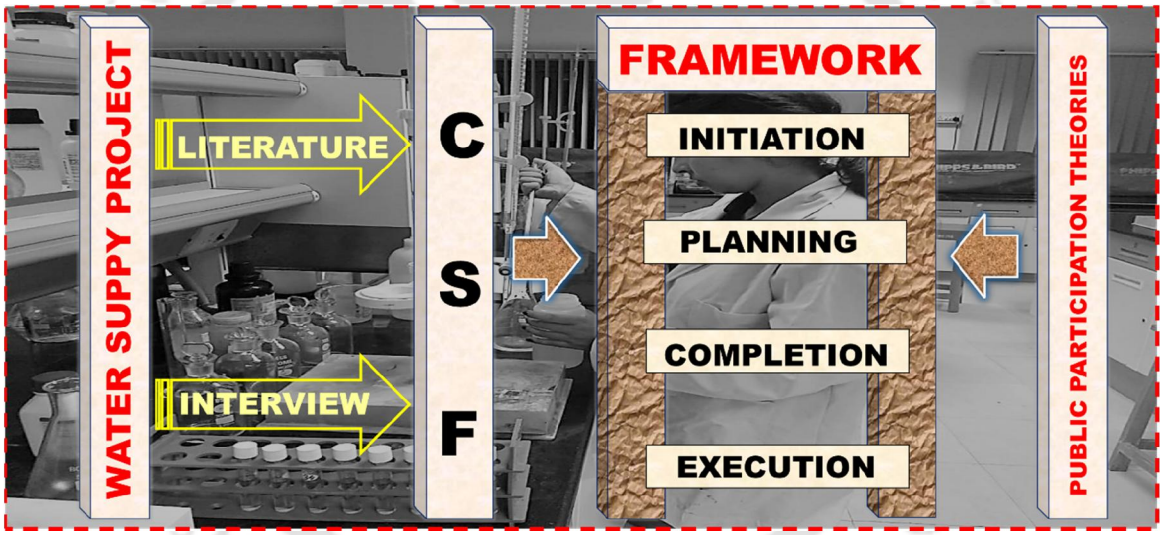
Chapter–8

Framework Development for Enhancing Public Participation in South-West Guwahati Water Supply Project



This chapter focuses on development of framework to enhance public participation in water supply project by considering various critical success factors, theories and principles of public participation.

8.1 Background

Rapid population growth owing to rural-urban migration and unplanned spatial expansion has led to a sharp increase in the demand and construction of urban infrastructure facilities and services. As a result, these have exceeded their serving capacity and proven to be insufficient to cope up with the growing demands (Ahmed et al., 2008). In addition, stringent environmental regulations, inadequacy of technical knowledge on project, differences in opinion and perception of risk among stakeholders (community and experts), and social conflicts aroused on grounds of dissimilarities in values, beliefs, and motivations are preventing convergence of infrastructure projects in stipulated time bound, delaying deliverables to society. The effects of these elements can be exemplified as irreversible damage to an infrastructure project through delays, protests, lawsuits. Furthermore, inadequacy of compelling steps addressing stakeholder opposition is likely to cause project relocation, indefinite postponement and even cancellation (Huang et al., 2015). In view of any infrastructure project, the stakeholders can be categorized as primary and secondary. The earlier includes owners/financiers/stockholders, customers, employees, suppliers and competitors, who have a direct interest (functional or financial) in the company. Whereas, later are the individuals, community and its advocates without any formal/official contractual relationship. The secondary stakeholders are neither formally involved in the economic activities of the project nor possess any legal authority over the organization (Cleland & Ireland, 2007; Crane & Ruebottom, 2011; Savage et al., 1991). The analysis of prevailing trends in construction projects reveals that the project managers see secondary stakeholders having little power and therefore are underestimated or neglected in commonplace (Newcombe, 2003). The changes in the governmental policies adopting delegation and decentralization in service sector and increased non-governmental organizations have rightly pointed the need for inclusion of public as an important stakeholder in regulating decision-making process (Jami & Walsh, 2014).

Studies from various parts of the world suggested the need to accord more attention to the secondary stakeholders as they pose potential menace for disruption to an infrastructure project development through unseen power and influential links (Di Maddaloni & Davis, 2017; Olander & Landin, 2008). Secondary stakeholder (public) opposition due to various factor/concerns and/or considerations has been one of the leading reasons for failure of infrastructure projects (Belout &

Gauvreau, 2004). The bitter experiences from past as an obstacle for an infrastructure project may help in planning and achieving success for water supply projects to accomplish vision of water for everyone. However, an incomplete understanding of the project among public, wrong interpretations about risk by individuals and experts, and political motives in some cases has jointly made water supply infrastructure projects as no exception for such public protests. The evidences of failure of water supply projects as a result of such massive public opposition are copious (Davis, 2005; McKenzie et al., 2003; Nickson & Vargas, 2002).

8.2 Methodology

The fourth objective of the research i.e. framework development is descriptive in nature, hence, the study used qualitative research approach. Primary and secondary data were collected and used as the source for research inquiry. The steps involved in this research inquiry to answer the research question of '*how to enhance public participation in water supply project?*' are as follows

- In step 1, secondary data was collected from studies on public participation in water supply projects in various countries and analyzed to identify critical success factors (CSFs) for efficient public involvement, timely completion and increased public acceptance of projects.
- In step 2, South-West Guwahati water supply project was taken up as a study area and a semi-structured questionnaire was designed to generate primary data in conjunction with secondary data as supplement on public participation. Thematic analysis was employed to identify the CSFs from primary data influencing public participation in the project.
- In step 3, the framework was formulated in accordance with the identified CSFs from primary and secondary data and the review of various theories on public participation to achieve the objective 'how to integrate public participation in South-West Guwahati water supply project'.

8.2.1 Secondary Data Collection and Analysis: Step 1

The existing literatures on CSFs of public participation in water supply projects around the globe were gathered through in-depth literature review. The relevant studies were analyzed through keywords search using search engines of Google Scholar, EBSCO Discovery Service, INSPEC, JGate Plus (JCCC), MathSciNet, SciFinder Scholar, SCOPUS, and Web of Science. The

keywords used for the search included 'public opposition', 'public dispute', 'public conflict', 'residence opposition', 'community resistance', 'critical success factor', and 'acceptance' concerning to water supply projects.

8.2.2 Primary Data Collection in the Study Area: Step 2

Primary data is the data collected directly from the source. It is of great importance in a study as it gives most helpful insights and every minute detail about the particular case of study (Arksey & Knight, 1999). The potential source of primary data used in our study is the expert interviews. For collecting interview data, it is required to plan the design of interview and carry out a pilot study followed by determination of sample size and selection of panel of experts.

8.2.2.1 Design of Interview

The semi-structured interview questionnaire was divided into two parts (Part A and Part B). The Part A included informative questions to interviewees (expert) such as demographic data, background and area of expertise (Appendix, Table A.4). The Part B of the questionnaire contained 11 semi-structured questions on public participation and groundwater (Appendix, Table A.5). These 11 questions were so designed that they included all (9 numbers) CSF identified from secondary data and also touch various aspects of public participation in the present study area.

8.2.2.2 Pilot Study

A pilot study was carried out to test the comprehensiveness of the interview protocol that has been developed to study public participation, existing regulation and the actual practices of the public participation adopted in South-West Guwahati water supply project. Specifically, the interview protocol aims to uncover common/analogous CSFs of present case and those from secondary data and ascertain additional obstacles, if any. Two local experts were selected based on their level of education and experience in the field of water supply and groundwater. The interviews lasted for about 25-35 minutes and were conducted in March 2018. Table 8.1 represents the demographic details of experts of the pilot study. The prime purpose of this pilot study was to assess the clarity of language, appropriateness and logic of questions, layout, degree of depth, ease of navigation, and user-friendliness of the whole template questionnaire. The suggestions from

pilot study were incorporated in the final interview template (Part B) that has been used for final interviews (main study) with 16 experts (Table 8.2).

Table 8.1: Demographic information of pilot study interviewees/experts

Expert code	PR1	PR2
Gender	Female	Male
Designation	Professor & Scientist 'G'	Site Engineer
Educational qualification	Post graduate degree	Graduate
Working Sector	Public sector	Private sector
Background	Environmental	Environmental
Years of Experience	18	11
Experience in project type	Groundwater, water supply	Urban water supply

Table 8.2: Final questionnaire for the expert interview

PART A		
1. Professional information		
a. Name:-		
b. Gender:-		
c. Age:-		
d. Organization:-		
e. Designation:-		
f. Years of professional experience:-		
g. Contact No.:-		
h. Email:-		
2. Educational qualification (please tick any that apply)		
☐ Undergraduate degree	☐ Postgraduate degree	☐ Postgraduate diploma
☐ Doctorate	☐ Other (please specify):	
3. Professional working sector (please tick any that apply)		
☐ Public Sector	☐ Private sector	☐ Financial Institution
☐ Transaction Advisor	☐ NGO	☐ Researcher in Academics
4. Professional background with specialization in projects (please tick any that apply)		
☐ Civil Engineering	☐ Economics	☐ Management
☐ Environmental	☐ Finance	☐ Social Science
☐ Other (please specify):		

5. Experience in types of projects (you may select more than one box)

☐ Groundwater ☐ Solid waste management ☐ Wastewater

☐ Water Supply ☐ Other (please specify):

PART B	
Sl.	**Questionnaire for expert opinion**
1.	Can you tell about legislations/laws related to public participation in water supply projects? How are they followed in real context?
2.	To what extent do South-West Guwahati water supply project address public participation?
3.	What happens with the data, after being collected from engaging the public? How is the data analyzed and processed?
4.	What are the obstacles for public participation in South-West Guwahati water supply project?
5.	How aware the public are in South-West Guwahati about the current household groundwater quality?
6.	What are the initiatives taken in South-West Guwahati to educate people on groundwater quality and its health hazards?
7.	Please indicate how important the following theoretical critical success factors (CSFs) are w.r.t South-West Guwahati water supply project

Sl.	CSFs	Not important → Neutral → Very important				
		1	2	3	4	5
1	Transparency	○	○	○	○	○
2	Communication	○	○	○	○	○
3	Timeliness	○	○	○	○	○
4	Information on project	○	○	○	○	○
5	Public involvement	○	○	○	○	○
6	Regulatory governance	○	○	○	○	○
7	Public influence	○	○	○	○	○
8	Tariff uncertainty	○	○	○	○	○
9	Privatization	○	○	○	○	○

8.2.2.3 Determination of Sample Size and Basis of Expert Selection

Determination of sample size i.e. minimum number of experts for a study is determined statistically. However, there is no hard and fast statistical rule in fixing sample size for getting expert opinion in qualitative research unlike qualitative research. Thus, it may vary depending on numerous factors not limiting to geography of area, pattern of living, and socioeconomic status of population. However, guiding principle in qualitative research describes sample size as per the concept of saturation (Mason, 2010). Saturation is considered to be reached when certain number

of experts are interviewed and no themes/points emergences thereafter (Francis et al., 2010). Maximum number of experts can thus be adopted up to the saturation limits. Dworkin (2012) emphasized on having a minimum number of 5 and maximum 50 experts for a study, whereas Guest (2006) in his study reached the saturation point with 12 interviewees (Dworkin, 2012; Guest et al., 2006). Bertaux's (1981) guideline on sample size consider 15 as the smallest number of participants for a qualitative study irrespective of the methodology with a homogeneous group (Bertaux, 1981). In the present study, saturation point was reached around the 10th interview but further interviews were carried out till the interview with the 16th expert. Selection of experts were based on criteria such as knowledge, educational qualification, position in the organizational hierarchy of the firm, and number of years of experience in water supply and groundwater quality (Hallowell & Gambatese, 2009). Experts in above sectors are hard to find, and often reluctant to discuss their unsuccessful ventures. Hence, the experts for interview represented a significant challenge, so a combination of referral and chain (or 'snowball') sampling was employed to select the experts. Thereafter, experts and policymakers (decision-holders) of government and private organizations in Guwahati city were reached through proper channel in order to incorporate their views in the development of the framework. The list of the selected experts, respective office/company/institution, designation, and the type/date of the interview is given in Table 8.3.

8.2.3 Thematic Analysis of Primary Data

The thematic analysis was carried out as suggested by Burnard (1991) and Braun and Clarke (2006). The primary data of interviews were transcribed, organized and coded using NVivo 11 software. The analysis began with highlighting important points with the aim at identifying principal themes by capturing important quotes and efforts were made to represent or extract some level of patterned response or meaning within the data set (Braun & Clarke, 2006). The typical analysis procedure was followed, which involved 6-phase guide (Table 8.4) viz. familiarization with the data, generation of initial codes, searching of themes, reviewing of themes, definition and naming of themes, and producing the report. The description of process of each phase is tabulated in Table 8.4 and its application or relevance in the present study explained below.

8.2.3.1 First Phases

Familiarizing with data was achieved by multiple readings of the interview transcripts as

Table 8.3: Experts for semi-structured interview

Sl.	Code	Office/company/institution	Position held
1	R01	Guwahati Jal Board	Managing Director
2	R02	NJS Consultant Ltd., Guwahati	Senior Consultation Manager
3	R03	Central Groundwater Board, Guwahati	Scientist B
4	R04	NJS Consultant Ltd., Guwahati	Site Engineer
5	R05	JICA water supply project, Guwahati	Deputy Project Manager
6	R06	Public Health Engineering, Guwahati	Assistant Executive Engineer
7	R07	Assam Engineering College, Guwahati	Associate Professor
8	R08	Assam Engineering College, Guwahati	Associate Professor
9	R09	Assam Engineering College, Guwahati	Associate Professor
10	R10	Tahal Group, Guwahati	Manager (Civil)
11	R11	Public Health Engineering, Guwahati	Water Quality Consultant
12	R12	Guwahati Institute of Science and Technology, Guwahati	Assistant Professor
13	R13	NJS Consultant Ltd., Guwahati	Site Engineer
14	R14	Public Health Engineering, Guwahati	Additional Chief Engineer
15	R15	Gammon India Ltd., Guwahati	Site Engineer
16	R16	NJS Consultant Ltd., Guwahati	Site Engineer

NJS - Nippon Jogesuido Sekkei Engineers India Pvt Ltd, JICA - Japan International Cooperation Agency

well as carefully listening to audio recordings of the original interviews. Listening to the original audios had a dual benefits, as it provided additional check on the text noted down during interviews and secondly, repeated listening to the audios revealed various probabilities and different aspects of the interview conversation according to the gestures and interactions of the interviewees. The primary recorded data was transcribed and imported into Nvivo 11 software, a Computer Assisted Qualitative Data Analysis Software (CAQDAS). It helped to present an accurate and transparent picture of collected qualitative data along with an audit of the data analysis process (Welsh, 2002). The primary data transcripts were scrutinized, read through, and interesting segments were

Table 8.4: Phases of thematic analysis (Burnard, 1991)

Phase	Description of the process
1. Familiarizing with the data	Transcribing data (if necessary), reading and re-reading the data, noting down initial ideas.
2. Generating initial codes	Coding interesting features of the data in a systematic fashion across the entire data set, collating data relevant to each code.
3. Searching for themes	Collating codes into potential themes, gathering all data relevant to each potential theme
4. Reviewing themes	Checking if the themes work in relation to the coded extracts and the entire data set, generating a thematic 'map' of the analysis.
5. Defining and naming themes	Ongoing analysis to refine the specifics of each theme, and the overall story the analysis tells, generating clear definitions and names for each theme.
6. Producing the report	This final phase involves weaving together the analytic narrative and data extracts, and contextualizing the analysis in relation to existing literature.

highlighted and noted.

8.2.3.2 Second and Third Phases

In the second phase, the data items were again reviewed to generate initial codes with interesting features across the entire data set, collating relevant data to each code. In the third phase, codes were given/taken under various potential themes, gathering all data relevant to each potential theme (Srnka & Koeszegi, 2007). This phase was executed through repeated review of the interview transcripts and listening to the audio again. The opinions of the interviewees were assigned to a particular theme and the work focused on coding important and interesting segments of the interview data. To do so, thorough efforts were put to code the interview data into a thematic view. A new file in Nvivo was prepared manually listing out the codes from each of the interview, considering comments and quotations from the original transcription.

8.2.3.3 Fourth and Fifth Phases

This fourth phase commenced with an iterative process of changing, eliminating, adding and re-categorizing the data set to capture the essence of the phenomenon under investigation to prepare the pre-final list of codes. It was then reviewed and a final list of thematic codes or

principal themes was evolved as shown in thematic map (Figure 8.1). Further, the list of codes from all interviewee was merged into single theme to study patterns amongst them. For example, the master document brought in the discussions and comments related to the same issue under one roof, which allowed effortless comparison and discussion of commoners and differentiators in regard of subjects. Furthermore, this also revealed the unique categories raised by an interviewer. This process went on even as findings from the interview data corpus were documented until a perfect fit for all themes and codes was ascertained (Braun & Clarke, 2006). The framing of themes is attainment of a range, where we get a more of general idea from a particular one and can reach an abstract view from a real data sources (Strauss & Corbin, 1998). In the fifth phase, the themes were further defined and refined for the analysis. These themes are then systematically interrelated leading toward the development of a theory or a framework or a report (Saldaña, 2015).

8.2.3.4 Sixth Phase

The sixth phase began with the set of fully worked-out themes, and involved the final analysis. The final task of thematic analysis was achieved by writing-up of report with the data in a way to convince the reader of the analysis (Braun & Clarke, 2006).

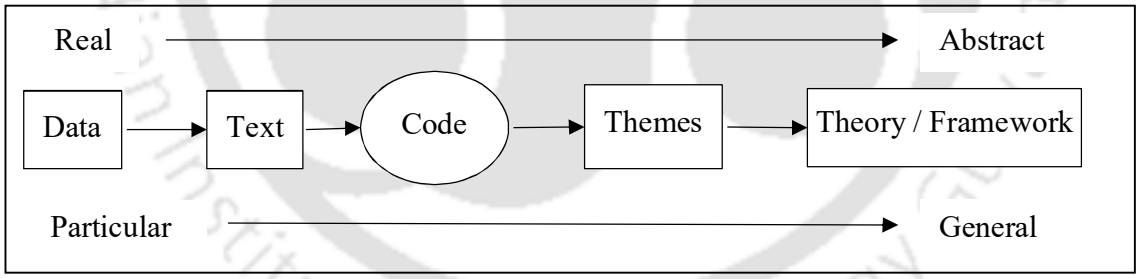


Figure 8.1: Development of framework from data.

8.2.4 Public Participation Theories/Principles for Framework Development: Step 3

Arnstein's ladder of participation is one of the most established and commonly used typologies pertinent to examining participation and power of public in decision-making processes (Rowe & Frewer, 2005). The ladder comprised of eight participation steps (as shown in Table 8.5) with three levels of public empowerment viz. non-participation, tokenism, and citizen power. In non-participation level, the manipulation and therapy are implemented; in case of failure, tokenism

is implemented through informing, consultation, and placation. However, the step provides no assurance that their opinions and views will be considered in policymaking. The next level would be citizen power, which is the most powerful and ensures that the public views will be considered.

Table 8.5: Ladder of public participation (Arnstein, 1969)

Sl.	Public participation	Description	Public empowerment
8	Citizen control	It is the most powerful principle that credits absolute control to public	Citizen power
7	Delegated power	Offers power of accountability to public and can bargain with authorities for their demands	
6	Partnership	Public is treated as partners in project and the responsibilities of planning and decision-making are shared through joint policy boards, planning committees	
5	Placation	The regulatory authorities are not answerable to the public and have the power of decision making	Tokenism
4	Consultation	Conducted through attitude surveys, neighborhood meetings, and public hearings	
3	Informing	The information of project is passed from officials to public without system of feedback or negotiation	
2	Therapy	It is a trick to involve public in planning the project to change their mindset rather than victimizing their disagreement	Non-participation
1	Manipulation	Including public on advisory body to enhance their technical knowledge on the project	

In response to Arnstein's ladder, Connor (1988) proposed a new systematic and universally applicable ladder comprising of 7 stages (Figure 8.2). The stepwise application, next stage in case of failure of earlier was practiced likewise in Arnstein's (1969) ladder. This ladder gave higher flexibility for public with increased possibility of dispute solution within two stages, as information-feedback is proposed to be conducted in presence of leaders (Connor, 1988). Connor's ladder used mediation and litigation to resolve dispute following cumulative sequence. However, bringing of mediation or litigation in dispute will not be helpful in enhancing the level of participation. Hence, in the need of an inclusive spectrum that will be inclusive of merits of both ladders, the International Association for Public Participation (IAP2) developed a multilevel public participation spectrum in decision-making (Table 8.6). This spectrum comprises of five types of

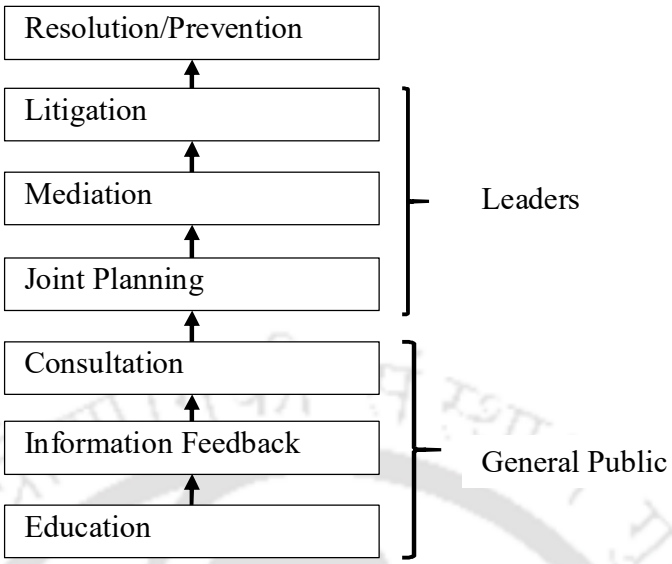


Figure 8.2: Ladder of public participation (Connor, 1988).

participatory relationships viz. informing, consulting, involving, collaborating and empowering (Head, 2011). The spectrum focuses mainly on public engagement in decisions made by government agencies, particularly situations where the government retains final authority but may inform, consult, involve, collaborate or empower with others in the process of making decisions. It thus can be partially applied in water sector. The public participation spectrum begins with the simple provision of information and considers public views in levels of consulting and involvement. At the end of the spectrum, collaborate and empower require a higher level of co-operation, shared goals, and joint decision-making. These three theories are partially merged to prepare a recommended framework. In addition to theories, efforts were made to incorporate CSFs identified from primary and secondary data into framework. The CSFs (either one or more) are addressed or included in one of the stages of public participation viz. inform, educate, consult, involve and collaborate. For example, first stage i.e. informs addresses 'information on project', 'tariff structure', 'incentives', 'privatization' and 'transparency'. When the public will be informed well about the project the problems, disputes, or fear will be reduced or eliminated from public minds. Similarly, other CSFs are also embedded in relevant stages of public participation.

Table 8.6: IAP2 Levels of public participation and empowerment (Connor, 1988; Head, 2011; IAP2, 2014)

Participation achievement	Participation stage	Description
Goal	Inform	Provide the public with balance and objective information to assist them in understanding the problems, alternatives and/or solutions
	Consult	Obtain public feedback on analysis, alternatives and/or solutions
	Involve	Work directly with the public throughout the process to ensure that public issues and concerns are consistently understood and considered
	Collaborate	Partner with the public in each aspect of the decision including the development of alternatives and the identification of the preferred solution
	Empower	Place final decision-making in the hands of the public
Promise to the public	Inform	We will keep you informed
	Consult	We will keep you informed, listen to and acknowledge concerns and provide feedback on how public input influenced the decision
	Involve	We will work with you to ensure that your issues and concerns are directly reflected in the alternatives developed and provide feedback on how public input influenced the decision
	Collaborate	We will look to you for direct advice and innovation in formulating solutions and incorporate your advice and recommendations into the decision to the maximum extent possible
	Empower	We will implement what you decide
Example Tools	Inform	Fact sheets, Web sites, Open houses
	Consult	Public comment, Focus groups, Surveys, Public hearings
	Involve	Workshops, Deliberative polling
	Collaborate	Citizen Advisory Committees, Consensus building, Participatory decision-making
	Empower	Citizen juries, Ballots, Delegated decisions

8.3 Results and Discussion

8.3.1 CSFs for Public Participation: Analysis of Secondary Data

Collection of secondary data aimed at identifying CSFs of public participation for greater success of water supply projects. The analysis of secondary data identified transparency,

communication, public involvement, effective public participation, contract design, certainty of water pricing and tariff review as significant CSFs for successful implementation of water supply projects. The study also revealed that public participation in such projects can be enhanced through multiparty planning, mediation, and negotiation with the public (Chen & Wikstrom, 2010). In many projects, dissatisfaction and public conflict/resistance takes place due to ineffective public participation/involvement and fear of increase in tariff due to private-sector involvement (Ameyaw & Chan, 2015; Easter & Hearne, 1995). Other reasons for failure of the projects include weak regulatory and monitoring regime, tariff uncertainty and delayed or non-payment of bills (Ameyaw & Chan, 2015). Review of many failed projects have indicated that many projects faced local opposition in its initial stages and later, based on input from the public, the authority made commitments to redesign the project. Such step helps in changing the public perception and effective public engagement and embodiment of public views/suggestions in decision making upsurges public acceptance and success of the project (Garfi & Ferrer, 2011). Whereas, public involvement in decision making was found to be dependent on household satisfaction and acceptance of the project (Prokopy, 2005). Organizing public gathering/hearing for name sake will, however, not enhance public participation but necessary institutional arrangements for participation will be required to ensure effective public participation (Watson & Jagannathan, 1995). It was also noticed that acceptance of project can be improved by information disclosure, resident supervision and residents' participation in decision-making (Zhenhua, 2013). It has also been stated that reforms are being carried out in India on the basis of four cardinal principles viz. awareness generation, transparency, community participation, and social auditing (Naidu, 2002). However, the cases of failed water projects in India highlight that these principles are not being followed effectively. For example, water supply project in India (Latur, Aurangabad, Mysore) had faced massive public protest and was eventually terminated (World Bank, 2014). It has also been observed from review of water supply projects that 'public involvement' has been rated to one of the CSFs (Table 8.7). 'Public involvement' has been, in fact, coded by the highest number of sources (i.e., 12 times). Other factors include transparency, communication, timeliness, information on project, regulatory governance, public influence, tariff certainty, privatization. The descriptions of these factors are presented in Table 8.8. These nine CSFs were found to have an important bearing on public participation in most of the water supply projects, thereby indicating that these factors need to be considered to reduce public disapproval of water supply project.

Table 8.7: Critical success factor (CSF) for public participation in a water supply project

Sl.	Sources/Authors	CSF for public participation								
		1	2	3	4	5	6	7	8	9
1	Ameyaw & Chan (2015)	-	-	✓	-	-	✓	-	✓	-
2	Boudet et al. (2011)	✓	✓	-	-	✓	✓	-	✓	-
3	Brearley & Curry (2006)	✓	✓	-	-	✓	-	✓	-	-
4	Chen & Wikstrom (2010)	✓	-	-	-	-	-	-	-	
5	Ameyaw & Chan (2013)	-	-	-	-	-	✓	-	✓	✓
6	Easter & Hearne (1995)	-	-	-	-	✓	✓	-	✓	-
7	Garfi & Ferrer (2011)	-	-	-	✓	✓	-	-	-	-
8	Grigg (1997)	-	-	-	-	✓	-	✓	-	-
9	Watson & Jagannathan (1995)	-	-	-	-	✓	✓	-		-
10	World Bank (2014)	✓	✓	-	-	✓	✓	-	✓	-
11	Naidu (2002)	✓	✓	-	✓	-	-	-	-	-
12	Zhenhua (2013)	-	-	-	-	✓	-	✓	-	-
13	Prokopy (2005)	✓	-	-	-	✓	-	✓	-	-
14	Nisha (2006)	-	-	-	-	✓	-	-	-	-
15	Sara & Katz (2004)	-	-	-	-	✓	-	-	-	-
16	Narayan (1994)	-	-	-	-	✓	-	-	-	-
17	Singh (2007)	✓	-	-	-	-	-	-	-	-

Acronyms for CSFs: 1. Transparency 2. Communication 3. Timeliness 4. Information on project 5. Public involvement 6. Regulatory governance 7. Public influence 8. Tariff certainty 9. Privatization

8.3.2 South-West Guwahati Water Supply Project

This section presents the public participation process adopted in South-West Guwahati water supply scheme. Attempts were also made to identify the flaws in carrying out these processes. However, to have a better view on the public participation, experts in the field of water supply were interviewed. The results of experts' interviews and analysis are discussed in this section.

Table 8.8: CSF and its description

Sl.	Factors	Description of CSF for public participation
1	Transparency	Transparent decision-making process to build trust among participants
2	Communication	Communicate with participants about importance of participation and feedback in decision-making process
3	Timeliness	Realistic milestones and deadlines must be managed along with public involvement through the process
4	Information on project	Share all detail information about the project: advantage and disadvantages
5	Public involvement	Consist of a broadly representative sample of the population of the affected public
6	Regulatory governance	Clear and visible responsibilities and actions of governmental agencies in decision-making process
7	Public influence	Issues of concern of the public, and relevant to the decision at hand, must be taken into account in reaching a decision
8	Tariff certainty	Adequate disclosure of pricing (tariff) of water services prior to project implementation
9	Privatization	Private sector involvement in implementation of water supply project

8.3.2.1 Public Participation Attempts in Study Area

In the investigation on public participation process being followed in the study area it was observed that unlike in other private entity funded projects, public consultation was not carried out in the planning phase. However, Guwahati Jal Board (under Guwahati Metropolitan Drinking Water and Sewerage Board) has maintained a website that is accessible publicly and contains information on present water supply schemes in Guwahati. The website provides information about Jal Board formation, its functions, water regulatory and connection rules. The website also shares information on new water supply projects overview, and its contract documents. For public awareness, it provides information on their objectives, major activities to be carried out in the project, press releases on project update as well as awareness creating meetings, and GIS maps of project area (GJB, 2011). Apart from this, the Guwahati Jal Board had organized public meetings after the construction work was almost over at various locations throughout the city to make people aware of the project benefit. As per information provided by the Guwahati Jal Board authorities, the public meetings started with screening of documentary film based on the project, followed by presentation and an interaction session between the public and the project team members. In

addition to this, telephonic support center has been established for sharing more information to the public regarding the project and for their grievance redressal (The Assam Tribune, 2013a).

8.3.2.2 Flaws in Public Participation Process

Although efforts were made by Guwahati Jal Board for successful public participation in project by information sharing through websites, there were few unaddressed points such as disclosure of tariff, creating awareness on existing groundwater quality of region and information sharing on ownership of project (government or private). Although there is exponential enhancement in number of internet users in India (Grover et al., 2010), the use of internet surfing for visiting government information portals is rarely often (Ramani, 2015) as most the people lack access to computers or smart phones. While, the root cause of miscommunication between public and information shared was that the information was uploaded in the website but Indian public is not habituated to online medium for information sharing. This has been the main reason for miscommunication and has resulted in public dissatisfaction leading to protests. The resident blamed government of executing various schemes without informing public and taking their feedback. They believe that the schemes were implemented in the name of development of the city by keeping public in dark (The Assam Tribune, 2013b). The protestors believed that the cost of installing and operating water supply projects would be recovered in the form of water tax from the public, which was unacceptable. In fact, public was highly concerned about privatization of drinking water supply schemes that could lead to increase in tariff (The Assam Tribune, 2013b). The public quoted that instead of privatizing water supply, the authorities would do well to continue with the existing arrangements and improve the same. The public in their protest demanded of greater representation of citizens in the Jal Board by amending the law (The Assam Tribune, 2013b; The Telegraph, 2013). The whole exercise of Guwahati Jal Board finally did not serve the purpose it aimed at due to lack of any kind of guidelines from government over conduct of public participation in water supply projects.

8.3.3 Expert's Interviews: Analysis of Primary Data

The 16 experts, who had participated in the interviews, possess expertise in the field of water supply and groundwater projects especially in Guwahati. Their educational qualification and experience in the area of expertise is presented in Figure 8.3. It could be observed that most of the

interviewees possessed higher education degrees, precisely 94% of the interviewees have either graduation degree, postgraduate degree, or doctorate degree. In terms of experience, most of the experts have experiences of minimum five years, while 47% of the experts have experience of more than 16 years in the field of water supply. The list of 16 experts with its code, designation and details of serving organization is shown in Table 8.3. The experts were coded with a specific identity number for ease in referring in the text.

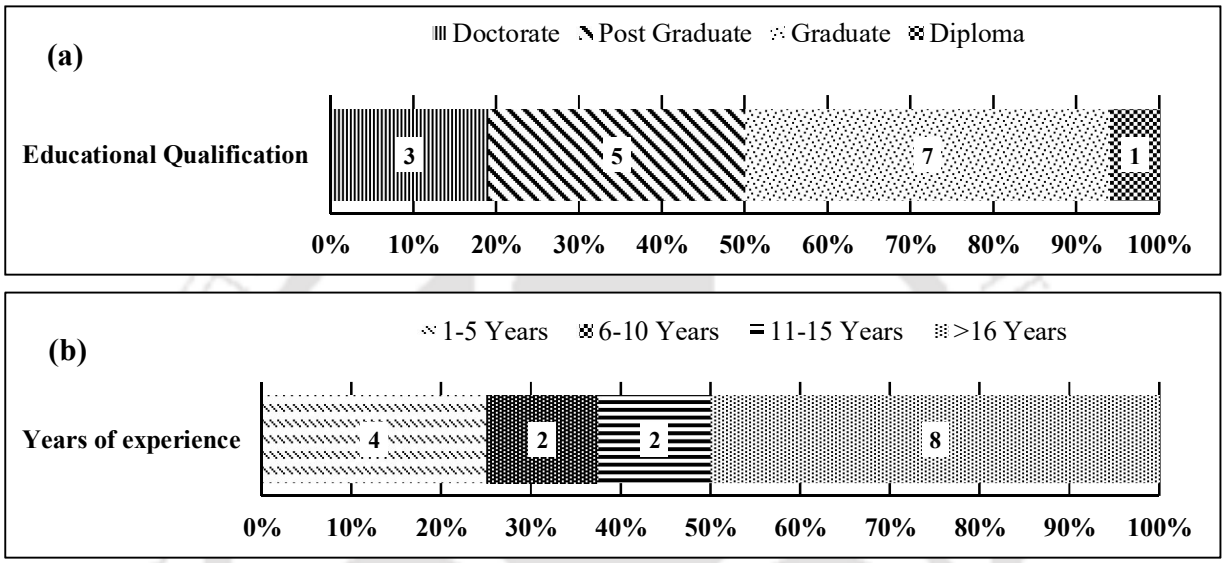


Figure 8.3: Demographic information of experts (a) Educational Qualification (b) Years of Experience.

The responses from the experts were coded through qualitative data analysis method of thematic analysis. The thematic analysis of interview data involved reading, coding and collation to produce findings on legislative laws related to public participation in water supply project, obstacles faced during participation and groundwater quality awareness/education. In this analysis, each interview transcript was analyzed following the steps described in Section 8.2.3 of this Chapter and the results are summarized in Table 8.9. The analysis evolved eleven thematic codes (themes). The themes identified from interviews were concurrent or closely matched with the CSFs identified from the secondary data. Out of these eleven themes, eight themes were found to be common with CSFs obtained from secondary data namely, communication, information on project, public involvement, public influence, privatization, regulatory governance, timeliness, transparency. Whereas, availability of water, awareness on household groundwater, and rewards/incentives were the additional themes obtained from the primary data (expert interview). There were multiple, individual and commonly occurring themes pointed out by one or more

interviewees and referred by various researchers (Table 8.9). Table 8.9 summarizes the theme along with frequency of occurrence. The frequency is the number of times particular theme is referred by an expert. The themes were further reviewed to evolve additional CSFs from primary data for the present study area. Each of the CSF is discussed in details for its relevance in case of South-West Guwahati project.

8.3.3.1 Availability of Water

According to R03, one of the many reasons for lack of participation in South-West Guwahati is abundance of groundwater. In many regions, public seldom face water shortage to opt for an alternate source of water. "*Most of the places in Guwahati, people do not face water shortage that's why I think at times they become reluctant towards water supply projects*" as referred by R03. "*Since water is available here people are not that serious, unlike other states where people protest for water*" as said by R15. However, R06 mentioned that in some areas of Guwahati people are concerned about water these days as the groundwater table is depleting. "*Another major problem in Guwahati is groundwater depletion. Increase in population density and higher extraction rate led to water table going down. Another thing is urbanization, land use pattern, where there is more pavement or concreting leading to less groundwater recharge*" as informed by R06. Similar views were being shared by R10 and R16 and it is in line with the views shared by Jansky & Uitto (2005) and Megdal et al. (2017). It was pointed out that engaging public in discussions on alternative approaches to address water scarcity is an important factor to improve water governance (Jansky & Uitto, 2005; Megdal et al., 2017). The expert's views on groundwater availability were dissimilar, few suggested high spatial variations in groundwater in study area. "*In South-West Guwahati as it has areas where water table remains high and sometimes in some areas it goes very deep*" as expressed by R05.

8.3.3.2 Awareness on Household Groundwater

R06, R12 and R15 believed that since groundwater is abundant in Guwahati, people are less worried about water quality, they lack the knowledge to do so. "*People are not at all aware like what water they are drinking either it is good or bad, whether it has arsenic, fluoride*" (R08). "*They are using water for their domestic purposes, so they are not concern or consider about the quality*" as disclosed by R12. Further, according to R12 in a study conducted in Guwahati, high

Table 8.9: Themes obtained from primary data analysis

Sl.	Theme	Description	Experts	Frequency
1	Availability of water	Water is available throughout the year so public are reluctant to participate	R03, R05, R06, R08, R10, R15, R16	10
2	Awareness on household groundwater	To make people aware on their household groundwater contamination and its health hazards	R01, R02, R03, R05, R06, R07, R08, R09, R10, R11, R12, R13, R14, R15, R16	42
3	Communication	Provides participants with the understanding about importance of participation and feedback in decision-making process	R03, R04, R05, R06, R07, R08, R09, R10, R13, R15, R16	35
4	Information on project	Share all detail information about the project: advantage and disadvantages	R01, R02, R03, R04, R05, R06, R07, R10, R11, R12, R13, R14, R15, R16	18
5	Public involvement	Consist of a broadly representative sample of the population of the affected public	R01, R02, R03, R04, R05, R06, R08, R09, R10, R11, R13, R14, R15	16
6	Rewards/Incentives	Public sometimes need incentives to participate	R03	1
7	Public influence	Issues of concern of the public, and relevant to the decision at hand, must be taken into account in reaching a decision	R01, R03, R04, R05, R09, R12	2
8	Privatization	Private sector involvement in implementation of water supply project	R07	1
9	Regulatory governance	Clear and visible responsibilities and actions of governmental agencies in decision-making process	R01, R03, R05, R06, R07, R08, R09, R10, R11, R12, R13, R14, R16	17
10	Timeliness	Realistic milestones and deadlines must be managed along with public involvement thought the process	R07	2
11	Transparency	Transparent decision-making process to build trust among participants	R04, R08, R09	9

levels of fluoride have been observed. "*These people are not aware about the high percentage or level of fluoride present in groundwater of their residency*" as indicated by R12. Besides these, R11 has experienced that most of the people are not aware of bacteriological contamination. R01, R02, R03, R10 and R13 felt that the people in the region were ignorant about the groundwater quality earlier but with time, they have become much more concerned. Similar observation was made by Li (2016). "*A common man is worried about two things in water, one is the water quality and the other is tariff*" as expressed by R01. The most important role for this transformation goes to the media (TV and radio) for broadcasting about groundwater contamination (Assadollahi, 2009; Kačaroğlu, 1999; Li, 2016). "*TV channels broadcast that how arsenic and fluoride are affecting people*" as said by R03. "*The Public Health Engineering Department (PHED) had recently circulated that that the groundwater contains high concentration of lead*" as expressed by R07. R03 and R05 have also observed people complaining about their groundwater contamination. "*I find people complain about occurrence of iron in their groundwater*" as informed by R03. People nowadays are however getting aware of the quality of water they are consuming. "*The public of South-West Guwahati area are well aware of their household groundwater quality as such so many households approach our state referral laboratory to get their drinking water sample tested*" as believed by R14. R07 and R03 believed that increasing concern about quality of household groundwater among public has led to the installation of water filters at home including candle filter and water purifiers. The expert's opinion on this theme ultimately means that as people can start using filters after becoming aware of groundwater quality they can also be made to participate in public meetings for such projects.

8.3.3.3 Regulatory Governance for Public Participation in Water Supply Projects

R01, R03 and R06 believed that government is now looking at public participation as an important aspect for success of a project. R03 referred that the government is planning to consider and implement public participation as a mandatory regulatory governance. However, "*at present public have to give representation through unions and welfare associations*" as quoted by R01. R03 further clarified that the government is working on to define laws and steps for public participation process but as of now it is not implemented. "*Legislation for public participation is not been implemented till now but it is in the process*" as pointed by R03. However, R07 and R11 confirmed that presently there is no regulatory governance for public participation in water supply

projects for smooth functioning. "*There is no such legislation to carry out public participation in water supply projects, so there is no follow up of it in real context*" as mentioned by R07. Moreover, experts like R08, R09, R12 and R13 were not aware of any laws or legislations related to public participation in water supply project. "*I don't know any laws related to public participation in water supply projects. So, they are not followed in real context but some NGOs or some individuals are working as a pressure group*" as specified by R09. Similar views have been shared by R16.

8.3.3.4 Inform Public About the Water Supply Project Benefits

R03 and R07 felt that the public lacks knowledge about the upcoming project's advantages or disadvantages. Similar observation in case of environmental decision making was also reported by Beierle (1999). "In general, *people in the area are unaware of the pros and cons of the project; so that they don't even know, how water would be supplied or whether to every household it would be supplied or to what quantity it will be supplied*" as told by R03. R01, R02, R10, R13, R14, R15 and R16 suggested institution of special social awareness wing 'Institutional Capacity Development Consultant (ICDC)' for creating meetings and making people aware on the project benefits. "*They use to go to each and every corner of the city and elaborate the things*" as made known by R04. Jal Board website is also used for uploading the updated events of the project according to R05. R12 also added that people were also made aware through print and electronic media. The same feeling was being shared by R07. R07 pointed out on the busy schedule of public, due to which they were unable to attend the meetings organized by the water supply project authority. "*Due to busy schedule, the face to face interaction between the concerned authority and the public is not working or happen*" as believed by R07. The last point made by R07 is analogous to one of the CSFs i.e. timeliness.

8.3.3.5 Public Involvement

Most importantly R03, R08 and R09 feels that public is not included in the decision-making process of the project. "*Public were not consulted at any stage. Government goes for some other agencies for the fund and after getting the fund they just started construction*" as stated by R08. R09 believed that there are some pressure groups who force the government to include public in a project. "*The project is not inviting the community to participate instead some very small group of*

people who are aware of the situation are trying to pressurize the government on involving the public" as informed by R09. R01 further stated that public is not involved but some representatives (either one or two) were invited from unions and welfare association in the meetings. "*The public is totally ignorant about the things like they do not know about the management part as how the government is going to do the water supply"* as averred by R03. Moreover, R03 highlighted the departmental failure to involve public in a project. R10 believed that lack of public involvement has resulted in public complains about the project. R10 and R13 highlighted that ICDC tried to educate people on the benefits of the project but were not 100% successful. R03 highlighted the fact that sometimes people show arrogance and ignorance to participate. The reason probably they do not know the importance of participation. *"Some people are very much ignorant about importance of public participation, even if they have been educated towards working in this field but they show kind of ignorance*" as told by R03.

8.3.3.6 Rewards/Incentives for Public to Participate

According to R03, one of the obstacles for public participation is lack of reward for public participation programs and allocation of incentives for public to participate. Research suggests that rewards/incentives can attract as well as motivate public to participate actively, despite their unwilling mindset earlier (Davis et al., 2009). Specifically, rewarding public enhances public attendance and involvement programs (Axelsson et al., 2010). Lowndes et al., (2001) also emphasized on providing appropriate incentives, for engaging public who would not ordinarily take part (Lowndes et al., 2001). The public is reluctant to participate in many instances due to lack of financial aids or incentives, without which they may show lesser interest in public meetings. "*Well there are definitely some obstacles in bringing the public into the scenario because sometimes there is lack of fund because the public do not want to involve themselves with no monetary benefit or on own expenses*" as expressed by R03. As can be observed that only one expert raised this point referring to theme Rewards/incentives.

8.3.3.7 Public Influence Opinion/Views on the Decision-Making Process

R03 shared the actual fate of public suggestion/opinion/views on a project. He stated that the feedback obtained from public were considered for decision making process. However, many a times, the feedback has to be ignored. "*Usually, only part of the feedback is taken into*

consideration because of unrealistic suggestions and demands from public" as observed by R03. R05 also shared the same view as R03.

8.3.3.8 Privatization

R07 noticed that the public fear privatization of a water supply scheme, which is in line with views presented by Mahalingam (2009). People in South-West Guwahati feared that the government would transfer the responsibility of construction and maintenance of the water supply projects to private entity. Therefore, this fear of privatization is one of the prime reasons for protest against the proposed water supply projects. "*After protesting against privatization of water supply project, the authorities of concerned department called on public to talk about the water supply project*" as explained by R07. The identified theme from interview data was analogous to the CSFs from secondary data.

8.3.3.9 Timeliness

Public participation was never a timely organized event in South-West Guwahati according to R07. She emphasized that lack of planning to incorporate and inform public led to disappointment against the current water supply project. However, public were informed about the project at a very late stage when the construction was almost over. She also pointed out the need for appropriate timing for organizing public meetings as many public could not attend due to their busy schedules at work (Ameyaw & Chan, 2013).

8.3.3.10 Communication

R07 believed that there was lack of communication between authority and public, right from the beginning of the project and public was not even aware of the project. R08 shared an incident about communication policy of water supply project authorities. They started reservoir construction at hilltop without informing people or government educational institutions at foothills. "*We were not able to understand from where all the mud, sand has come and they have not consulted or informed, our administration, as result our hosteller students suffered. All of a sudden there has been all mud and sand all over hostel premises and roads from hilltop. After that we came to know that there has been cutting of land at hilltop for the reservoir of the water supply project from which it came*" as informed by R08. The communication in terms of meeting took

place during the construction phase after public protest on privatization of water supply project. "*After protesting against privatization of water supply project, the authorities of the concerned department called on public meeting to talk about the water supply project*" as told by R07. According to R04, R05, R06, R10, R13, R15 and R16, meetings were held by ICDC wing of Jal Board to educate people about the project but that was insufficient. Moreover, according to R09, some of the social groups including retired engineer's forum, senior citizen's forum and certain NGOs pressurized government in organizing meetings. "*Government is not inviting these groups but these group are giving pressure on them. They are arranging meetings, invite the mayor and Jal Board authority. They are being asked question and are defending and these are all technical questions. So it is not gone to the common people*" as explained by R09.

8.3.3.11 Transparency

Transparency has been referred as an important theme by R07, R08 and R09. R07 considered that there had been lack of transparency in the South-West Guwahati water supply project. There was no information/document sharing and feedback taken from public regarding the project. Sharing information on project and considering public feedback in decision making would definitely increase transparency and build public trust on the project. Regarding transparency, R08 and R09 shared similar views. "*So many areas are being identified to have contaminations in Guwahati by academic institutions like IITG and AEC but the data is not gone to public*" as observed by R08. "*Things are not transparent. Awareness on water quality among the public is very poor*" as indicated by R09. Transparency of a project has been identified as a key factor that inhibits public support if not maintained. It implies adequate opportunities for the public and other stakeholders to make an input during the decision-making process (Henjewele et al., 2013).

8.3.4 Importance of CSFs from Secondary Data

The importance of 9 CSFs for water supply project in the study area was assessed and rated by different experts having expertise in the water and groundwater sectors using a five levels Likert scale of 1 to 5. Table 8.10 shows the rating of the CSFs by the experts. The mean values of the CSFs were calculated and accordingly the ranking was given to the CSFs based on mean values as shown in Table 8.11. From Table 8.11, the most important CSF in the study area was observed to be 'tariff certainty' with a highest mean score of 4.63, followed by 'transparency' and

'timeliness' with mean score of 4.25 and 3.94, respectively. A mean score above '3' represents an agreeable importance of that particular CSF (Cheung, 2009; Yeung, 2007). Therefore, as the mean value of all the CSFs were above 3, it represents significant importance in the study area.

8.3.5 Progression of Ideal Public Participation Process

Public participation processes are more likely to evolve good results when planned with legitimate timing. Public should be intimated about such event a priori so that they can plan accordingly. It is also important not to rush the process unnecessarily and the aim should be to get an effective outcome from the process (Dietz & Stern, 2008). It should be well-organized in a way that the stages and scope are clearly identified/defined. In addition, public centered timings should be adopted for each stage to enhance participation. This timing depends on the objective of the activity, the expected outcome of public participation, historical and political situation and the public participation results (Özerol & Newig, 2008). Public should be engaged in participation as early as possible at the problem defining stage. Early involvement ensures that public concern is settled/addressed and decisions after incorporation of public view will result in greater public acceptance (Özerol & Newig, 2008). If public participation is conducted lately or even after the decision is made, the opportunities to benefit from public insights, experience and knowledge are lost. This also hampers public involvement, public influence in decision making and ultimately acceptance of the decisions (Kasperson, 1986; Özerol & Newig, 2008). Local authorities can, thus, play a vital role in public participation but the absence of a regulatory governing framework and administrative procedures at local level poses a major obstacle in public participation (Tang et al., 2008).

The interactions and communications with public should be consistent and quality based in order to build their trust through level of quality delivered (Zeithaml et al., 1993). The participatory process should ensure that every person has equal opportunities to reach information supply and give feedback. Participatory processes should facilitate the incorporation of public values into decision-making process, even in case of contradiction with decision maker's values. This may be a fundamental weakness of participatory decision-making but should be undertaken for a greater cause of project acceptance. The most important could be maintaining transparency, tariff certainty and sharing information on the project. The process of inducing tariff, water quality awareness and

Table 8.10: Expert rating nine CSFs obtained from secondary data analysis

Experts code	Transparency	Communication	Timeliness	Information on project	Public involvement	Regulatory governance	Public influence	Tariff certainty	Privatization
R01	5	3	4	3	2	4	4	5	4
R02	4	3	4	4	2	3	3	5	4
R03	4	4	5	3	3	4	4	5	3
R04	5	4	4	3	2	3	3	4	4
R05	4	4	4	5	5	2	5	5	3
R06	5	5	4	5	3	4	4	5	4
R07	5	4	4	5	4	3	4	5	3
R08	5	3	3	3	3	3	3	5	3
R09	4	4	4	3	4	4	4	5	3
R10	4	4	5	3	2	2	4	5	3
R11	4	4	4	4	3	3	3	4	3
R12	4	3	3	3	4	3	4	4	4
R13	3	3	4	3	3	3	5	4	3
R14	4	5	3	4	4	4	3	5	3
R15	4	4	4	3	5	4	4	4	4
R16	4	3	4	4	4	3	5	4	3

Table 8.11: Results of the mean ranking for importance of CSF in water supply project

No.	CSFs	Mean	Rank
8	Tariff certainty	4.63	1
1	Transparency	4.25	2
3	Timeliness	3.94	3
7	Public influence	3.88	4
2	Communication	3.75	5
4	Information on project	3.63	6
5	Privatization	3.38	7
9	Public involvement	3.31	8
6	Regulatory governance	3.25	9

Note: Items were rated on a 5-point Likert scale (1=Not important; 3=Neutral / No Comment and 5=Highly important).

decision making needs to be transparent so that the public can see what is going on and how decisions are being made (i.e., it should not be held behind closed doors). By being transparent, it is likely that public suspicions about the funding agencies and their motives may be allayed. In maintaining transparency, minutes of meeting should be shared widely amongst public. If any secret information is withheld from the public, reasons of sensitivity or security should be well informed to, rather than risking the discovery of such secrecy, with subsequent adverse reactions (Rowe & Frewer, 2000).

8.3.6 Recommended Participatory Model for Water Supply Project

After reviewing CSFs for water supply projects worldwide, collecting primary data from experts in South-West Guwahati and studying theories of public participation, a conceptual framework is proposed as a guideline to improve public participation in water supply projects. As shown in Figure 8.4, the framework is formulated encircling the lifecycle of a water supply project.

The project life cycle represents the path a project that takes place from the beginning to its end (Cleland & Ireland, 2007). It is categorized into four phases of (i) initiation, (ii) planning, (iii) execution and (iv) completion (Burke, 2013). During the first phase i.e. initiation phase, the project objectives are identified with a feasibility study and a final proposal is recommended (Burke, 2013; Verzuh, 2015). In planning phase, steps are planned to meet the project's objective (Burke, 2013; Verzuh, 2015). During next phase of implementation, the project plan is put into motion and construction work of the project is carried out. Lastly, during the final phase (completion phase) the emphasis is laid on releasing the final deliverables to the concern authority which includes handing over project documentation and releasing the project (Cleland & Ireland, 2007). However, public participation in the framework is designed to take place at the planning phase of a water supply project. This allows the public to participate and contribute to bring about better planning solutions (Creighton, 2005). The public role in planning is vital in terms of securing project acceptance, well-functioning and efficient planning processes (Cullingworth, 1999). The public participation part of framework encircles spectrum [inspired by principles put forward by Connor (1988) and the IAP2 (2014)]. The presented framework is built on Connors' theory of public participation that mandates spreading awareness among public and educating them (Connor, 1988). However, it remains silent on information sharing during the lifecycle of the project.

Information sharing being one of the most critical parameters in effective public participation, the developed framework incorporates it along with the advantages of Connors theory (awareness and education). The presented framework not only mandates information sharing but also authority-public collaboration in final decision-making for greater acceptability of projects. It is important to emphasize that different levels of participation are incorporated in the framework and multiple CSFs are addressed at various levels. Also, one CSF might be addressed at two different levels of the framework. It is not mandatory that particular CSF is addressed at particular level but it might be involved/addressed at different levels of framework.

The developed framework achieves effective public participation in five levels viz. inform, educate, consult, involve, and collaborate. It is important to note that these are the levels of participation and not steps to be followed in sequence. Any of the level could be accomplished earlier or later according to the ground conditions, goals and promises of public participation (as depicted in Table 8.6). The selection of executive medium or tool among available ones is also not hard and fast but case specific and needed to be followed based on ground condition's feasibility. Further, the public engagement process starts with the competent authority such as ULB exploring existing conflicts, if any, and identifying a preliminary list of possible solutions (alternative options). This may begin by informing public on the benefits of the project, and showing preferred project details and alternatives. This should be carried out through public meetings, public affairs, and media programs (authorities may explore additional options). Next is to identify the public stakeholders (determined through initial involvement of interested public) and carry out public stakeholder analysis (identify problems and the preferences of public). The detailed procedure on stakeholder analysis is presented in a later section (Section 8.3.6.6). Stakeholder analysis is identifying the most influential stakeholders and their potential threats and cooperation to the project. It allows decision maker to structure the problem and solve it in collaboration with all interested parties/stakeholders to establish an information exchange relationship. Early involvement of the public may be considered as a preliminary fulfillment of the requirements of the water supply project development in terms of public participation. This process is followed by adequate actions to inform public about the entire decision process and process outcomes. It also helps to create an intent for change in final decision and explore alternatives, if required. This represents next level of the public participation process and is to be followed by educating public

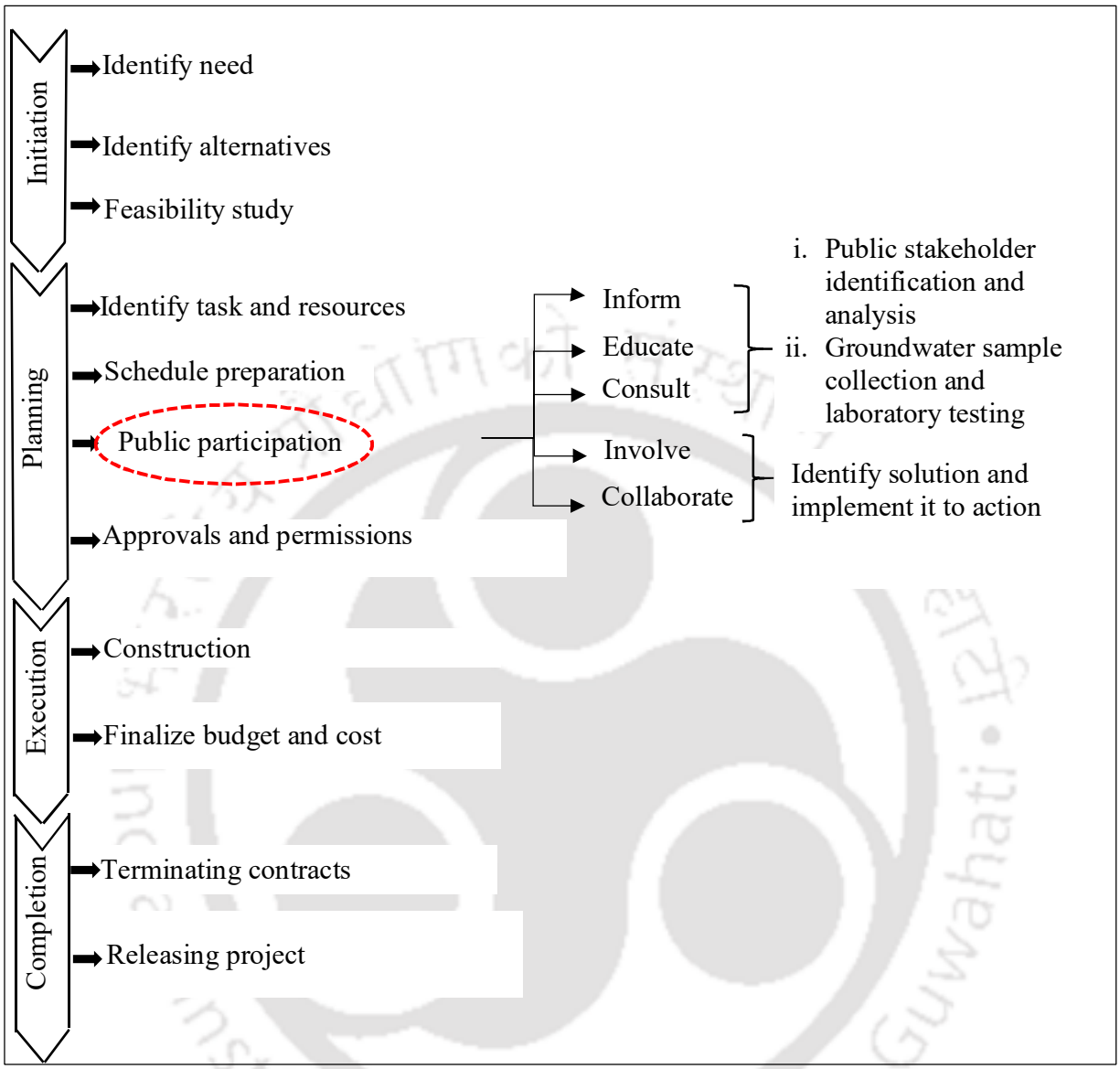


Figure 8.4: Framework for effective public participation in water supply project.

on existing groundwater quality and its health impacts. Collection of sufficient number of groundwater samples and its laboratory testing is advised at this level, in case no record on groundwater quality is available. The public feedback and queries raised during education/awareness program are to be evaluated and investigated. It is of utmost importance that information circulation and public consultation should continue until implementation of the final decision. However, the decision makers may also decide to bring the public participation to the level of active involvement and collaboration on each aspect of the decision including the development of alternatives and the identification of the preferred solution. In this level of

proposed framework, the public acceptance of the project is increased through participation, however the primary motivation for increasing participation is public centered i.e. not by removal of opposition but through consultative resolutions. Being a democratic society, participation of public in decision-making has to be made morally justified in its own right, which is well protected through proposed public participation framework. Henceforth, the proposed framework will help guide authority to undertake an effective and morally justified approval process for water supply projects through effective public participation. The different levels of effective public participation are further elaborated as follows.

8.3.6.1 Inform

This level of participation is informing the public about the project e.g. objectives, need and its benefits. It helps public to identify botherations, questions, doubts and disagreements regarding project along with feasible alternatives and possible solutions for them (Bruns, 2003; IAP2, 2014). It is more of a one-way channel of sharing information on project like project documents, contracts or providing an advance notice for making decision (Tambouris et al., 2007). Many possible conflicts are to be resolved at this stage through information sharing or announcements about the project, e.g. information passing on tariff structure will remove tariff uncertainty among public. Provisions of the incentives or rewards for participation, if any, will be informed at this stage. The basic information such as ownership of the project along with public benefits and losses from the project can be made available in public domain, in order to maintain transparency in this project (Bruns, 2003). This whole exercise at this level will address total of four CSFs viz. information on project, tariff certainty, incentives and transparency. The authorities are required to keep public informed using tools or mediums like fact sheets, websites, open houses, media campaigns through newsletters, newspapers, radio and television, training programs, and mailings (Bruns, 2003; Nabatchi, 2012).

8.3.6.2 Educate

This level of public participation of the proposed framework is crucial and serves as the foundation of the public participation process in order to avoid and resolve public controversies. First of all, efforts are made to avoid the controversies, primarily through spreading awareness on the household groundwater quality and its availability throughout year. Although groundwater is

available abundantly in the region throughout the year, the public has to be encouraged to test their groundwater quality. The presented public participation framework mandates ULB to collect and test sufficient number of groundwater samples in project service area. After which, mandatory awareness programs on groundwater contamination and consequential acute or chronic health hazards through various means are to be carried out. Secondly, if there exist any public controversy, dispute, ambiguity, misconception about the project, it has to be considered with highest priority at this level. Public is to be well informed and given fair knowledge over the issue, before it gets aggravated (Bruns, 2003). This will eradicate the possibility that public can be provoked or misled by politically or vested interest driven biased elements. The controversy has to be resolved in time because once anxiety and hostility reach high levels, educating those affected becomes almost impossible. In this level two CSFs viz. information on project and awareness on groundwater quality will be addressed. The tools or mediums that could be adopted are fact sheets, websites, media campaigns through newsletters, newspapers, radio and television, door to door awareness campaign, and mailings.

8.3.6.3 Consult

This level of public participation starts after the decision has been made with public consent and after educating them about the project as well as the groundwater quality. This level aims at obtaining public feedback on ULB decisions, analysis and alternatives adopted from earlier levels (IAP2, 2014). It has been constituted as a limited two-way channel where the ULBt informs public, listen to them, acknowledge their concerns and provide feedback on how public input influenced the decision (IAP2, 2014; Tambouris et al., 2007). It involves obtaining public feedback about plans, ideas, alternatives and/or issues, but with little interaction. The promise is to "listen and acknowledge" the issues being raised, but not necessarily to act on them (IAP2, 2014). Hence, in this level the issues or the concern of the public will be heard, and only feasible or appropriate concerns will be addressed. Responding to all concerns is not made mandatory at this level as the decisions made earlier were taken with public consent. It is also possible that the demands or issues raised at this point are exaggerations and unrealistic suggestions/demands from public. This level of the public participation framework addresses three CSFs viz. full public participation, public influence and communication. Listening and acknowledging to all public concerns or issues and collecting their feedback achieves full public participation. The information on how public input

influenced the decision brings them feeling of being influential. This exercise of two-way channel at this level in fact builds better communication between the ULB/authority and public. The tools or medium recommended for consultations at this level include public comments, focus groups, surveys, public meetings, public hearings and public comment devices (IAP2, 2014; Nabatchi, 2012). Public hearing is the most commonly used way to gather public input on governmental decisions. In addition, written comments and interviews are also recommended for the same (Bruns, 2003).

8.3.6.4 Involve

In this level of participation, the authorities are absolutely working with the public i.e. the public groups are invited to the workshops and/or deliberate polling and their views has to be incorporated in the decision-making. This level of participation runs throughout the public participation process to ensure that public issues and concerns are understood and considered (IAP2, 2014). This level of participation is more than a consultation that witness decisions taken in the project as well as alternative arrangements carried out on the public demand. The public influence in this level is so high that the decision of the government/authority can also be revised considering possible suggested alternatives. Unlike previous level i.e. consult which is a limited two-way channel (listen, acknowledge and provide feedback), this level is full-fledged two-way communication. The public involvement is promoted through interactive discussion such as workshops. They are encouraged to undertake and express concerns and grievances and new ideas from public are welcomed at this level considering alternative options. This method is incorporated to make them believe that they can change the final decision and that ULB does not have full control over the final decision. At many instances, information sharing on public panicking issues or technically complex issues is not advisable without alternate arrangements, henceforth authorities take decision without public consent e.g. if people are informed about unfit groundwater quality for consumption, overnight they may panic without alternative arrangement. Hence, sometimes technical complexity and legislation mandate that agencies limit the sharing of information and make the decisions. Contrarily, Arnstein (1969) have clearly indicated in its ladder rungs of placation i.e. satisfaction that participation without any substantial influence/impact can backfire by generating disappointment, anger, opposition, and suspicion (Bruns, 2003; Nabatchi, 2012). Banking on the success stories of these ladders, CSFs such as full

public participation, public influence, and communication will be taken care of by this level of public participation. The recommended tools or mediums for involvement are conducting workshops and deliberate polling.

8.3.6.5 Collaborate

The last level of the public participation framework ensures partnering with the public for direct advice and innovation in decision making, developing alternatives, and in identifying preferred solutions to the maximum extent possible (IAP2, 2014). It is framed as enhanced two-way channel between citizens and government, where representatives have "a seat at the table". However, active partnering of citizen is essential for a joint problem-solving effort (Tambouris et al., 2007). It requires restructuring of the processes, with strong and clear legislative mandate for collaboration (Bruns, 2003). However, the final decision still lies with the authority. However, in regards of CSFs, this level would further enhance 'public influence' on the project and its 'participation' in decision making. The recommended executional tools or mediums are citizen advisory committees, consensus building and participatory decision-making.

The unaddressed CSFs from above five stages participatory framework are 'timeliness' and 'regulatory governance' those are already being addressed in the beginning i.e., at planning stage of the project life cycle. The public participation is mandated through a regulatory governance in a project with specification on how and when to conduct/organize participation. Furthermore, timings for participation is to be maintained and scheduled beforehand i.e., at the beginning of the project to avoid mess and chaos in participation.

8.3.6.6 Public Stakeholder Identification and Analysis Procedure

Public stakeholder identification is to be carried out as an iterative process wherein the common men who are thought to be influential in project's long run are chosen as public representatives or stakeholders (Reed et al., 2009). The stakeholder can be anyone from public such as individuals, groups, negotiators, and representatives. In fact, it could be everybody that can influence or are influenced by the project. The recommended tools and techniques for influential public identification are focus group interviews, expert opinion, structured or semi-structured questionnaire interview, snow-ball sampling, focus groups, brain-storming, brain-

writing and crawford slip sessions (Reed et al., 2009). With these tools the selected stakeholders are tested and only influential ones are invited to take part in the next process (El-Gohary et al., 2006). After identifying influential stakeholders, the competent authority has to identify how important these stakeholders are to the project and also to each other as well. Groups with conflicting ideologies and objectives are advised to be handled carefully (Prieto, 2011). Public stakeholder groups/individuals are further ranked based upon the needs or importance in the project, threat or co-operation to the project, power, proximity or urgency (Chinyio & Olomolaiye, 2010; Gausset, 2004; Mitchell et al., 1997; Sheehan & Ritchie, 2005). The ULB/authority will have to identify, categorize and rank these groups according to usefulness of the issues in the context of project success (Henjewele et al., 2013). Prioritizing the public stakeholder groups is an agonizing process and should be free from any prejudicial decision as it may induce unnecessary disagreements over ranking. The prioritization and public stakeholder issue identification can be worked out by asking the groups to submit position statements, by looking at previous public engagement, with the help of press releases and through public statements. This can also be achieved by taking opinions of public stakeholders around typical major issues, direct public interviews, organizing single or multi-public stakeholder workshop and by going through on-line forums or moderated blogs (Prieto, 2011).

8.3.6.7 Identify Solution and Implement it to Action

Information and proper notification to the public is to be released regarding the project. This involvement and collaboration with public would help in identification of visions and desires for the development of the project. They should be made aware on the factors that may have an impact on the infrastructure. Feasible design layout alternatives are to be presented to the interested groups or the public. Each design alternative is to be discussed individually against the design criteria incorporating the input from the public. Once the design team has developed details of the preferred design alternative, another public involvement meeting needs to be held so that the details can be discussed and modified for maximum aesthetic appeal or convenience (Li et al., 2012; Ng et al., 2013; Sherman, 2001). The traditional tools adopted are as brainstorming session, direct discussion, public hearings, district forums and written responses, roving exhibitions and surveys.

8.3.7 Practical Implication of the Framework

Practical limitations do exist in attempting to adopt this framework in a real case scenario. The ideal condition under which the proposed framework could be implemented at site will be only after the people are made aware of their household groundwater quality at the planning stage of the project. However, sharing information on quality of groundwater to the households will be counterproductive in the earlier stages of project implementation lifecycle when no alternative supply of water could be provided to the residents. As the households have no alternative to their groundwater sources, sharing the groundwater quality may create panic amongst the public and force them to explore other alternative water sources such as getting water from private water suppliers. Presently, the people in the study area are solely dependent upon groundwater and the ULB serves only 30% of the population. Sharing the information that their groundwater is not fit for drinking will compel the people to opt for Brahmaputra river water as alternative source, which is again not fit for direct consumption without proper treatment. Hence, the practical difficulties that may be faced while implementing this idealistic public participation framework should be taken into consideration while adopting it for any city water supply schemes. Furthermore, if possible such disclosure of groundwater quality as part of the public participation should be adopted only after establishing water supply from alternate sources.

8.4 Conclusions

The current study focusses on the primary and secondary data for public participation in water supply projects. The study identifies CSFs for public participation and studies the relevancy of these CSFs in the study area of South-West Guwahati. A public participation framework is developed to deemphasize the effects of disincentives in water supply projects. This framework is grounded on primary, secondary data and theories of public participation. Qualitative primary interview data was collected through a semi-structured questionnaire for the study area of public participation in South-West Guwahati water supply project. Analysis of data using Nvivo revealed 11 (eleven) themes for public participation. Moreover, the 9 CSFs identified from secondary data analysis were found to be quite relevant for the study area of water supply project. The framework is envisaged to enhance public acceptance, timely completion and successful comprehensive management of a project through various levels of public participation.

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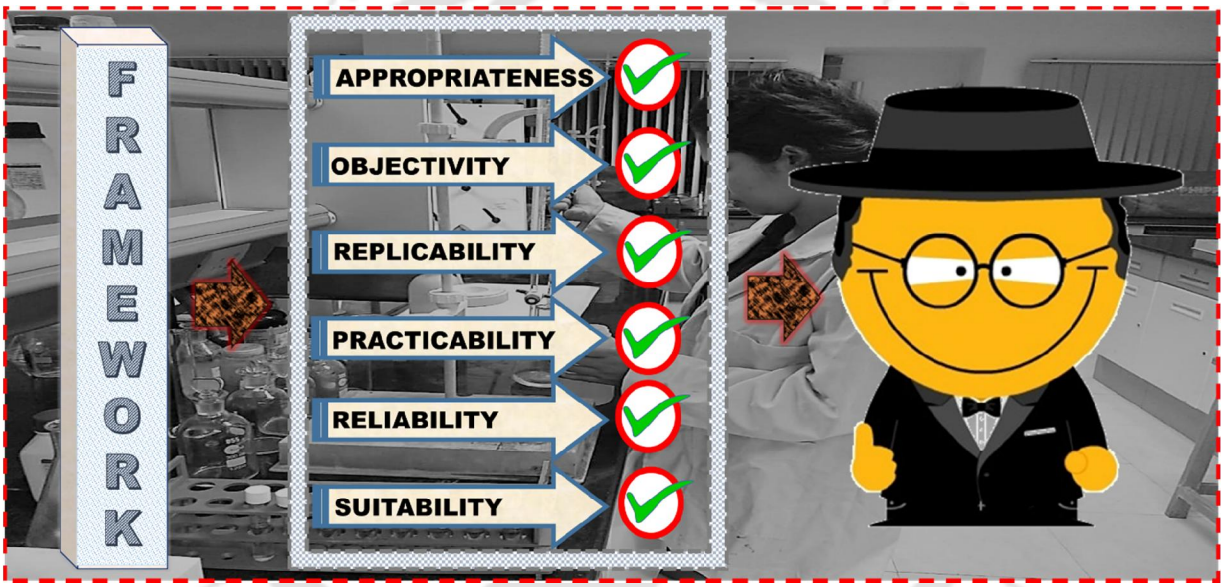
Chapter–9

Framework Validation



This chapter attempts validation of the developed framework through face to face questionnaire survey of 16 experts.

9.1 Background

Validation is an essential process to authenticate the quality of the research outcomes. This process is to be carried out at final stage of the research work (Cheung, 2009). Its primary intention is to minimize the risk and to verify that the framework is performing as expected or in line with the designed objective and professional uses. In order to validate newly developed framework for enhancing public participation, a face to face survey was conducted. Selection of compelling experts for the validation is a crucial parameter as he/she should be aware of the situation presented in the study alongside the expertise in the domain of study area. Hence, the experts who had participated earlier in the interviews during the development of framework were requested for the validation of framework developed. This chapter presents methodology and procedures adopted for validation along with the results.

9.2 Research Method for Validation

Validation of the framework for enhancing public participation in water supply projects is aimed at defining whether the framework is appropriate, objective, reliable and practicable. In doing so, retrospection on various validation aspects such as degree of appropriateness, degree of objectivity, degree of replicability and overall reliability was performed and a face to face questionnaire survey was conducted. This method of survey is considered superior and reliable over other methods of validation such as surveys through mail and telephone (Balakrishnan et. al. 2014). The added advantage of the survey is that an expert is physically present to answer the survey questions which may lead to the additional queries those can be cleared from both sides. This survey approach is advantageous compared to both mail and telephonic surveys in terms of the complexity and quality of the data collected (Balakrishnan et al., 2014). The relevant validation aspects were selected on similar validation process conducted by Yeung (2007) and Cheung (2009). Six aspects regarding the model were assessed and it includes:

1. Degree of appropriateness – Assess whether the framework has included the appropriate strategy in the associated processes/activities of public participation process in water supply project.
2. Degree of objectivity – Evaluate whether the framework has considered all essential and

meaningful issues of public participation.

3. Degree of replicability – Assess whether the framework has encompassed the expert's propositions along with its inclusion at appropriate stage of public participation process.
4. Degree of practicability – To speculate and evaluate the capability of framework to accomplish enhancement of public involvement in water supply project.
5. Overall reliability – Appraise whether inclusion of various public participation theories in the framework would maintain the holistic decentralization process throughout the project.
6. Overall suitability for water supply projects – Assess whether the framework, developed through inclusion of various strategies and theories, would be appropriate for public participation practices for water supply infrastructure projects in South-West Guwahati.

Responses would be collected in regard to the extent of satisfaction for every validation aspect on the basis of a scoring scale of 1 to 5, where 1 represented 'poor' and 5 represented 'excellent' (Cheung, 2009; Yeung, 2007).

9.3 Survey Procedure

The questionnaire template comprised of three sections (shown in Appendix, Table A.6). The first section explains purpose of the survey highlighting motive of interview, background information about the research, and instructions for completing the surveys. In the second section, a brief description of the developed framework is provided and the third section focuses on framework validation scoring sheet along with the guideline for validation. Using the scoring sheet, the experts were requested to rate the extent of satisfaction for each of the six validation aspects on the basis of a scoring scale of 1 to 5. The survey with 16 experts were conducted during June to July' 2018.

9.4 Results of Validation

The descriptive statistics derived from the statistical analysis of the responses provided by the experts who had participated in the validation study for each validation aspect are shown in Table 9.1. The experts were asked to rate six aspects of the framework using a Likert scale of 1 to 5. A mean score above '3' would represent satisfactory performance for that particular aspect (Cheung, 2009; Yeung, 2007). The results showed that all the aspects were rated significantly high

i.e., above '3' by the experts. The aspect rated highest was 4.13 for 'degree of practicality' and the aspect with the lowest mean was 3.38 for 'degree of replicability'. Therefore, it can be interpreted that the newly developed framework was validated to be appropriate, objective, replicable, practicable, reliable, and suitability for water supply in South-West Guwahati.

Table 9.1: Interview results for validation of framework

Expert code	Degree of appropriateness	Degree of objectivity	Degree of replicability	Degree of practicability	Overall reliability	Overall suitability for water supply in South-West Guwahati
R01	4	4	2	4	3	4
R02	3	2	2	2	2	3
R03	5	4	4	5	4	5
R04	5	4	4	4	4	5
R05	4	4	4	4	4	4
R06	3	4	4	4	3	4
R07	5	3	4	4	3	4
R08	2	3	2	4	3	3
R09	3	4	4	5	5	4
R10	4	5	4	5	5	4
R11	2	2	2	3	4	2
R12	5	4	4	5	4	4
R13	2	2	2	3	4	2
R14	5	4	4	5	4	4
R15	5	5	5	5	5	4
R16	4	4	3	4	4	4
Mean	**3.81**	**3.63**	**3.38**	**4.13**	**3.81**	**3.75**

9.5 Conclusions

The current study focusses on validation of the framework developed in the previous chapter. The framework was scrutinized to assess the extent of fulfilment of the six validation aspects. The experts rating for all aspects of validation was significantly high which reflect their level of satisfaction with the framework. The framework achieved its major objective of enhancing public participation in water supply projects as indicated by highest rating for 'degree of practicability'. Satisfactory ratings for all aspects of framework validation demonstrated that the newly developed

public participation framework is appropriate, objective, replicable, practical, reliable, and suitable for water supply projects.

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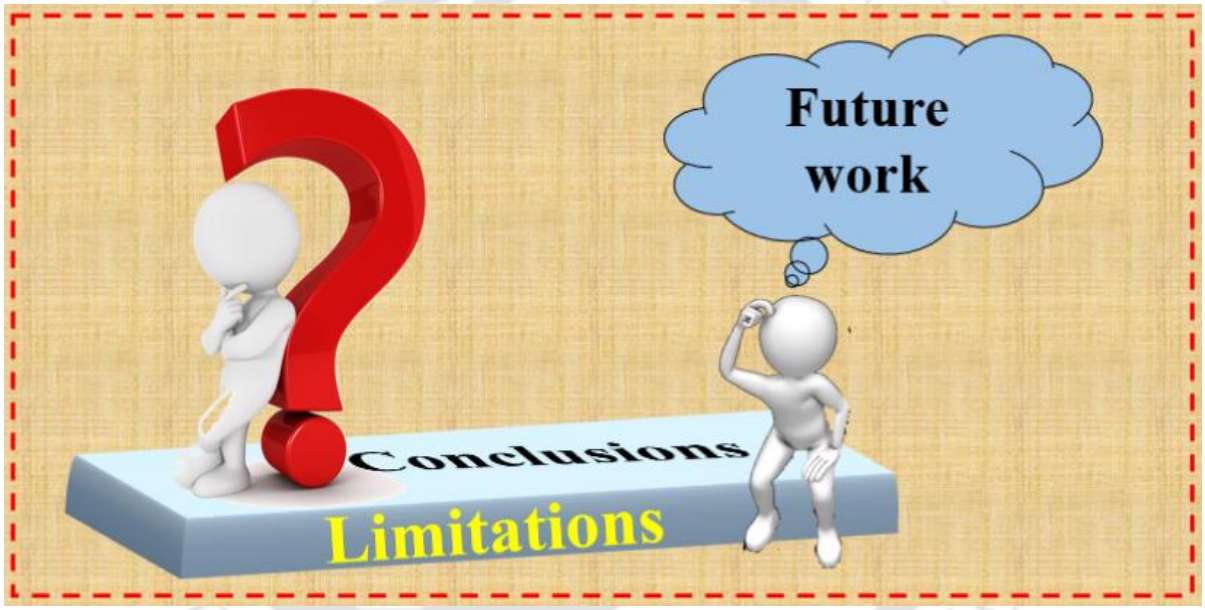
Chapter–10

Summary and Conclusions



In this chapter, major conclusions of the entire doctoral work, and limitations of the present work are summarized. The future research directions to carry out explorations in this areas are also presented.

10.1 Summary of the Study

The current study was carried out to identify rationale for public opposition to upcoming water supply scheme through mixed approach of qualitative and quantitative research methodology. A door to door survey was taken up to identify prejudicial public perception on groundwater quality and its health effects, along with public willingness to procure (WtP). Groundwater sample collection during survey followed by laboratory testing revealed groundwater contaminations in study area and identified critical water quality parameters. In line with the results, public awareness on groundwater quality was spread and a fresh public WtP was undertaken through second round of door to door survey. The study also uncovered that ineffective, insufficient or no public participation as reason for public opposition to the water supply scheme. Furthermore, the reason for ineffective public participation could be attributed to lack of any kind of guidelines from government over conduct of public participation in water supply projects. Henceforth, a conceptual framework to enhance public participation especially in water supply projects was developed on the basis of critical success factors (CSFs) from secondary (literature review) and primary (expert interviews) data, entrenched on fundamental theories of public participation. Lastly, the pertinence of the developed framework was validated through expert opinions survey adopting six validation aspects.

10.2 Overall Conclusions

In order to achieve the research objectives of the study, four research phases were designed to develop public participation framework. The phase wise conclusions are presented below:

1. The first objective of this research was to identify rationale of public opposition and to assess level of public acceptance and WtP for upcoming water supply scheme. The document analysis on public opposition revealed that the project failed to encourage public participation and maintain transparency in project related issues. The questionnaire survey on assessing perception on groundwater and WtP revealed that information on funding sources, executing agency, contract/sub-contracts and tariff wasn't properly circulated to convince and build public trust, resulting in lower (58%) public WtP. The survey also revealed that a greater proportion (98%) of the people have never tested groundwater quality.

Only 4% were aware of groundwater contaminations and 30% were found to be using household filters, thereby indicating a high level of ignorance and lack of knowledge on groundwater quality.

2. Laboratory testing on groundwater quality of 1568 household samples from the study area revealed presence of iron, fluoride and arsenic. The concentrations of these contaminants were found to be exceeding permissible limits as per WHO guidelines. The highest concentration of iron, fluoride and arsenic was found to be 21 mg/L, 7.93 mg/L and 35.7 µg/L, respectively. This indicated unsuitability of groundwater for direct consumption. The percentage samples exceeding WHO guideline/BIS permissible limit was observed to be 55, 12 and 9 for iron, fluoride and arsenic, respectively. The concentrations were found to be highest at the foothills and then decreased radially outward.

3. The third objective of this research was to create groundwater quality awareness, compare public WtP and investigate the significant factors in the study area. It was observed that public awareness on groundwater quality and its health hazards improved their WtP from 58 to 74%. Moreover, comparison of WtP considering and excluding income parameter revealed that thee common factors influencing WtP are education level of respondent (EDU), source of drinking water (SOURCE), groundwater had taste (TASTE) and household is within the project domain (WITHIN).

4. The fourth objective of this research was to develop framework enhancing public participation through identification of CSFs from expert's interview (primary data) and literature (secondary data) and in consideration of various participation theories. As a result, primary and secondary data identified 11 and 9 CSFs, respectively. Three additional CSFs such as availability of groundwater in abundance, incentives/rewards and awareness on quality of groundwater were identified from expert interviews through semi structured questionnaire, whereas remaining 8 were found to be common to both.

5. The developed framework is an attempt to address the flaws in the current public participation process. The framework further improves the public participation process by incorporating the CSFs. This will help the policy-makers/advisors to enhance public participation, public acceptance, timely completion and successful comprehensive

management of water supply projects. Further, the framework validation with 16 experts received satisfactory rating for all the six validation aspects with highest score (4.13/5) obtained for 'degree of practicability'. Satisfactory ratings from expert demonstrated that the newly developed public participation framework is appropriate, objective, replicable, practical, reliable, and suitable for water supply projects.

10.3 Limitations and Scope for Future Work

Followings are few limitations which may serve as scope for future work:

1. The statistical formula used for representative sample size determination showed minor variation with respect to number of households in ward/zone and became stable after certain value. Exploration on statistical estimation of representative sample size can be undertaken.
2. In an attempt to identify the reason for public opposition to South-West Guwahati water supply project, very few chronological events (7 numbers) were identified through document analysis. This may not give insightful picture of the situation, hence, detailed investigation on the events and facts should be carried out involving participatory groups of opposition/protests.
3. The study considered 11 water quality parameters to assess groundwater quality in study area. However, presence of other contaminants such as microorganisms and/or heavy metals can be studied along with its health effects.
4. Effect of seasonal variation on groundwater quality was not considered in present study. Hence, further explorations on seasonal variation in groundwater quality can be studied.
5. In the present study, public hesitated to disclose income in the direct method of questionnaire survey that proved to be fairly incompatible for Indian public. Hence, the questionnaire could be further improved to assess income through inclusion of indirect methods of assessment.
6. The expert panel for development of framework and its validation was the same, this might have created biasness in validation of the framework. Hence, validation of the framework from a different set of experts will give an unbiased view to improve the framework further.

7. As a first attempt to develop framework for water supply projects in India, the present study considered only one water supply project which may not be representative for all regions of similar environmental pattern. However, further studies considering multiple water supply projects will help in the development of robust framework for water supply projects in India.

8. Given the fact that groundwater is abundant in the study area and the participating experts are from the region, the framework developed could be effectively applicable to the groundwater abundant areas. However, requisite modification for its possible implementation in arid areas can be explored by undertaking similar study in arid region using the same line of inquiry.

Appendix

Table A.1: Preliminary questionnaire for public perception on groundwater and WtP from South-West Guwahati water supply scheme

Sl.	Questions	Response scale
Objective: Demographic		
1	Name of respondent	
2	Age of respondent	
3	Gender	Female = 0, Male = 1
4	I am head of the household	Yes = 1, No = 0
5	Years living in the present neighborhood	
6	Monthly household income	
7	I own the home and it is not rental	Yes = 1, No = 0
8	The house is made of brick	Yes = 1, No = 0
9	Number of people in household earning a wage	
10	Number of people living in respondent's household	
11	Monthly household's income grouping in India in Indian Rupees	
12	Household water storage capacity (cubic meters)	
Objective: Household groundwater and current knowledge on its quality		
13	Main source of water at my household	1 = groundwater, 2 = surfacewater, 3 = private water supply, 4 = municipal water supply, 5 = other specify…..
14	Domestic water source at my household	1 = dugwell, 2 = handpump 3 = tubewell with motor, 4 = private water supply, 5 = municipal water supply, 6 = other specify…..
15	I am satisfied with the current source of water	Strongly disagree (1) / Disagree (2) / Neutral (3) / Agree (4) / Strongly agree (5)

16	My family has access to improved water supply	1	2	3	4	5
17	Water available from my source is sufficient throughout the year	1	2	3	4	5
18	Water is available throughout the dry season at my source	1	2	3	4	5
19	I purchase water from vendor	1	2	3	4	5
20	I prefer cold-drinks for drinking purpose	1	2	3	4	5
21	I consume bottle water on regular basis	1	2	3	4	5
22	Quantity of water/Cold-drinks I buy per day from vendor					
23	Average amount spend on water/Cold-drinks during dry season					
24	Groundwater quality is a problem in my area	1	2	3	4	5
25	I use preventive measure for my domestic water	1	2	3	4	5
26	My household groundwater quality is contaminated	1	2	3	4	5
27	I have heard of the groundwater quality of my area is not good	1	2	3	4	5
28	I was informed of the ground water quality by	1 = NGO, 2 = neighbor, 3 = government representative, 4 = media, 5 = specify if other specify…..				
29	I have checked the groundwater quality	1	2	3	4	5
30	I treat water for all my domestic choirs	1	2	3	4	5
31	I treat water before drinking at home	1	2	3	4	5
32	I frequently treat water before drinking at home	1	2	3	4	5
33	I treat water before cooking at home	1	2	3	4	5
34	I frequently treat water before cooking at home	1	2	3	4	5

35	To treat water I use	1 = filter 2 = disinfectant 3 = specify if other specify…..					
Objective: Health effects on consuming contaminated water							
	Arsenic effect						
36	Me or any of my family member have experienced discoloration of skin	1	2	3	4	5	
37	Me or any of my family member have experienced superficial growth/patch of skin	1	2	3	4	5	
38	Me or any of my family member have experienced hard patches on palms and soles of feet	1	2	3	4	5	
39	Me or any of my family member is suffering from bladder, kidney or lung cancer	1	2	3	4	5	
	Fluoride effect						
40	My or any of my family member has discolored teeth	1	2	3	4	5	
41	My or any of my family member has yellowish color teeth	1	2	3	4	5	
42	Children have teeth cavities at my home	1	2	3	4	5	
43	Me or any of my family member has bone disease(pain, tenderness, weak or deformed)	1	2	3	4	5	
	Iron effects						
44	My household groundwater produces stains in clothes and utensils	1	2	3	4	5	
45	My household groundwater has odour	1	2	3	4	5	
Objective: awareness about new water supply project							
46	I am totally aware of the new water project	1	2	3	4	5	
47	I am sure that my household is within the project domain	1	2	3	4	5	

Objective: availability of water						
48	I have domestic water supply from different sources	1 = one, 2 = two, 3 = three, 4 = four, 5 = more				
49	My past water supply facilities was good	1	2	3	4	5
Objective: water purchase intension						
50	I am willing to purchase water from new water treatment plant (WtP)	1	2	3	4	5
51	I don't require water from other alternate source	1	2	3	4	5
52	I don't want to pay for water	1	2	3	4	5
53	I will pay for water only if my groundwater is contaminated	1	2	3	4	5
54	I will pay for water only if water is sold at a reasonable price	1	2	3	4	5
Objective: water purchase intension after educating people about groundwater quality						
55	I am willing to procure water from new water supply scheme	Yes = 1, No = 0				

Note: 1 - Strongly agree, 2 - Agree; 3 - Neutral; 4 - Disagree; 5 - Strongly disagree

Table A.2: Pilot study questionnaire for public perception on groundwater and WtP from South-West Guwahati water supply scheme

Sl.	Questions	Response scale
Objective: Demographic		
1	Name of respondent	
2	Age of respondent	
3	Gender	Female = 0, Male = 1
4	Years living in the present neighborhood	
5	My monthly income (in Indian Rupees)	
Objective: Water Availability		
6	Main source of water at my household	1 = groundwater, 2 = surface water, 3 = private water supply, 4 = municipal water supply, 5 = other specify…..
7	My family has access to improved water supply	Yes = 1, No = 0
8	Water available from my source is sufficient throughout the year	Yes = 1, No = 0
Objective: Water purchase		
9	I purchase water from vendor	Yes = 1, No = 0
Objective: Awareness about ground water		
10	Groundwater quality is a problem in my area	Yes = 1, No = 0
11	My household groundwater quality is contaminated	Yes = 1, No = 0
12	I was informed of the ground water quality by	1 = NGO, 2 = neighbor, 3 = government representative, 4 = media, 5 = specify if other specify…..
13	I have checked the groundwater quality	Yes = 1, No = 0
Objective: Water treatment related		
14	I treat water for all my domestic choirs	Yes = 1, No = 0
15	I treat water before drinking at home	Yes = 1, No = 0, Sometimes = 2
16	I treat water before cooking at home	Yes = 1, No = 0, Sometimes = 2
17	To treat water I use	1 = Candle filter 2 = Aqua guard 3 = Disinfectants 4 = specify if other …..
	Arsenic effect	
18	Me or any of my family member have experienced discoloration of skin	Yes = 1, No = 0
19	Me or any of my family member have experienced superficial growth/patch of skin	Yes = 1, No = 0

20	Me or any of my family member have experienced hard patches on palms and soles of feet	Yes = 1, No = 0
21	Me or any of my family member is suffering from bladder, kidney or lung cancer	Yes = 1, No = 0
	Fluoride effect	
22	Me or any of my family member has yellowish color teeth	Yes = 1, No = 0
23	Children have teeth cavities at my home	Yes = 1, No = 0
24	Me or any of my family member has bone pain, tenderness, weak or deformed	Yes = 1, No = 0
	Iron effects	
25	My household groundwater produces stains in clothes and utensils	Yes = 1, No = 0
26	My household groundwater has odor	Yes = 1, No = 0
Objective: Awareness about new water supply project		
27	I am aware of the new water supply project	1 = Fully aware 2 = Partially aware 3 = Not aware
28	My household is within the project domain	Yes = 1, No = 0, Not sure = 3
Objective: Water purchase intension before educating the people		
29	I am willing to purchase water from new water treatment plant	1 = At any cost 2 = Only if groundwater is contaminated 3 = Only if water price is reasonable 4 = If other, specify
Objective: Water purchase intension after educating the people		
30	I am willing to purchase water from new water treatment plant	Yes = 1, No = 0

Table A.3: Final questionnaire for public perception on groundwater and WtP from South-West Guwahati water supply scheme

Sl.	Questions	Response scale
Demographic information		
1	Name of respondent	
2	Age of respondent	
3	Gender	Female = 0, Male = 1
4	Household size	
5	Years living in the present neighborhood	
6	If the respondent household is owner of the house	Owner = 1, Rented = 0
7	Monthly household's income (in Rupees)	
8	Education	1 = Illiterate 2 = Up to primary school 3 = Up to 10th 4 = Up to 12th 5 = Up to graduate 6 = Up to PG 7 = Doctorate
Objective: Household groundwater and current knowledge on its quality		
9	Main source of water at my household	Dug well = 1, Hand pump = 2, Tube well = 3, Specify if other
10	My family has access to desired water quality	Yes = 1, No = 0
11	Water available from my source is sufficient throughout the year	Yes = 1, No = 0
12	I purchase water from vendor	Yes = 1, No = 0
13	My household groundwater quality is contaminated	No = 0, Yes = 1
14	I have checked the groundwater quality	Yes = 1, No = 0
15	I treat water for all my domestic choirs	Yes = 1, No = 0
16	I treat water before drinking at home	Yes = 1, No = 0
17	I treat water before cooking at home	Yes = 1, No = 0
18	To treat water I use	5 = Water purifier, 4 = Candle filter, 3 = Sand filter, 2 = Boil, 1 = Direct

Objective: Health effects on consuming contaminated water		
	Arsenic effect	
19	Me or any of my family member have experienced discoloration of skin (pigmentation)	Yes = 1, No = 0
20	Me or any of my family member have experienced superficial growth/patch of skin (keratosis)	Yes = 1, No = 0
	Fluoride effect	
21	Me or any of my family member has yellowish color teeth	Yes = 1, No = 0
22	Children have teeth cavities at my home	Yes = 1, No = 0
	Iron effects	
23	My household groundwater produces stains in clothes and utensils (visible impurity)	Yes = 1, No = 0
24	My household groundwater has bitter taste	Yes = 1, No = 0
Objective: Information on and willingness to procure water from water supply scheme		
25	I am aware of the new water project	Yes = 1, No = 0
26	My household is within the project domain	Yes = 1, No = 0
27	I will procure water from water supply scheme	Yes = 1, No = 0
Objective: Willingness to procure water after educating people on groundwater quality		
28	I am willing to procure water from new water supply scheme	Yes = 1, No = 0

Table A.4: Demographic and background information of the experts

1. Professional information

   a. Name:-
   b. Gender:-
   c. Age:-
   d. Organization:-
   e. Designation:-
   f. Years of professional experience:-
   g. Contact No.:-
   h. Email:-

2. Educational qualification (please tick any that apply)

☐ Undergraduate degree	☐ Postgraduate degree	☐ Postgraduate diploma
☐ Doctorate	☐ Other (please specify):	

3. Professional working sector (please tick any that apply)

☐ Public Sector	☐ Private sector	☐ Financial Institution
☐ Transaction Advisor	☐ NGO	☐ Researcher in Academics

4. Professional background with specialization in projects (please tick any that apply)

☐ Civil Engineering	☐ Economics	☐ Management
☐ Environmental	☐ Finance	☐ Social Science
☐ Other (please specify):		

5. Experience in types of projects (you may select more than one box)

☐ Groundwater	☐ Solid waste management	☐ Wastewater
☐ Water Supply	☐ Other (please specify):	

Table A.5: Pilot study questionnaire for the expert interview

Sl.	Questionnaire for expert opinion
1.	Can you tell about legislations/laws related to Public Participation (PP) in water supply projects? How are it followed in real context?
2.	How are public involved before and since commencement of the project?
3.	What is your say on protest related to water supply project?
4.	How is the protest/opposition of public is taken care of?
5.	How Public Participation could be improved in the project?
6.	What category of people participate in projects and what steps taken to improve their skillsets?
7	What are the positive and negative aspects of the current process?
8	How aware the public are about the household groundwater quality?
9	What initiative taken to educate people on groundwater quality and its health hazards?
10	To what extent do South-West Guwahati water supply project address public participation?
11	What are the obstacles for public participation in the projects?
12	How important are the following CSFs identified from literature in context of South-West Guwahati?

Sl.	CSFs	Not important		Neutral		Very important
		1	2	3	4	5
1	Transparency	○	○	○	○	○
2	Communication	○	○	○	○	○
3	Timeliness	○	○	○	○	○
4	Information on project	○	○	○	○	○
5	Public involvement	○	○	○	○	○
6	Regulatory governance	○	○	○	○	○
7	Public influence	○	○	○	○	○
8	Tariff uncertainty	○	○	○	○	○
9	Privatization	○	○	○	○	○

Table A.6: Survey Template

Section 1: Background Information and Instructions for Validation Process

Purpose of the interview: To validate that the framework for enhancing public participation in water supply project at South-West Guwahati.

Background: This framework was developed as part of the Ph.D. research study conducted at the Indian Institute of Technology Guwahati in India by Rakhee Das.

Instructions: This document consists of three sections. First section (current page) includes background information and instructions for validation process. Second section explains the framework for enhancing public participation in water supply project at South-West Guwahati. The framework has been developed through in-depth literature review obtaining 9 Critical Success Factors and from face to face interviews with the water and groundwater expert's involved in the development and implementation of water supply projects in Guwahati. These face to face interviews were carried out during April 2018 to June 2018 and valuable insights were obtained through these interviews. The last section deals with the validation of the framework from the perspective of following six validation aspects. You are kindly requested to rate the six validation aspects by simply selecting the appropriate boxes.

(i) Degree of appropriateness
(ii) Degree of objectivity
(iii) Degree of replicability
(iv) Degree of practicability
(v) Overall suitability for water supply in South-West Guwahati

Your kind assistance in completing this questionnaire is very appreciated.

Thank you,
Yours sincerely,
Rakhee Das (Research Scholar)
Mobile No: +91 8011478888
Email: rakhee@iitg.ac.in

Dr. Mohammad Jawed and Dr. L. Boeing Singh (Thesis Supervisors)
Email: jawed@iitg.ac.in and boeing@iitg.ac.in

Section 2: Framework for Enhancing Public Participation on Water Supply Project

The factors influencing public consultation efficiency were obtained from in-depth literature review on worldwide cases in water supply projects are shown in Table A.6.1.

Table A.6.1: Factors influencing public consultation efficiency in water supply projects from various literature

Sl	Factors	Description of factors influencing consultation efficiency
1	Transparency	Transparent decision-making process to build trust among participants
2	Communication	Provides participants with the understanding about importance of participation and feedback in decision-making process
3	Timeliness	Realistic milestones and deadlines must be managed along with public involvement thought the process
4	Education on project	Share all detail information about the project: advantage and disadvantages
5	Full public involvement	Consist of a broadly representative sample of the population of the affected public
6	Regulatory governance	Clear & visible responsibilities and actions of governmental agencies in decision-making process
7	Influential	Issues of concern of the public, and relevant to the decision at hand, must be taken into account in reaching a decision
8	Tariff uncertainty	Adequate disclosure of pricing (tariff) of water services prior to project implementation
9	Privatization	Private sector involvement in implementation of water supply project

Figure A.6.1 shows the public participation framework developed incorporating the 9 CSF from secondary data and 11 primary CSF obtained from interview. Steps for public participation

- Competent authority exploring existing conflicts and list of possible alternative
- Inform public on benefits of project, and showing project details and alternatives
- Through public meetings, public affairs, and media programs
- Followed by educating public on existing groundwater quality and its health impacts
- Inform public stakeholders on entire decision process, its outcomes and to create alternative option
- Evaluate feedback and queries expressed by public and find possible solution to implement it into action

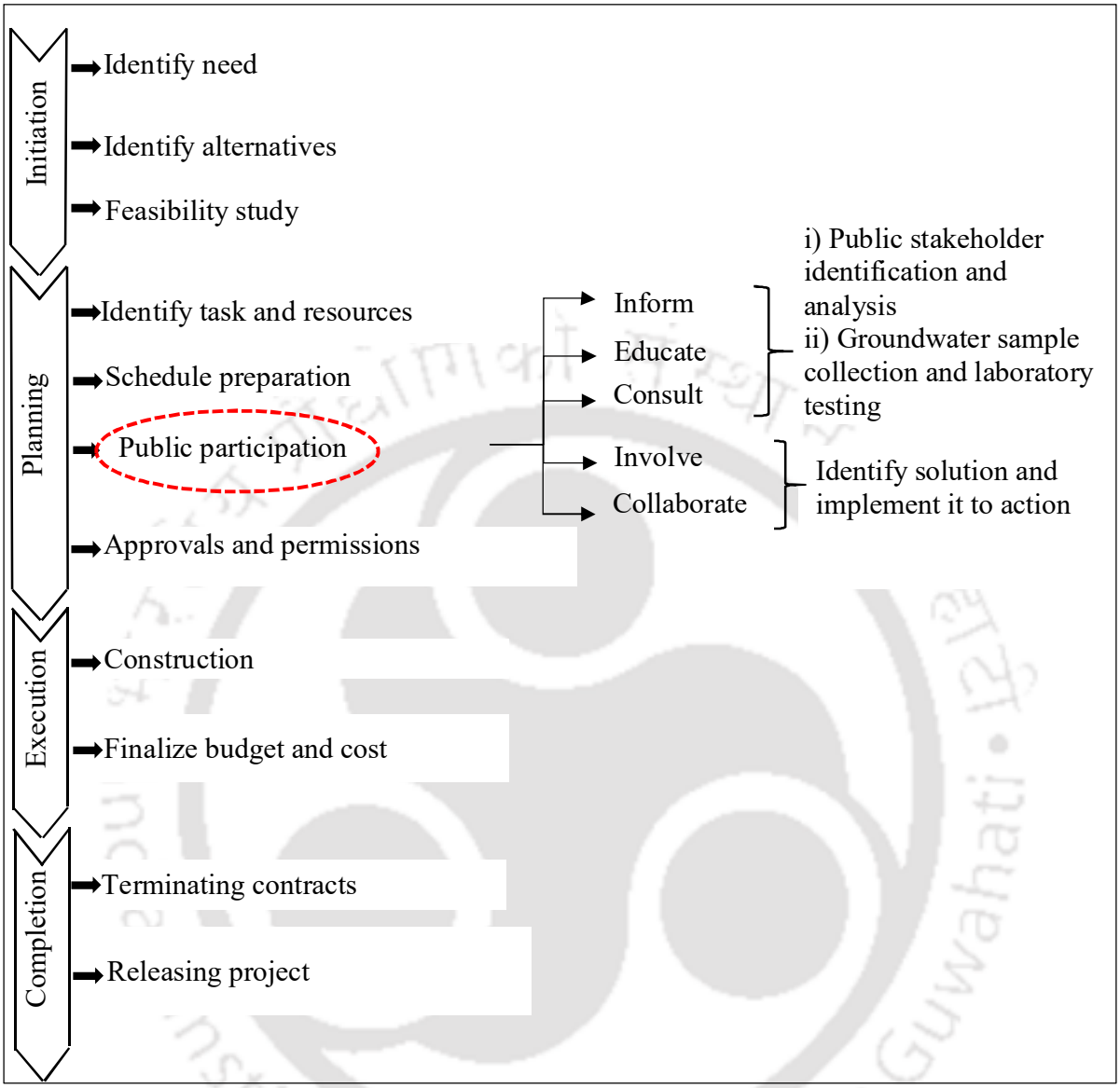


Figure A.6.1: Framework for public participation in South-West Guwahati water supply project.

Inform

- Provide information to public on project and its objective with the tools or medium suggested below
- It assists public in identifying problems, alternatives and solutions associated with project
- One-way channel on sharing information on project

- Government - promises to keep public informed with tools like fact sheets, websites, open houses, media campaigns through newsletters, newspapers, radio and television, training programs, and mailings

CSF addressed: 'information on project' including 'tariff structure', provision of 'incentives', disclosure and ownership on whether project is being 'privatized' or government owned,
this builds 'transparency' in project

Tools: fact sheets, websites, open houses, media campaigns through newsletters, newspapers, radio and television, training programs, and mailings

Educate

- Make people aware of their household groundwater quality
- Groundwater available abundantly - public needed to encourage to test their water quality
- Competent authority needed to analyze quality of water in vicinity
- Public to be educated on contamination present water and respective health hazards

CSF addressed: making people 'aware' of their groundwater quality, although they have 'abundance of freely available groundwater'

Tools: fact sheets, websites, open houses, media campaigns through newsletters, newspapers, radio and television, training programs, and mailings, door-to-door awareness campaign, meetings

Consult

- Obtain public feedback on governmental decisions, analysis and alternatives
- Limited two-way channel - government inform public, listen to and acknowledge concerns
- Provide feedback on how public input influenced decision
- Mandatory legal procedure in environmental impact assessments
- Public hearing - most commonly used in governmental decisions

CSFs addressed: 'full public participation', incorporating the feeling of being 'influential' , builds better 'communication' between government and public

Tools: public comment, focus groups, surveys, public meetings, public hearings, public comment devices, and focus groups

Involve

- Direct working with public
- Ensure public issues and concerns understood and considered
- Public can influence decision of government/authority
- Involvement of public result in providing input into internal decision processes
- Promote interactive discussion and dialogue to explore concerns, formulate new ideas and consider options
- Public can change final decision and that government does not have full control over final decision

CSF addressed: 'full public participation', 'influential' public opinion on the project and making effective 'communication' among the public about project

Tools: Workshops, Deliberate polling

Collaborate

- Partnering with public for direct advice and innovation in decision making
- Enhanced two-way channel with public representatives "a seat at the table"
- Active partnering of citizen is essential for a joint problem solving effort
- Restructuring of the process, with strong and clear mandate for collaboration
- Final decision still lies with government/agency

CSFs addressed: enhance 'public influence' on the project and its 'participation' in decision making

Tools: Citizen Advisory committees, Consensus building, Participatory decision-making

Section 3: Framework Validation Scoring Sheet

Guidelines: Please select the relative score for each validation aspect below to represent the extent of satisfaction (1 represents "poor" and 5 represents "excellent"). The brief explanation of each validation aspect is as follows:

- Degree of appropriateness – Framework has included the appropriate strategy
- Degree of objectivity – framework considered all the issues (shortfalls) of public participation
- Degree of replicability – Could be duplicated at another location or time

- Degree of practicability – Capable of being put into practice.
- Overall reliability – Could produce similar results under consistent conditions.
- Overall suitability – Assess framework suitability in South-west Guwahati water supply project.

Sl.	Validation Aspects	Scoring Scale *(Please select the appropriate circle)*				
		Poor				Excellent
		1	2	3	4	5
1	Degree of appropriateness	○	○	○	○	○
2	Degree of objectivity	○	○	○	○	○
3	Degree of replicability	○	○	○	○	○
4	Degree of practicality	○	○	○	○	○
5	Overall reliability	○	○	○	○	○
6	Overall suitability for South-west Guwahati	○	○	○	○	○

INFORMATION OF THE RESPONDENT

Name of the Respondent or Expert:

Name of your organization:

Publications

Journals

1. R. Das, L.B. Singh and M. Jawed, Perception of groundwater quality and health effects on willingness to procure: The Case of upcoming water supply scheme in Guwahati, India. Journal of Cleaner Production (accepted on 9th April, 2019).

2. R. Das, L.B. Singh and M. Jawed, Public participation in planning of urban water supply projects – The case of South-West Guwahati, India. Water Research (under review).

National/International Conferences

1. R. Das, L.B. Singh and M. Jawed, Strategies to ensure efficient operation and maintenance of water treatment plant through PPPs – A case study. *International Conference on Environmentally Sustainable Urban Ecosystems (ENSURE),* Indian Institute of Technology Guwahati, India, February 24-26, 2012.

2. R. Das, L.B. Singh and M. Jawed, Public awareness towards drinking water and acceptability of public private partnership (PPP) in South-West Guwahati – A case study. *Indian Chemical Engineering Congress (CHEMCON),* Panjab University, Chandigarh, India, December 27-30, 2014.

3. R. Das, L.B. Singh and M. Jawed, Drinking water quality status in South-West Guwahati, Assam, India. *A National Conference on New Frontiers in Civil Engineering: Challenges and Opportunities in North-East India,* Royal School of Engineering & Technology Guwahati, India, November 5-6, 2015.

4. R. Das, L.B. Singh and M. Jawed, Increased willingness to pay for safe drinking water: A case study of South-West Guwahati. *30th Indian Engineering Congress,* Pragjyoti-ITA Centre for Performing Arts Machkhowa, Guwahati, India, December 17-20, 2015.

5. R. Das, L.B. Singh and M. Jawed, Public awareness towards fluoride in household groundwater sources of south-west Guwahati, Assam, India. *Indian Chemical Engineering Congress (CHEMCON),* Indian Institute of Technology Guwahati, India, December 27-30, 2015.

6. R. Das, L.B. Singh and M. Jawed, An investigation on public awareness towards drinking water and acceptability of Public Private Partnership (PPP) in South-West Guwahati. *National Conference on Challenges in Environmental Research,* Indian Institute of Technology Guwahati, India, June 4-6, 2015.

7. R. Das, L.B. Singh and M. Jawed, Development of framework for public consultation in a water supply project. *ASCE India Conference,* Indian Institute of Technology Delhi, India, December 12-14, 2017.

8. R. Das, L.B. Singh and M. Jawed, Upcoming water supply scheme at South-West Guwahati – From mass opposition to public acceptance. *World Water Day*, The Institution of Engineers (India), Guwahati, India, March 22, 2019.