Information and awareness as a means to develop water supply systems in rural and peri-urban Bangladesh

Designing the Knowledge module of the TAPP App.

Master Thesis

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Nayantara Thomas

Executive Summary

Safe drinking water for all is a basic human right. Climate change, increasing water scarcity, population growth, demographic changes and urbanization already pose challenges for water supply systems. By 2025, half of the world's population will be living in water-stressed areas (WHO, 2019). Management of all water resources will need to be improved to ensure provision and quality. This project proposes information and awareness as a means to help develop water supply systems in rural and peri-urban Bangladesh. Water is essential to maintain life on earth but as a resource it is not always located and in the state that is ideal for consumption. Often what is accessible is either contaminated, in dispute or not appropriate for its intended use. With regards to water safety, Bangladesh is the country with the largest proportion of people exposed to arsenic contamination around the world.

From the various technologies available, it has been established that Piped Water Supply Systems show a lot of promise in providing safe water to rural and peri-urban communities of Bangladesh. Issues with this new system include lack of trust in the system, high costs, infrastructural and technical issues and operation and maintenance issues. These along with a lack of knowledge on water safety and varied literacy rates are some of the factors that contribute to low acceptance of the system.

Awareness and educational campaigns have had a positive influence on communities regarding their choice of safe water sources. New and effective methods of building awareness through different channels is needed for long term viability of technologies and behaviour change. Approximately 50% of the rural households own and use smart phones with Internet access, and this number is rapidly increasing. This shows scope for monitoring water supply systems and building knowledge with smart phones in order to reach and engage communities.

Uncertainties within the system were identified and information topics under the themes of Water quality, Health, Water practices and Water sources was designed to be communicated to the people of Bangladesh through the TAPP smart phone application, in order to build their knowledge and understanding around the issue of water safety. The long term goals of this project includes acceptance and engagement of Bangladeshi communities towards Piped Water Supply(PWS) systems and to affect the behaviour of people with regards to their choices on consuming safe drinking water. The use of ICT as the communication channel is relatively low cost and has a broad range of possibility to reach the citizens. Looking closely at the user perspective through exploratory research provided key inputs in designing information in formats that can be accessed and understood by everyone in the target group. The impact can be great if the knowledge penetrates within the families, and thus help in changing people's decisions around drinking water.

Preface

When growing up, any ailment I had the solution my mother almost always gave me was to drink water. If I had a headache, “drink water” If I was tired, “drink water”. The importance of water was always something that was known subconsciously but I never stopped to think, where it came from or what it took to have it in the glass that I was holding. On starting this project it highlighted how much I took water for granted. When I moved to the Netherlands from India I could drink the water that came directly from the tap without any worry. This was a new concept to me as in India we bought drinking water at home, it came in large 20 litre plastic cans every week or so. We were able to afford it and were happy with the quality for no other reason than we did not fall sick.

The reality in many parts of the world is almost dystopian in nature. First the problem of access comes into light and even when access is solved often the quality is not sufficient and can lead to irreversible damage. More and more sources of water are getting compromised due to different factors like climate change and pollution. Overpopulation, poverty and other critical issues make it extremely difficult to ensure that everyone has access to safe drinking water. With disparities only increasing, the steps to achieve “safe drinking water for all” won’t be getting any easier. Knowing this has been one of the driving forces to pursue this project and to really understand the complexity behind it all, to see where design could play a role in helping to balance the scales and work for social value and sustainable development.

Project Background

This graduation project is being pursued as part of the Master track, Design for Interaction at the Faculty of Industrial Design Engineering, Delft University of Technology (DUT). The project falls under a larger umbrella called Delft Global Drinking Water, which is a Civil Engineering and Geo sciences faculty research group of TU Delft, and part of the Delft Global Initiative, a university wide organization for the development of technology for all people worldwide.

This thesis is part of the TAPP-BDP project, which is a research project funded by the Dutch Scientific Research organization (NWO). The TAPP-BDP project is led by the Environment and Population Research Centre(EPRC) situated in Dhaka, Bangladesh. DUT and three local partners complement the project consortium. The project is a follow-up of the DELTAP project, whose aim is an integrative approach for Smart Small-scale Piped Water Supply (SPWS) in the Ganges-Brahmaputra-Meghna(GBM) Delta in Bangladesh and India. The TAPP-BDP project hopes to deliver an open-access smart phone application, which will aid communities, local governments, CBOs, NGOs and private water suppliers in end-user inclusive monitoring, operation and maintenance of improved piped water service solutions. The smart-phone application 'TAPP' intends to assist water suppliers and water consumers in rural and peri-urban Bangladesh to manage their Piped Water Supply (PWS) systems. Its functionalities are to include water quality monitoring, service delivery, interaction, payment, and knowledge/information on water safety. Developing the knowledge module, which provides information and raises awareness about several water-related topics, is the focus of my MSc graduation project at Delft University of Technology. It must be noted that the other functionalities of the App will be developed simultaneously by others involved in the project.

Abbreviations

NWO - Netherlands Organisation for Scientific Research

EPRC - Environment and Population Research Centre(

SDG - Sustainable Development Goals

GBM - Ganges - Brahmaputra - Meghna Delta

TAPP-BDP - TAPP Bangladesh Delta Plan

ICT - Information and Communication Technologies

PWS - Piped Water Supply

SPWS - Small-scale Piped Water Supply

DPHE - Department of Public Health Engineering

DUT - Delft University of Technology

IEC - Information and Education communication

WHO - World Health Organisation

UN - United Nations

UNICEF - United Nations Children's Fund

WASH -Water Sanitation and Hygiene

Contents

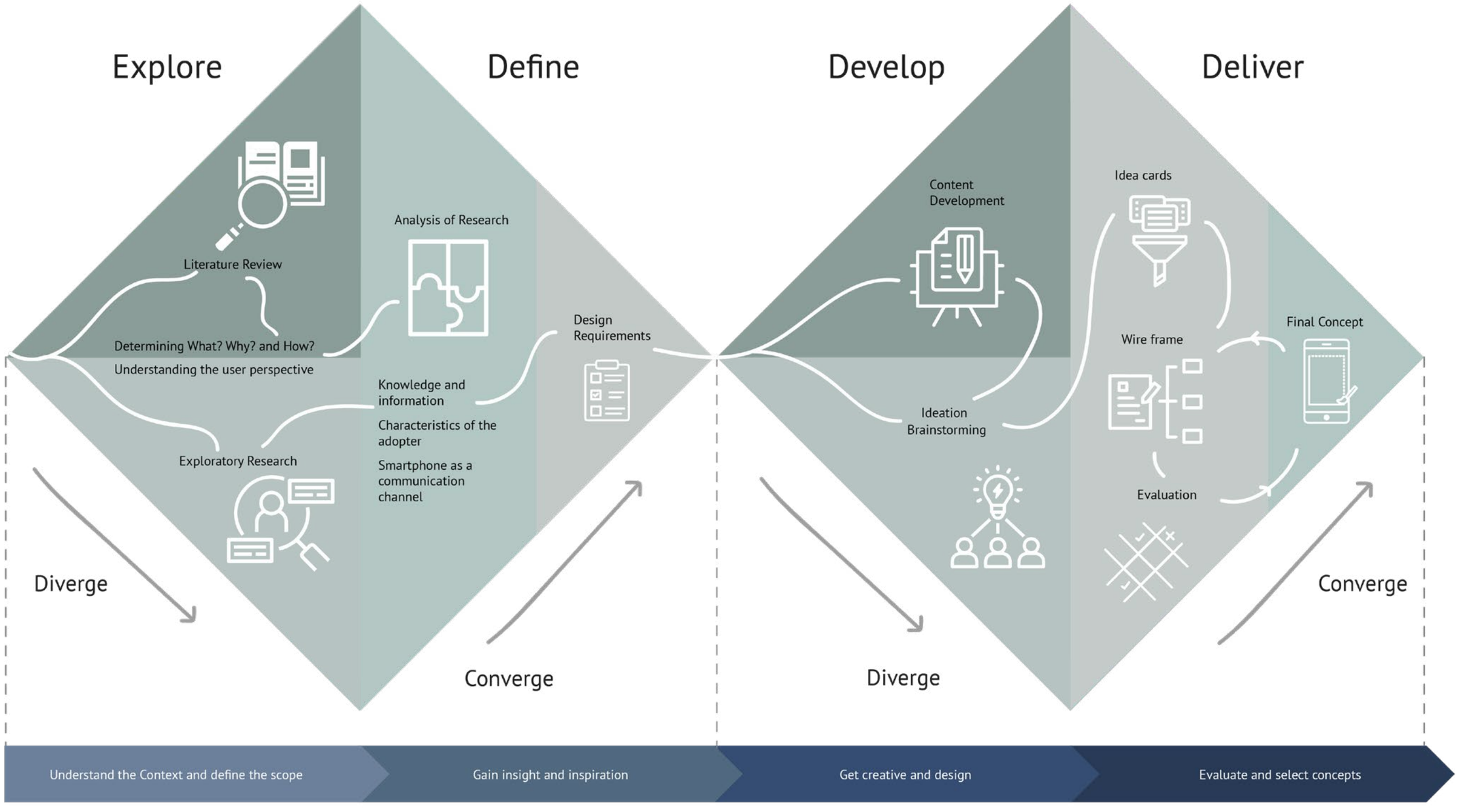
Thesis Structure

The following thesis report is structured into two general phases, the Research phase and the Design phase —these parts are divided into different chapters that will be explained here and by which you will be guided through the report. I start with the Introduction in Chapter 1 - describing the context and the different concepts that are relevant to this project. I cover the topic of safe drinking water, the water scenario in Bangladesh, the role of awareness in developing water supply systems and the use of ICT for sustainable development (chapter 1.1 and 1.2). The conclusions drawn from the preliminary research and context analysis have been used in chapter 2 to define the scope of the project, covering the main research and design questions that were chosen to be answered in the course of this project. The theory diffusion of innovations (Rogers, 2003) was also used as a guideline in developing the short term and long term goals of the project and to identify concepts of the innovation decision process that were relevant to this context(Chapter2.1)

Chapter 3 - consists of the exploratory research that I conducted to get a better understanding of the user perspective and to get more detailed insights into the topics of knowledge and information, characteristics of the target users that are referred to as 'adopters' and attributes of the communication channel which included understanding current smart phone usage. I looked into sub-questions like: What is the current information available to communities on water safety? And: What values do Bangladeshi people place on safe and clean drinking water? General insights were identified (chapter 3.2.1) and water quality, water sources, water practices and health were developed as the themes of the TAPP App knowledge domain (chapter 3.2.2). Analysis of existing communication materials used in awareness campaigns of different Bangladeshi organizations can be found in chapter 3.2.3. Characteristics of the target users were used to form Personas (chapter 3.3.2) and Inspiration was derived from the exploration of existing Apps in Bangladesh and around the world (Chapter 3.4.3), The research phase ends with a list of Design requirements to guide the design phase (chapter 3.6).

The design phase starts with Chapter 4 - which covers the content development of the TAPP App. It includes translating water safety themes of chapter 3.2.2 into information topics (Chapter 4.1.1) and the prioritization of these topics by experts in the field (chapter 4.1.2). It is followed by the outcomes of creative sessions used to generate ideas around ways to communicate information through a smart phone application. 'How-to' questions were used as prompts for brainstorming (Chapter 4.2.1) and n overview of the ideas are shown. Using the design criteria(Chapter 3.6) as a guideline, 10 idea cards with more detailed concepts were created and evaluated ultimately narrowing down to one final concept. Detailing of the App was done in the form of a wire frame and evaluated with a programmer(chapter 4.2.3) . The final design Mock-up was then created highlighting key characteristics and visual attributes of the design interactions (chapter 5.1). This is followed by the conclusion of the project and recommendations.

Design Process



Chapter 1

Introduction

When we think about the fact that 70% of the earth is covered by water, it may be easy to assume that water is abundant and that it would never have to be an issue in terms of having a constant supply to drink. In reality, it is a very complex matter for everyone to be able to access and drink safe water. Water is essential to maintain life on earth but as a resource it is not always located and in the state that is ideal for consumption (Cathy, 2013). “Often what is accessible is either contaminated, in dispute or not appropriate for its intended use” (Michael, 2009, p. 1927).
With population growth, industrialization, climate change and countries already competing over various resources, running out of usable water should be looked at as a priority while avoiding the risk of it being taken for granted (Paul et al., 2019)

In this thesis I will be working towards providing design interventions to mitigate the problems faced by the people of Bangladesh with regards to safe drinking water. The focus will be on helping to build awareness around water safety amongst Bangladeshi communities, through the use of a smart phone application. To define this graduation project, I first zoomed out to grasp a comprehensive view of the water situation and context. The exploration that was done is described in this first chapter. The following parts of this chapter are based on literature reviews done on topics like water safety, the water scenario in Bangladesh, piped water supply, the role of awareness and ICT for sustainable development. It includes insights from academic research, industry reports, Literature surveys, news articles and other relevant sources.

1.1 Safe Drinking water

"The United Nations (UN) General Assembly declared in 2010 that safe and clean drinking-water and sanitation is a human right, essential to the full enjoyment of life and all other human rights."(WHO,2017)

Water safety and Sustainable Development Goals:

According to the World Health Organization (WHO, 2019), whether it be used for drinking, domestic use, food production or recreational purposes, water needs to be safe and readily available in order to maintain public health. The Sustainable Development Goal (SDG) target 6.1 reflects the same sentiment and calls for "universal and equitable access to safe and affordable drinking water." (UNSD- SDG Indicators, 2020) A key aspect of "safe drinking water" is the quality of water, it can be characterized on the basis of physical, chemical and microbiological water parameters, and human health is at risk if values exceed acceptable limits (Akter et al., 2016). Biological or microbial contaminants in drinking water include bacteria, viruses, protozoan, and parasites (EPA, 2016). According to WHO (2012), "the greatest microbial risks are associated with ingestion of water that is contaminated with faeces from humans or animals". Chemical contaminants can be described as elements or compounds that are present in water and may be naturally occurring or man-made. Examples of chemical contaminants include nitrates, bleach, salts, pesticides, metals and metalloids like Arsenic, Iron and Manganese, and toxins produced by bacteria (Ibid) . For chemical contaminants there are limits of what is acceptable for their presence in drinking water. These limits can either be based on health impact, regulatory impact, aesthetic impact and compliance impact. WHO sets guidelines for drinking water quality, but countries also often set their own guidelines.

Water plays a vital role in the environment, socio-economic development and poverty reduction (Cathy, 2013). The way we manage, use and treat water has a significant impact on everything in the system. Judicious use of resources and maintaining the quality of water through the reduction of pollution will ensure that ecosystems are safe and the balance in the water cycle is maintained for future use (How Humans Affect the Water Cycle, 2011).When it comes to accessibility of safe drinking water, globally around 785 million people lack even a basic drinking-water service, including 144 million people who are dependent on surface water and at least 2 billion people around the world use a drinking water source contaminated with faeces (WHO, 2019). It has been predicted that by 2025, half of the world's population will be living in water-stressed areas (Ibid).

Water safety in Bangladesh:

With regards to water safety, Bangladesh is the country with the largest proportion of people exposed to arsenic contamination around the world, the situation of which has been described by the World Health Organisation (2010) as the "largest mass poisoning of a population in history". The presence of manganese, chloride and iron contamination also reduces the quality of drinking water. A third of the water points in Bangladesh has manganese levels above WHO guidelines. Also, more than 41 per cent of people in Bangladesh drink water from sources with faecal contamination (Better Access to Safe Drinking Water, n.d.).

Effects of safe drinking water:

What does it mean to have access to safe drinking water? When water comes from improved and more accessible sources, people spend less time and effort physically collecting it, giving the opportunity to be productive in other ways (WHO, 2019). This can also result in greater personal safety by reducing the need to make long or risky journeys to collect water. Better water sources mean less expenditure on health, as people are less likely to fall ill and incur medical costs, and are better able to remain economically productive. With children particularly at risk from water-related diseases, access to improved sources of water can result in less child deaths under the age of 5 years, better school attendance, with positive longer-term consequences for their lives (WHO, 2019). Access to safe drinking water is directly connected to goal 3 of the SDG—Ensure healthy lives and promote well-being for all at all ages. Statistics revealed by the United Nations (2016) show that inadequate water, sanitation and hygiene is linked to 60 percent of the disease burden from diarrhea, and along with the burden from infection through soil-transmitted helminths and the burden owing to malnutrition, it has led to a total of 870,000 deaths in 2016. This large disease and death burden could be significantly reduced if safely managed drinking water and sanitation services were universally available, and good hygienic practices were followed (UNSD, 2020).

Figure 1 : Infographic of SDG goal 6, Source: https://www.unwater.org/publications/sdg-6-infographics/

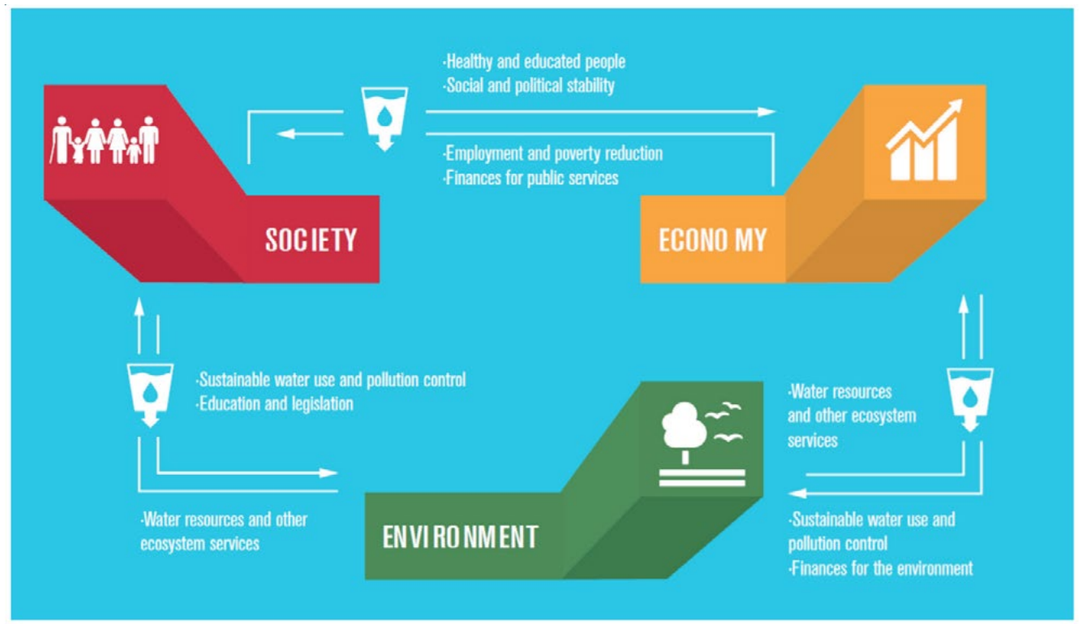


Figure 2: Safe drinking water is connected to all aspects of sustainable development, social, environmental and economical. Source: Water and Sanitation Interlinkages across the 2030 Agenda for Sustainable Development, 2016

1.2 Context

In order to be able to design for communities in Bangladesh it is essential to first know about Bangladesh as a country. As an outsider that has never been there, I resorted to desk research and talking to people from Bangladesh to get a better idea about the geography, the culture, the people and the current state of affairs. I further looked into the context identifying the different aspects surrounding the water scenario in Bangladesh. These aspects included understanding the history of water consumption and use in Bangladesh and the opportunities and problems related to it. Looking at photographs taken during prior research initiatives done s part of the DELTAP project allowed for a better understanding of the environment and helped in visualizing the context better.

Footnote:

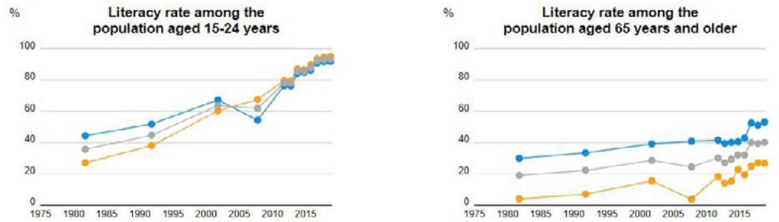
For this thesis, I planned to visit Bangladesh and the TAPP project areas, but unfortunately this became impossible due to travel restrictions as a consequence of the COVID-19 Pandemic.

1.2.1 About Bangladesh

Demography, People, Culture, Geography:

Bangladesh, officially known as the People's Republic of Bangladesh, is located in south Asia and is the eighth-most populous country in the world, with a population exceeding 165 million people (Bangladesh Population, 2020). It is also one of the most densely populated countries that is nestled in between India to the west, north and east, Myanmar to the south- east and the Bay of Bengal to the south. A large portion of the population, 63% as of 2019, are considered to be living in rural areas (World Bank, 2020). Although industrial development has prompted migration to the cities, Bangladesh is one of the least-urbanized areas in South Asia (Husain & Tinker, 2020). The Bengali language, Islamic religion, and rural character of Bangladesh all serve to unify the country's culture to a considerable degree. Although some regional variation occurs across the Bengali community, cultural differences between ethnic, religious, and social minorities and between rural and urban populations are much more salient (Husain & Tinker, 2020).

Large strides have been made in terms of educating the Bangladeshi population. UNESCO's fourth Global Report on Adult Learning and Education (GRALE) showed that about 58 percent of urban and 40 percent of rural males above 60 years of age are literate in Bangladesh, while only 24 percent of urban and 12 percent of rural females over 60 are literate (GRALE 4, 2019). The new report, however, reveals that this disparity between men and women has been addressed in newer generations, with literacy rates at 80 percent and 74 percent among urban and rural boys aged 10-14, while 83 percent among urban and 81 percent among rural girls of the age group (BSS, 2019).



	TOTAL	MALE	FEMALE	
Literacy rate (%)				
15-24 years	93.3	91.8	94.91	(2018)
15 years and older	73.91	76.67	71.18	(2018)
65 years and older	40.12	53.07	26.76	(2018)

Figure 3: Literacy rates amongst different age groups. Source: (UNESCO, 2018)

Figure 4: Photo collage of Bangladesh revealing the environment and surroundings . Photo credits: Annemarie Mink

The geography of Bangladesh is unique in that, some of the biggest rivers flow through the country to form the largest delta in the world (see figure 5). The Ganges-Brahmaputra river system forms in the Bengal Basin a delta of 25,000 square miles. It is therefore quite obvious that this distinctive geography characterises certain physical aspects of Bangladesh (Rashid, 2020). Due to it's geography as well as climate change the country is prone to various natural calamities like floods, droughts and cyclones, and much of the country is routinely inundated during the summer monsoon season (World Bank, 2018).

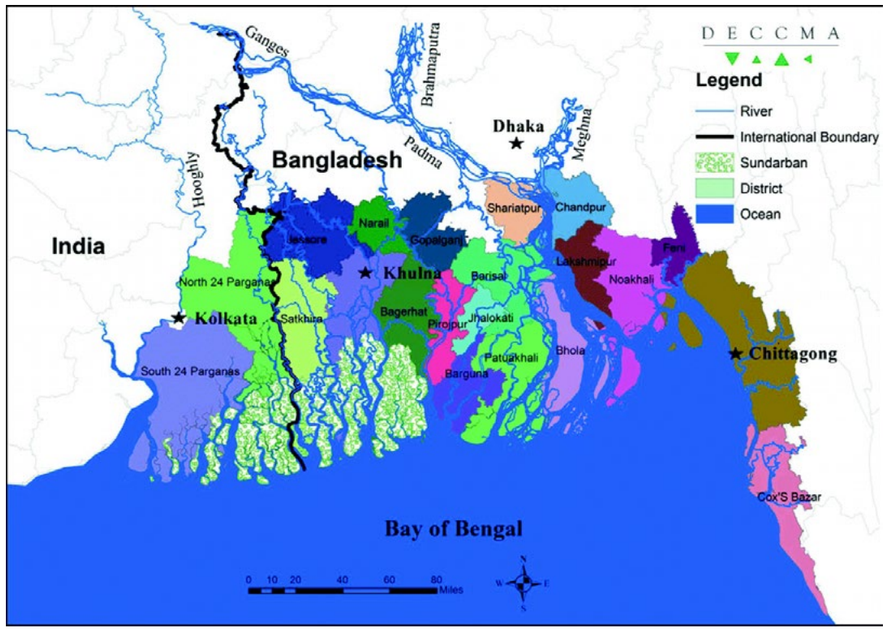


Figure 5: The Ganges-Brahmaputra-Meghna Delta showing the coastal zone with administrative districts in both India and Bangladesh Source: (Rahman et al., 2019, p. 34)

The majority of the population of Bangladesh has access to basic drinking water (98%) and most report access to adequate amounts of water (see figure 6). However, this water is often overwhelmingly (see figure 8) contaminated with E-coli at both the source and household level (A Statistical Snapshot of Status of WASH Bangladesh, 2019). Groundwater is seen to be less bacterially contaminated than surface water. However, research of bacterial contamination at the water source by Ferguson et al (2011) also revealed that the pump itself can act as a persistent reservoir for microbial indicator bacteria, potentially influencing drinking water quality and bias testing of water quality.

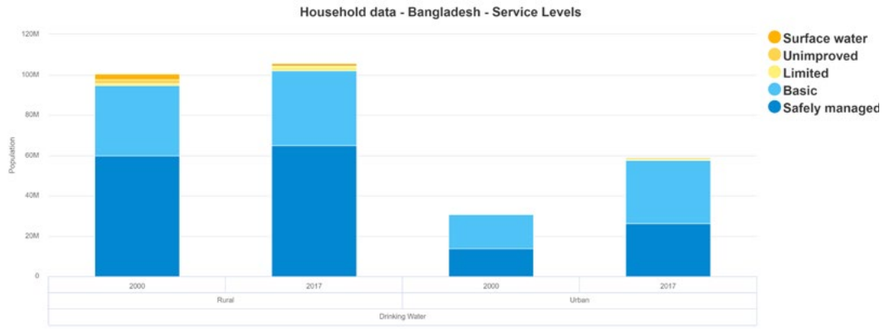


Figure 6: JMP Access and type of water source- rural and Urban Source: https://washdata.org/

Considering a very high population density, the country's propensity towards natural calamities and the large portion of rural areas that make up the country, safe water supply and sanitation services in sufficient quantities is said to be one of the largest challenges that Bangladesh is currently facing (Ndaw, 2016).

Figure 7: Roads inundated by water from the monsoons. Photo credit: Annemarie Mink

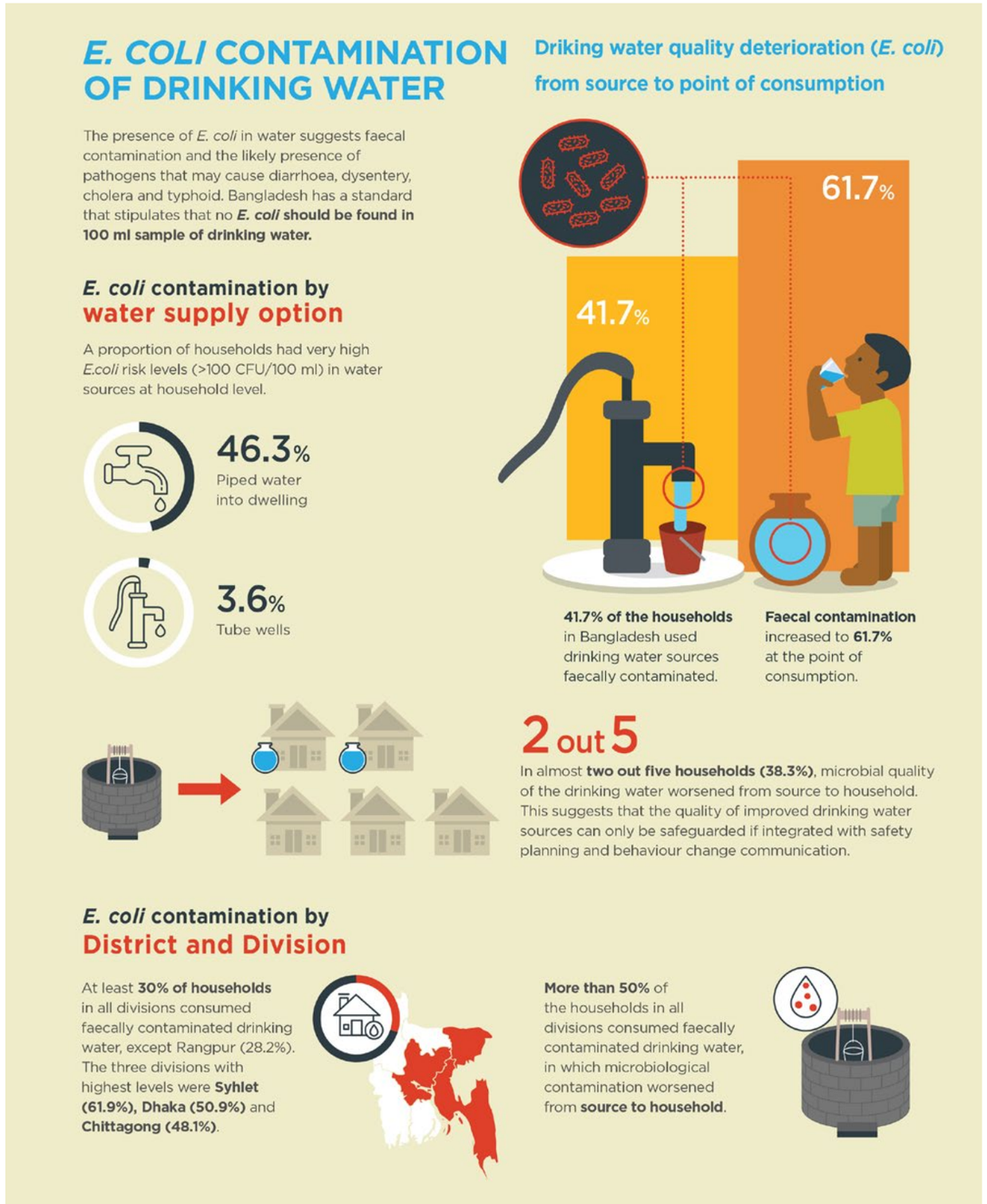


Figure 8 : Infographic on E.coli contamination of drinking water, specific to the Bangladeshi context. Source: https://www.unicef.org/Bangladesh/sites/unicef.org.Bangladesh/files/2018-10/Drinking%20Water%20Quality%20in%20Bangladesh.pdf

1.2.2 Water Scenario in Bangladesh

History of water use:

Historically, surface water sources in Bangladesh have been contaminated with micro-organisms, causing a significant burden of disease and mortality. The presence of E. coli in water suggests faecal contamination and the likely presence of pathogens that may cause diarrhoea, dysentery, cholera and typhoid. The World health organisation as well as Bangladesh has the standard that stipulates that no E. coli should be found in a 100 ml sample of drinking water (UNICEF, 2018).

Supply and use of water in Bangladesh had a major shift in the 1970's from surface water to the use of tube wells in order to prevent pathogen related illnesses being transmitted (Smith et al., 2000). Major steps were taken, the Department of Public Health Engineering (DPHE) along with the United Nations Children's Fund (UNICEF) worked to install tube-wells to provide what was presumably a safe source of drinking-water for the population. These wells consist of tubes that are 5 cm in diameter that are inserted into the ground at depths of usually less than 140 feet. The tubes are then capped with a cast iron or steel hand pump (see figure 9). Studies have revealed that it was not a governmental effort alone that attributed to the success of shifting from surface water to groundwater. Households wanted their own private hand pumps. The Tube well Census revealed that a majority of the hand pumps were privately owned (86%) while 12 % were installed by public authorities and around 1% by NGOs (Caldwell et al., 2003).

The overwhelming acceptance of tube well water has been seen to be because of multiple reasons, the first being access to what was then, safe drinking water. Many also placed great importance on convenience and no longer having to rely on neighbours. Waiting in a row for collecting water at a community tap point was also an issue as well as long walks to surface water / community hand pumps. A study on the gender–water nexus conducted in seven different locations of Bangladesh, found that on average, women spent 2.5 hours a day (about 17 to 18 hours a week) for collecting water for various purposes (Faisal & Kabir, 2005). Women placed more emphasis on convenience and control as they were the ones most involved in the water related activities(collection and decisions) of the household (Caldwell et al., 2003). Now most households in Bangladesh (77%) spend less than 30 minutes each day collecting water; however, women and young girls (90%) are still overwhelmingly responsible for water collection (A Statistical Snapshot of Status of WASH Bangladesh, 2019).

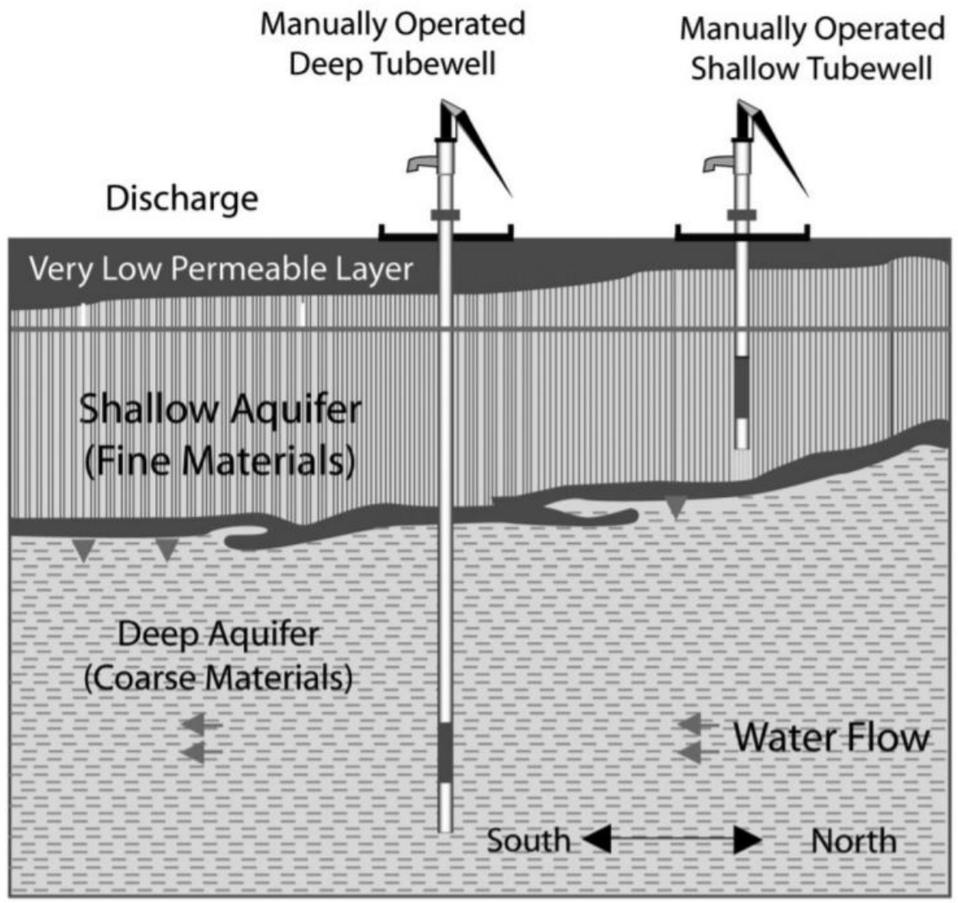


Figure 9: Technical design of deep tube well (.150 m) and shallow hand pump tube well (,45 m). Source: (Ahmed, 2002 D.K. Kundu et al, 2016)

Arsenic contamination in tube-wells:

At the time the tube wells were installed, arsenic was not recognized as a problem in water supplies, and therefore standard water testing procedures did not include tests for arsenic (Smith et al., 2000). In the 1990s it was identified that the very same water that was meant to prevent communities from falling sick is now poisoning them with Arsenic (Mink et al. 2019). Skin diseases and mortality due to various types of cancer are the most occurring consequences of long-term ingestion of high doses of arsenic (see figure 10). Arsenic can occur naturally in groundwater without an anthropogenic source and specifically in the Bengal basin there are strong indications that its occurrence is facilitated by microbial metabolism of organic matter contained in river floodplain and delta deposits (Ahmed et al, 2006). Unlike contamination of drinking-water by pathogens, arsenic does not affect the taste or appearance of drinking-water and, moreover, the health effects from ingesting arsenic-contaminated water appear very slowly(Aziz et al, 2006). The latency period for arsenic-caused skin lesions (i.e., the time from first exposure to manifestation of disease), in particular keratoses, is typically about 10 years (Smith et al., 2000).The World Health Organization (WHO) has set a provisional guideline value of 0.01 mg/l (10 ppb) for total arsenic in drinking water. The Government of Bangladesh has set a provisional water quality standard of 0.05 mg/l (50 ppb) arsenic for drinking water.

Upon its discovery, Arsenic mitigation measures included tube well testing and replacing; usage of deeper wells; surface water preservation and treatment; use of sanitary dug wells, river sand and pond sand filters; rainwater collection and storage; household-scale and large-scale arsenic filtrations; and rural pipeline water supply installation (Milton et al, 2012). Many national and international organizations have also come forward to work on the mitigation of the Arsenic crisis from the beginning of the problem. A lot of research on the clinical, social and safe water technology aspects is being done. Different information, education and communication (IEC) materials including participatory learning materials have been and are being developed by different agencies which are very much important for the mitigation strategy of the arsenic catastrophe in Bangladesh (Rahman et al,. 2007)

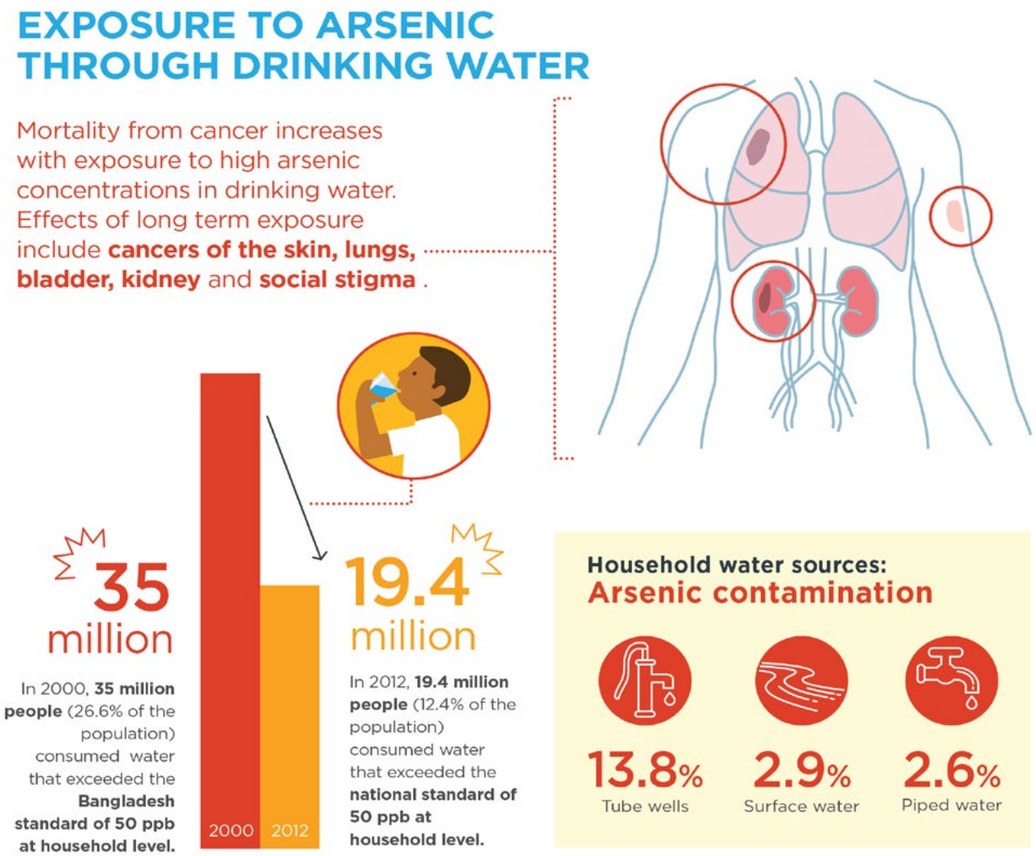


Figure 10: Effects of Arsenic contamination Source: https://www.unicef.org/Bangladesh/sites/unicef.org.Bangladesh/files/2018-10/Drinking%20Water%20Quality%20in%20Bangladesh.pdf

Piped water supply as a potential solution:

On the technological front of mitigating consumption of Arsenic contaminated water, Piped Water Supply (PWS) systems show promise (Ibrahim, 2004). It is considered better in comparison to other technologies like rain water harvesting or deep tube wells (Mink et. Al, 2019). Rainwater harvesting by individual households can provide safe drinking water but there is a large potential for microbial contamination and there are high costs for storage especially in the 8 month dry season in Bangladesh (Ahmed et al, 2006). Deep tube wells are usually ≥ 300 feet deep and require different and more expensive technology (Wu et al., 2011). The Bangladeshi people were used to having a high level of service in water supply. On an average, there was one tube well for 2.5 households (Ibrahim, 2004). As the emergence of arsenic in ground water changed the scenario, piped water supply appears to be a viable option to restore this level of service at a reasonable cost (Ibid). It can be seen that there is an enabling environment to promote the PWS system as communities have indicated wanting the system for its convenience (Mink et. al, 2019). In piped water systems the dirt can be filtered out as well as contaminants that arise from the source like Iron and Arsenic. If a new, dangerous substance is detected in the groundwater, the filter can be adjusted centrally, immediately providing all the households with safe water again. A central system is easier to adjust than the enormous number of hand-pumps, especially ones that are privately owned, which are harder to track. Testing of water becomes more manageable from a centralized system.

Although piped water supply is touted as the solution, higher capital and maintenance costs relative to tube wells is a likely reason for it being seen in more urban and affluent areas (Ahmed et al, 2006). Larger distances between homes, a characteristic common to rural areas, require more piping infrastructure, adding to the cost. In urban areas the return on investment is much higher, as less piping is required to serve a large number of households. Small scale piped water supply shows most promise in rural settings, due to the degree of centralization and the scale allowing for manageability (Mink et. al, 2019). Existing Issues with PWS include trust in the system, costs, long term viability of the technology, infrastructural and technical issues and operation and maintenance issues. These factors lead currently to low acceptance of the system(Ibid). Infrastructural and technical issues include low water pressure, intermittent supply, open tank, improper tank cleaning, chances of microbial contamination due to intermittent supply, breakage and leaking of pipes, illegal tapping (also results in bacterial contamination), reliance on electricity and water going untreated. Furthermore, collection of money from community members has proven to be difficult. Resistance of the population can be expected, as why would they trust – again - a new system, when the former change has now revealed to be a burden.

Figure 11: Water towers installed by different stakeholders(DPHE, EPRC) in Manikganj Khulna districts (2017) Photo credits: Annemarie Mink

The importance of participation and knowledge:

Community involvement in the system is considered essential in order to deal with the supply of safe water, as participation improves acceptance, accessibility, applicability and adoption of technologies and enhances successful implementation and community ownership (Mink et. al, 2019). Attributes like low literacy, resistance to behavioural change and poverty can be constraints in acceptance of choosing a safe water source. In order for communities to adopt the SPWS system as a solution, uncertainties with the system need to be alleviated both from a technical standpoint as well as from an attitudinal and behavioral standpoint.

1.2.3 Role of Information and Awareness

Information and communication activities are a fundamental element of any rural development activity. While education and training help in developing cognitive skills, it is information that gives content to knowledge (Chapman & Slaymaker, 2002). Literature shows that experts in the domain of water safety and access to clean drinking water are seen to be making efforts on the technological front and public education often receives less systematic attention (Hanchett, 2002). Attention should be equally distributed and should occur parallel, as existing efforts on building awareness have shown to have a positive influence on drinking safe water.

A number of agencies and organizations like UNICEF and DPHE have developed public education programmes with various modes of providing information including radio and TV spots. They have produced brochures and detailed communication manuals to be used at a community level. In Srinagar, a subdistrict of Bangladesh, high levels of concern amongst local leaders and the public was created after a mass awareness campaign was conducted through village, courtyard and school level meetings promoting information about the possibility of arsenic contamination and spread, especially because most of the water samples that were tested in the area showed contamination (Hoque et al., 2004).

The discovery of natural arsenic poisoning comes as a shock to society and is frequently met with disbelief and denial (UNICEF, 2018). When analyzing the water scenario in Bangladesh, and looking into what has already been done, the sustainability of arsenic mitigation programmes and other such solutions are said to be dependent on knowledge development on water safety and regular monitoring and maintenance of water systems through community participation (Khan, M.A.S et al, 2016). Managing information, raising knowledge and changing individual behaviours and social norms at all levels is essential to mitigate arsenic contamination risks (UNICEF, 2018).

A study that used retrospective data collected from 16,052 households between November 2006 and June 2007 from the Research and Evaluation Division (RED) of Bangladesh Rural Advancement Committee (BRAC) revealed that willingness to pay for a new and safe source could be attributed to efforts made by NGOs through promotion and campaigning on clean water, hygienic sanitation and raising awareness related to diseases and prevention methods (Chowdhury et al., 2017). “Increased awareness should enhance the social acceptability of new technologies especially ones that may be more costly” (Ahmad et al., 2005). Studies have shown that awareness and educational campaigns have also had a positive influence on communities regarding their choice of safe water sources. Many households have switched to safer sources as their awareness on arsenic increased, however there are many aspects that still prevent them from being able to access safe water, which I will discuss now.

Interventions of testing and painting wells red or green have proven to be short lived due to issues of paint fading and the difficulty in tracking large numbers of hand pumps. It is likely that a single visit to a village, during which the water is tested and the nearest well painted red, will not have a long-term impact on the behaviour of members of the community, particularly if none of the villagers has any signs of arsenic-caused disease (Smith et al., 2000). Habits are difficult to break; often efforts will not be convincing when the villagers look at the clear, clean water which smells and tastes good, and are not able to understand the risk of consuming it. Other attributes that hamper the choice of people include the lack of alternative sources to switch to, inadequate levels or mechanisms of sharing information about test results and fading knowledge (Mink et al, 2019). From a community perspective there is a lack of faith and trust on ‘outsiders’ that come to ‘fix’ the problem as the prior solution is what has led to the access of water contaminated by Arsenic. Follow-up monitoring and education are essential to sustaining the impact of any of the first interventions and to safeguarding the population’s health (Smith et al., 2000). With the water scenario already being quite complex, contamination of drinking-water with arsenic further illustrates the difficulties of community based interventions. Multiple strategies for awareness should be used to complement the communities varied needs and appropriateness (Amin, 2013). Creative and effective ways of communicating information needs to be incorporated into solutions in order for there to be a sustained and long term impact on people.

The findings of a study evaluating the impact of a 1999 campaign by the 18 District Towns Project to educate the public about arsenic problems in six Bangladesh towns, led to certain principles (see table 1 below) on effective public communication (Hanchett, 2002). Although much has changed since then, it would not be in vain to keep some of these principles in mind when looking at providing awareness on water safety.

Principles for effective public communication (from Hanchett, 2002)
• Allowing for people to ask questions is essential especially for those who cannot read. • Take people’s preferences into account (beliefs of taste of water and freshness) • Repetition is important as memory and motivation fade with time. • Continue to educate children about serious health risks, which includes surface water and groundwater. • Children can be family or community change agents. • Educational programmes need to be monitored for their effectiveness.

Table 1: principles for effective public communication(Hanchett, 2002)

1.2.4 ICT for Sustainable Development

ICTs are a particularly important opportunity for smart water management, facilitating the measurement and monitoring of water supplies as well as necessary interventions, and enabling practitioners at the local level to ensure the equitable and sustainable extension of water, sanitation and hygiene (WASH) services. As the costs of ICTs continue to fall, governments will be able to better integrate ICTs into monitoring and evaluation frameworks to optimize operations and improve the quality of service (Goal 6. Water & Sanitation, n.d.). The list of ICT components is exhaustive, and it continues to grow. Some components, such as computers and telephones, have existed for decades. Others, such as smartphones, digital TVs and robots, are more recent entries (Rouse, 2019).

Approximately 50% of the rural households in Bangladesh own and use smart phones with Internet access, and this number is rapidly increasing (Mink et al,.2019). Results from a report based on nationally representative surveys of households and individuals conducted by Dirsi, Lirneasia and research ICT Africa (2018) show that in Bangladesh, 89% of people who fall in the category of above average income own a mobile phone while 73% in the below average income and 54% of people in the zero income categories own mobile phones (see figure 12). The same report also highlights the difference in the type of phone that people own in both Urban and Rural areas. The phone type is categorized as basic phone, feature phone and smart phone. Figure. 12, shows that urban areas have a marginally higher ownership percentage of smart phones (27%) while in rural areas it is 22%. With the vision of the Government to make Bangladesh Digital by 2021 numbers will continue to rise in the coming years. This shows scope for monitoring water supply systems and providing awareness with smart phones in order to engage and empower communities(Mink et al,.2019).

There is a new emphasis on the acquisition of information and enabling the rural poor to request information specific to their particular livelihood needs (Chapman & Slaymaker, 2002). Communication specialists increasingly recognise the enormous potential of ICTs to support and enhance these changes. Increased connectivity that comes from the use of phones have been seen to help timely disaster management (Bayes, 2019). Using a smart phone as a communication channel for awareness building comes with various advantages apart from the obvious increase in connectivity amongst users. An interview that I conducted with the Director of MAX Foundation in Bangladesh, a Dutch organisation providing safe water supply systems, shed light on certain drawbacks faced with current awareness communication. It was discussed that local organisations and NGOs are often reliant on larger international agencies in terms of resources and funds for campaigns. Further insights from this interview can be found in Appendix E. Having digital communication material is seen to be more cost effective and can

be sustained over a longer period of time especially in areas with less-developed infrastructure or suffering from natural disasters flushing the infrastructure away. From the perspective of water suppliers, Information transparency can be achieved as they have a direct connect to users through ICT. Some of the Key advantages of the mobile phone include affordability, wide ownership, voice communications, and instant and convenient service delivery (Qiang et al, 2012). Further, the multimedia nature of mobile devices allows for illiterate users to gather and share information in ways that traditional text-based media would prevent due to their support of audio and visual media (Dew et al., 2013).

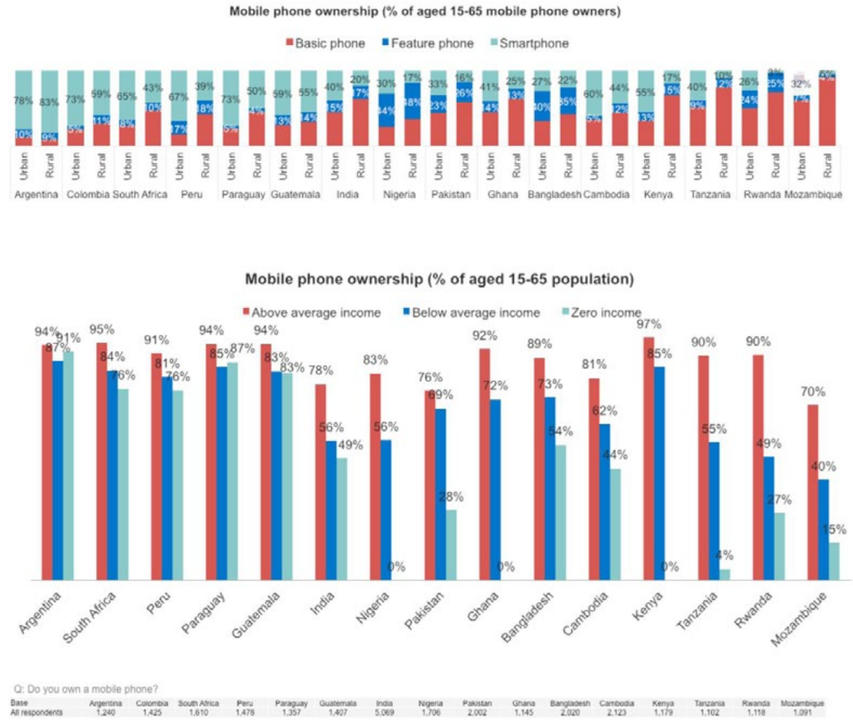


Figure 12: Mobile phone ownership based on type of phone as well as income level. Source: https://www.unicef.org/Bangladesh/sites/unicef.org.Bangladesh/files/2018-10/Drinking%20Water%20Quality%20in%20Bangladesh.pdf

The flip side of the coin must also be looked at in order to understand the potential as well as the drawbacks of using a smart phone application to help in maintaining water systems in Bangladesh. With regards to providing information to help build awareness through a smart phone, issues like legitimacy and trust play an important role. In the era of digital misinformation, users have to be able to trust the sources of their information, and this becomes all the more important when using digital channels, which are often impersonal or attempt to reach a wide variety of audiences at once (Baptista et al., 2020). ICT is seen to provide new opportunities but it is not always inclusive to all. Those who are literate, have a good education and adequate resources are more likely to directly benefit . Factors like gender equality must also be kept in mind when looking at ICT as a means to provide awareness on water safety. Women are less likely to be mobile phone owners and Internet users than men globally and this trend is especially pronounced in Bangladesh where 58% of women vs. 87% of men own mobile phones and 7% of women vs. 18% of men use the Internet (K4D, 2019). It is also worth mentioning that ownership of a mobile or smart phone is not the only factor to look into. Access and usage of Internet can be seen as a challenge. It has been reported by Senior analyst Mike Rogers in the GSMA report (2018), that Bangladesh has a predominantly 2G mobile market, and faces a significant digital divide where only one in five Bangladeshis subscribed to mobile Internet services in 2017, despite 3G networks covering in excess of 90% of the population. Unavailability of proper Internet services can hinder ICT based solutions for sustainable development. While network coverage remains a barrier to access, particularly in rural and remote areas of the country, coverage by itself does not guarantee access. The enablers critical to creating the right conditions for mobile Internet connectivity to flourish rank low in Bangladesh, despite the progress made in recent years (GSMA, 2018).

Keeping both, potentials and pitfalls in mind further inspiration can be derived from various other sectors making use of ICT in recent years. It can be seen that there is a growing trend of Smart phone Apps for health promotion, disease management and lifestyle, which are becoming the globally accessible platforms for client's health needs (Sagar & Pattanayak, 2015, p. 1). The dynamic growth of mobile communications technology is creating opportunities for economic growth, social empowerment, and grassroots innovation in developing countries. One of the areas where there has been great impact is in the contribution that mobile applications have made to agricultural and rural development (ARD), by providing access to information, markets, and services to millions of rural inhabitants (Qiang et al, 2012).

1.3 Conclusion

"In the arsenic-contaminated Ganges-Brahmaputra-Meghna Delta in India and Bangladesh, small scale piped water supply seems a promising way to provide safe drinking water to households in the region. The use of smart-phone applications can support monitoring of the system and enhance local engagement and empowerment"(Mink et. Al, 2019)

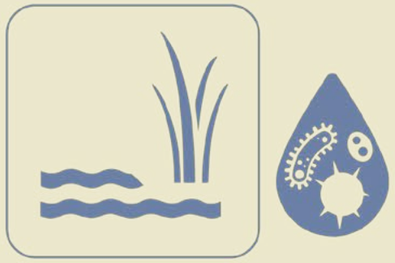
The people of Bangladesh have already transitioned once from drinking surface water to drinking ground water in order to avoid the consequences of bacterial contamination. Over time it was established that the groundwater that they have switched to, is contaminated with high levels of Arsenic, a chemical substance that is tasteless, odourless, colourless and most often shows effects on a person's health only over time. With a new transition in mind, Government organizations along with NGOs have taken it upon themselves to provide a suitable system for the Bangladeshi people that will give them access to safe drinking water. From the various technologies available, it has been established that Piped Water Supply Systems show a lot of promise. In a rural setting due to the distances between houses, costs for Piped Water Supply are higher and Small-Scale Piped Water Supply (SPWS) allows for similar benefits at a more manageable scale. Resistance to the new system is expected as the previous transition did not pay off. Issues with the new system include lack of trust in the system, high costs, infrastructural and technical issues and operation and maintenance issues. These along with a lack of knowledge on water safety and low literacy rates are some of the factors that contribute to low acceptance of the system. Studies have shown that awareness and educational campaigns have had a positive influence on communities regarding their choice of safe water sources. It has also been established that community participation is key to long term viability of the SPWS system. New and effective methods of building awareness through different channels is needed for long term impact and behaviour change. Approximately 50% of the rural households own and use smart phones with Internet access, and this number is rapidly increasing. This shows scope for monitoring water supply systems and building knowledge with smart phones in order to reach and engage communities.

BANGLADESH

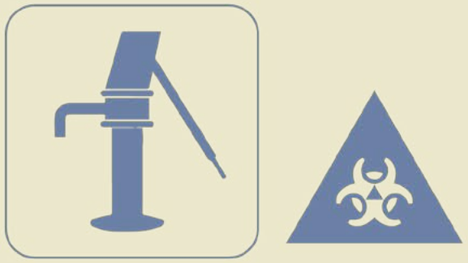
Water Scenario & Solution space

Unsafe water situation and poor sanitation facilities in Bangladesh accounts for estimated three-quarters of all Disease burden.

In rural areas, 97% of the population relies on tube-wells installed since the 1970's to reduce disease from ingestion of pathogen-laden surface water.



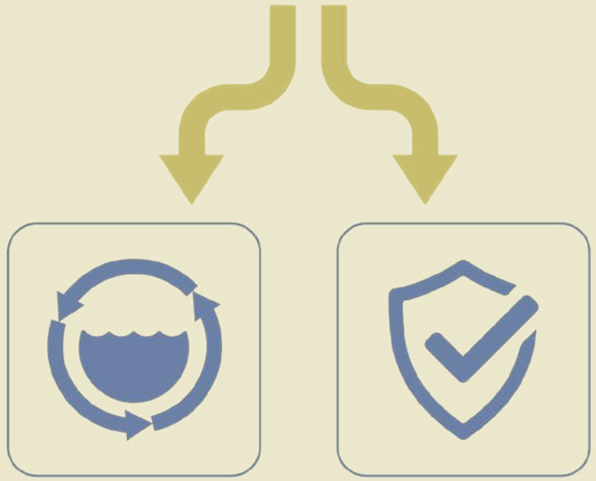
Use of surface water



Use of shallow tube wells

Analysis of data on screening of tube wells shows that there are many villages where almost all water sources are arsenic contaminated. About 8000 villages have been found where Arsenic contamination rate is more than 80%.

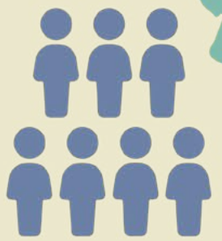
Arsenic mitigation plans



Treatment of contaminated water

Alternate safe sources of water

Many national and international organizations have come forward to work on the mitigation of the Arsenic crisis in Bangladesh from the beginning of the problem. A lot of research on the clinical, social and safe water technology aspects is being done.



Provide safe water through Piped Water Supply

In the arsenic-contaminated GBM Delta in India and Bangladesh, small-scale piped water supply seems a promising way to provide safe drinking water to households in the region

Build Trust and Awareness towards the system through proper dissemination of knowledge and information on water safety

Increased awareness should enhance the social acceptability of new technologies especially ones that may be more costly

In these areas, the use of smart phones and Internet access are growing rapidly and smart phone applications would enable real-time water quality monitoring, payment of water bills, awareness creation and a dialogue between the end user and the water supplier.

Use of smart phone application to monitor system and empower community

Effectiveness of awareness campaigns in Bangladesh suffers from low demand, resistance to behavioural change, poverty, low literacy and other constraints

Experience with these new systems is limited, costs of the system might be an issue and it will take time before these systems are fully realised in the country

Up take of the new system by end users

Chapter 2

Project Scope

The topics covered in Chapter 1 included findings from desk research and literature that demanded a divergent outlook to amass information regarding the water scenario in Bangladesh as well as other relevant ideas related to it. Determining what falls under the purview of this project involves convergence of opportunities from the preliminary research into routes for further discovery and design that are most relevant and feasible within the given amount of time. There are a variety of problems with regards to providing access to safe water that have been discussed in literature. Some of these problems can be tackled through cost effective methods whereas others require very expensive and extensive interventions. This chapter is dedicated to defining the solution space that this project will fall under and which are the most feasible issues to be tackled by design. The chapter discusses findings from the theory, Diffusion of innovations (Rogers, 1983) that help to guide the project and determine the research questions and Design Goal.

2.1 Adoption of Innovations

It can be useful to look at theories that help to explain certain themes or aspects of this project. Drawing parallels from a theory can give insights into what is known around certain phenomena and give way to exploring what is yet to be understood. Rogers (1983) posits in his theory, Diffusion of innovations, that diffusion is the process by which an innovation is communicated through certain channels, over time among the members of a social system and in order for an innovation to be accepted, an individual (or other decision-making unit) passes from first knowledge of an innovation, to forming an attitude toward the innovation, to a decision to adopt or reject, to implementation of the new idea, and to confirmation of this decision. These steps collectively form the innovation decision process (see figure 13).
When related to the water safety context in Bangladesh, it reveals that knowledge and awareness development is an essential first step towards determining if an innovation will be adopted.

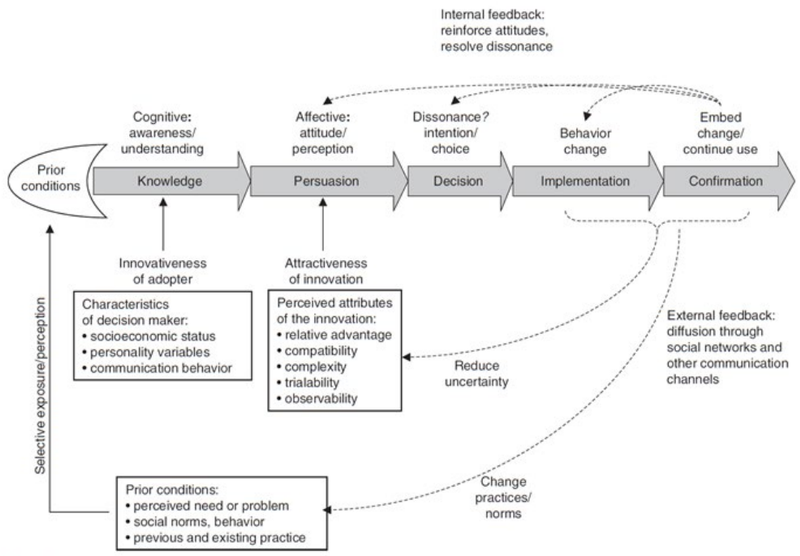


Figure 13: The Innovation Decision Process, source: Rogers (1983)

An innovation in this context can be looked at as multiple ideas to be adopted rather than a single entity or technology. In an ideal scenario the PWS system would supply clean and safe water to all households in a community and members of each household would adopt this innovation for their water needs. As it is a complex system it requires multiple ideas to be adopted simultaneously in order to achieve the desired behaviour change of community members. With the different types of contaminants, the different sources of water that are available, the different points at which contamination can occur and the existing norms, behaviours and practices all having an impact on adopting the innovation it requires a group of ideas to be promoted. “Some change agencies promote a cluster or package of innovations because they find that the innovations are thus adopted more rapidly.”(Rogers, 1983). When we zoom into the he model (see figure 14) it an be seen that the first step towards adopting an innovation is knowledge. Rogers (1983) states that this stage is the process that occurs when an individual (or other decision-making unit) is exposed to the innovation’s existence and gains some understanding of how it functions. At the knowledge stage an individual mainly seeks ‘software information’ that is embodied in a technological innovation. Software information within this theory is described as information that reduces uncertainty about the cause-effect relationships that are involved in the innovation’s capacity to solve a problem. It is suggested that Mass-media channels can effectively transmit such software information.

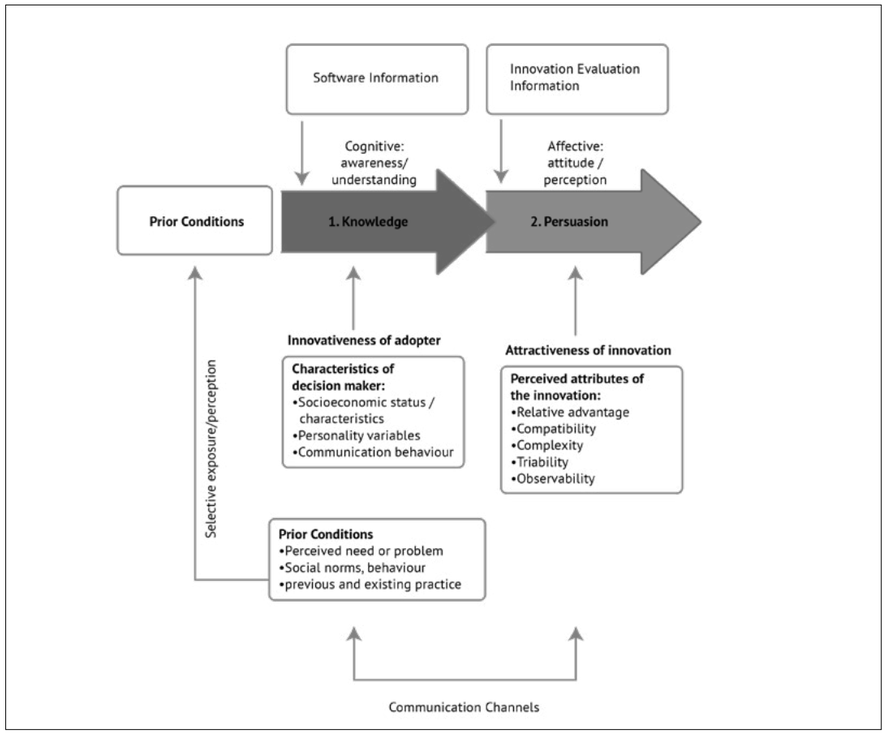


Figure 14: Zoomed in look at the Innovation Decision process

Following the first step of knowledge is persuasion (figure 6), this occurs when an individual (or other decision-making unit) forms a favorable or unfavorable attitude towards the innovation. Increasingly at the persuasion stage, and especially at the decision stage, an individual seeks innovation-evaluation information in order to reduce uncertainty about an innovation's expected consequences. Here an individual wants to know the innovation's advantages and disadvantages in his or her own situation. Interpersonal networks with near-peers are particularly able to carry such evaluative information about an innovation (Rogers, 1983).

Having identified the importance of information and awareness within the water supply system from the preliminary research (Chapter 1.2.3), a parallel can be drawn to what the innovation decision process theorizes. The knowledge stage is a cognitive stage where individuals seek information to gain an understanding and awareness around a problem. Determining what information is required within this knowledge phase and how it can be communicated could be a determining factor in people choosing a safe water source and in turn maintaining public health. The types of knowledge within this stage are as follows:

1. Awareness Knowledge : Consists of information that allows for the users to be aware of the existence of the innovation and it motivates an individual to seek "how-to" knowledge and principle Knowledge

2. How-to Knowledge: Consists of information necessary to use the innovation properly. The adopter must understand how to use it etc. If adequate how -to knowledge is not obtained prior to the trial and adoption, rejection/discontinuance is a likely result.

3. Principle knowledge: Consists of information dealing with the functioning principles underlying how the innovation works. The long range competence of individuals to judge future innovations is facilitated by principle know-how.

Figure 15: Visual representation of the types of Knowledge based on E.M. Rogers theory of diffusion of innovations(1983)

The model also discusses factors that affect the stages of the innovation decision process. Often individuals may know about an Idea but do not regard it as relevant to their situation or potentially useful. Individuals attitudes and beliefs about an innovation have a significant impact on their passage through the innovation decision process. Similarly, prior conditions , innovativeness of the adopter, and attractiveness of the innovation all impact the different stages in different ways. The environment, cultural context, upbringing and values as well as the perceived need for an innovation are all important aspects to whether or not an innovation gets adopted and at what rate.

These concepts helped to scope the project and determine what aspects were relevant to be researched further. Using the Model(see figure 13) as a guideline I determined the short term and long term goals of this project which can be seen in the following figure(16) . Furthermore, it highlights the change agents, the adopter, the context, the innovation(idea) and the communication channel that are specific to this project.

2.2 Purpose Statement

The purpose of this study is to build awareness on water safety among rural and peri-urban communities in Bangladesh through the use of a smart phone application. At this stage in the research, awareness will be generally defined as communicating and delivering information to the targeted users in order to build knowledge and understanding towards the issue of water safety. The primary focus in providing awareness on water safety would be to encourage the use of (Small-scale) piped water supply systems as a source of drinking water.

THE INNOVATION-DECISION PROCESS is essentially an information-seeking and information-processing activity in which the individual is motivated to reduce uncertainty about the advantages and disadvantages of the innovation. It is the process through which an individual (or other decision-making unit) passes from first knowledge of an innovation, to forming an attitude toward the innovation, to a decision to adopt or reject, to implementation of the new idea, and to confirmation of this decision.

RQ1 What types of information needs to be provided to build awareness on water safety for rural communities in Bangladesh?

RQ2 Which existing and envisioned possibilities are there to provide information on water safety through an app?"

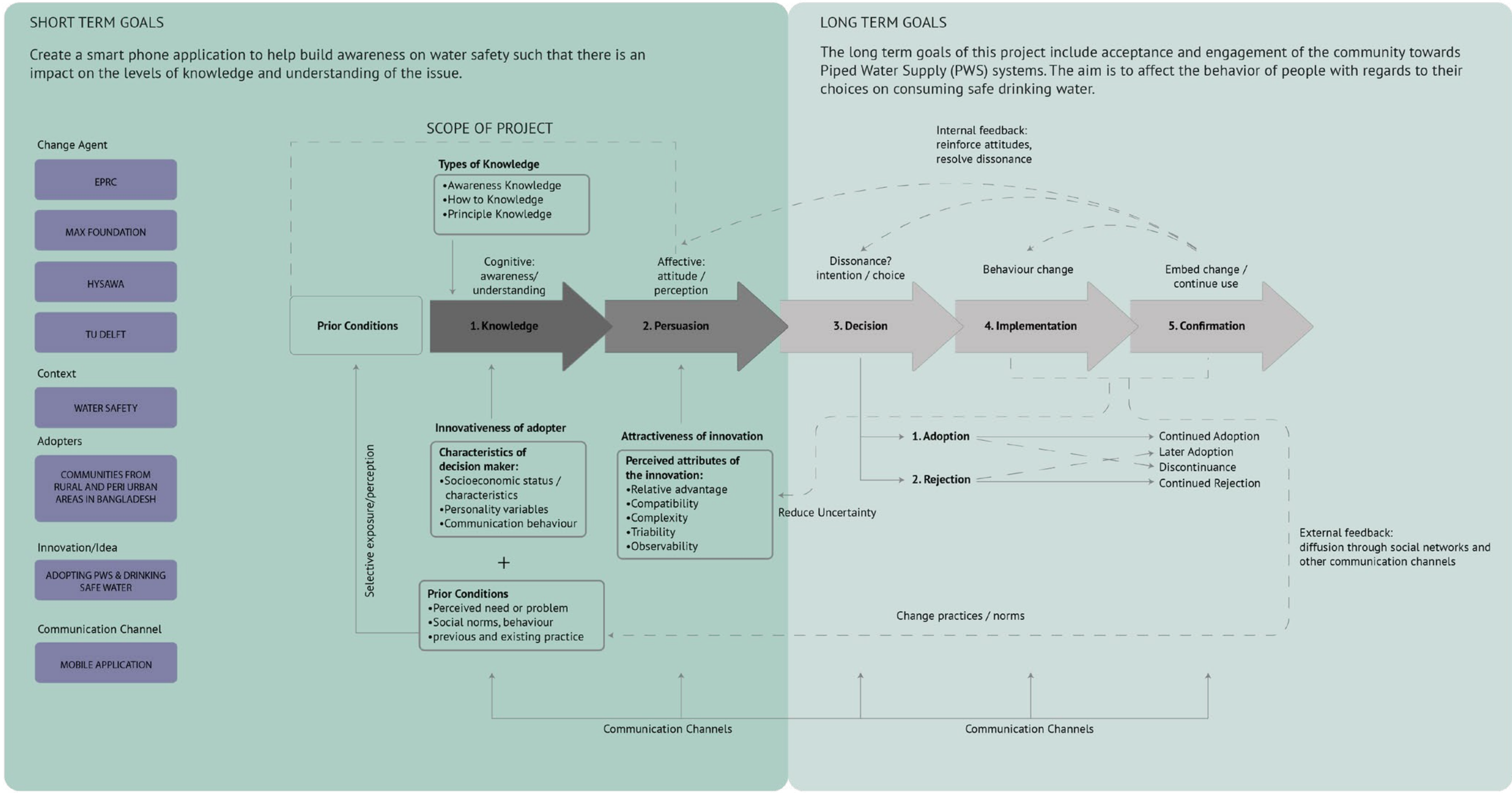
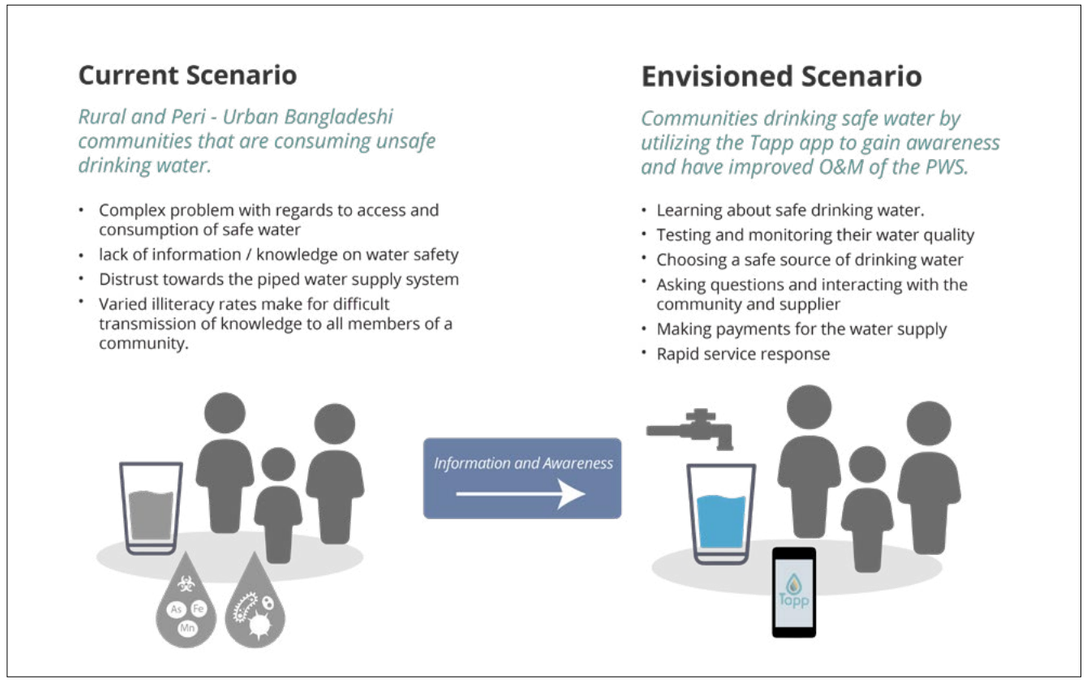


Figure 16: Adapted model of the Innovation decision process based on E.M. Rogers theory of diffusion of innovations(1983)



2.3 Design Goal

Provide **Information** through a **smart-phone application** to help **build awareness on water safety** such that there is an impact on the **levels of knowledge and understanding** of the issue.

The long term goals:

The impact of this project includes acceptance and engagement of Bangladeshi communities towards Piped Water Supply(PWS) systems and to affect the behaviour of people with regards to their choices on consuming safe drinking water.

Target group:

The Target Group chosen for the project has been generalised to include households from peri urban and rural communities of Bangladesh, as a whole.

Research and Design Questions:

1. **Which information needs to be provided to build awareness on water safety for Rural and Peri-urban communities in Bangladesh?**

Sub-questions:

- What is the current information available to communities on water safety?
- What are the current behaviours and beliefs of community members and existing norms and values surrounding water safety?

2. **Which existing and envisioned possibilities are there to provide information on water safety through an App?**

Sub-questions:

- What are the current sources of information on water safety?
- What is the existing scenario around smart-phone usage in rural and peri-urban Bangladesh amongst the target group?
- What are the successes and failures of existing information Apps around the world?
- What are the attributes and needs that define the target group with regards to water safety and smart phone usage?

Chapter 3

Exploratory Research

In my context analysis(chapter 1.2), I got an overview of the water scenario and was able to determine the solution space for this project. Before moving on to ideating interaction concepts towards building awareness on water safety, it was important to further explore the Research questions and sub-questions that arose while determining the scope of the project. This chapter covers my exploratory investigation through the review of secondary data, literature and desk research, and primary data collected from the field.

3.1 Research Activities

Learning from literature and desk research:

A lot of research has been done in the area of water safety and reading industry reports from organisations like WHO and UNICEF was essential to give me a basic overview of the technical know-how surrounding water safety. Desk research helped to understand the standard guidelines that have been developed around the world. Existing awareness and educational programmes gave insight into developing communication material and understanding information strategies related to behaviour change.

Learning from secondary data:

The TAPP App has been the result of two years of extensive research within the DELTAP project which helped to determine the App functionalities, requirements and possibilities. A Joint Master's Programme(JMP) student team from the Industrial Design faculty of TU Delft, developed the first prototype of the TAPP App and contributed to the existing research done on the project. Their main focus was on context research where they went into the field and conducted user research activities, focus group sessions and interviews with communities in Manikganj and Narail in Bangladesh. Transcripts from these interviews were analysed and helped to build an understanding of the user perspective. Furthermore, the DELTAP project did follow up research a year later in the district of Rajshahi based on new insights that were identified. This data also contributed to key insights for my project. The interview transcripts had relevant qualitative data from which statement cards(see figure 17) were created and helped to form clusters and themes.

Collecting primary data:

In collaboration with researchers of the DELTAP project, I co-developed a telephone-based interview (Appendix-) to collect additional information from one of the project areas of the TAPP research project (Faridpur) districts of Bangladesh. The survey was conducted in two parts with each participant. Part 1 included questions covering Socio economic /general information, Technology, Information and communication. Part 2 included questions on Water quality, and the Piped water supply system.

The findings from these activities were guided by the research questions developed in Chapter 2 and they were categorised into three main areas of exploration that can be seen in figure(18).

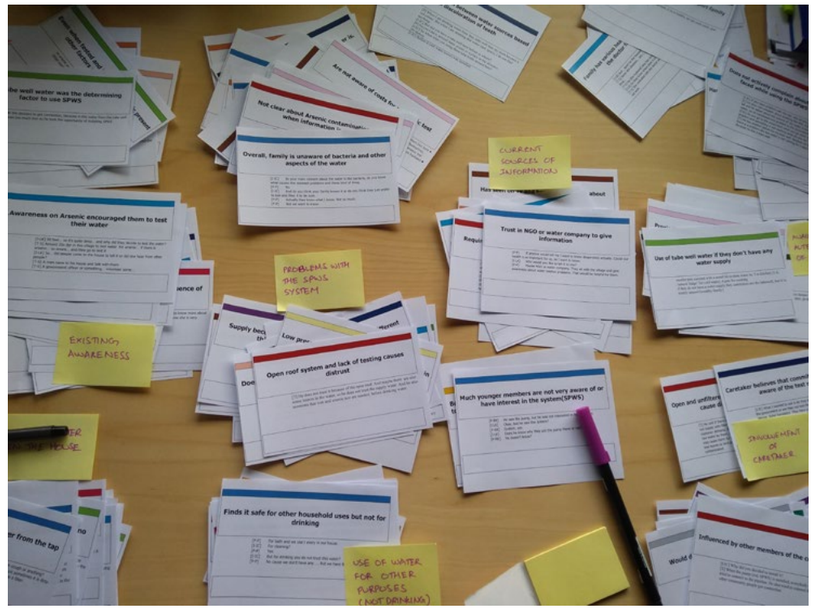


Figure 17: Statement cards made to analyse secondary data.

Figure 18: Three main areas of research that were explored .

3.2 Knowledge and Information

Research was done to answer the following sub questions:

- What is the current information available to communities on water safety?
- What are the current sources of information on water safety?
- What are the current behaviours and beliefs of community members and existing norms and values surrounding water safety?

3.2.1 General insights

- Existing knowledge on water include , awareness about arsenic contamination, differences between tube well and Piped water, Red and green demarcation for safe and unsafe sources, presence of Iron in water and it's connection with arsenic.
- Health consequences of bacterial contamination like diarrhea is well known.
- Water safety information is important to the people in the community so that they can make the choice of which source to use.
- They have indicated wanting to know about health consequences of contaminated water and preventive measures that can be taken within the house.
- There is a lack of general information towards the quality of their own water sources, causes of illnesses, and what needs to be done/can be done at the household level to maintain quality of water.
- Current sources of information for people include NGOs, Government organizations, Doctors, Books, television, radio, and newspapers. Also Internet through their smart phones, elderly, village leaders, religious leaders, car announcements, posters.
- There is a lack of information on testing. People are not aware of when the last tests were done or if they were done at all. The actual results of testing are not known. Water quality Information about their specific water sources are also not always known.
- There is a strong sense of community, where people are willing to trust information coming from the people they know and alternatively they would like to share what they find out with the rest of the community.

Figure 19: Graph of data from telephonic interviews showing top 3 wishes for drinking water.

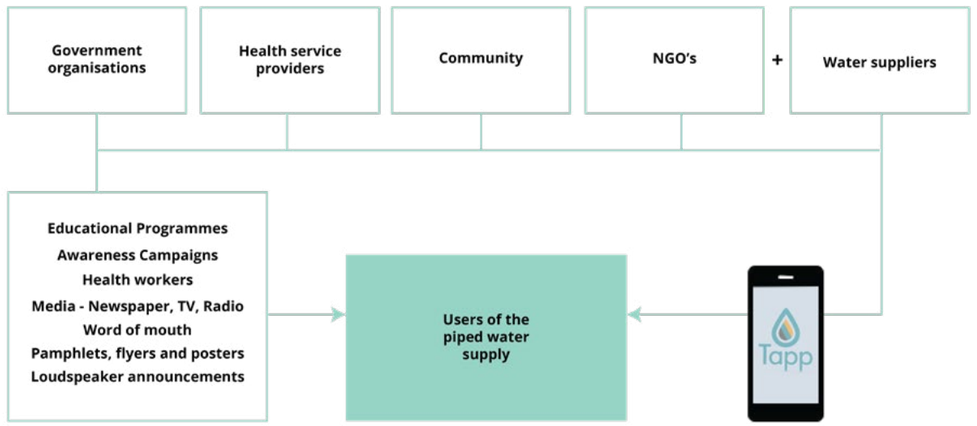


Figure 20: Consolidated model to show how users currently receive water safety information and the addition of the TAPP App as a communication channel.

3.2.2 Themes under water safety

With regards to drinking water and water safety there are various aspects to keep in mind. Water can get contaminated through various different ways. If groundwater contains high levels of chemical contaminants like Arsenic, Manganese and chloride, or if water is exposed to microorganisms then it is considered to be contaminated. Dumping of waste pollutes surface water. Water can also be contaminated if the water supply system is not operated properly and/or the distribution line is faulty or leaking. If regular operation and maintenance is not carried out water can get contaminated. In addition, poor hygiene practices during the collection, transportation, storage and use of water can lead to recontamination. This section looks deeper into the themes of water quality, water sources, water practices and health with regards to the user perspective.

Water quality:

Water quality in this project refers to the condition of water, including chemical, physical, and biological characteristics, with respect to its suitability for drinking. Contaminants that affect drinking water quality in Bangladesh include Iron, Salinity, Bacteria and Arsenic. This project looks into Arsenic and Bacterial contamination specifically. Many people would assume that clear and transparent water is safe. This notion is not always true as harmful microorganisms, which are generally too small to be seen by the human eye may be present in the water. Apart from this there are also Chemical contaminants like Arsenic that you cannot see, smell or taste in water. The lack of visual indicators from different contaminants can give a sense of false security when it comes to water quality.

Key insights:

- **Taste of water affects the choice of water sources. The Tube well water is considered to have a 'sweeter taste'. Also the temperature of the water plays an important role. In a water tank the water heats up while if directly pumped from the ground through a hand pump, it remains cold.**
- **People want to maintain "freshness" of water. (meaning without dirt)**
- **There is the belief that clean water is water without dirt. If there is dirt in the water it is either filtered or not deemed fit for drinking.**
- **It is easier for people to identify Iron in the water as Iron can be tasted, smelled and seen in the water, while arsenic cannot.**
- **The red colour in the water is an association with Iron and sometimes even arsenic. Even though arsenic is colourless, tasteless and without smell. This could be because iron and arsenic often co-occur (if there is arsenic in the groundwater there is always iron in the groundwater, if there is iron in the groundwater there is not always arsenic in the groundwater).**

Water sources:

Generally water comes from three different sources: surface water, groundwater and rainwater. Water is then collected from these sources through various technologies. Water can be extracted from the ground using various different technologies liked Piped water supply, deep/shallow tube well. ringwell/dug- well etc. Surface water and rain water sources can be collected through various technologies like Piped water supply, rain water harvesting systems, Pond sand filters and gravity flow system to name a few. Water sources in this project refers to where the water comes from, like groundwater or surface water as well as how the water is supplied. This project focuses on piped water supply and other sources that are used for drinking water.

Key insights:

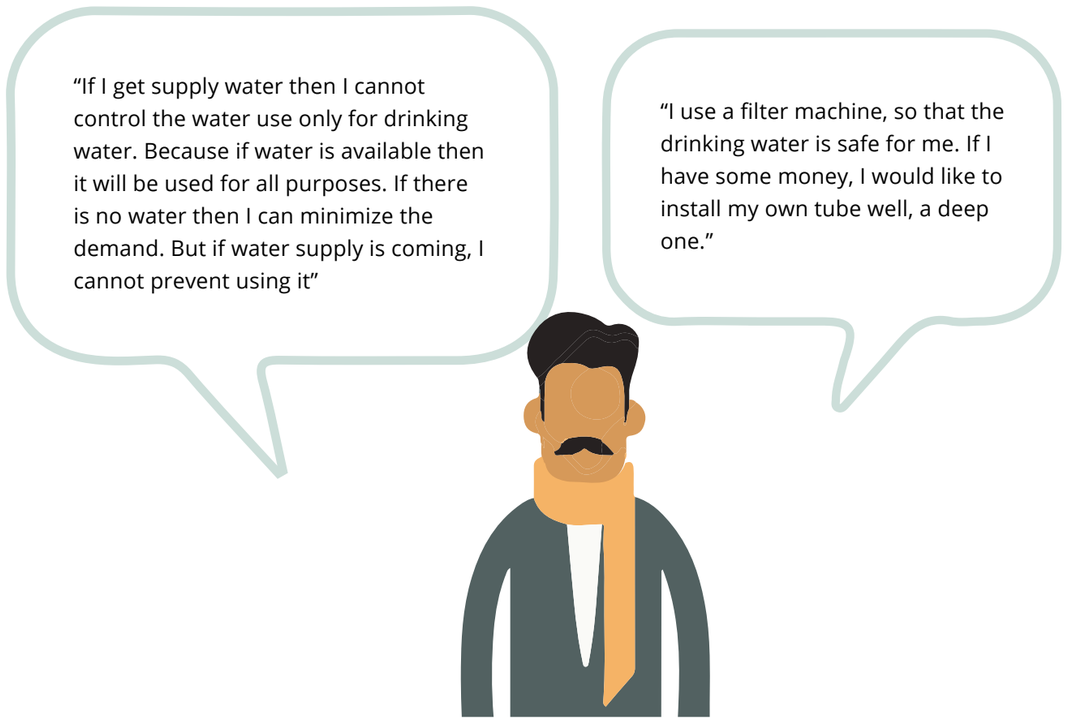
- **Piped water is used for convenience, for purposes like cleaning, washing clothes etc., while for drinking people often prefer tube-well water.**
- **Availability of alternate sources of water has an impact on what water is used for drinking.**
- **The cost of the system can be a deterrent to using it. When the payment changed from a fixed rate to a metered amount people realized they used a lot of water and they may not be able to afford it.**
- **Operators have an important role when it comes to maintenance as well as interaction with the rest of the community. But currently their status is low, training is insufficient and payment is insufficient.**
- **It is not a priority to complain about the piped water supply system, usually alternate solutions are found if water is not available. Nobody actively complains and there is a one way relationship between the operator and community members.**

Water practices:

Water practices include all aspects surrounding the storage, handling and use of drinking water by community members in and around their households. Two out of five households, that is 38.3 percent of the population, in Bangladesh drink water from sources already contaminated with disease-causing bacteria and viruses. But due to poor hygiene practices at households, the number of people drinking water with microbial contamination jumps to 99 million (Better Access to Safe Drinking Water, n.d.) Despite these obvious ill effects and inexpensive water-purification methods, adoption of safe drinking-water practices is not prevalent (Aziz et al, 2006).

Key insights:

- **Often, people hang pieces of cloth on the mouth of the tube-well to remove the iron and dirt from the water and in this way improve its taste, or to better guide the water (to prevent splashing). Unfortunately, this cloth is a good breeding ground for bacteria.**
- **Religious Rituals play a role in the use of water and the amount of water required. Also cleaning and washing consume a lot of water.**
- **People are aware of practices like washing hands and covering storage containers in the house.**
- **People often use filtering machines in the house for drinking water.**
- **With a continuous supply it is hard to control the amount of water usage.**



Health:

Drinking of water contaminated with microorganisms can cause diseases like diarrhea, cholera, typhoid, hepatitis and jaundice. Drinking of arsenic contaminated water causes Arsenicosis. People generally drink less amounts of water than what is required if it is saline or has high amounts of Iron which in turn leads to dehydration. The diseases caused by drinking contaminated water weaken the body, hinder regular work and lessen incomes for households. There is also the risk of these diseases turning fatal and causing death especially amongst children and those with weakened immunity. Studies have indicated that awareness of the link between water and disease risk is an important condition for people in developing countries to demand safe drinking-water (Aziz et al, 2006). The theme of Health in this thesis refers to drinking water related health consequences specific to Arsenic and Bacterial contamination.

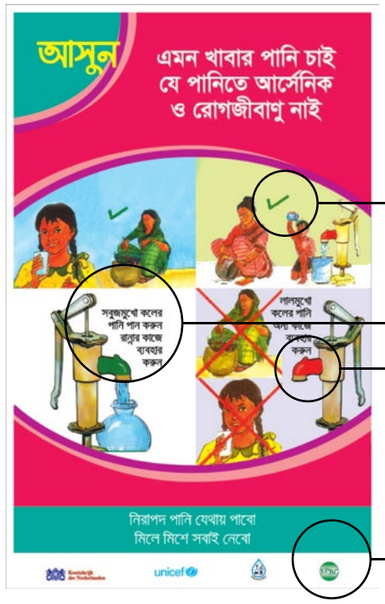
- **People are able to connect the symptoms they are experiencing to the source of water. In this case, hair fall and stickiness of water is associated directly with the piped water source, creating uncertainties with regards to continued usage.**
- **Incidents of sickness are related to the water source. If one does not fall sick from the source then it is considered "safe". Which is true for bacteriological contamination, but not for arsenic poisoning.**
- **Not all consequences of contaminants are known. There is more knowledge about health consequences from bacteriological contaminants as they affect the body immediately.**
- **Diseases like Diarrhea and cholera and symptoms like stomach problems and fever are mentioned as consequences.**
- **Families wish for good health and education for their children.**

3.2.3 Analysis of existing communication material

Looking into existing Behaviour change communication material used in awareness campaigns serves as inspiration and shows what communities have already been exposed to. Awareness campaigns, TV, newspapers, brochures etc. all can act as the first stimulus for participants to better understand the information provided through the App. Simultaneously the App can act as the first stimulus to these channels. Interview results have also revealed that many of the participants do not continuously receive water safety information from any specific avenue but if they were to receive news the preferred route would be through pamphlets and flyers from the pourashava or water supplier. This could be an indication that familiar and trusted sources are considered to be appropriate channels for receiving information. The following material that has been chosen are posters, flyers, flip charts and stickers developed to be used for awareness building and it has been analyzed(figure) based on the visual language used along with identifying details that can be translated to a digital medium.

Key insights:

- **Visual language includes hand drawn sketches as well as semi abstract icons.**
- **Photographs are also used to give a realistic idea of the problem.**
- **Images are of people from the same demographic/region**
- **A combination of visuals and text is used in the material.**
- **Text includes key messages that have been identified as important.**
- **Use of red and green colours to show safe and unsafe**
- **Indication of the existing demarcations on the tube wells is also illustrated.**
- **There is a use of bold indicators like ticks and crosses to show safe and unsafe water**
- **A comic strip or story format is used where all the visuals come together to describe what needs to be done or what the context is.**
- **Detailed and information heavy flipcharts are designed to be shown during courtyard meetings by field staff over multiple sessions.**
- **Logos of organisations are included on the material.**



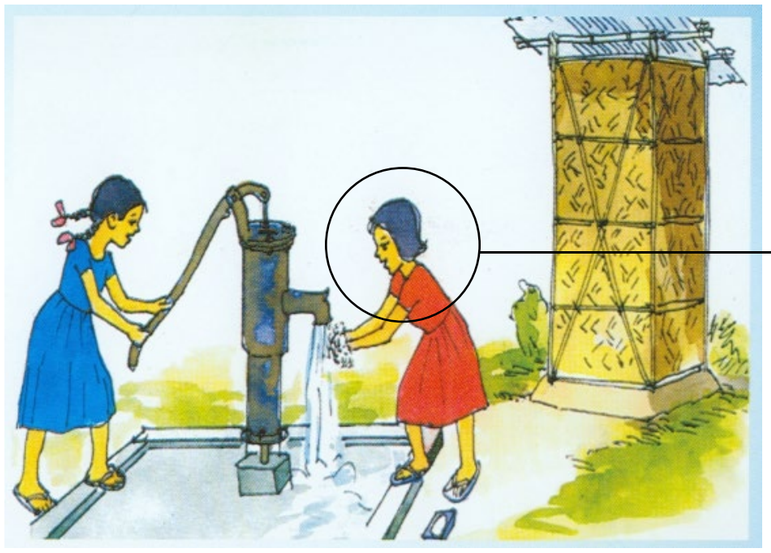
Use of visual indicators like ticks and crosses

Combination of text and visuals

Existing demarcations are shown

Logos are included

Semi abstract visuals

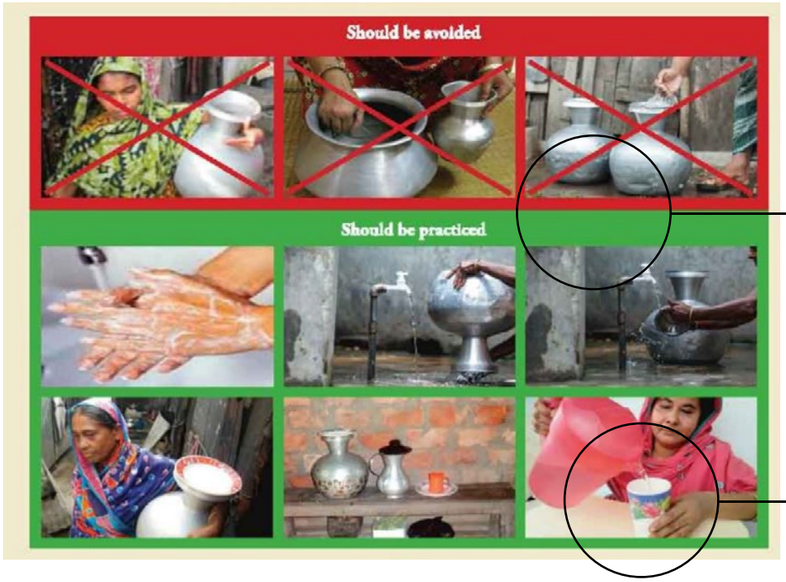


Hand drawn Visuals

Content heavy flipchart

Use of photographs

Images give an idea of the context



Use of green and red to show safe/unsafe

All steps from collection to home are seen

3.3 Characteristics of the Adopter

By understanding the characteristics and attributes of the target users it can help to guide the design phase. The target group chosen was households from rural and peri urban communities of Bangladesh. The composition of these households can be categorized into elders, parents and their children. Attributes of these families have been identified and synthesized into characteristics, personal goals and smart phone usage and categorized under Women, Men and Adolescents. This gives a basic impression of members of a household however certain nuances are left out that have been covered in the Personas that were developed with more detailed information from the users. Furthermore, as the goal of the project is to spread awareness, stakeholders within the water supply system were identified and then mapped out based on the influence of participants on the target group with regards to a communication strategy.

3.3.1 Attributes of Families

Women

Characteristics

Most of the time is at home or nearby the home • Is responsible for the household chores, including water collection and taking care of the children • The children's health is of great importance to the mothers.

Personal goals

• Keep their children healthy • Be efficient in their household chores • Communicate with other women of the community

Smart phone usage

Use smart phones for communication predominantly • Often is not the owner of one • Can be intimidated or believe they are not capable of using one.

Men

Characteristics

• Often work in the city • Is responsible for the financial decisions, such as getting supply connection and paying for the system.

Personal goals

• Earn a living • Make good financial decisions (e.g. save money) • Give advice for family • Communicate with other men of the community

Smart phone usage

communication • Internet searching, • enquiry and entertainment

Adolescents

Characteristics

Are obliged to attend school, so they tend to be more literate and knowledgeable than older generations • very young kids are not very aware of the water system

Personal goals

• Learn and be successful at school • Interact and be up-to date with their friends

Smart phone usage

social networking, entertainment or studying purposes

3.3.2 Personas

A persona is a representative of the main user group and is an integral method of visualizing the user group to describe their lives, interests, and values. Having a persona provides the reader with an example of the key players of the existing systems and their interaction with newly designed interventions that would focus on making their lives better.

A detailed version of a Persona can be seen on page (). Core values of the user have been indicated when it comes to water safety and an overview of key characteristics of the user based on information, drinking water, PWS and technology is also noted.

Munira

Core Value : Convenience **Technology**

"I have a private piped water supply because of the availability of water and I use it for all household purposes including for drinking"

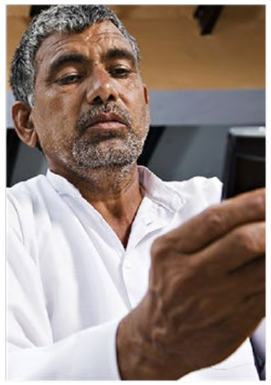
Key Characteristics

- Currently uses the PWS for all purposes.
- Uses a filter in the house before drinking the water.
- Would like to recieve information on contaminants and consequencs of drinking unsafe water.
- Is in charge of collecting water and has a tap point inside the house.
- Would like to receive information from pourashava and mechanic.
- Owns a smartphone but does not use the internet or apps
- Is aware about diarrhea as a health consequence
- Does not know if her own water is tested but believes it is necessary so the supplier can fix the problem.

Nabil

Core Value : Cost + Health **Technology**

"I would like to drink from supply water, then we do not need to pay water vendor for drinking water."



Key Characteristics

- Currently sources drinking water from a vendor while using the PWS for other household activities.
- Top prirority for water is that it should be cheap, followed by safety and then available
- He and his son are in charge of the drinking water.
- Suggests television and leaflets as mode for water related information
- Would like to know about pollutants so he can understand the risks and decide what to do.
- Does not own a smartphone.
- Is aware about bacteria related health consequences
- Believes supplier should test water and then take measures to purify.

Syed

Core Value : Health + Convenience **Technology**

"Water is essential for all, if we know what will happen after drink polluted water, then people will avoid drink polluted water. "

Key Characteristics

- Currently uses community tube well for drinking water and PWS for all other purposes
- Top prirority for water is that it should be available, followed by take less physical effort available and then safe.
- His wife is mostly in charge of collecting water.
- Suggest announcements by pourashava for water related information
- Believes awareness on water practices is essential especially for women
- Owns a smartphone and has different games and communication apps
- Is aware about bacteria related health consequences
- Believes water should be tested and results should be shared with everyone.

Farhaan

Core Value : Cost + Health **Technology**

" It is our right to know if supply water is safe or not. I do not have any other source option so I filter the water before drinking."

Key Characteristics

- Currently uses the PWS for all purposes but would prefer a deep tubewell for drinking water.
- Uses a filter in the house before drinking the water.
- Top prirotiy for water is that it should be cheap followed by available and then safe.
- Would like to receive water related information from pourashava/service provider through cirulars, leaflets or brochures
- Owns a smartphone and uses internet for different apps including social media
- Is aware about diarrhea as a health consequence
- Does not know if his water is tested but strongly believes it is necessary.

Namrata

Core Value : Health + Convenience **Technology**

"If the quality is good then it would be good to use the PWS for all purposes, that is my wish"

Key Characteristics

- Currently uses a private tubewell for drinking water and it is located in her neighbours house.
- Uses a Private PWS for all other water related purposes
- Would trust water related information from an app if provided by pourahsava or supplier
- Is in charge of collecting water along with her mother and sister
- Owns a smartphone and uses different apps.
- Health knowledge for bacterial diseases is high.
- Believes that PWS water specifically should be tested regularily as there are high chances of contamination.

Persona

Maaryam

Core Value : Health + Convenience **Technology**

"I would prefer the tube well water as a source for drinking water because it is available at all times and is good for health(no germs) and has less iron."

Key Characteristics

- Currently uses community tubewell for drinking water.
- Would like to recieve information on what water is safe to drink to ensure community is healthy.
- Is in charge of collecting water as well as other water related decisions.
- Finds face to face interactions most useful.
- Does not own a smartphone.
- Health knowledge for bacterial diseases is high.
- Believes that water should be tested regularily.

Details

About Maaryam

Maaryam is 27 years old and is a Housewife who lives along with her husband, her mother in law, and her two children. She conducts household chores and activities through out the day and also takes care of her children and family. She is in charge of desicions related to drinking water in the home. Maaryam often attends community meetings and is aware of consequences related to bacterial contamination of drinking water.

Current sources of information:

Current sources of information include, Talking with a wise person in the community or someone with experience. Also getting information from the television, mobile, NGO workers, Health workers and neighbour. The pourshava is her source for water related information.

Drinking water and PWS

Maaryam is responsible for collecting the water for her house and sometimes her daughter as well. She uses the community tubewell as the source for drinking water. She believes there is less iron and no germs(based on testing) for this source. She would prefer the tube well water as a source for drinking water because it is avaialble at all times and is good for health. Piped water is considered convenient to use as well however, She is likely to trust the PWS for drinking only if the water is clear as well as has a positive result after water quality testing.

Technology

Maaryam owns a button phone and does not have difficulty using it. Her husband owns and uses a smartphone in the household. It is possible that she has used this as she indicates that she prefers Video, text message and audio formats of information in a smartphone.

3.3.3 Stakeholder map

The visualisation of stakeholders involved in the Piped water supply system has been done in terms of three levels. Primary, Secondary and Tertiary(see figure 21). This format shows the participants that have been identified for the communication strategy and highlights the relationships between each group in terms of their potential influence on each other with regards to the communication of information.

The primary participants(PP) include the people who are directly involved in the Piped water supply system which is both the suppliers of the water as well as the demand side(receivers of the water). The target group for this project lies within this section and focusses on members of households who use the Piped water supply system. Each household can be further divided into elders, adults, adolescents and children. The behaviour of this primary side towards the innovation is what determines the effectiveness of the communication strategy and success of an awareness program in the long run.

Currently their use of the PWS may be limited to household activities rather than for drinking water. If problems arise they do not complain or have a relationship with the caretaker.

The secondary participants are the people whose behaviour or actions strongly influence the primary participants behaviour. They may come from the cultural and social environment of the primary participants and they can play a major role in promoting the expected behaviour going beyond information and message dissemination. These include health workers, school teachers and elders of the community.

There are also tertiary participants who can help or hinder the behaviour of both the Primary Participants and Secondary Participants. These participants actions reflect the broader social, cultural and policy factors that create an enabling environment to sustain desired behavioural change. Eg) politicians, religious leaders, government officials.

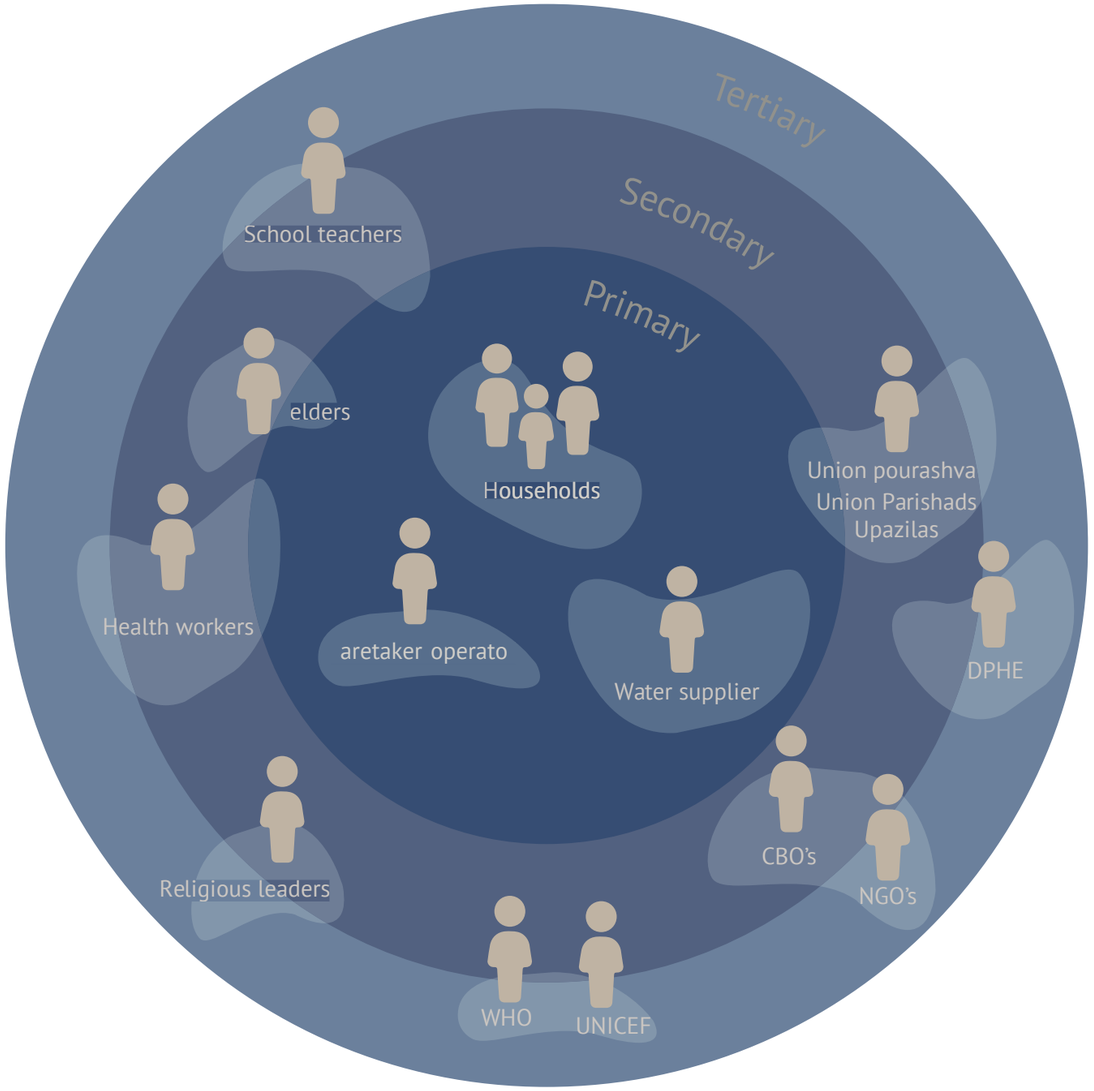


Figure 21: Mapping of target users in relation to other stakeholders involved in the system based on influence in communicating information.

3.4 Smart phone as a communication channel

As exploration has revealed, currently people receive information from many different sources. Exploring smart phone usage among the target users would give insight into how to develop the TAPP App further.

3.4.1 General insights:

- **Smart phone ownership although increasing still has it's limitations, including gender disparity, lack of Internet access, and low digital literacy.**
- **The type of phone that is owned amongst the target group members ranges from button phones, feature phones and smart phones.**
- **There are varying degrees of usage for those who own a smart phone: Some use the basic functions like calling and messaging while others use Apps.**
- **The younger generation both girls and boys are more experienced with a smart phone.**
- **Within a household it is often seen that men are more likely to own a smart phone than women especially within the older age groups.**
- **Most people indicated they would trust the information from a phone however some said it was not at all trustworthy.**

3.4.2 Smart phone App usage:

- **It is a priority that the application should not take up too much space on the phone or too much data.**
- **Some have indicated that they do not use the phone to make payments yet showing that it is something they know of.**
- **Communication Apps - Imo, Facebook Messenger**
- **Social Networking Apps include – Facebook**
- **Entertainment Apps – YouTube**
- **Internet Searching – Google**
- **Commonly used phone functions include Calling, Messaging, Taking photos**
- **Most easy to use Apps include YouTube and Imo.**

3.4.3 Review of existing learning Apps

Three Apps falling under different sectors that are relevant to this context were chosen to be analysed. Key characteristics of how the Apps provided information were looked into.

BYJU's - The learning app

Description

BYJU'S is an Indian educational technology (edtech) and online tutoring firm founded in 2011 by Byju Raveendran. Their main product is a mobile app named BYJU'S-The Learning App, launched in August 2015. The app is designed to help students practice, learn and understand concepts in an in-depth and easy-to-grasp manner. It includes comprehensive learning programs for school students aged 4 - 18 years. Every lesson is visualized for better understanding and the program takes students on a personalized learning journey, based on their unique learning style and pace. It also offers adaptive practice, revision and intensive tests to ensure that students have a complete conceptual understanding.

"Become lifelong learners with India's best teachers, engaging video lessons and personalised learning journeys"

Key Characteristics

- Simplification of complex knowledge, explained with clarity.
- Use of everyday examples that make information more tangible.
- Deconstruction of content into modules (5 minute)
- Use of special effects - two dimensional objects that are animated or gamified
- Personalisation of the experience, whether the person is a contextual, visual or theoretical learner
- Curious minds are encouraged to access advanced levels

Krishoker Janala - The Farmers Window

Description

The Department of Agricultural Extension (DAE) launched three mobile apps-based services to help farmers solve various problems they face during crops production. One of them is Krishoker Janala. It is a user-centric validated, pictorial and text-based mobile and web based app for easy and accurate identification and mitigation of important plant diseases by relevant actors. It is a digital effort to solve farmers' crop problems quickly and effectively. It has been created by logically arranging the images of various crop based problems. By looking at the pictures, the farmer can identify a problem by themselves and by clicking on the marked picture, the solutions to the problem appear.

"The best solutions are added to the database after srutinizing every aspect."

Key Characteristics

- Consists of a database with photos so farmers have control of their own crops
- Provides solutions along with information on diseases
- Covers a large number of problems(1000) for many different crops.
- Can be used both online and offline on Android mobile phones.
- The app is designed to save time for farmers and in turn their money.
- The app is used along with a facebook page and website and there is active two way communication.

Inshorts - Stay informed in 60 words.

Description

In 2013, three IIT students in India, Deepit Purkayastha, Azhar Iqubal and Anunay Pandey, launched an application called Inshorts, a pioneer in short form content. Inshorts is a news app that selects the latest news from multiple national and international sources and summarises them to present it in a short and crisp 60 words or less format, personalized in both, English or Hindi. All summarised stories contain only headlines and facts, no opinions, to help stay informed of the current affairs.

"We understand you don't have time to go through long news articles everyday. So we cut the clutter and deliver them, in 60-word shorts. Short news for the mobile generation."

Inshorts

Key Characteristics

- Tries not to burden the consumer with information
- Catered towards the 20-30 age bracket who are their main active users
- Information is condensed into a 60 word brief
- Use of Story cards - multiple a day, sent through Push notifications
- All briefs are linked to original stories for people who are interested in reading more
- The app works on form factor most suited for digital media rather than print media

3.5 Conclusions

General insights reveal that principle knowledge on water safety is lacking amongst people. There are those who are aware of Arsenic poisoning or Bacterial contamination but there are others who lack the understanding of what that means with regards to choosing a safe source to drink. Arsenic and Bacteria as contaminants add a complexity to the context as they are contaminants that cannot be seen tasted or smelled so the risk of consuming water that is contaminated is diminished. People are used to assessing water quality based on visual indicators like change in colour or dirt. As testing is the only way to detect these substances, it is a method that should be promoted. In the case of Bacterial contamination there are many chances for contamination to occur, including within the house when handling storing and using water. Health impacts of bacterial contamination are almost immediate, allowing for people to understand the risk and this can been seen as people are aware of diseases like cholera and diarrhea. With Arsenic the latency period diminishes the perceived risk. With regards to the water sources, PWS is used mainly for convenience however due to infrastructural and technical issues it is not used for drinking. All these unncertainties need to be addressed with the appropriate information.

The target users have many defining characteristics that will be relevant to developing the design. Women and girls are the most involved in the water related activities and decisions in the household however, older women are the least digitally literate. This highlights the need to find creative ways of communicating information to them that does not rely on having to use the smart phone. Core values that were identified in terms of 'why' or 'why not' people use the PWS for drinking water include, Convenience, Health and Cost. Men seem more oriented to having cost as a core value. Younger women and men use the smart phone for various things including communication, entertainment and social media. The analysis of existing information Apps revealed the potential of having information on the smart phone and gave unique insights into the formats of the information.

3.6 Design Requirements

The Design goal developed in chapter 2, "Provide Information through a smart-phone application to help build awareness on water safety such that there is an impact on the levels of knowledge and understanding of the issue", gave a good direction to take, and helped to explore the context in Bangladesh. The topic of water safety and awareness buidling is vast and based on the conclusions drawn from of all the research, the creation of a structured list of requirements was necessary to be able to guide the design phase.

In terms of Content:

• Information should be understandable and reflect the needs of the target user in order to reduce uncertainty that comes with accessing and drinking safe water.

• Content should include relevant information identified under the themes of water quality, health, water practices and water sources

In terms of visual language and Format:

• The visual language and format chosen for the information should be easily replicable for new information and should be customizable based on the type of information.

• Information should be presented in a way that is accessible and understandable by both illiterate and literate members of the target group.

In terms of communication:

• Information should be appropriate to communicate through an android smart phone.

• The information should partly or wholly be accessible for users without Internet.

• The design should be inclusive of everyone regardless of gender, age, and educational background.

In terms of TAPP – BDP project:

• The design should be feasible to use as part of the TAPP App for testing with users (Programmable).

Chapter 4

Design of Digital Information and Awareness Communication Material

This chapter covers the design phase of the project and it is further divided into two main sections, content development and design of interactions. Utilising the four themes identified under water safety and the insights from the exploratory research, information topics were created. These topics were then prioritised with experts in the field of water safety and is presented in the form of a table accompanied with preliminary forecasts on their importance in awareness building around water safety and their relevance to the TAPP App. Determining how these information topics would be communicated, in what formats and what interactions, comes in the second half of this chapter. Brainstorming sessions were conducted to generate a broad range of ideas on ways to deliver water safety information to the target group. The results were a set of 10 idea cards. Each card was evaluated and the startegy of using promising elements was used to develop a single concept. The chapter concludes with the detailing of the Knowledge module of the TAPP App and a preliminary evaluation of it's feasibility from a programming stand point.

4.1 Content Development

The content development chapter discusses what information is needed to build awareness around water safety. It is only after deciding the relevant information can we determine the best ways of communicating it through a smart phone. The themes identified in the exploratory research helped to guide this phase.

The themes of water quality, health, water practices and water sources are all significant to the water supply system. Using insights and uncertainties from the research of these themes, information topics were created and are represented in the following four tables.

It was important to first validate the findings from the research and also prioritize the information topics in terms of it's importance in building awareness around water safety and the relevance of it in the TAPP App. I developed a session(Appendix D) to be conducted with experts in the field of water safety in order to evaluate the information topics. The results from these sessions were then incorporated into tables indicating reasons for why a specific topic is important and relevant to be used in the App.

4.1.1 Creating information topics based on themes

WATER QUALITY	
Insights and Uncertainties	Information topics
• Difference in WHO standards and Bangladesh standards for Arsenic levels. • Lack of awareness of test results of their own source of water. • Safe and unsafe sources may no longer be legitimate indicator due to the lack of knowledge on when last tests were done. • Dirt in the water is often what is related to bad water quality. • Taste, colour and odour also affect perception of water quality (organoleptics). • Not all are aware of Arsenic contamination especially because it cannot be seen, tasted or smelled. • Difference in season affects quality of water.	a. Definition of 'safe water' including the criteria of taste, colour and odour. b. Names and types of possible contaminants that occur in drinking water. c. Ways that different contaminants can be identified. d. Levels at which contaminants are dangerous in drinking water (World standard and Bangladeshi standard) e. Water quality changes based on seasons f. Test results of their water source

HEALTH	
Insights and Uncertainties	Information topics
• All details of arsenicosis are not known/ are not clear in everyones mind - level differs from no information to having skin lesions, and some know about cancer. • Hair fall and stickiness is associated with contaminated water • Stomach problems are associated with contaminated water • Connection between sickness and water is not always made • All Health consequences of drinking contaminated water aren't widely known - Easier to identify bacteriological ones as opposed to • Arsenicosis as there are no immediate effects with the latter.	a. Health consequences based on contaminants (Diseases) b. Identifiable symptoms both short term and long term c. How drinking contaminated water affects differently aged members of the family like a child vs. an adult d. Direct connections with health professionals for check ups. e. Benefits of drinking safe water on health.

WATER PRACTICES	
Insights and Uncertainties	Information topics
• Use of filters in the home to ensure safety of water • Preference of tube-well water as it is considered fresh. • Distance from alternate sources like rivers is a factor in choice of water • Convenience of SPWS allows for it to be used for various different purposes • Use of plastic containers or pots with metal lids to collect and store water - also to maintain temperature of water • Misuse of water if it is freely available • Different sources are used for different purposes sometimes. • Use of cloth as filter on tap point, to remove dirt. • Sharing may happen if neighbours request for water	a. Safe handling and storage practices of drinking water b. Appropriate uses of different sources of water. c. Water conservation practices d. Ways to treat water at home e.g. Boiling e. Safe and hygienic sharing practices for shared tap points.

WATER SOURCES	
Insights and Uncertainties	Information topics
• Problems with infrastructure of the SPWS system • Requirements to maintain the SPWS system - keeping it clean • If alternate sources are not available, SPWS water is used for drinking. • Details of Depth of tube well gives indication on safety of water • Intermittent supply of SPWS water • No proper relationship with operator • Low water pressure in pipes • Tube-well sources are used based on old demarcation of red and green • Power cuts affect supply of water • Long term viability of the system needs to be promoted	a. Functioning of Piped Water Supply - How the water is treated/-supplied/how the system works/ where the water comes from. b. Timings of water supply c. Different types of water sources. d. Safe/unsafe sources for Drinking water and risks associated with specific sources and supply. d. At home tap point and tank Maintenance requirements for the user. e. FAQ database + complaint section

4.1.2 Prioritization of content with experts

Water Quality

Information topic	Appropriate group	Importance to awareness building	Relevance in the app	Reasoning
a. Definition of 'safe water' including the criteria of taste, colour and odour.	Households	Important	Relevant	Definition of good quality water is basically whether the water is harmful or safe. Aesthetic factors should be differentiated.
b. Names and types of possible contaminants that occur in drinking water.	Households	Very Important	Very Relevant	People need to be informed about types of contaminants to improve upon the current idea of safe and harmful.
c. Ways that different contaminants can be identified.	Households	Very Important	Very Relevant	Arsenic and manganese are not seen in water - people get misguided by colour.
d. Levels at which contaminants are dangerous in drinking water (World standard and Bangladeshi standard)	Households + Community leaders + Pourashava	Very Important	Relevant	Valuable information to build knowledge but can prove to be challenging to communicate to less educated

Health

Information topic	Appropriate group	Importance to awareness building	Relevance in the app	Reasoning
a. Health consequences based on contaminants (Diseases)	Households	Very Important	Very Relevant	Essential for people to establish the health risks from drinking contaminated water
b. Identifiable symptoms both short term and long term	Households	Very Important	Very Relevant	Health related symptoms with photos is important, only for those contaminants with serious health implications.
c. How drinking contaminated water affects differently aged members of the family like a child vs. an adult	Water suppliers	Important	Relevant	Additional information that can be covered within health consequences from drinking contaminated water.

Water Practices

Information topic	Appropriate group	Importance to awareness building	Relevance in the app	Reasoning
a. Safe handling and storage practices of drinking water	Households	Very Important	Very Relevant	Directly relates to behaviour change required at home. This will also compliment existing programmes like WASH.
b. Appropriate uses of different sources of water.	Water suppliers	Important	Relevant	It will be hard for the community to use this information. Determining what they are using and telling them what risk level will be difficult. Currently it will be more valuable to the supplier.
c. Water conservation practices	Households	Very Important	Very Relevant	Misuse of water is very high especially if there is a continuous supply.
d. Ways to treat water at home e.g. Boiling	Households	Very Important*	Very Relevant*	It is difficult to know what kind of water quality can be expected at home and what can actually be treated. It is very context specific. *However in a disaster situation or an emergency situation it is more relevant.

Water Sources

Information topic	Appropriate group	Importance to awareness building	Relevance in the app	Reasoning
a. Functioning of Piped Water Supply - How the water is treated /supplied/how the system works/ where the water comes from.	Households	Important	partly Relevant	Through a community leader it may be more valuable rather than through the app. It may overload the app with information.
b. Different types of water sources.	Households	Very Important	Very Relevant	It is important to know where the water is coming from eg) deep tubewell which means ground water - should just reveal ground water , surface water or rain water.
c. Safe/unsafe sources for Drinking water and risks associated with specific sources and supply.	Water suppliers	Very Important	Relevant	For the supplier this is important but for the consumer or user it may not be as important as the tap should provide clean water. Ranking of safety and what level of risks can get complicated to give as information to the user.

4.1.3 Conclusions

The expert session that were conducted gave a good perspective into what information topics were relevant and important but not just that, understanding ‘why’ was key to the whole process of evaluating them. It must be kept in mind that a user perspective is also integral to evaluating the information topics. As direct communication with users could not occur this leaves space for further evaluation of the topics in terms of desireability and need. Information topics that were missing but that were discussed to be relevant included payment information in order for people to be able to evaluate in terms of expenditure and how they spend money, it is important that they have knowledge on the costing.

There are lots of contradictory issues when it comes to water supply which adds to the challenge of communicating information. A person can use both tap and tube well water and then will process information differently from others who don’t use both. Water quality has variability and because of this over time people no longer want to pay or use the PWS.

The question, “is the information topic relevant to e communicated through the smart phone”, brought out interesting insights. Certain types of information were said to be better communicated through a community leader rather than the smart phone. understanding the social relations within the community could help to reveal new ways of communicating information that may or may not involve a smart phone.

The tables created in this chapter can act as a repertoire of information topics for people in the field of water safety and awareness programs to confer to in order to develop information and awareness material.

4.2 Ideation

This chapter consists of different design activities that were conducted in order to develop solutions towards providing awareness on water safety through a smart phone application. It includes a process of diverging to think of 'out of the box' ideas and then narrowing down to one final concept. The insights from the previous research phase and the information topics developed under the four different themes of water safety was the basis for the ideation period and the creative process.

4.2.1 Brainstorming using 'How-To' questions

The act of brainstorming or idea generation is a key part of any design process. It allows for the generation of out-of-the-box ideas which helps in identifying an optimized solution for any design problem or opportunity. This design activity was conducted with the notion of exploring all possibilities and was driven by quantity over quality. Diverging at this stage is essential in order to get a variety of different perspectives and ensuring that a larger scope is covered before narrowing down to a final solution. Six digital brainstorm sessions were carried out with a diverse group of people* (in terms of nationalities, specializations and expertise). An overview of the sessions and unique points from each group can be seen in table 2. I applied the 'How-To' method, which consists of devising different questions that act as prompts to further the ideation process (Van Boeijen, 2014). Brainstorming, lead to a wide collection of interaction ideas and an overview of the ideas generated can be seen in the following pages.

Example How-to Questions:

- How can you convey complex information through a smart phone application?
- How can you give credibility to the information that is provided?
- How can you ensure that the information provided is accessible by different groups of people, literate as well as illiterate?

Creative Sessions Overview	
1. Graduates from Dhaka university, department of Hydrogeology	*Technical and contextual knowledge from this group gave a unique perspective on ways to communicate water quality information through a smartphone*
2. Indian students - Varied backgrounds	*Sessions conducted with students from India gave solutions aligned with a general understanding of receiving information on water quality.*
3. DFI Students From TU Delft	*Design for interactions students brainstormed on ideas from a broad perspective, including experiences from different parts fo the world like Germany and Brazil.*
4. IPD and SPD Students From TU Delft	*Sessions conducted with Integrated product design and strategic product design students brought forth a broader range of ideas and made the brain storming more holistic.*
5. Psychologists with a background in early childhood development, Education Counseling and humanitarian work	*Sessions conducted with Psychologists who have had experience in the field gave insight into the behavioural aspects of learning.*

Table 2: Overview of creative sessions conducted during the ideation phase

Figure 22: Categorization of brainstorming ideas

4.2.2 Creation and Evaluation of Idea cards

In order to narrow down on ideas from the brainstorming sessions 'Idea-cards' were developed. Each card has a description and illustration to represent the different ways to communicate water safety information to people through the TAPP App.

10 idea cards were created keeping the Design requirements in mind, each was evaluated using the 'vALUe Method' in order to identify advantages, limitations and unique elements (Van Boeijen et al., 2014).

IDEA CARD 1

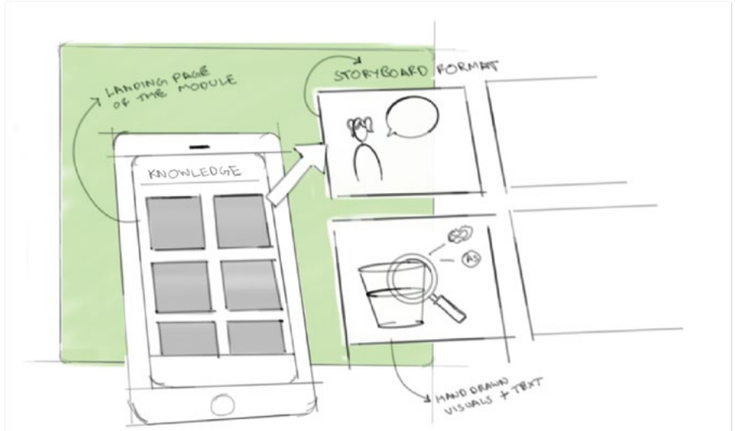
The story of Kamala

TARGET USER: WOMEN AND CHILDREN

DESCRIPTION : Creating a relatable story that includes key information from the different themes of water safety.

The story of Kamala allows the reader to follow along a day in the life a girl and her family. Along the way the reader is introduced to the different information topics under water safety like possible contaminants, health risks and call to actions.

The story is explained through the eyes of a child, keeping the information simple and understandable. The the story will be conveyed through hand drawn sketches in the form of a storyboard along with a brief description of each image.



vALUe - Method

What are the advantages of the idea (A)?	• Format tailored to those most involved in the water practices • Simplification of complex information through story format
What are the limitations of the idea (L)?	• Excludes needs of certain users eg) Men in the family • Can be difficult to update the story
What are the unique elements of the idea (U)?	• Unique format that can be used to convey information to the younger generation

IDEA CARD 2

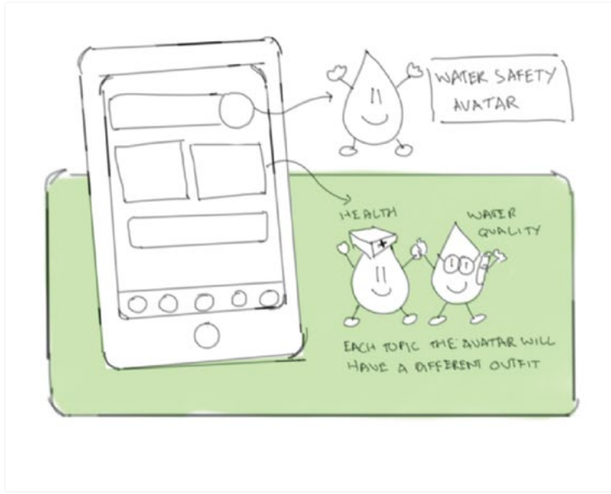
Water Safety Avatar

TARGET USER: WOMEN AND CHILDREN

DESCRIPTION : The use of an Avatar to convey information on water safety. The aim of the Avatar is to be a symbol for water safety.

The Avatar will be a prominant visual throughout the application. He will have important information to convey in the form of catch phrases and quotes. Through the Avatar users will be able to access information from any part of the app by clicking "Learn More".

The Avatar will be customised within the Knowledge module, wearing different outfits like a nurses cap or holding a magnifying glass based on the theme of Health/water quality etc. The Avatar will act as a personal helper who has information in the form of key points and visuals. An audio feature from the Avatar will allow for information to be read out loud.



vALUe - Method

What are the advantages of the idea (A)?	• Use of symbolism to help in making information attractive and helping with Retention • 'LEARN MORE' function facilitates exploration
What are the limitations of the idea (L)?	• Avatar can evoke negative emotions if not appropriate to the culture and context. • Can be difficult to update the story
What are the unique elements of the idea (U)?	• Layered information and unique symbol to address people with different levels of awareness

IDEA CARD 3

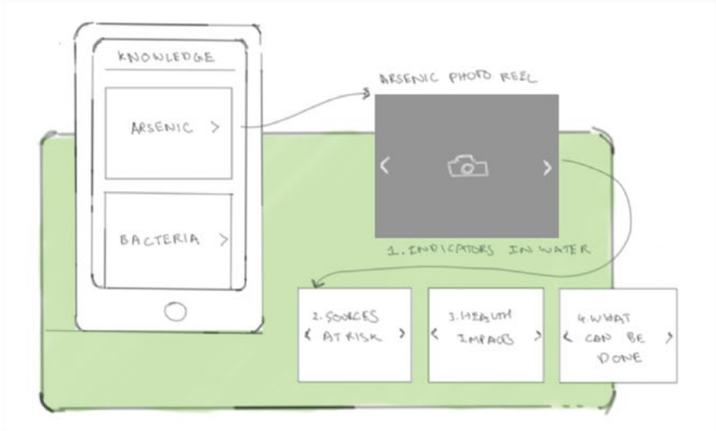
Photo Reel

TARGET USER: GENERAL HOUSEHOLD LEVEL

DESCRIPTION : Photographic representation of information in the form of reels. Each contaminant will have a set of images associated with it.

Users of the app can gain knowledge on different contaminants in water through a set of images along with captions. Each photo reel consists of 4-5 photos covering specific topics like ways to identify the specific contaminant, sources that are likely to have a risk, effects on health and actions that can be taken.

Using photographs will give a more realistic understanding of the types of contaminants and how visual indicators is not the only parameter to be used to assess the safety of water.



vALUe - Method

What are the advantages of the idea (A)?	• Photographs give a realistic impression of the context • Familiar to photo reels in existing Apps like facebook • Easily customisable
What are the limitations of the idea (L)?	• Photos can be too specific to one context and become unrelatable • Difficult to show contaminants through photos
What are the unique elements of the idea (U)?	• Information is categorised into a concise manner making it easy to grasp important points

IDEA CARD 4

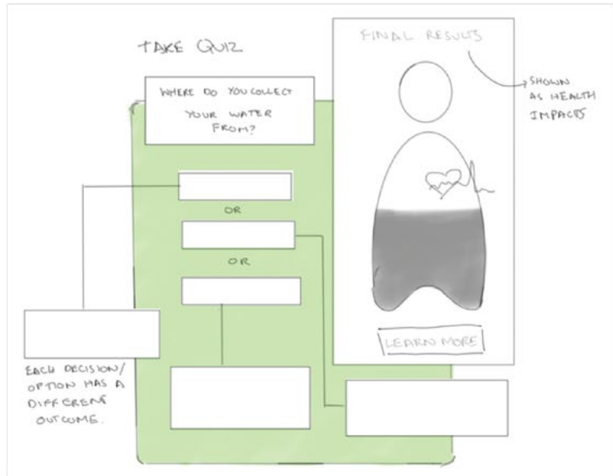
Flow chart QUIZ

TARGET USER: ADOLESCENTS/CHILDREN

DESCRIPTION : An Interactive QUIZ for people to go through to establish the impacts of different choices that they make with regards to drinking safe water.

The Quiz will pose questions to the user along with multiple choice answers. It will be in the form of a flowchart where every decision will lead to a certain outcome that either maintains a persons health or negatively affects it.

Each decision will come with a brief explanation and the final results will show an over all impact on the users health. The Quiz can be taken mutiple times where each different decision will have a different impact. There will be call to action buttons along with the Quiz so apart from againing wareness people can do something about it.



vALUe - Method

What are the advantages of the idea (A)?	• Interactive nature gives unique and personal experience to user • Allows for user to think in different ways
What are the limitations of the idea (L)?	• Can only experience one set of choices at a time and may not be encouraged to repeatedly do the QUIZ • Can take up too much space on the phone
What are the unique elements of the idea (U)?	• Direct relation between users choices and outcomes

IDEA CARD 5

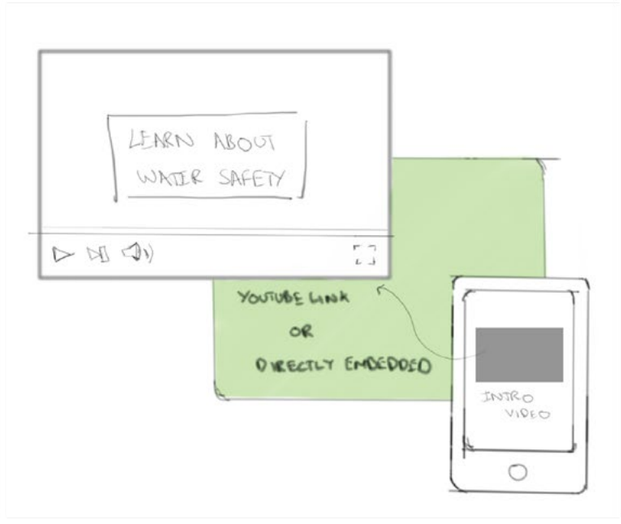
Water Safety Movie

TARGET USER: GENERAL HOUSEHOLD LEVEL

DESCRIPTION : A video with subtitles showcasing the four themes of water safety.

The video can be embedded in the app or can be linked via Youtube. It can describe the different information topics with infographics and visuals from the context, highlighting what can be done. The use of an influential person/authority figure to be in it or to promote it can help in making it popular. A tag line/jingle can also help in retention and buidling awarness knowledge.

A person who downloads the app can first be directed to the video, in the form of an introduction. The video can also be shared easiy via a link through other social media platforms like Whatsapp, Facebook and IMO.



vALUe - Method

What are the advantages of the idea (A)?	• Entertaining format for users that can have a lasting impression • Can give an overview in an understandable format.
What are the limitations of the idea (L)?	• Take up too much space/ Internet on the phone • People will lose interest if the video is too long
What are the unique elements of the idea (U)?	• Introductory video allows for user to be informed from the first moment of using the App

IDEA CARD 6

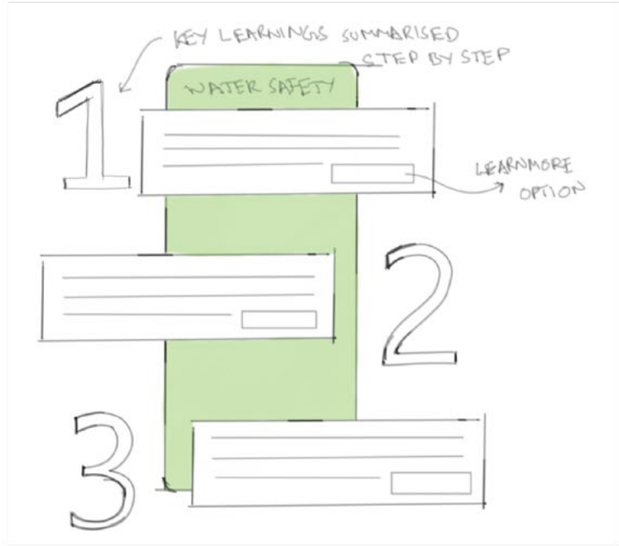
Step by Step Guide

TARGET USER: GENERAL HOUSEHOLD LEVEL

DESCRIPTION : A comprehensive quide to gaining knowledge on water safety through 5 simple steps.

Each step highlights what is most essential to know within the themes of water safety and will be represented in the form of visuals and text under each number. The Guide will highlight what is expected from the user in terms of having safe water to drink and maintaining their health.

Links to learn more will be provided while also highlighting that it is essential to share the information. An overview in the form of helpful steps can make it easier to remeber and retain.



vALUe - Method

What are the advantages of the idea (A)?	• Overview of Key points makes it easy to understand • There is clarity on what is needed and it isn't required to search/ sift through lots of information
What are the limitations of the idea (L)?	• Can be restrictive and discourage exploration • Difficult to include all relevant information in the list format.
What are the unique elements of the idea (U)?	• Information format is easy to follow, remember and retain and gives an overview of the relevant information topics.

IDEA CARD 7

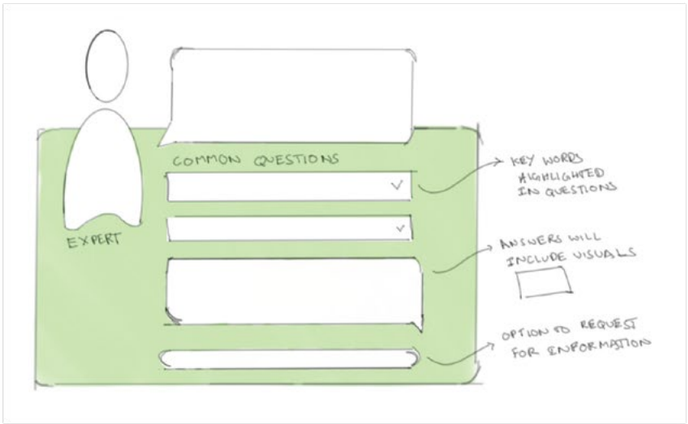
Dialogue on Water Safety

TARGET USER: GENERAL HOUSEHOLD LEVEL

DESCRIPTION : A conversational format of providing information.

Replicating how community meetings and awareness campaigns happen in a digital format. Presenting the information as though it is a conversation happening with a health worker/water safety inspector where they are the expert who is providing the information you need to know.

The information will be in the form of a Q&A where the reader will get the feeling that they are having a conversation with someone. The option to click on specific questions that reveal an answer will make it interactive and only reveal what the user wants to read.



vALUe - Method

What are the advantages of the idea (A)?	• Familiar to social media chatting formats • Can be constantly updated • Easy to look for specific information
What are the limitations of the idea (L)?	• Not all people are used to using the chatting function of a phone • Can become text heavy and exclude people who cannot read
What are the unique elements of the idea (U)?	• Conversational format replicates receiving information directly from a person, adding the element of validity.

IDEA CARD 8

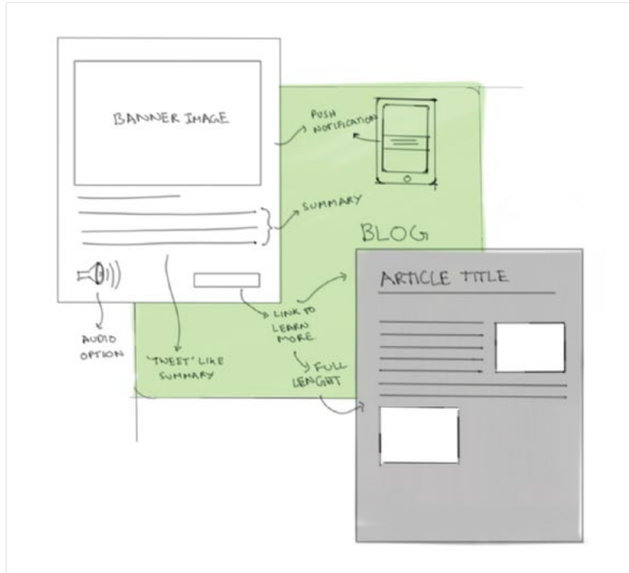
Quick Reads - Bite sized information

TARGET USER: GENERAL HOUSEHOLD LEVEL

DESCRIPTION : Summaries of important information under each theme that also highlight that there is a lot more to learn.

Each summary will link to a full length article that is part of a Blog. Push notifications for the summaries can be sent to the user highlitghting different points of the main article. The USer has the option of reading the summary and the more curious can then click the link to the full length article.

The summaries will have a banner image with text under a word limit, replicating the concept of tweets etc. An audio option can allow for the summary to be read outloud for those who are unable to read or do not have the time to look at the phone and prefer to listen(like the radio).



vALUe - Method

What are the advantages of the idea (A)?	• Summaries are good for readers with limiter time. • Audio option can be beneficial to both literate and illiterate • Push notifications can act as triggers
What are the limitations of the idea (L)?	• Can become text heavy • Unscheduled notifications can become annoying to users
What are the unique elements of the idea (U)?	• 'Tweet' like information allowing for quick reading and deeper knowledge can be received from the blog.

IDEA CARD 9

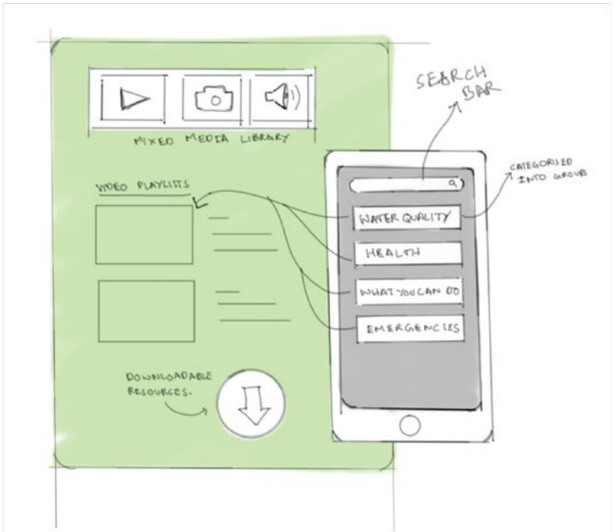
Library of information

TARGET USER: GENERAL HOUSEHOLD LEVEL

DESCRIPTION : A collection of resources that can be accessed at anytime.

A set of mixed media resources including infographics, stories, articles and videos categorised based on clear titles for easy identification. Users can browse through and read what interests them. They can also make use of the search function to identify specific information through key words.

The appropriate resource can be linked to specific pages on the app so people are encouraged to have a look at it. These resources can also be downloaded and used in different settings like commnity meetings etc. It acts as an open source database of information for those who are interested in learning about water safety.



vALUe - Method

What are the advantages of the idea (A)?	• Multiple different formats of resources keeps the information impactful and suits different needs and tastes • Easily accessible by other stakeholders(health workers etc.)
What are the limitations of the idea (L)?	• Can be overwhelming to those with low levels of awareness or limited experience with a smart phone. • Can take time to populate the database/ takes space and Internet on the phone
What are the unique elements of the idea (U)?	• Search function helps to navigate through a lot of information • Downloadable formats of information encourage sharing

IDEA CARD 10

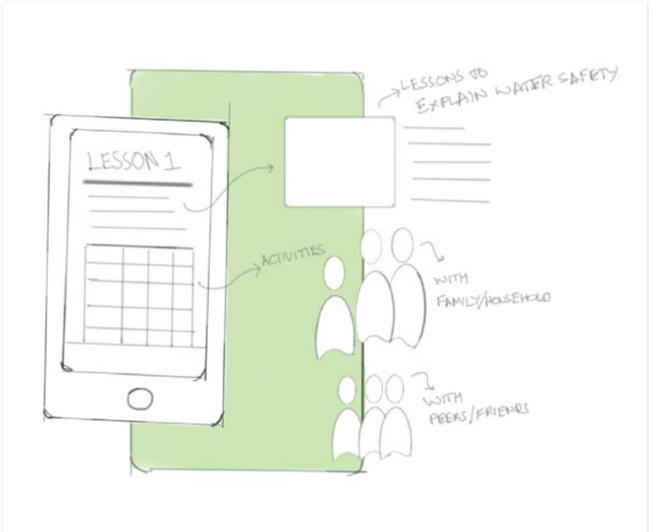
Reverse learning - Children as change agents

TARGET USER: ADOLESCENTS/CHILDREN

DESCRIPTION : Information catered to children adapted for them to be able to transfer knowledge to others in the household.

Use of activities that can be done with different members of the family with regards to water safety in the home. Simple GIF formats to make the information dynamic and easily understandble followed by a list of activities or task like a scavenger hunt.

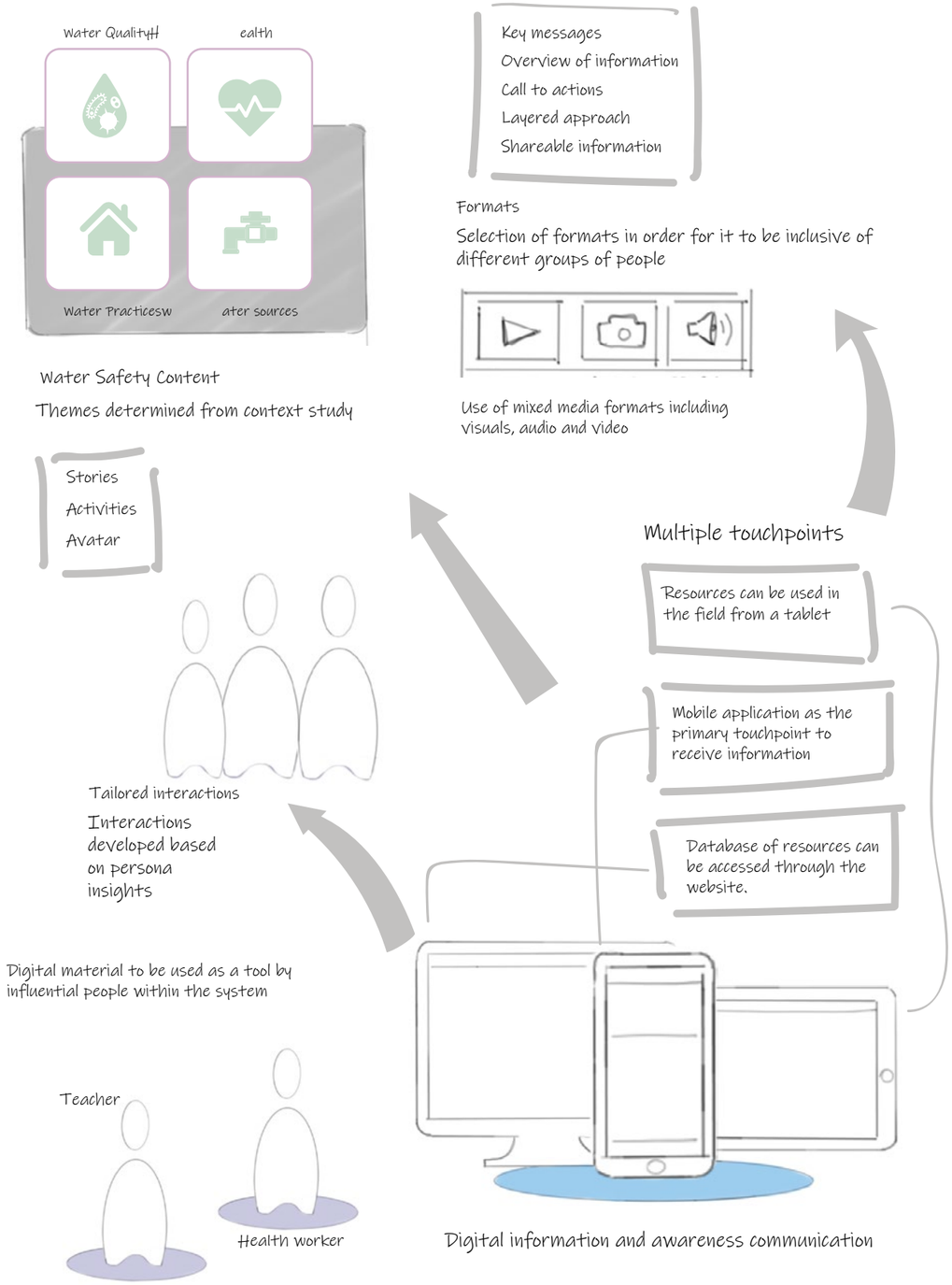
Can be in the form of group activities to be conducted with other children in the community. Each activity will be prefaced with a lesson to be learned by the child.



vALUe - Method

What are the advantages of the idea (A)?	• Familiar for children who are used to school based lessons • Activities help to keep users engaged and learn by doing
What are the limitations of the idea (L)?	• Children can find it too similar to school work • Complex information can be misconstrued when activities are done together.
What are the unique elements of the idea (U)?	• Social aspect of learning and transmitting knowledge

4.2.3 Final Concept



4.3 Conclusions

Initial brainstorming with 'How-to' questions gave rise to a vast number of ideas in the form of possible formats, interactions and functions that can be used in a concept. These ideas were not just limited to the smart phone but also included ideas using alternative communication channels, behaviour change startegies and persuasive methods.

One of the findings applying the 'vALUe method' was that the ideas generated could all work to provide awareness on water safety through the smart phone and at the same time each had limitations that did not align with the design requirements. From this it was determined that the Design goal could be fulfilled through the combination of ideas that were generated. Using the method also triggered reflection, that helped to identify specific elements of the ideas that can be added to a single overarching concept.

Feedback from programmer:

Based on the final concept a wire frame was created for the App (see figure 23) and preliminary feedback was received from a programmer who answered questions of feasibility. The wire frame was used to demonstarte the user flow through the knowledge module and specific design elements were discussed. A few of the functions that were decided are reliant on the user having Internet. The downloads page specifically would be a dynamic page where the user is taken to the host website if they clicked on a link. Downloading videos and large PDF's would not be feasible for the user as it would make the App heavy and also use up Internet.

In order to have audio functions for users who cannot or do not want to read, a voice recording can be added to the page keeping the size small and manageable. In order to keep the App lightweight the use of images and audio files with a maximum file size of 200-300 kb would be optimal.

The feature of having a pop over screen to receive feedback can only be removed once the App is updated. The decisions about what information should be fixed in the App and what should be dynamic or updated should be thought through in the intial stages so that any new updates can be made in the formats that have been fixed.

A floating icon can be added in order for users to ask questions however it will only be feasible if there is a knowledgable represntative available to answer the questions. The final mock up of the concept in the next chapter was made keeping all these inputs in mind.

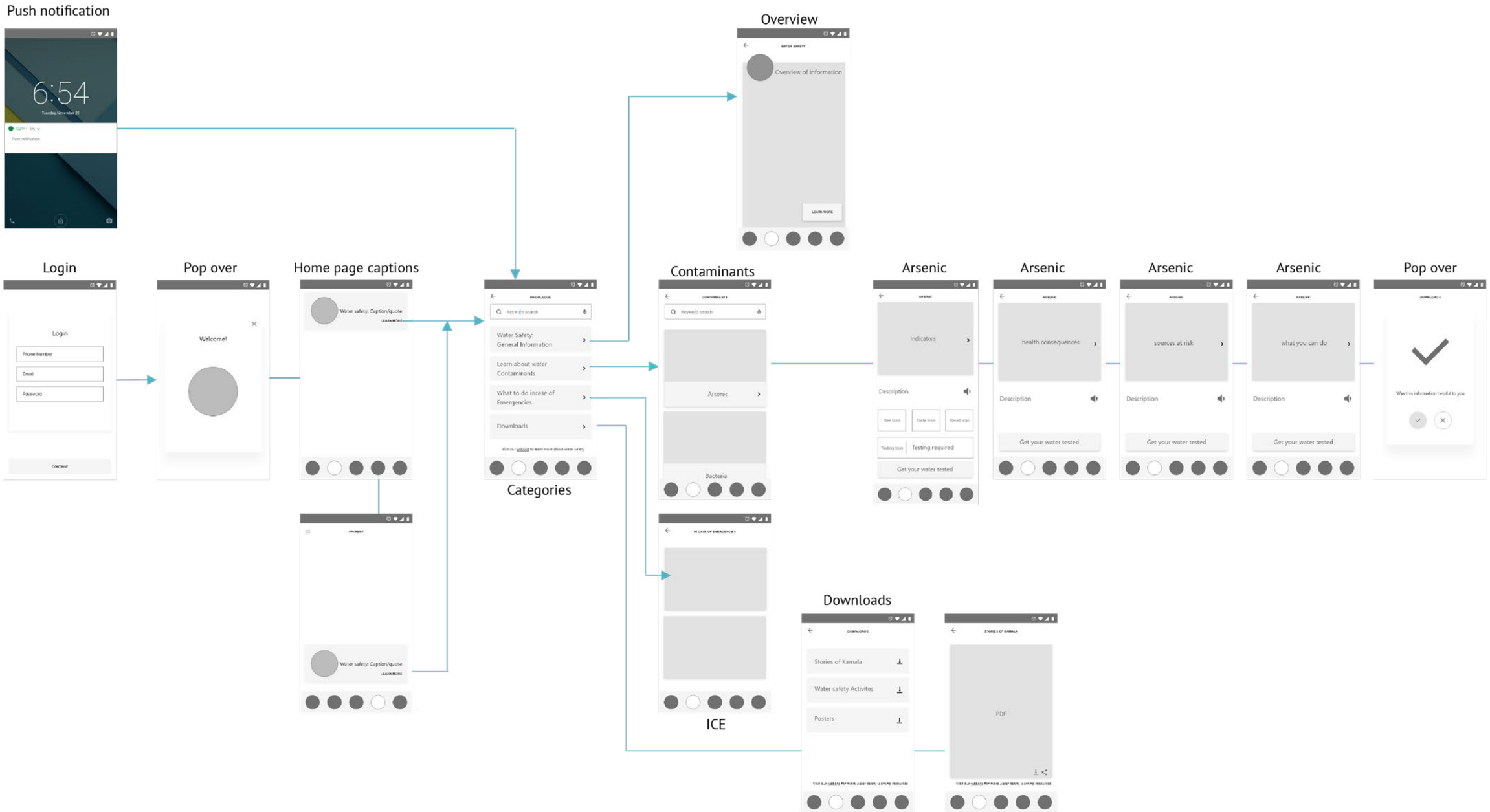


Figure 23: Wire frame of the knowledge module in the TAPP App

Chapter 5

Final Design Mock-up

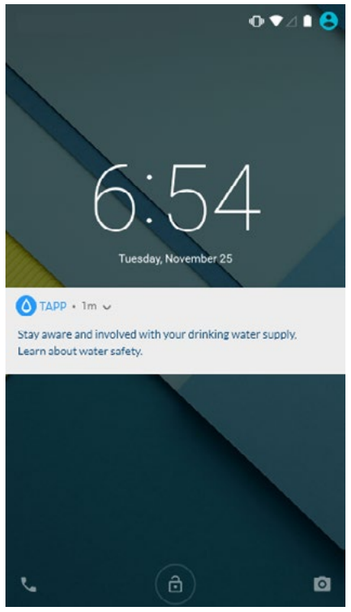
5.1 Walk through of the Knowledge module

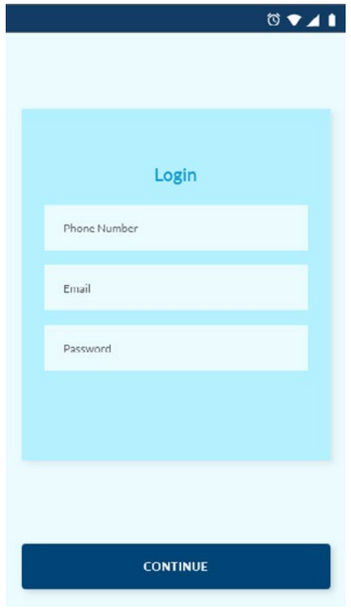
Design Description:

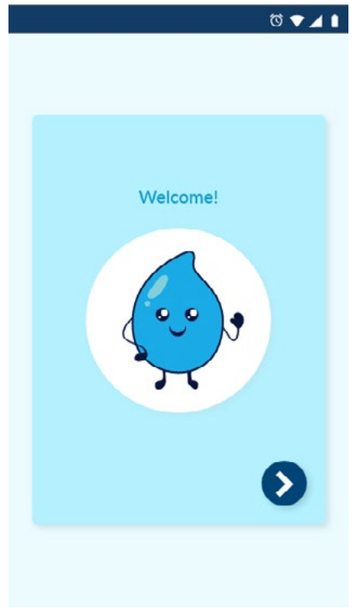
The Final design of the Knowledge module of the TAPP App has been developed based on a combination of ideas that came from the brainstorming sessions in chapter 5. The Design consists of the Smart phone application as the main touchpoint to receive information and is complimented with a website for users to be able to explore and learn more. A selection of specific information topics and an initial wire frame with the user flow was designed and evaluated with feedback from a programmer. The Final design is presented in the form of a detailed mock up of the App with the combination of content and interactions. Specific formats have been identified and incorporated in the design and the user is exposed to information in various different levels. The following pages will walk you through the knowledge module and highlight the important elements of the design.

The user is introduced to a caption/ quote on water safety through a push notification

acts as a reminder and trigger to learn more about water safety





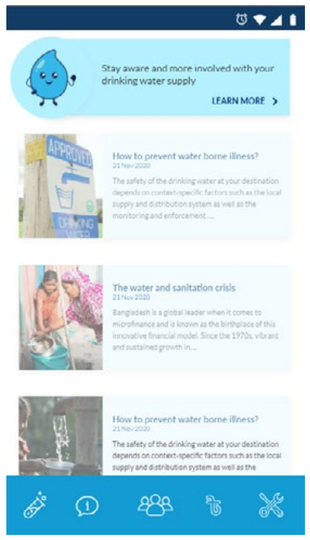


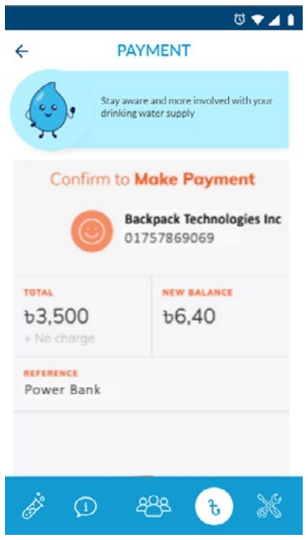
Upon loging in the user is welcomed by the TAPP App avatar.

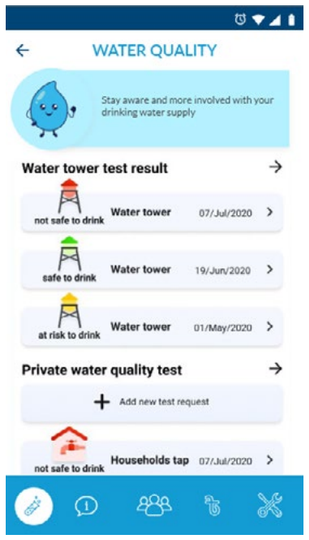
A symbol to associate with water safety

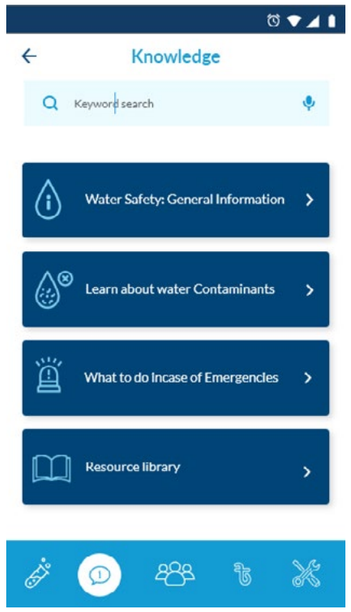
Interactions with any of the main home pages/ functions of the App comes reveals snippets of information introduced by the Avatar

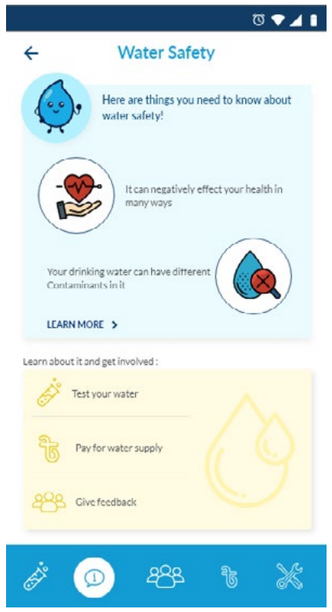
Exposure to information at all times











The overview allows for the user to grasp the essence of the issue, indicating that drinking water can be contaminated by different pollutants and they must take ceratin actions to maintain their health

Awareness knowledge is gained directly from the overview

Users scroll through each card and covers the topics of indicators, health consequences, sources at risk and what you can do.

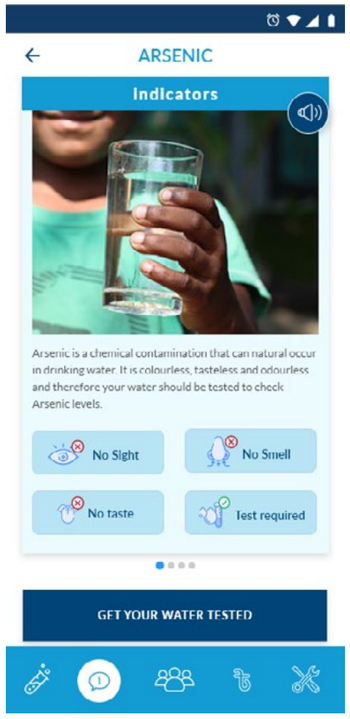
Each contaminant is represented in the same format making it familiar to grasp

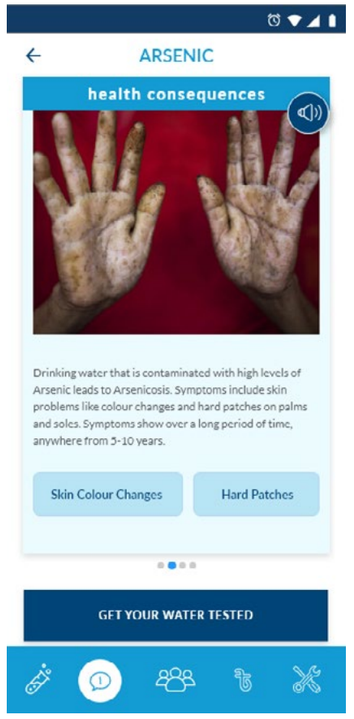
Water safety information is divided into four categories, a general overview, information on contaminants, emergency protocols and a resource library

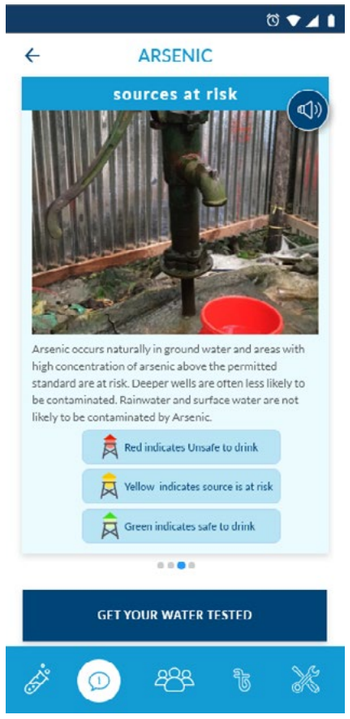
The categories include icons for easy identification

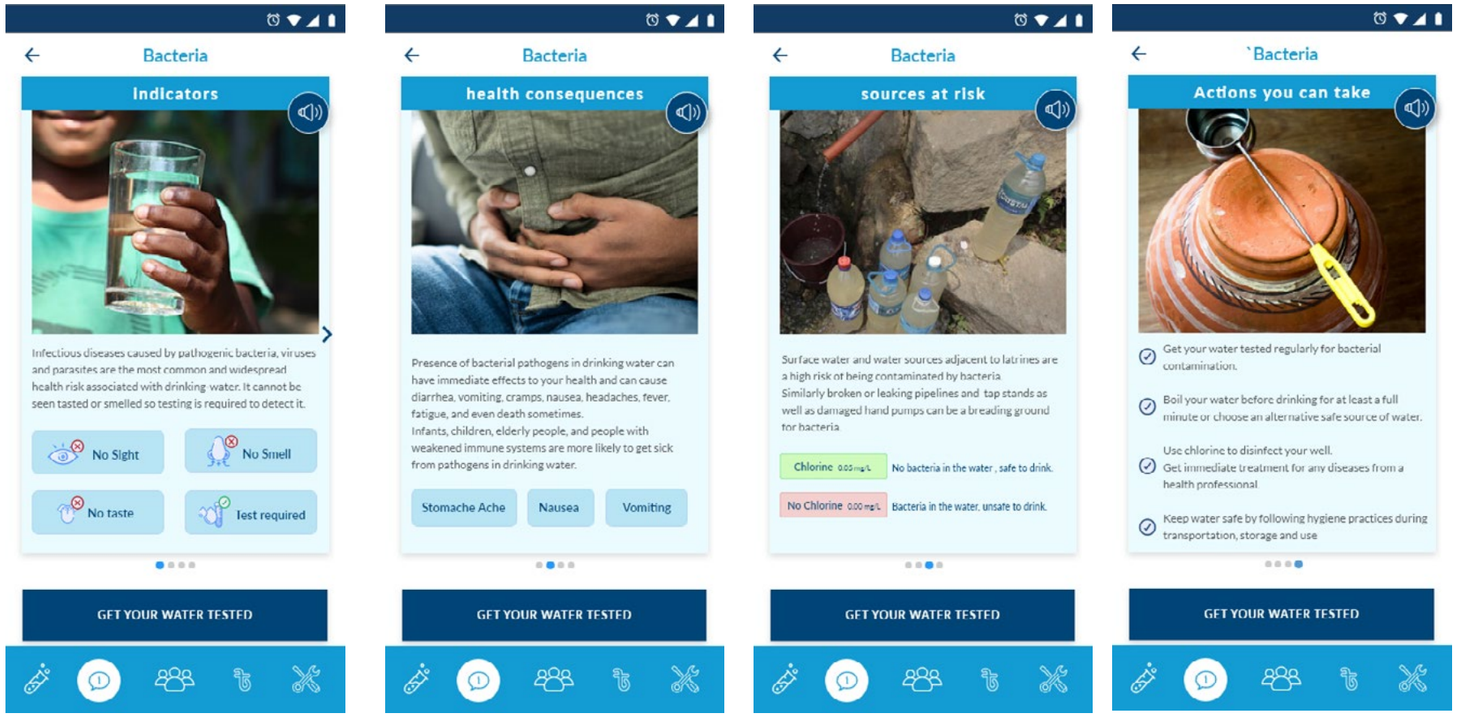
This remains as fixed information on the App so the user does not require Internet to access it

Each contaminant is described with a photograph or collage , a description and visuals highlighting the key points. An audio recording option is also provided to read what is on each card.









A call to action button is present on each page that makes it easy for the user to proceed after learning about the specific contaminant

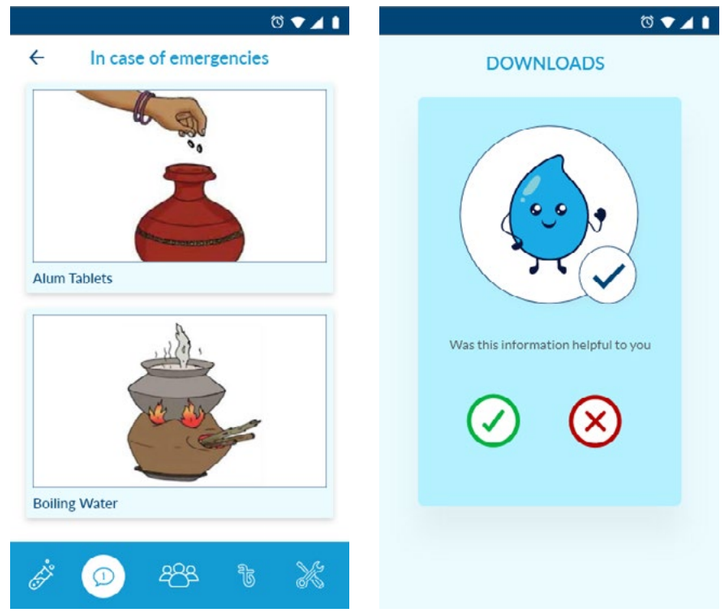
The main call to action is for users to get their water tested or see the results of the PWS. This information will elp in the decision of what water to drink

This function is integral to evaluating the information and optimising it

When the App is first released a feedback pop up is included after each category of information is seen

Format is chosen to be understood at a glance without having to spend too much time on it.

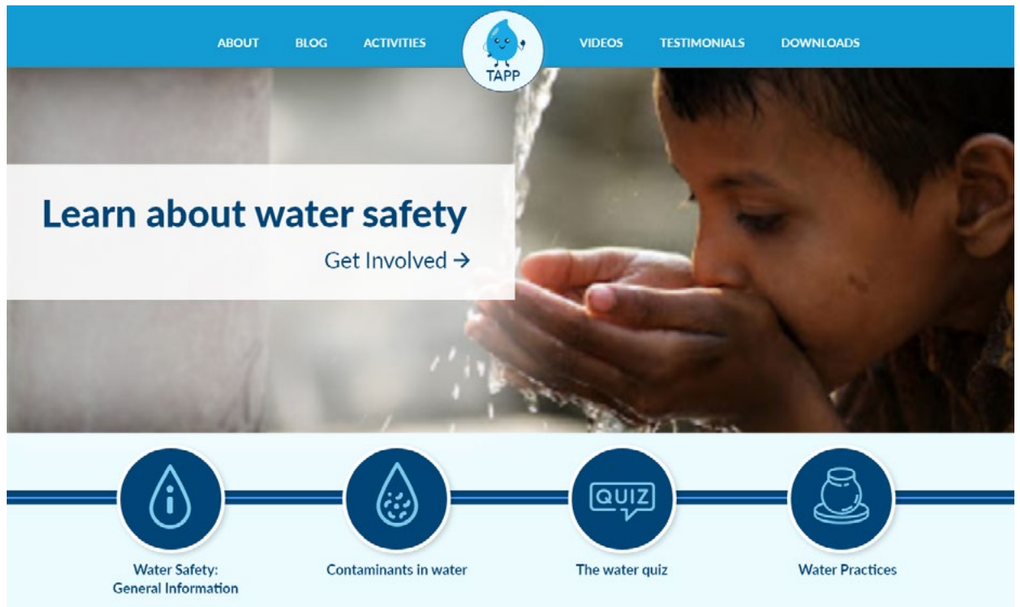
hand drawn illustrations are used to indicate what to do in the case of emergencies.

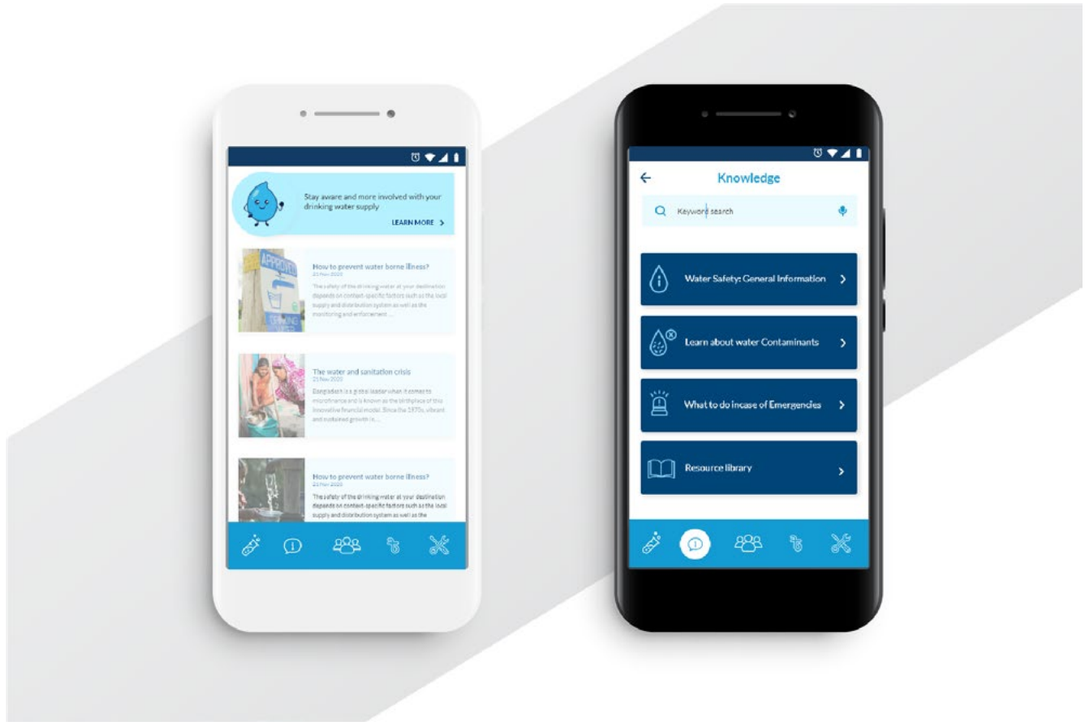


The resources section will reveal thumbnail versions of videos, posters and activities and when clicked will take the user to the real source. This function can be used only if the user has Internet access

Eager learners have the option of exploring the topic of water safety

The website is a hub for different interactions and awareness material that can be accessed by people conducting awareness initiatives in the field.





Chapter 6

Conclusion and Recommendations

This chapter outlines how this thesis contributes to the existing research in the field of water safety and development of digital information and awareness communication material. Furthermore, the limitations I experienced in this thesis project and its consequences for the final design are discussed. I also provide Recommendations for how my final design can be further developed and put into practice. Finally, this chapter closes with a personal reflection.

The main goal of this masters thesis was to contribute to building awareness around water safety in rural and peri urban Bangladesh through a smart phone application. The literature research done showed that water safety is a vast and complex topic and often interventions are needed not just from a technological front but also from a behavioural standpoint. Having piped water supply as a technological solution to provide clean drinking water for all is promising but heavily relies on community acceptance and participation. The exploratory research revealed key insights around the four themes of water safety,and highlighted factors that affect the process of adopting an innovation from a user perspective. Discussions with experts in the field of water safety have revealed that the four themes, water quality, water sources, water practices and health prove to be integral in building knowledge and understanding around the issue. The use of ICT as the communication channel is relatively low cost and has a broad range of possibility to reach the citizens. The impact can be great if the knowledge penetrates within the families, and thus help in changing people's decisions around drinking water. In the long run, it can raise citizen's knowledge levels of water safety, in turn improving public health. Building trust towards an innovation can be hard regardless of how small a change it is in people's daily life. On top of which, In the Bangladeshi context for some it may be considered a small change to choose a safe source of water while for another it could be nearly impossible. The current solution, information and awareness, can be considered as one of the long term plans to maintain trust.

Recommendations:

- Once communication materials and methods are developed they still need to be field tested and modified accordingly. Working directly with users to test the App should be the next step in optimising the designs.
- Literature has shown that effective communication campaigns are an invaluable investment in mitigating the risks of arsenic exposure and ensuring the effectiveness of communication campaigns requires the allocation of sufficient resources to their monitoring and evaluation.
- Digital tools, in addition to being effective output channels, can also serve as valuable input channels for behaviour change campaigns. By conducting baseline surveys (say, through texting) of current knowledge, attitudes, and behaviour, programs can identify priorities, establish targets, and measure progress over time.
- Good communication is important, but more often than not, simply improving the way we communicate the main messages of water safety may not be enough. Many successful behaviour change initiatives focus relentlessly on removing barriers to adopting and practicing the desired behaviours. Identifying the right problems to tackle and having interventions at mutliple levels should be explored.

Limitations faced while working on this thesis:

In the scope of this project, my research was limited to understanding two specific contaminants, Arsenic and Bacteria. This narrowed my understanding of water quality as different contaminants prevalent in different areas of Bangladesh may bring about different uncertainties with them.

Remote user research comes with many limitations. Understanding the context without having been to the place and not being able to meet the people you are designing for has affected the richness of the data collected. Observation would have been valuable in creating a clear picture of the environment without relying on too many assumptions however that was not possible in this project.

Prototyping and testing of a large number of ideas was not possible and severely hindered the iterative process that is so valuable to designing. Design is usually characterized and put forward by collaborative discussions and iterations. I was able to speak with experts in the field that provided a detailed perspective but the process was still lacking as I was not able to work in a participatory manner with the target users.

Personal Reflections:

Delving into the Bangladeshi hardships with accessing and guaranteeing healthy water, shows how the reality of things we take for granted can be vastly different for other communities. Their challenges are complex and, much like arsenic contamination in seemingly pristine water, the underlying causes might not be apparent under a superficial analysis. This project also helped see the scope of technology in sustainable development initiatives, showing how smart-phones, digital channels and media sharing can be part of people's lives all around the world.

Work in the times of a Pandemic:

This graduation project has fallen directly in the months of the COVID-19 pandemic this year and it has had an impact on the work based on the situations in both Bangladesh and the Netherlands. A key part of Designing for sustainable development is to be able to work in the field and work directly with the people of the community that you are designing for. Although it may not have been ideal circumstances new plans were drawn and with the help of many it continued on. With the world slowly recuperating I hope the outcomes of this project can be carried forward into the field as it was intended to be done.

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Appendix

A - Personal Project brief
B - Telephonic field survey
C - Statement cards overview
D - Expert Session Script
E - Interviews with Experts : notes
F - How - To questions
G - Digital brainstorming sessions

Appendix A - Personal Project brief

Personal Project Brief - IDE Master Graduation

TU Delft

Providing information on water safety for communities in Bangladesh — project title

Please state the title of your graduation project (above) and the start date and end date (below). Keep the title compact and simple. Do not use abbreviations. The remainder of this document allows you to define and clarify your graduation project.

start date 19 - 02 - 2020 — 31 - 07 - 2020 end date

INTRODUCTION **

Please describe, the context of your project, and address the main stakeholders (interests) within this context in a concise yet complete manner. Who are involved, what do they value and how do they currently operate within the given context? What are the main opportunities and limitations you are currently aware of (cultural- and social norms, resources (time, money,...), technology, ...).

"Over the past several decades, ever-growing demands for – and misuse of – water resources have increased the risks of pollution and severe water stress in many parts of the world. The frequency and intensity of local water crises have been increasing, with serious implications for public health, environmental sustainability, food and energy security, and economic development."(SDG, Water and Sanitation)

In Bangladesh it is estimated that 32 to 77 million people suffer from overexposure to arsenic through drinking water and apart from the arsenic contamination, communities are also overexposed to manganese, iron and salinity (Mink et. Al, 2019). There are many strategies that can be adopted to enable access to safe drinking water to households in Bangladesh, of which Small-scale Piped Water Supply(SPWS) shows promise.

This thesis falls under a larger umbrella called the DELTAP project which is a joint faculty research group of the TU Delft, whose aim is an integrative approach for the SPWS system in the Ganga Brahmaputra Meghna(GBM) Delta in Bangladesh and India. The project hopes to deliver a smart, open-access app, which will aid communities, local governments, community based organizations, NGO's and private water suppliers in end-user inclusive monitoring, operation and maintenance of improved water service solutions. It hopes to enhance the sustainability of improved water supply services among poor and marginalized groups in the GBM delta.

Prior research has shown that uptake and sustained use of SPWS is limited due to multiple reasons such as, intermittent supply, costs, water quality, water quantity, billing, illegal tapping, distrust, and poor operation and maintenance. According to A. Mink, the use of a smart phone application can support monitoring of the SPWS and enhance local engagement and empowerment. Based on surveys conducted, it has been seen that there is a desire for piped water systems as well as interest in monitoring it through smart phones. 50% of the households already own smart phones with Internet access, with the numbers continuing to rise. These findings stimulate further research towards determining the functionalities and the actual development of an application. A first prototype of a water supply app 'TAPP' has been developed. Its functionalities include water quality monitoring, service delivery and interaction, payment, as well as an educational package on water quality, preventive measures and health consequences.

Context research has also revealed key social and cultural attributes of the end users that this app is intended for. It is seen that there is a strict division of roles within the households. Women often do not dare to leave their houses. Almost all interviewed women prefer talking to someone in person, as they can ask questions and learn more. In some households the men work in the city and sometimes come home for lunch or only for the weekend. Women also almost never 'own' the household smart phone, which is handled by their husband or children, because they believe they will not be able to handle the phone. Adolescents use the smart phone for educational purposes, messaging, picture taking and playing games, the men mainly for calling, picture taking and messaging. Children are obliged to attend school, so often the adults are less literate than the younger generation (Mink et. Al, 2019).

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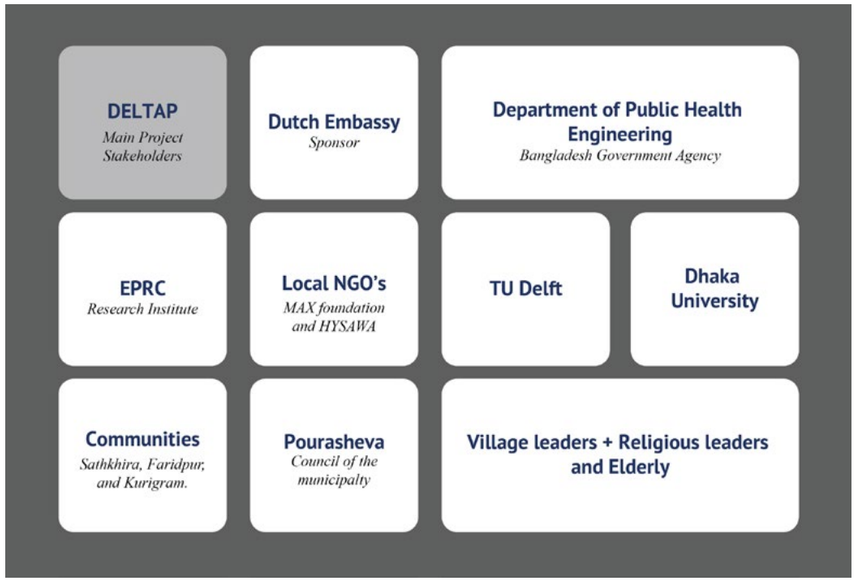


image / figure 1: Main stakeholders currently involved in the DELTAP project.

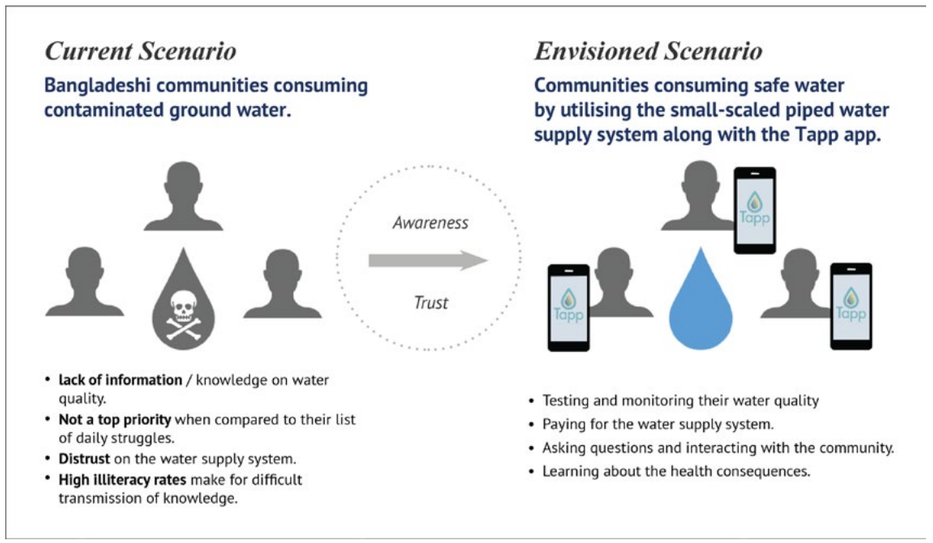


image / figure 2: Current and envisioned scenarios of the SPWS system along with the 'TAPP' app.

PROBLEM DEFINITION **

Limit and define the scope and solution space of your project to one that is manageable within one Master Graduation Project of 30 EC (= 20 full time weeks or 100 working days) and clearly indicate what issue(s) should be addressed in this project.

From existing research done in the DELTAP project, the first prototype of the 'TAPP' app was developed by a JMP student team along with Bangladeshi partners and end users. The mobile application was created to help households in rural parts of Bangladesh, test their water supply for Arsenic and E-coli and other water contaminants. This project will focus on the development of the informational part of the app.

Research/Design question:
How can a smart phone application provide information and knowledge to communities in Bangladesh, in order to increase awareness on water safety and build trust with the SPWS system?

The solution space will include designing for both literate and illiterate members of the community as a whole. Further research will also be done to highlight key social and cultural factors that have an impact on how the communities currently view water safety. Existing apps including educational apps and apps for people who are illiterate will be analyzed and ideas will be tested in the field in order to arrive at an optimized solution. It will involve creating multiple end-user personas and identifying effective ways of communicating water safety to them.

ASSIGNMENT **

State in 2 or 3 sentences what you are going to research, design, create and / or generate, that will solve (part of) the issue(s) pointed out in "problem definition". Then illustrate this assignment by indicating what kind of solution you expect and / or aim to deliver, for instance: a product, a product-service combination, a strategy illustrated through product or product-service combination ideas, ... In case of a Specialisation and/or Annotation, make sure the assignment reflects this/these.

For this project, I will develop innovative ways to provide information through a smart phone application in order to promote the use of the SPWS along with building awareness on water safety, amongst the rural communities of Bangladesh.

The research will include understanding the context as well as looking into sub-questions that arise from the main research question. How members of the community currently communicate? What are their current water use practices and their existing beliefs on water safety? would be some of the essential questions to answer.

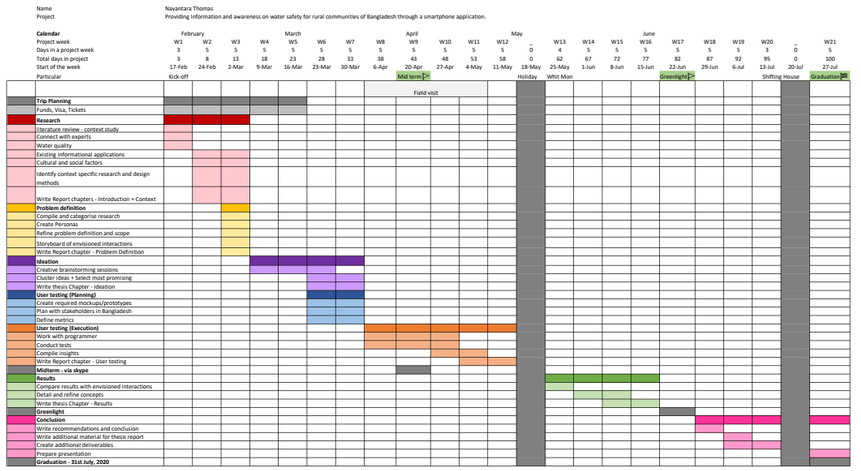
Furthermore, researching existing ways of communicating to a specific target group and validating concepts through testing in the field will help in generating and iterating on ideas. The project will be done with EPRC and Dhaka University as partners, who will enable us to meet and test with end users. By identifying specific attributes of the users and creating a metric to measure the success of the strategies qualitatively it could contribute to existing knowledge of Educational app designs.

The goal is to identify the most effective way to transmit information through an app in order to promote trust and awareness for a system. The solution will include development of the content and interface of the app, specific to the solutions that are made.

PLANNING AND APPROACH **

Include a Gantt Chart (replace the example below - more examples can be found in Manual 2) that shows the different phases of your project, deliverables you have in mind, meetings, and how you plan to spend your time. Please note that all activities should fit within the given net time of 30 EC = 20 full time weeks or 100 working days, and your planning should include a kick-off meeting, mid-term meeting, green light meeting and graduation ceremony. Illustrate your Gantt Chart by, for instance, explaining your approach, and please indicate periods of part-time activities and/or periods of not spending time on your graduation project, if any, for instance because of holidays or parallel activities.

start date 19 - 2 - 2020 31 - 7 - 2020 end date



The planned approach for this project will combine research and design explorations to come up with creative ways to disseminate information amongst the rural communities of Bangladesh. Talking to experts already involved in the project will help create a clear picture of the context. From there, identification of context specific participatory methods to answer social and cultural questions as well as to validate prototypes will be done in the initial research phase. Besides established research methods, the project will also use creative problem solving techniques and persuasive methods to ideate and test concepts. This will help in understanding a broader approach to providing awareness through an app and the effects of it.

An intensive ideation phase in the Netherlands is planned in order to include multiple groups of people within the creative field who will take part in brainstorming sessions. With different types of sessions, the hope is to be able to generate out of the box ideas.

As the DELTAP Project has been ongoing for many years and has a strong network of collaborators in Bangladesh, validation of concepts will be possible. Testing ideas in the field will give a realistic picture of the most appropriate solutions. Working closely with a programmer in Bangladesh will also help in identifying the feasibility of the concepts. The project will involve full-time activities from start to end date, except for a 1-week break after returning from Bangladesh and another 1.5 week break after the greenlight meeting due to moving houses.

Appendix B - Telephonic field survey

Interview questions - Households

The following document contains questions relevant to developing the two Master's graduation Projects under DELTAP. It is a consolidated set of questions created by Annemarie, Cheng and Nayantara to be used in a field survey in Bangladesh. It is based on specific Research questions/sub questions for each project.

The survey is to be conducted in two parts with each participant. ***Part 1*** *includes Socio economic /general information, Technology, Information and communication.* ***Part 2*** *includes questions on Water quality, and the Piped water supply system. The survey will be conducted via telephone. This field Survey is to be translated to Bangla and then back to English in order to ensure that we deliver the right meaning and information.*

PART 1

General information:

GOAL - Establish an idea of the context and personal situation of the participant

	District / Union / Upazilla / Ward / Village	
	Gender of participant	F/M
Nr.	**Question**	**Question type**
1	What is your name?	Short answer
2	What is your age?	Short answer
3	What is your religious belief?	Short answer
4	What is your educational level?	Short answer
5	household composition: Who lives in your house? - Gender and Age	Open answer Long explanation not required.(an indication for age is also okay)
6	What is your occupation?	Short answer
7	What is the monthly income of your household?	Number - can be an estimate
8	What is the monthly expenditure of your household?	Number - can be an estimate
9	Who makes the decisions in your household with regards to: - Financial decisions - Drinking water	Short answer / Open
10	Who makes the decisions for your community?	Open Can have multiple answers/ based on participants perception

Technology:

GOAL - Establish an idea about the experience and use of technology by the participants.

Research question / sub-research question

Nayantara: *What is the existing scenario around smartphone usage amongst the community members?*
Cheng: *What are difficulties of Bangladeshi piped water users in using ICT? What factors may influence them to learn and use ICT?*
Annemarie: *Are Bangladeshi piped water users able and willing to pay their water bills through their smartphones?*
Are Bangladeshi piped water users able and willing to interact with their operator and community members through their smartphones?

Nr.	**Question**	**Question type**
11	Which electronic devices do you use in your daily life?	Open
12	Do you own any of these: - Television - Button Phone - Water pump - Radio - Computer/Laptop - Tablet/iPad - Smart Phone	Y/N
If they don't have smartphone:		
13	Did you face any difficulty in learning to use these electronic devices?	Y/N (From the Devices listed above)
14	If yes, which devices did you face difficulties with and what were these difficulties?	Open
15	Have you ever used a smartphone?	Y/N
16	Does anyone in your household own a smartphone? Who?	Open - Gender and age of person who owns one
If they have a smartphone:		
17	Does anyone else in your household own a smartphone? What is their gender and age?	Short Answer

18a	Did you face any difficulty in learning to use your smartphone?	Y/N
18b	If yes, what were the difficulties?	Open
19	How frequent do you have internet access on your smartphone?	Short answer
20	Do you have apps on your smartphone?	Short Answer - Prompt with apps like facebook, whatsapp etc.
21a	Do you use it alone or do you require any help from others to use the smartphone app?	Short Answer
21b	If you require help in what part do you need help with?	Open
22a	What smartphone app / function is your favourite to use? Name 2 to 3.	Open
22b	And why?	
23a	What smartphone app / function do you think is easy to use? Name 2 to 3.	Open
23b	And why?	
24	What do you do with your / a smartphone? - Calling - Messaging - Searching information - Taking photographs - Watching videos - Listening to songs - Playing games - For educational purposes - Making payments - Other (please describe)	Y/N
25	What are the three things that you do the most with your smartphone?	Short Answer
26a	If you receive water information from an app on your phone, would you trust it?	Y/N
26b	Why/ why not?	Open
27a	Do you think it will be helpful if you can submit your queries or complaints about the piped water system to the water supplier(s) via a smartphone app?	Y/N
27b	Why/ why not?	Open

28a	Do you think it will be helpful if you can submit your queries or complaints about the water supply to other community members via a smartphone app?	Y/N
28b	Why/ why not?	Open
29	From the following list, what are the three most important aspects for you in the current apps that you use: - How it looks - How much internet data it uses - How well you understand the information given in the app - How easy it is to learn to use the app - The space the app occupies on your phone	Rank - If possible mix the sequence of options in each interview

Information/Communication:

GOAL - ***Establish an idea of the preferred modes and means to communicate information.***

Research question / sub-research question

Nayantara: *How can information on water safety be communicated through an app to rural communities in Bangladesh?*

Cheng: *How can information on water quality be communicated through an app to rural communities in Bangladesh?*
How can water quality testing procedures be communicated through an app to operators of water supply systems in Bangladesh?

Annemarie: *How can information be communicated through an app to rural communities in Bangladesh?*

Nr.	Question	Question type
30	If you require information or advice, how do you get that? From who / where?	Open Channels + people they get information from (detailed way)
31	From who or where do you currently receive information about drinking water?	Open
32a	Would you like to know more about pollutants in your drinking water?	Y/N
32b	And Why?	Open
33a	Would you like to know about the consequences of drinking polluted water?	Y/N

33b	And Why?	Open
34	Would you like to receive information about which water sources are safe to drink in your community?	Y/N
35	Would you like to know about ways to collect and store your water to ensure it remains suitable to drink?	Y/N
36	Is there any other information you would like to receive regarding your drinking water?	Open
37	From who and via which medium(how) would you like to receive this information?	Open
38a	Have you ever shared information on the condition of your drinking water within your community?	Y/N
38b	If yes: what was the information and why and how did you share it?	Open
39	Do you ever share information with groups of people in your community?	Y/N
40	How do you share the information amongst the group?	Open
41	Choose the top three of the following types of media which you prefer to receive information on your smartphone? - Text - Photograph/picture - Bar chart - Symbol (Like on a smartphone) - Drawing - Audio - Video	Short answer- Describe list to participant
42	Would you prefer to know: a. if your water is safe to drink or not b. exactly how much of which pollutants are in your drinking water and how much is safe for your health c. Both of the above	Option - describe options to participant

Part 1 estimated time : 21 minutes

PART 2

Drinking water / Water safety:

GOAL - Establish an idea of the current drinking water situation and awareness of water quality and water safety

Research question / sub-research question

Nayantara : *What types of information needs to be provided to build awareness on water safety for the communities in Bangladesh?*
Cheng: *What does water safety mean to you? What do you care the most about related to water safety?*
Annemarie: *What is the existing knowledge of the community members regarding water quality?*
What are the preferences and desires of the community members regarding their drinking water?

Nr.	Question	Question type
43	Can you explain your activities with regards to using water during a full day?	Open - Ask from Morning to evening so participant can organise their thoughts in a timeline
44	From which source do you collect your drinking water? Multiple answers possible. - Private tubewell - Community tubewell - Shared tubewell - Private dug well - Community dug well - Shared dug well - Private Piped water supply - Community tap point - Spring water - River/lake water - Rain water - Bottled water - Other	Option
45	Why do you use this water for drinking purposes?	Open
46	What is your most preferred source for drinking water?	Open
47	Why is this the most preferred source of water for you?	Open
48	From where do you collect your drinking water and how long does it take you to get there?	Open
49	What do you use to carry the drinking water to the house?	Open - Ask the method of collection in terms of containers used.
50	Who collects the most water for your household?	Short answer - *This concerns all water collection, not only drinking water*
51	Who collects the drinking water in your household?	Short Answer

52	Do you store drinking water in your house? if so where and how?	Open
53	Do you cap the drinking water you store in the house?	Y/N
54	If you are thirsty, how do you fill your glass of water?	Open - Participant should Describe the method of filling
55	Do you know what ways your water can get contaminated during collection, storage and use?	Open
56	Can you name any health issues that can be caused from drinking water?	Open - View of the participant (Need to take down their perception)
57	Have you done anything to prevent these health issues?	Open
58	Have you done anything to treat your drinking water?	Open
59	Can you name any contaminants in the drinking water that might endanger your health?	Short answer
60	Please rank the top three: My drinking water should: - Be cheap - Be safe to drink - Taste good - Take little time to collect - Take little physical effort to collect - Always be available	Ranking
61	What are the reasons you would trust your water for drinking purposes?	Open
62	Has your drinking water ever been tested?	Y/N
63	If yes: by whom and was the result shared with you?	Open
64	If no: why not?	Open
65	Would you like your water to be regularly tested to ensure it is safe to drink? Why / why not?	Open

Piped Water System:

GOAL- Establish the existing beliefs and practices towards the Piped water supply system.

Research question / sub-research question

Nayantara : *What are the perceived uncertainties towards the PWS system?*

Annemarie: *What are the preferences and desires of the community members regarding their piped water supply system?*

Nr.	Question	Question type
66	Do you have a connection to the piped water supply system?	Y/N
67	Do you have a private or shared connection?	Short answer
68		
If yes, then:		
69	Why do you have the piped water supply connection?	Open
70	How do you pay your water bill for your piped connection?	Open
71a	Do you trust piped water for drinking purposes?	Y/N
71b	Why / why not?	Open
72a	Are you regularly in touch with the piped water system operator(s)?	Y/N
72b	Why / why not?	Open
73	What are the current problems you face with the piped water system?	Open
74	What actions do you take when you experience these problems?	Open
75a	Are you satisfied or dissatisfied with the piped water supply system?	Short answer
76b	Why?	Open
If no, then:		
77	Why don't you have piped water supply connection	Open
78a	Would you like to have a connection to the piped water supply system?	Y/N
78b	Why/ Why not?	Open

Part 2 estimated time = 16 minutes

Total estimated time for part 1 and 2 = 37 minutes

Appendix C - Statement cards overview

AWARENESS

WATER SAFETY

There has been a successful transition from surface water to groundwater earlier, and now a new transition is required in order to provide people with safe drinking water. Resistance of the population can be expected, as why would they trust this new system, their former change did not pay off very well.

Water safety is a vast topic which includes potential illnesses from both chemical contamination as well as biological contamination. (e.g., Arsenic, salts and E-coli)

INFORMATION

Awareness and information campaigns? have shown a positive influence in communities regarding their choice of safe water sources.

Mitigation programmes often concentrate on developing technologies while giving less attention to awareness building and follow-up.

Current sources of information for people include NGOs, Government organizations, Doctors, Books, television, radio, and newspapers. Also internet through their smartphones, elderly, village leaders, religious leaders, car announcements, posters.

Existing knowledge on water include , awareness about arsenic contamination, differences between tube well and Piped water, Red and green demarcation and its meaning, Presence of Iron in water and it's connection with arsenic. There is also knowledge on bacteriological contamination

There is a lack of specific information towards their own water sources, causes of illnesses, and what needs to be done/can be done

There is a Large lack of information on testing. People are not aware of when the last tests were done or if they were done at all. The actual results of testing are not known. Information about their specific water sources are also not known

COMMUNITY

There is a strong sense of community, where people are willing to trust information coming from people they know and they would like to share it with the rest of the community.

Community participation is key to the long term viability of the SPWS system.

TECHNOLOGY

SPWS AS THE SOLUTION

Small scale piped water supply shows most promise in rural settings, due to the degree of centralization and the scale allowing for manageability.

Piped water supply is widely regarded as the long term goal for water supply around the world, however, that goal cannot be reached in one go, it requires intermediate steps, of which SPWS can be one. Repetition of information is important!

Issues with PWS include trust in the system, costs, unsustainability of the technology, infrastructural and technical issues and operation and maintenance issues. These factors lead to low acceptance of the system.

The SPWS system has various problems that include low water pressure, Intermittent supply, open tank, improper tank cleaning, chances of microbial contamination due to intermittent supply, breakage and leaking of pipes, illegal tapping (also results in bacterial contamination), reliance on electricity, water may go untreated, and collection of money from community members gets difficult.

SMARTPHONE USAGE

Approximately 50% of the rural households own and use smartphones with internet access, and this number is rapidly increasing. This shows scope for monitoring water supply systems with smart phones in order to engage communities.

WISHES OF THE PEOPLE

Water safety is important to the people in the community and they want to know about health consequences and preventive measures.

Children are the future , and can be looked at as change agents

Families wish for good health and education for their children.

PEOPLE

PRACTICES OF THE PEOPLE

Availability of alternate sources of water has an impact on what water is used for drinking.

Piped water is used for convenience, for purposes like cleaning, washing clothes etc., while for drinking people often prefer tube-well water.

Religious Rituals play a role in the use of water and the amount of water required. Also cleaning and washing consume a lot of water.

It is not a priority to complain about the piped system, usually alternate solutions are found if water is not available. Nobody actively complains and there is a one way relationship between the operator and community members.

ESSENTIAL PEOPLE

Caretakers have an important role when it comes to maintenance as well as interaction with the rest of the community. But currently their status is low, training is insufficient and payment is insufficient.

Caretakers are key players in the system and need to be identified from within the community and they require proper training and payment.

BELIEFS OF THE PEOPLE

People relate symptoms to the source of water, like hair fall and stickiness of water is associated with piped water.

The red color in the water is an association with Iron and sometimes even arsenic.

Taste of water affects the choice of water sources. A sweeter taste is associated to tube well water. Also the water temperature plays a role. In a water tank the water heats up.

Incidents of sickness are related to the water source. If one does not fall sick from the source then it is considered "safe". Which is true for bacteriological contamination, but not for arsenic poisoning.

Local people regard clean water as water without dirt. If there is dirt in the water it is either filtered or not deemed fit for drinking.

It is easier for people to identify Iron in the water.

People want to maintain "freshness" of water. (meaning without dirt)

COST OF THE SYSTEM + FINANCIAL BACKGROUND OF THE PEOPLE

Rural parts of Bangladesh cannot afford costly technologies and are often bound by financial constraints

Attributes like low literacy, resistance to behavioral change and poverty can be constraints in acceptance of choosing a safe water source

The cost of the system can be a deterrent to using it. When the payment changed from a fixed rate to a metered amount people realized they used a lot of water and they may not be able to afford it.

Appendix D - Expert Session Script

Session with Experts in the field of Water Safety in Bangladesh

Goal of Session:
To prioritize what type of information should go into the 'knowledge module' of the 'TAPP' app and understand the reasoning behind it.

Project Description:
This session is part of the TAPP-BDP project, which is a research project funded by the Dutch Scientific Research organisation NWO, and led by EPRC, with involvement of Delft University of Technology. The project hopes to deliver an open-access smartphone application, which will aid communities, local governments, CBOs, NGOs and private water suppliers in end-user inclusive monitoring, operation and maintenance of improved piped water service solutions. The smart-phone application 'TAPP' intends to assist water suppliers and water consumers in rural and peri-urban Bangladesh to manage their Piped Water Supply (PWS) system. Its functionalities are to include water quality monitoring, service delivery and interaction, payment, and knowledge/information on water safety. Developing the knowledge module, which provides information and raises awareness about several water-related topics, is the focus of my MSc graduation project at Delft University of Technology. The intent behind this session is to engage with experts from different organisations in Bangladesh who have worked in the field of water safety, in order to gain insight and validate specific findings from the project.

Purpose:
This session is part of an ongoing research project with EPRC. The TAPP app, when it is programmed, will become available open-source. By participating in this session it would be an opportunity to explain what you would like to include in the app, and what should get priority. The outcomes of this session will be included in the graduation thesis report that will be shared with all participants.

What to Expect:

- The session is divided into three parts:

- **PART 1** - Watching an introductory video that will describe the themes Water quality, Water sources, Water practices and Health in the context of this project.
  Time : 4 minutes
- **PART 2** - Filling in a google form Questionnaire to rank the specific types of information developed under each theme.
  Time: Approximately 15 minutes

The next day

- **PART 3** - Video Call over Zoom to discuss each theme in more detail. Responses from the Questionnaire will be looked into and experts will also be prompted to dive into a deeper discussion based on their own experiences and insights.
  Time: Approximately 1 hour

- The session will be held in English.
- The Zoom session will be voice- and video-recorded. After transcription the recordings will be destroyed.

Session Info:

Part 1
Link to introductory Video : https://youtu.be/LnvJaN8-Z1M
This should be watched one day prior or anytime that is suitable for the participant before the video call on Zoom.

Part 2
Link to Google form : https://forms.gle/GDNJZB88R5Fq4v6VA
This should be filled in one day prior or anytime that is suitable for the participant before the video call on Zoom. Please be sure to press 'submit' at the end to submit your answers.

Part 3
Link to Zoom call :
This will be set up once the participant has confirmed a suitable day and time.

During the Call the following questions will be used as prompts to discuss each theme:

- What are the reasons for your choices made on the google form?
- What are the barriers faced in communicating information(based on themes) to these communities?
- What other information do you feel could be important and relevant to build awareness through and interest in the app?
- What would be, according to you, the best way for you to communicate such type of information to households in rural and peri-urban areas?
- What would be, according to you, the best way for you to communicate such type of information through a smartphone application to households in rural and peri-urban areas?

EPRC TU Delft

Appendix E - Interviews with Experts

Expert Participant 1: Riad Mahmud, Director of MAX foundation, Bangladesh.

General remarks :

Payment information - expenditure that people make for the water supply, it is important that they have knowledge on the costing. They have to understand how they spend money and evaluate it in terms of expenditure.

The App is expected, now a days they(Private sector)are trying to reduce the costs especially in awareness campaigns and reaching the community. Cost of communication is quite high and it should be more financially viable. The TAPP App will be complimentary to DSBCC- Digitalized social behavior Change communication.

Questions:

Cost - things cannot be independently done. In the last 30 schemes he faced this challenge. it is very dependent on other organizations especially for awareness. support e.g. like WASH program etc.

Construction challenges - supplying enough water etc.

PWS related to the capex and opex - monthly tariff varies for low income communities so then funding is needed,

Available technology particularly for treatment - Many sources are contaminated so there are many challenges. It is a very complex system so finding a good solution is very challenging, either it is costly or too high tech etc.

User side two major challenges - quantity consumed by the user - when there is a tap water they use it. Awareness is important for this aspect. Water meter is used for this purpose but it complicates the payment.

There are lots of contradictory issues so that becomes challenging to communicate. Both tap and tube well are available etc. Value of tap water is much higher but people come back with different arguments like tariff especially during floods etc. Water quality has variability and because of this over time people no longer want to pay or use the PWS. The community needs to be involved in future solutions and decision making.

Updating is important but people are habituated with the screen so when there is a change they do not want to accept it so frequent updating is less popular.

DSBCC - started two years ago - awareness for leaders and middlemen who negotiate and provide awareness to communities. Decision making process needs to be handled and awareness is essential for consumers but cost of communication to reach rural and remote areas is high. So now mobile messaging and calls are done for awareness and creating demand. Manual communication method is difficult so they want to explore digitalized material. Rainbows communication strategy.

Learning through smart phone is becoming popular and use and access to it is increasing , that is why people have started thinking of it now.

Discussion of information topics in terms of importance in building awareness and relevance in the TAPP App.

Water quality:

a. Definition of good quality water is basically whether the water is harmful or safe. Aesthetic factors should be differentiated but are not as relevant to be promoted.

b. Very important, people need to be informed about type of contaminants- improve the current idea. They should know this so they can decide what water to use.

c. Very important- Arsenic and manganese are not seen in water - people get misguided by colour.

d. It is important but it is challenging- more educated it would be more understandable.- it has to be not numeric - it has to be in a communicable way to uneducated.- still very valuable to be aware.

Water sources:

a. Partly important - They should know if it is ground or surface water and if it is treated or not, considering they are educated and will understand it. Through a community leader it may be more valuable rather than through the App. It may overload the App with information.

b. It is important to know where the water is coming from e.g.) deep tube well which means ground water - should just reveal ground water , surface water or rain water.

c. PWS should ensure that they are using a safe source. For the supplier this is important but for the consumer or user it may not be as important as the tap should provide clean water. Ranking of safety and what level of risks can get complicated to give as information to the user. For consumer 1-2 but for supplier 4-5.

Water practices:

a. Very important

b. Again important for supplier, community it will be hard to use this information. Determining what they are using and telling them what risk level will be difficult. It

should be provided but it will take time to before it can be used properly from the App.

c. Very important - misuse of water is very high

d. Can have a backlash- what kind of water quality can be expected at home? and what can actually be treated. it is very context specific. However in a disaster situation or an emergency situation it is more relevant.

Health:

a. very important

b. Important

c. Additional knowledge to a household- if they can understand the symptoms then this is also usually covered in that.

Expert Participant 2 : Bilqis Amin Hoque, head of EPRC Bangladesh.

Information on treatment of the water - chlorination at source

For arsenic treatment there should be an Integrated arsenic and Iron removal treatment.

Household management practices are very important. This should include handling practices by user. Household treatment is not needed in the household level, it should be done by the suppliers.

Health related symptoms with photos is important, only for those contaminants with serious health implications.

Iron repeatedly comes up by users as a reason for not drinking the water - this is important to highlight.

Government standards as well as neighboring country standards as well as coverage in terms of the Piped water supply could be important information for Community leaders and Pourashava.

Water sources - There can be more bacteriological contamination in the PWS but if treatment methods like chlorination are done centrally the risk goes down. As PWS distributes to many people at a time , that's where the advantage lies even though in Hand pumps there is less bacteriological contamination. However, information should not be given with any conclusions drawn of which source is better.

There is an expectation that the PWS should work properly but in the current context there are still various challenges to solve so the information should remain neutral.

Financing information maters when using the PWS: information on this should highlight the need to pay for water as opposed to other expenditure.. IT is key because it is a recurring expense and people are not motivated by that.

Expert Participant 3 : Annemarie Mink, Lead Designer DUT

Water quality:

I think definitions will not directly help the people in their understanding of water safety, although it highly depends on how this definition is provided. An explanation would help better. Criteria regarding odour, colour and taste might be misleading: contaminants can be present without any change to odour, colour and taste and that might give people a false sense of water safety.

Names and types of contaminants are relevant to mention. To provide the people an idea of what can all be present in water, even without noticing it. I would therefore argue that not only the names and types of contaminants are mentioned, but also directly linked to the health consequences.

I think ways of identifying water contaminants are not directly of most interest to the people, but relevant. I think people are aware of the lab option, but not so much aware of the possibility of field testing. If they are aware, they might be better empowered to requests such tests. I do think more information is required than only ways to identify contaminants, such as the price and availability of different options.

I do not think that the exact values will contribute a lot to awareness raising. However, in combination with the values of people's own water supply it becomes interesting and relevant.

Water Sources

More knowledge on their own system is something that water consumers are already asking for.

I do think that people are already aware of the options they have, but additional information as possible contaminants for different type of water sources, possible issues that can occur an how these can be solved is certainly relevant. Perhaps combined with distance from their household, time and effort of collection, availability. Such kind of parameters

Water sources:

I think water consumers are eagerly waiting for more knowledge on ‘doing the right thing’. Especially women, but men as well, want the best for their children / families and would like to act upon that.

“appropriate uses” sounds a bit paternalistic. I would try to avoid that tone, and aim at providing options so that people can make an informed choice.

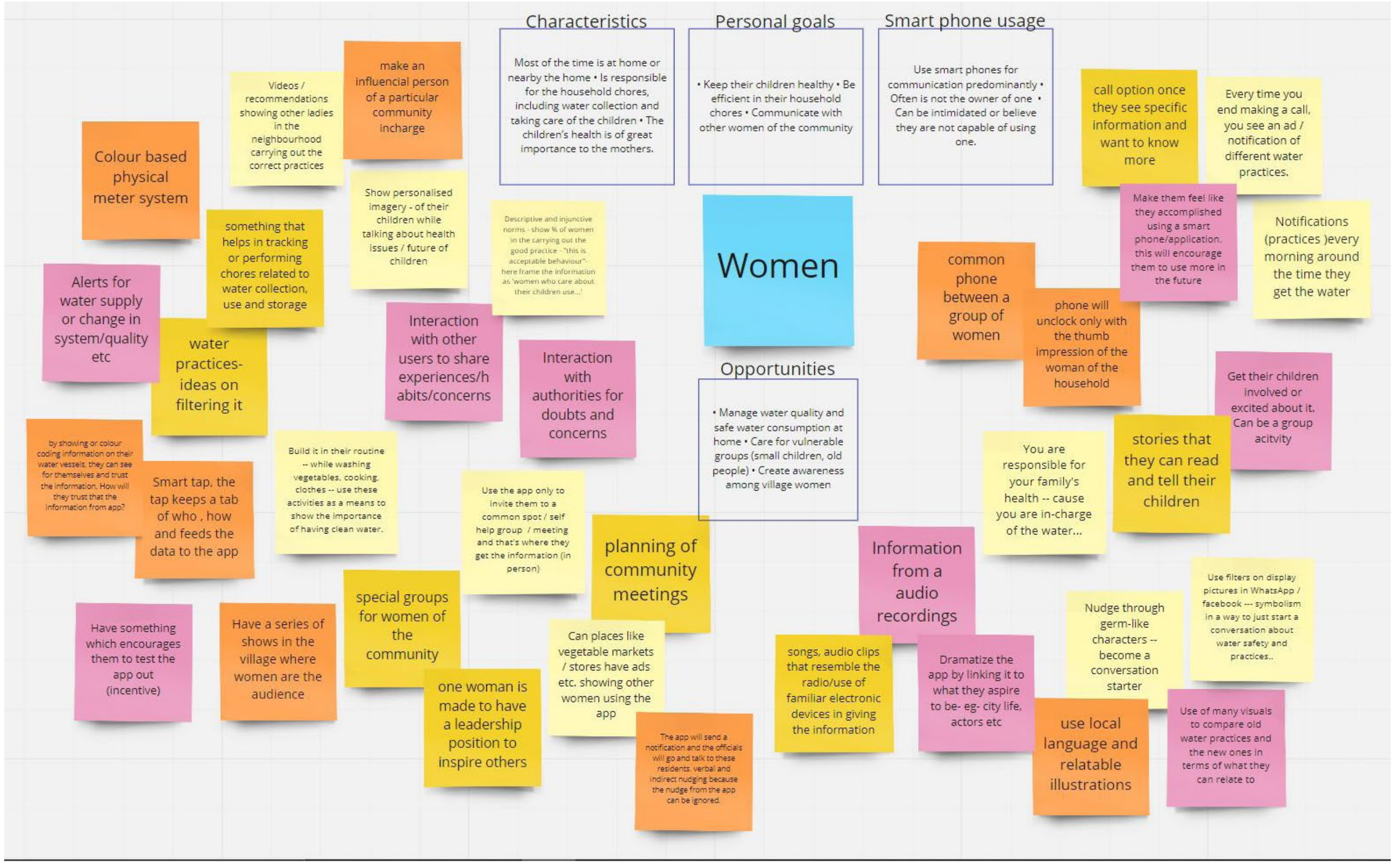
Health consequences give the information an urgency, so that people take the knowledge seriously. For children this information should not be too scary.

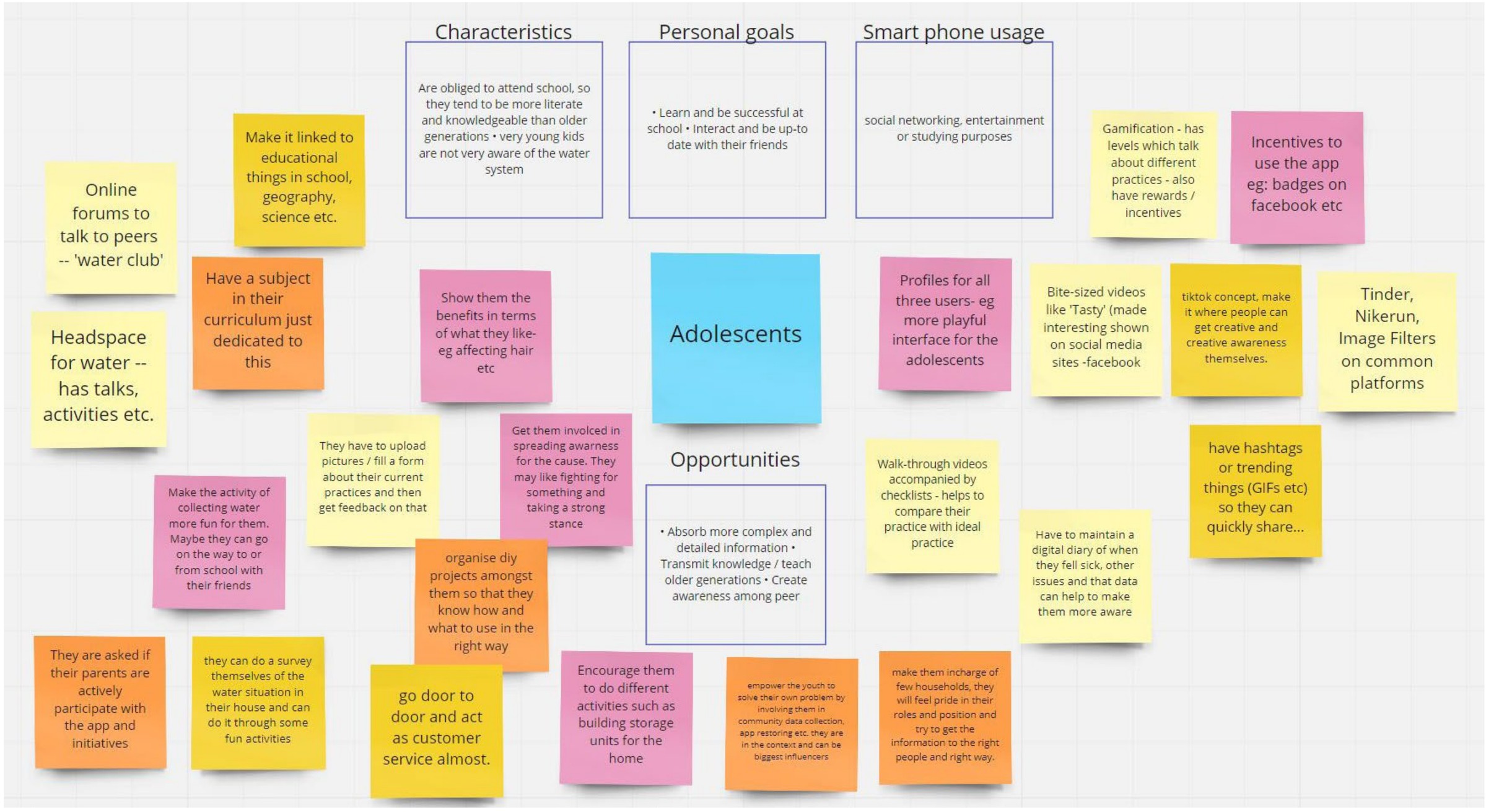
In the field, people often asked about symptoms, learning more, but do not forget to include knowledge on what to do when these symptoms arise! Then the people will feel empowered and the information becomes usable / valuable.

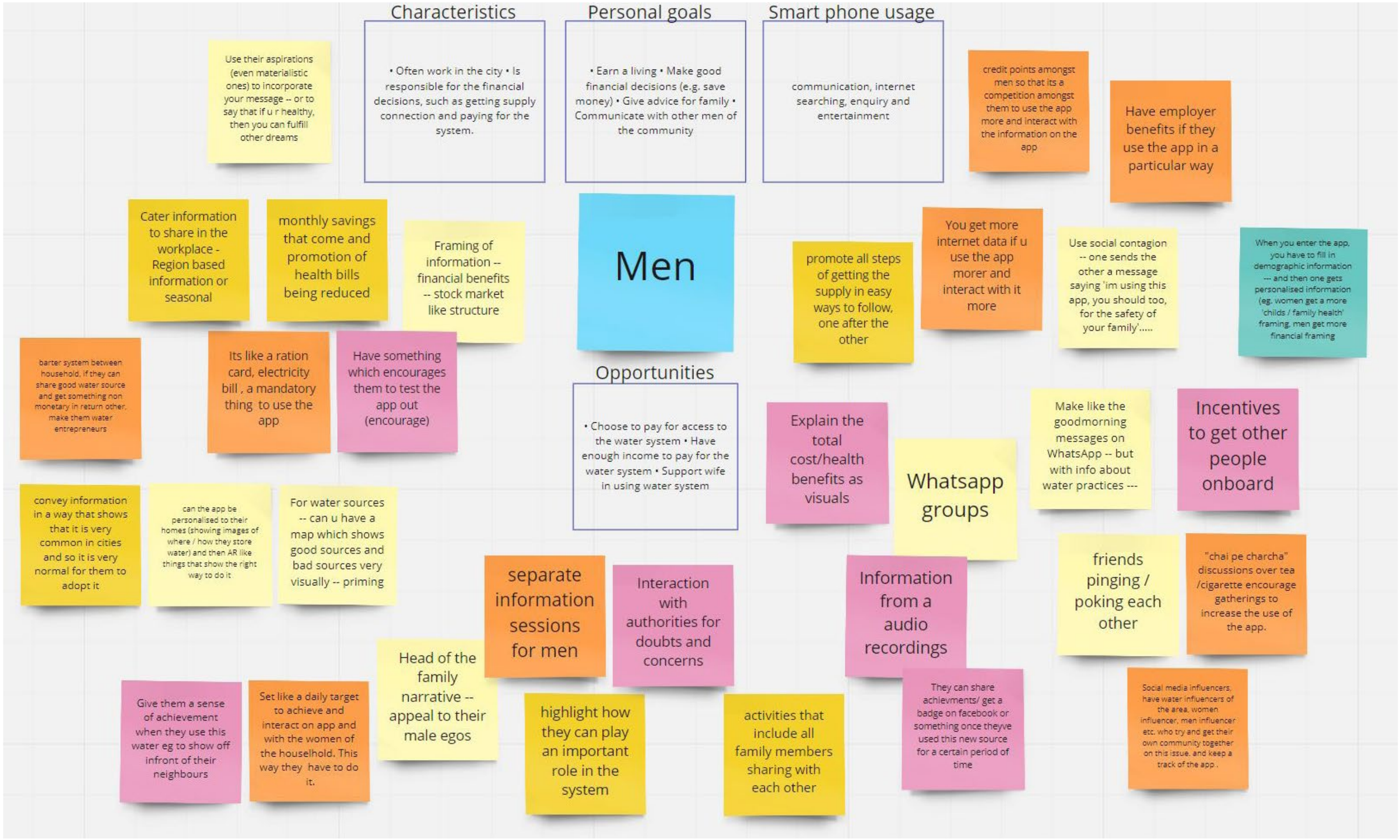
Appendix F - ‘How - To’ questions

- How can you convey complex information through a smart phone application?
- How can you give credibility to the information that is provided?
- How can you convey information over a long period of time? This includes new information as well as repetition of old information.
- How can you encourage sharing of information through the application?
- How can you ensure that the information provided is accessible by different groups of people, literate as well as illiterate?
- How can you ensure that the information is impactful?
- How can you tailor the information to the target group and make it more personal?
- How can you connect existing applications and phone functions to provide information? eg) facebook, whatsapp, call feature, messaging etc.
- How can you create a safe environment for people to be able to complain and voice their concerns?
- How can you show consequences of drinking contaminated water in a way that is not demotivating but is still taken seriously?
- How can you provide information that encourages behaviour change?

Appendix G - Digital brainstorming sessions




Characteristics
Are obliged to attend school, so they tend to be more literate and knowledgeable than older generations • very young kids are not very aware of the water system
Personal goals
• Learn and be successful at school • Interact and be up-to date with their friends
Smart phone usage
social networking, entertainment or studying purposes
Adolescents
Opportunities
• Absorb more complex and detailed information • Transmit knowledge / teach older generations • Create awareness among peer
Online forums to talk to peers -- 'water club'
Make it linked to educational things in school, geography, science etc.
Have a subject in their curriculum just dedicated to this
Show them the benefits in terms of what they like- eg affecting hair etc
Headspace for water -- has talks, activities etc.
They have to upload pictures / fill a form about their current practices and then get feedback on that
Get them involced in spreading awarness for the cause. They may like fighting for something and taking a strong stance
Make the activity of collecting water more fun for them. Maybe they can go on the way to or from school with their friends
organise diy projects amongst them so that they know how and what to use in the right way
They are asked if their parents are actively participate with the app and initiatives
they can do a survey themselves of the water situation in their house and can do it through some fun activities
go door to door and act as customer service almost.
Encourage them to do different activities such as building storage units for the home
empower the youth to solve their own problem by involving them in community data collection, app restoring etc. they are in the context and can be biggest influencers
make them incharge of few households, they will feel pride in their roles and position and try to get the information to the right people and right way.
Profiles for all three users- eg more playful interface for the adolescents
Walk-through videos accompanied by checklists - helps to compare their practice with ideal practice
Have to maintain a digital diary of when they fell sick, other issues and that data can help to make them more aware
Gamification - has levels which talk about different practices - also have rewards / incentives
Bite-sized videos like 'Tasty' (made interesting shown on social media sites -facebook
tiktok concept, make it where people can get creative and creative awareness themselves.
Incentives to use the app eg: badges on facebook etc
Tinder, Nikerun, Image Filters on common platforms
have hashtags or trending things (GIFs etc) so they can quickly share...


Characteristics
• Often work in the city • Is responsible for the financial decisions, such as getting supply connection and paying for the system.
Personal goals
• Earn a living • Make good financial decisions (e.g. save money) • Give advice for family • Communicate with other men of the community
Smart phone usage
communication, internet searching, enquiry and entertainment
Men
Opportunities
• Choose to pay for access to the water system • Have enough income to pay for the water system • Support wife in using water system
Use their aspirations (even materialistic ones) to incorporate your message -- or to say that if u r healthy, then you can fulfill other dreams
Cater information to share in the workplace - Region based information or seasonal
monthly savings that come and promotion of health bills being reduced
Framing of information -- financial benefits -- stock market like structure
barter system between household, if they can share good water source and get something non monetary in return other. make them water entrepreneurs
Its like a ration card, electricity bill , a mandatory thing to use the app
Have something which encourages them to test the app out (encourage)
credit points amongst men so that its a competition amongst them to use the app more and interact with the information on the app
Have employer benefits if they use the app in a particular way
promote all steps of getting the supply in easy ways to follow, one after the other
You get more internet data if u use the app morer and interact with it more
Use social contagion -- one sends the other a message saying 'im using this app, you should too, for the safety of your family'.....
When you enter the app, you have to fill in demographic information --- and then one gets personalised information (eg. women get a more 'childs / family health' framing, men get more financial framing
Explain the total cost/health benefits as visuals
Whatsapp groups
Make like the goodmorning messages on WhatsApp -- but with info about water practices ---
Incentives to get other people onboard
convey information in a way that shows that it is very common in cities and so it is very normal for them to adopt it
can the app be personalised to their homes (showing images of where / how they store water) and then AR like things that show the right way to do it
For water sources -- can u have a map which shows good sources and bad sources very visually -- priming
separate information sessions for men
Interaction with authorities for doubts and concerns
Information from a audio recordings
friends pinging / poking each other
"chai pe charcha" discussions over tea /cigarette encourage gatherings to increase the use of the app.
Give them a sense of achievement when they use this water eg to show off infront of their neighbours
Set like a daily target to achieve and interact on app and with the women of the household. This way they have to do it.
Head of the family narrative -- appeal to their male egos
highlight how they can play an important role in the system
activities that include all family members sharing with each other
They can share achievments/ get a badge on facebook or something once theyve used this new source for a certain period of time
Social media influencers, have water influencers of the area, women influencer, men influencer etc. who try and get their own community together on this issue. and keep a track of the app .