Sveriges lantbruksuniversitet
Swedish University of Agricultural Sciences

Faculty of Natural Resources and Agricultural Sciences

Gendered Groundwater Technology Adoption in Bangladesh

– Case studies from Thakurgaon and Rangpur

Sadiq Zafrullah

Master's thesis • 30 credits

Rural Development and Natural Resource Management – Master's Programme
Department of Urban and Rural Development
Uppsala 2019

Gendered Groundwater Technology Adoption in Bangladesh – Case studies from Thakurgaon and Rangpur

Sadiq Zafrullah

Supervisor: Stephanie Leder, Swedish University of Agricultural Sciences, Department of Urban and Rural Development

Examiner: Margarita Cuadra, Swedish University of Agricultural Sciences, Department of Urban and Rural Development

Credits: 30 credits
Level: Second cycle, A2E
Course title: Master Thesis in Rural Development, A2E
Course code: EX0889
Programme/education: Rural Development and Natural Resource Management – Master's Programme
Course coordinating department: Department of Urban and Rural Development

Place of publication: Uppsala
Year of publication: 2019
Cover picture: Sadiq Zafrullah

Online publication: https://stud.epsilon.slu.se

Keywords: Groundwater, technologies, irrigation, experiences, social construction, norms, intersectionality

Sveriges lantbruksuniversitet
Swedish University of Agricultural Sciences

Faculty of Natural Resources and Agricultural Sciences
Department of Urban and Rural Development

Abstract

Groundwater irrigation technologies are crucial for dry season agriculture in the North Western part of Bangladesh. The production of the major crop of the country, rice, is highly dependent on groundwater irrigation using Shallow Tube Wells (STW) and Deep Tube Wells (DTW). Along with the implementation of these irrigation technologies, concerns have been raised over the years on the unequal distribution of benefits of these technologies. This research explores farmers' experiences of the adoption of these technologies and analyses the impact on gender relations and the power dynamics between the machine owner and renter. The research has been conducted in two villages in the districts Rangpur and Thakurgaon. The findings present that social hierarchies have been strengthened due to the adoption of advanced technologies by providing uneven benefits between the owner and the renter. According to the farmers' experiences, the use of DTW may have an adverse effect on the water extraction capability of STWs that creates uneven benefits between the users' group of DTW and STW. Besides, women's access to irrigation may have increased with the adoption of advanced technology. The study shows how social identities of gender, economic class and religion shape farmers experience and influence social constructions of technologies.

Keywords: groundwater, technologies, irrigation, experiences, social construction, norms, intersectionality

Acknowledgement

I offer my gratitude to almighty Allah for giving me strength and patience throughout my thesis work. It was only possible to complete the work due to the blessings of Allah. Alhamdulillah.

I would like to thank my supervisor, Stephanie Leder, for the guidance and opportunities offered throughout my journey. I also offer my gratitude to her for introducing me to different local and international organizations and giving me the opportunity to work with them.

To my father, mother, my family and friends, Thank You very much for all the support, inspiration and motivation. I am indebted to all of them.

It has been an honour to receive a stipend from the Gustaf Hellsten's fund to support my travel to Bangladesh. I offer my gratitude to the Swedish University of Agricultural Sciences (SLU) for the grants to support my research.

Thanks to the Commonwealth Scientific and Industrial Research Organisation (CSIRO) and Bangladesh Rice Research Institute (BRRI) for funding the local costs of my fieldwork under the project *'Improving water use for dry season agriculture by marginal and tenant farmers in the Eastern Gangetic Plains'* funded by Australian Centre for International Agricultural Research (ACIAR) and led by The University of Southern Queensland (USQ).

My heartfelt appreciation to Muhammad Mainuddin, Principal Research Scientist at the CSIRO and Md Maniruzzaman, Principal Scientific Officer at BRRI, for the insightful information about the project and study sites, and for continuous support.

I want to express my gratitude to Md Mahbub Alam, Principal Officer at BRRI, for taking me to the study sites and introducing me with the farmers and key informants. It has been a great help for my fieldwork.

Thanks to all the participants who have voluntarily engaged in the research work and helped me during the data collection. I loved talking to the people of Dhandogaon village in Thakurgaon and Ramnather Para in Rangpur. I was moved by their hospitality.

The biggest credit goes to the Swedish Institute for offering me the scholarship to pursue my master's program in Sweden. It has been a great learning platform at the SLU and I am honoured to be awarded the scholarship.

Table of Contents

Acknowledgement **6**

Table of figures **9**

Acronyms and Abbreviations **10**

1 Introduction **11**
1.1 Problem Statement 11
1.2 Research Gap 12
1.3 Objective of the Study 13
1.4 Thesis Outline 14

2 Thematic Background **15**
2.1 Agriculture and Irrigation in Bangladesh 15
2.1.1 Agricultural production and rice cultivation 15
2.1.2 Irrigation in agriculture 16
2.1.3 Development of Minor Irrigation System 17
2.2 Social context in Bangladesh 18
2.2.1 Gendered division of labour 18
2.2.2 Social identities, economic class and religion 19
2.2.3 Intra-household dynamics of resource allocation 20

3 Concepts and Theories **21**
3.1 Norms and Institutions 21
3.2 Social Construction of Technology 22
3.3 Intersectionality 23
3.4 Analytical framework 24

4 Methodology **26**
4.1 Epistemology and Research Design 26
4.2 Selection of Study Sites 27
4.3 Qualitative Data Collection 28
4.4 Data Analysis 29
4.5 Ethical Considerations 29
4.6 Reflexivity of the Researcher 30

5 Farmers' experiences of irrigation technology adoption in Thakurgaon 31
5.1 Description of Dhandogaon and technology implementation 31

5.2 Farmers' experiences of different technologies 33
5.2.1 Variation of expenses 33
5.2.2 Time requirements 34
5.2.3 Impact of adopting advanced technology 34
5.2.4 An exceptional case 35
5.3 Management of the technologies 35
5.4 Women farmers and technology adoption 36
5.5 Equality issues based on class 38
5.6 Experiences based on religion 39

6 Farmers' experiences of irrigation technology adoption in Rangpur 40
6.1 Description of Ramnather Para and technology implementation 40
6.2 Access to the irrigation technologies 42
6.2.1 Variation of expenses 42
6.2.2 Machine operation 43
6.2.3 Women farmers and technology adoption 44
6.2.4 Norms, Culture and Religion 45
6.2.5 Water access for the owner versus renter 46
6.3 A comparison between the study sites 47

7 Discussion 48
7.1 Increasing inequality with the adoption of advanced technology 48
7.1.1 Uneven access to decision-making power 48
7.1.2 Variation of benefits based on technological capacity 49
7.1.3 Accumulation of social capital 50
7.2 Influence on social structure 51
7.2.1 Changes in the perception of gender roles 51
7.2.2 Impact on social identities 52
7.2.3 Improvement in social relations 53
7.3 SCOT and social stratification 53

8 Conclusion 57
8.1 The major findings – the social construction of irrigation technologies 57
8.2 Limitation of the study 58
8.3 Reflection on the methodological and theoretical choice 59
8.4 Suggestions for further studies 60
8.5 Recommendations and policy implication 60

References 62

Appendix 67

Table of figures

Figure 1: Analytical framework to understand the farmers' experiences and the social construction of technology. 25
Figure 2: Location of study sites in the map of Bangladesh 27
Figure 3: The DTW operator with smart-card system in Dhandogaon village 32
Figure 4: Diesel run STW in Dhandogaon village 33
Figure 5: A female farmer is irrigating a land with STW 37
Figure 6: Irrigation Technologies in Ramnather Para 41
Figure 7: A Model to analyse SCOT in Dhandogaon and Ramnather Para. 53

Acronyms and Abbreviations

AES	Agricultural Extension Services
BADC	Bangladesh Agricultural Development Corporation
BBS	Bangladesh Bureau of Statistics
BRED	Bangladesh Rural Electrification Board
BRRI	Bangladesh Rice Research Institute
CSIRO	Commonwealth Scientific and Industrial Research Organisation
D-STW	Diesel-Shallow Tube Well
DTW	Deep Tube Well
E-STW	Electric-Shallow Tube Well
FAO	Food and Agricultural Organization
GDP	Gross Domestic Product
HP	Horse Power
HYV	High Yield Variety
LLP	Low Lift Pump
MOA	Ministry of Agriculture
NGO	Non-Governmental Organization
SCOT	Social Construction of Technology
STW	Shallow Tube Well

1 Introduction

1.1 Problem Statement

Groundwater irrigation is one of the common inputs for agricultural production in Bangladesh. Since an irrigation system ensures agricultural water security and improves the crop production (Falkenmark, 2013), it is crucial for food security in a highly populated country like Bangladesh. A continuous development and implementation of irrigation system has manifolded the agricultural production since 1988 (Hossain, 2009, Fujita and Hossain, 1995). Currently, almost 71% of total arable land is irrigated using different minor irrigation technologies including Shallow tube well (STW), Deep tube well (DTW) and Low-lift pump (LLP) (MOA, 2018). Almost 80% of total agricultural land are used for cultivating rice and around 77% of total irrigation goes to rice production (Amarasinghe et al., 2014). Thus, the groundwater technologies play a vital role in agriculture in Bangladesh.

Although the implementation of technology seems to be beneficial for farmers' livelihood and food security (Hossain, 2009), a question may arise whether implementing DTW affect the users of other technologies (STW). Scholars argue that the intensive use of these technologies and failure of recharge in wet season results in drawdown in aquifer levels (Hossain, 2009, Mondal and Saleh, 2003, Mollah, 2017, de Silva and Leder, 2016). Hence, if DTWs can serve the irrigation year-round but STWs fall short of providing enough water supply, then it may create a sense of inequality among different technology users (de Silva and Leder, 2016).

Moreover, several scholars claim that technologies are developed from social interactions among different social groups (Howcroft et al., 2004, Prell, 2009), and different social factors and forces shapes technological development, which is termed as social construction of technology (Pinch and Bijker, 1987). Besides, Thompson (2016) suggests that the control over and access to the resources or technologies intersect with multiple intertwined social relationships that should be

addressed under the intersectionality[1] approach to examine the evolution of inequalities in the society. For example, de Silva and Leder (2016) report that there is assigned gender roles in relation to DTW adoption in Bangladesh as men are associated with implementation and operation processes, whereas, women are just water users. Thus, they call for further investigation on gender issues and analyse how technology adoption influence the beneficiaries differently (ibid).

1.2 Research Gap

A review of international discourses around technology adoption shows that the involvement of women in adoption processes can improve women's productivity in Burkina Faso (Appleton and Smout, 2003), overall economic condition in South Africa (Stimie and Chancellor, 1999), accumulation of wealth and bargaining position in the households in Kenya and Tanzania (Njuki et al., 2014). By analysing agricultural technology adoption data in Ghana, Doss and Morris (2000) argues that if men hold the control of resources (land, labour, etc.) then implementation of technology in agriculture will have uneven benefits to men and women. Another study on intrahousehold dynamics of technology adoption in Ethiopia, Ghana and Tanzania reveals that irrigation technology adoption entails different levels of costs and benefits across households, and men enjoy stronger claims of use rights than women (Theis et al., 2018). Humphreys (2005) suggest that the influence of technology on society and vice versa are mutually constitutive. However, Crenshaw (1991) argues that the intersections of race and gender influence one's experiences and emphasizes on "the need to account for multiple grounds of identity when considering how the social world is constructed" (p. 1245).

Several studies have focused on the impact of agricultural technology and minor irrigation system like STWs and DTWs in Bangladesh (Hossain, 2009, Mendola, 2007, Mondal and Saleh, 2003, Rahman, 2003, Shahid, 2011). These studies found out that the liberalization of the water market, strengthening extension services, and action from different private and government organizations have immense impact in increase of rice production, food security, farm household wellbeing and poverty reduction. However, these irrigation technologies have adverse effect on the environment and ecosystem, such as, the drawdown of groundwater (Hossain, 2009), and it can be a threat to the groundwater dependent agriculture in the future (Shahid, 2011). Besides, several scholars analysed the socio-economic aspects or agronomic issues related to irrigation technology and water management in Bangladesh (Chowdhury, 2010, Hossain, 2009, Mollah, 2017, Mondal and Saleh,

[1] Intersectionality is a theory that identifies different forms of social discrimination as a course of overlapping social identities.

2003, Rahman, 2003, Rasul and Thapa, 2004, de Silva and Leder, 2016). I couldn't find any study that addresses how uneven process of technology implementation affects the experiences of both male and female farmers and how it challenges different social norms in rural Bangladesh. Depicting a scenario of implication of the irrigation technology adoption would be necessary to comprehend how farmers' experiences have been evolved over the time.

1.3 Objective of the Study

The objective of the study is to explore farmers' experiences of technology adoption and the influence on social relations. The study mainly focuses on the social identities of gender, economic class and religion. The research took place in Rangpur and Thakurgaon in the North-western part of Bangladesh. The explanation to the following two questions may help achieving the research objective.

Question 1: How do the users of STW and users of DTW experience the impact of technology on irrigation?

The question collects different local narratives to explore similarity or divergence of experience between the users of DTWs and the users of STWs. It also elaborates how technology implementation shaped the experiences. These discussions sketch the scenario of equality or imbalance of benefits that may have accrued through these technologies. The answers to the following sub-questions help to discuss question no. 1.

- How was the decision to implement the technologies made? To what extent was farmers' participation maintained?
- How do the farmers get access to the irrigation technologies (STW or DTW)? Who has more accessibility and who has less?
- To what extent are the benefits distributed among the farmers? Which meanings do they assign to these technologies?
- To what extent do the technologies support irrigation to the land? How much dependent are the farmers on these technologies? How does the technologies improve the irrigation system?

Question 2: How does the access to irrigation technology influence the gender roles and the social relations within communities?

The assumption here is that gendered roles and social structure have influence over a farmer's experiences and social construction of technology. Thus, it provides a nuance discussion of how technology adoption shapes the roles of men and women. A close attention has also been placed on how social relations evolve with the adoption of the technology. Thus, the following sub-questions guides the research in answering question no. 2. While answering the questions, several social

factors are taken into account such as, livelihood strategies and opportunities, access to resources, gender division of labour, local norms and culture, and social identity.

- Who holds more power in deciding the implementation of technology (STW or DTW) and distribution of water for irrigation? How does a modern technology distribute the decision-making power to the community members?
- How does the access to the technologies shape the gender roles of work? How does the access to the technologies distributed between women and men?
- How do gender and class influence (in)equalities of access and benefits?

1.4 Thesis Outline

The outline of the thesis is as follows: chapter 2 discusses the contextual information on irrigation and agricultural production in Bangladesh. It also illustrates current scholarly debates on intersectionality in agriculture. Chapter 3 presents the key concepts and theories that this thesis follows. A description of methodology adopted in the research is elaborated in chapter 4. Both the chapter 5 and 6 details the empirical findings of the case studies of Thakurgaon and Rangpur respectively. The chapter 7 discusses the research questions based on linking the results to concepts and literature. The last chapter summarizes the research outcomes, reflects on methodologies, and recommends further study ideas and policy implications.

2 Thematic Background

This chapter illustrates current discourses around agriculture and irrigation in Bangladesh and sheds lights on the importance of groundwater irrigation and the development of irrigation system. Then, it briefly presents different scholarly discussion on different factors of social context of the country.

2.1 Agriculture and Irrigation in Bangladesh

2.1.1 Agricultural production and rice cultivation

Agriculture is one of the major economic sectors in Bangladesh where 71 percent of total land area was used for agriculture that contributed to 13.4 percent of GDP while comprising almost 41 percent of total employment in 2017[2]. Rice cultivation comprises almost 77 percent of the total agricultural lands and there are three cropping seasons (Ahmed et al., 2013). The winter season is the dry season and usually called *Rabi* season (November – end of March); *Khraif-1* is usually between end of March to April and can be regarded as spring pre-monsoon season; and the summer-monsoon season is called *Kharif-2* (May/June – November). *Boro* rice are cultivated in the winter season with the help of irrigation (Bryan et al., 2018, de Silva and Leder, 2016).

However, Majumder et al. (2016) pointed out the related factors of technological efficiency in rice production in Bangladesh. Those include size of the farm, farmer's education level, experience in farming, and access to training, microcredit and other extension services. Moreover, several government policies to withdraw diesel taxes and management criteria for farm machineries expanded the affordability of the irrigation machines in the 1990s (Hossain, 2009, Pearson et al., 2018).

[2] Data collected from the databases of World Bank Development Indicators and ILOSTAT on 23rd February 2019; https://databank.worldbank.org/data/source/world-development-indicators; https://www.ilo.org/ilostat

Subsequently, water markets were formed to serve the resource poor farmers which benefited both service providers and poor farmers (Mottaleb et al., 2016).

There are continuous debates around the literature concerning the impact of climate variabilities on rice production. The discussion spread over the issues of climatic impact on cropping patterns, adaptability of climate variabilities, natural calamities, groundwater level drawdown, accessibility of surface water, etc. With literature review, de Silva (2012) pointed out that climatic changes in Bangladesh are posing a threat to the agriculture and causing water and salinity hazards in the coastal area, increased drought in the north-west region, landslides in the hill tracts along with different natural calamities such as, floods, bank erosion, cyclones, etc. Chowdhury (2010) also argued that upstream withdrawal of surface water may affect the aquifer recharge in the coastal areas and increase the salinity of the soil. Besides, de Silva and Leder (2016) has reported that rainfall variability in three districts of north-western Bangladesh, Rajshahi, Rangpur and Thakurgaon, where farmers experience less amount of rainfall events. Extreme temperature level in both summer and winter have been reported in the recent years in these areas (de Silva and Leder, 2016). Similar outcomes have been found by Dey et al. (2011) that below average rainfall results in the drawdown of aquifer level causing water scarcity for household, agriculture and industry in the north-western region. Besides, droughts have become frequent incident in the country, especially in the north-western region (Alam, 2015, Habiba et al., 2011, Shahid and Behrawan, 2008).

2.1.2 Irrigation in agriculture

Irrigation has three distinct impacts on crop productivity: easy access to water scales down the crop loss; allows multiple crop plantation in the dry season; increases feasibility to irrigate large portion of area without being dependent on rainfall (Lipton et al., 2003). Several scholars suggest that irrigation has improved the agricultural productivity in Bangladesh (Asaduzzaman et al., 2012, Bell et al., 2015, Hossain et al., 2005, Palmer-Jones, 2001). Almost 60 percent of agricultural land was equipped with irrigation technology services throughout the country in 2016[3]. Groundwater irrigation has been popular since the adoption of shallow and deep tube wells (Bell et al., 2015, Shah et al., 2006). The rainfall in the monsoon season usually recharges the aquifers, whereas, northern region has highest recharge potential (Chowdhury, 2010, Shamsudduha et al., 2009).

Since research and development are much focused on the crop varieties cultivated on irrigated lands, Domènech (2015) suggests that the high-yielding crop

[3] Data collected from the database of World Bank Development Indicators on 24th February 2019; https://databank.worldbank.org/data/source/world-development-indicators

varieties generally performs better than the rainfed varieties. The surface water irrigation is uncertain as it depends on the water availability of the transboundary rivers (Chowdhury, 2010). The use of groundwater irrigation offers the farmer more flexible control of water use than that of the surface water irrigation (Bell et al., 2015). Asaduzzaman et al. (2012) argues that groundwater irrigation improves the efficiency of water use as the farmer shares the cost of irrigation facility.

However, dependency on the groundwater has several drawbacks. Kirby et al. (2015) investigated historic trends in water use and points out that excessive water withdrawal may cause a lower equilibrium level of groundwater aquifer in many places of the country. It suggests local level studies are required for sustainability issue of groundwater extraction (Kirby et al., 2015). Similarly, Dey et al. (2013) studied five districts (Rajshahi, Rangpur, Dinajpur, Pabna and Bogra) of the north-western region and found several flaws in groundwater irrigation management. It revealed that 21.3 percent of total irrigation water was extracted beyond the crop production requirement which increases irrigation and production cost (Dey et al., 2013). By analysing data of 1928 farm households, Chowdhury (2010) finds out that the level of efficiency of using irrigation water is lower than other agricultural inputs, such as, land, labour, fertiliser and ploughing with power tiller.

2.1.3 Development of Minor Irrigation System

Mechanization of agriculture started with the adoption of minor irrigation system in Bangladesh (Roy and Singh, 2008). In 1961-62, low-lift pump (LLP) was introduced to extract the water from surface waterways for irrigation. Later in 1966-67, Bangladesh Agricultural Development Corporation (BADC) implemented several Deep Tubewells (DTW) in Thakurgaon (ibid). In order to expand public groundwater irrigation schemes, BADC also supplied subsidized well equipment even though DTW installation requires capital-intensive intervention (Rahman and Parvin, 2009). Shallow Tubewells (STW) started its journey in Bangladesh from 1973-74 (Roy and Singh, 2008). Then on, privatization and implementation of minor irrigation system expanded manifold over the years and almost replaced LLPs while DTWs continued to lose its viability due to higher costs and management issues (Palmer-Jones, 2001). MOA (2018) reports that, almost 1.4 million STW was in operation for irrigation in 2016-17, whereas, around 37 thousand DTWs and 176 thousand LLPs were used for agriculture throughout the country. Almost one-third of the STWs are reported to be electricity operated machines while the others are oil run machines.

By analysing data from 1980-81 to 2006-07, Rahman and Parvin (2009) found that there is high correlation between *Boro* rice production and the amount of irrigated area. That is, increase of one hectare of irrigated area comes with the

growth of 3.22 Metric Tons of *Boro* rice (Rahman and Parvin, 2009). As stated earlier, several scholars criticised and concluded that the depletion of groundwater level is caused by the excessive extraction of groundwater (Ahmed et al., 2013, Alam, 2015, Kirby et al., 2015, Shahid and Hazarika, 2010, Shamsudduha et al., 2009). Noting the drawdown of the aquifer level in Rajshahi, de Silva and Leder (2016) reported that the advantage of DTW is time-bound and predicts that the adoption of it could promote further water stress in the region. However, Mondal and Saleh (2003) evaluated the performance of STWs and DTWs in Rajbari, a district of Central Bangladesh and found that the performance of both the tubewells was better than the past in terms of water discharge and delivery while agricultural performance between the technologies is somewhat similar.

The drawdown of aquifer levels in the recent years is of greater concern in Bangladesh, especially in the Barind Tract and Dhaka region. Kirby et al. (2015) showed that three-fold increase of the groundwater irrigation over the last few decades is the cause of the depletion of groundwater level. Besides, decline in the rainfall in monsoon season is the cause of insufficient recharge of groundwater (ibid). Several scholars have concluded that the irrigation through shallow aquifers in the north-western region is not sustainable (Ahmed et al., 2013, Alam, 2015, de Silva and Leder, 2016, Dey et al., 2013, Hossain, 2009, Kirby et al., 2015, Mollah, 2017, Mondal and Saleh, 2003). Dey et al. (2011) argues that farmer's lack of proper knowledge and improved technology are the reason behind the over extraction of groundwater. However, (Kirby et al., 2015) notes that the region other than Barind tract and Dhaka are out of the threat of groundwater extraction for irrigation.

2.2 Social context in Bangladesh

2.2.1 Gendered division of labour

Being a patriarchal society, men and women's behaviour within the household and society are shaped by the traditional and religious norms in Bangladesh (Clement, 2012). Women in rural area are usually involved in small-scale household agriculture and post-harvest works along with regular household chores, such as, cooking, cleaning, bearing water, taking care of the children, rearing livestock and poultry, etc (ADB, 2010, de Silva, 2012, Jaim and Hossain, 2011). On the other hand, all the public and economic tasks including agricultural and non-agricultural works are traditionally regarded as the space of men (ADB, 2010, de Silva and Leder, 2016). Broader socio-cultural norms limit the women's access to public space and some other factors like age, class, education and household position also

determines the extent to this restriction (Sultana, 2009). Some studies identified the undermining of women labour and female seclusion in agriculture as social and cultural norms (Kabeer, 1994, Rahman, 2000).

However, Asaduzzaman (2010) reports showing the statistics from the Bangladesh Bureau of Statistics that women participation in agriculture is growing over time. The change is attributed to poverty, increase of NGO interventions and male migration to non-farm jobs (Jaim and Hossain, 2011). Besides, women's participation in the public space, such as, markets, education and jobs, is also on rise in recent years but with a socially acceptable attire (Sultana, 2009). Sultana (2009) further argues that the acceptability of an attire depends on the social class of the person. Such socially constructed barriers restrict women from different types of labour. However, Clement (2012) states, "labour is not always and not only a burden but also carries a social function and cultural meaning" (p.4). To understand the complex pattern of gendered division of labour, specific cultural context needs to be analysed (Clement, 2012).

2.2.2 Social identities, economic class and religion

Social identities and status are determined by age, gender, wealth and ethnicity in most of the rural areas in the developing countries (Shitima, 2018). Social systems tend to benefit certain groups of people in the society, whereas, hurt others. Wong (2009) sheds light on the power inequality between the villagers and elites in rural area in Bangladesh. It shows that financially more capable persons hold the decision-making power which in turn facilitate them to access resources compared to the poor people (Wong, 2009). While analysing gender dimensions of water access in rural areas of Bangladesh, Sultana (2009) showed that, in certain situation and context, women tries to invoke affiliation to powerful or wealthy families to acquire access to water sources. It presents the divergence of benefits between the upper and lower classes of people.

de Silva (2012) analysed the gendered division of labour based on the social stratification by class, caste/ethnicity, and age. It showed that several ethnic minorities, such as Hindu, Dalits, and tribal groups, have less access to resources than the majority of Muslim in several cases (de Silva, 2012). It also argues that lower economic classes of people, characterized by poverty, are marginalized to live in the vulnerable, risky and unhealthy places (ibid). Analysing cases of social supremacy, Mallick and Vogt (2011) concluded that only the rich people got to participate in the local level disaster management planning process which restricted the benefits to the poor people. Moreover, financial capability influences the ownership and access to land resources. A large portion of the farmers rent land for farming. Ahmed et al. (2013) found that 34 percent of farmers are tenants, whereas,

37 percent owns a land and other 29 percent have both own and rented lands for cultivation. Most of the tenant farmers are likely to experience poverty and lack of resources while landowners have access to several other resources (Pearson et al., 2018).

There is also complex relationship between gender and religion that have strong relation with the core institutions of the society (Naher, 2006). The existing gender roles and relations are also influenced by the religious views and values. Naher (2006) argues that the religious institutions not only set rules for the individual level but also affect the norms of social life, such as, community affairs. The patriarchal system in the Bangladesh use religion to establish men's dominance over women (Chowdhury, 2009). However, Katnik (2002) opined that individuals' identities are shaped by the religion, so as their opinions and actions.

2.2.3 Intra-household dynamics of resource allocation

In Bangladesh, women have comparatively lower control of assets than men, such as, land, livestock, agricultural machinery, education, extension support (ADB, 2010, Quisumbing et al., 2013). ADB (2010) found that women's work in small-scale agriculture is often not considered as farming, hence, extension services and upgraded technologies do not reach to them, even when it might be important to their farming. Moreover, inheritance law in Bangladesh follows different religious laws which treat the women differently and offers unequal distribution of wealth (Clement, 2012, Pearson et al., 2018). For example, Muslim women can inherit half of their male counterpart, whereas, Hindu women are not eligible for inheritance (Clement, 2012).

Several NGOs have promoted micro-credit programs for poor and landless women, through which women could improve their economic status (Clement, 2012). It contributed to women empowerment in the rural areas and increased women's non-land assets (Pitt and Khandker, 1996). Nevertheless, several critics challenged the micro credit system and women's control of the loan (Kabeer, 2009). While analysing climate change adaptation, de Silva (2012) found that women are more vulnerable than men in every aspect. However, Shonchoy and Rabbani (2015) showed that Bangladesh has improved in the rate student enrolment in the education and achieved gender parity in recent years.

3 Concepts and Theories

To analyse the data collected from the fieldwork, a conceptual framework has been built through literature review. Even though a case study research is usually inductive (Creswell, 2014), a conceptual framework works as a guidance for the research process. In this study, the concepts of norms and institutions, Social Construction of Technology (SCOT) (Klein and Kleinman, 2002) and intersectionality (McCall, 2005) are deployed to analyse the empirical data in answering the research questions. An analytical framework has been developed by bridging these concepts and theories in order to drive the empirical analysis.

3.1 Norms and Institutions

A discussion of norms and institutions is necessary to have an in-depth analysis of farmers experiences of the irrigation technologies. North (1991) has defined informal constraints (e.g. (sanctions, taboos, customs, traditions) and codes of behaviour as informal institutions. Institutions construct different sets of incentives and disincentives to limit and shape actor's behaviour in a particular direction (Friel, 2017, North, 1991). Hence, they generate foundation of productive human interaction by creating order and reducing uncertainty in exchange (North, 1991). Friel (2017) argues that interactions are stronger in such atmosphere due to shared understanding of the implicit perceptions.

Similarly, Scott (2013) argued that institutions have three pillars; e.g. Regulative, Normative, and Cultural-cognitive. Regulative institutions impose written and unwritten rules to constrain present and future behaviour. The normative institutions are the norms and values that determines the standards of behaviour and construct a structure to compare and assess with the existing standards. By focusing on cognitive dimension of human existence, Scott (2013) asserts that the cultural-cognitive institutions create the basement upon which meaning is made. That is, the culture shapes the meanings and perceptions shared by the individuals in a society.

Several scholars have discussed about the differences between norms and values. The general moral principles can be regarded as values, whereas, norms are the regulation of action. Portes (2010) states, “norms are rooted in values that tend to resist change, and power structures change slowly because powerholders prefer not to give up their privileges” (p. 235). Even the changes in individual social norms are slow (Roland, 2004). The norms shape the role of an individual and constrain the set of behaviours in the society (Portes, 2006). The roles of different individuals contribute to the status hierarchy and social structure (ibid). It is because a culture is constituted through values, cognitive frameworks, and knowledge gathered while social structure is established through individual and collective interests based on various levels of power (ibid).

As we proceed further, the conception of the norms and institutions would be relevant in understanding the discussion of the social construction of technology. To analyse how farmers set the meaning of an artefact and how the institutions of society shape the experiences, this discussion will bring out the broader picture.

3.2 Social Construction of Technology

Technology in agriculture is usually used to ease the work, productivity growth and efficiency growth and to protect from various harmful substances (Piesse and Thirtle, 2010, Rahman, 2003). Since technology is a human creation, just as society, adoption of technology has influence on affecting social structures (Klein and Kleinman, 2002). Pinch and Bijker (1987) first introduced the theory of social construction of technology (SCOT). It provides a theoretical perspective on the technological impact on society (Bijker, 2009). The social embeddedness of a technology can be considered as the social construction of technology.

According to Klein and Kleinman (2002), the conceptual framework of social construction of technology offered by Pinch and Bijker (1987) can be divided into four different components. The first, *interpretative flexibility*, suggests that different social groups can interpret the outcome of a technology differently given that designing of a technology is an open process. Here, ‘designing’ refers to the shaping of common interpretation of an artifact (Prell, 2009). Several scholars apply this idea to show that artifacts are the results of intergroup negotiations (Bijker, 1997, Klein and Kleinman, 2002, MacKenzie, 1993, Pinch and Bijker, 1987). The second component is the *relevant social group* which assumes that everyone in a social group assigns similar set of meaning to the artefact. Therefore, Klein and Kleinman (2002) termed it as agency-centric approach. The third component considers that a multiparty design process may create conflicts and the design of the artifact continues until a consensus is reached, thus termed as *closure and stabilization*. The

last component is suggested by Klein and Kleinman (2002) as *the wider context* due to its solid relevance to the topic. It discusses the sociocultural and political atmosphere where the artefact is developed.

In today's world, technology is an integral part of the society and culture. According to Bijker (2009), a technological frame instigates the synergy of different members of the community and construct their way of thinking and acting. When discussion around an artefact takes place in that community, a technological frame starts to develop as different groups assign different meaning to the technologies (Bijker, 2009). The actions and interaction of the actors resembles to a technological frame which, in turn, defines how it is socially constructed (Bijker, 2009). That is, current actions influence future actions and it can be explained as impact of technology into the society. In my case, a discussion of uneven access to DTW and an increasing demand of it would be crucial to evaluate. That is, we have to examine if previous action of irrigation technology (STW) implementation influences the benefit to the farmer when more advanced system of irrigation is implemented and operated side by side. Besides, analysis of the experiences of the users of two different technology may present the variance of choices, affordability, access and negotiation power. Bijker (2009) further suggest that, other concepts should also be incorporated to address the question of technological impact on society using *sociotechnical ensemble* unit of analysis. That is, the analysis should not have a priori or context before determining the issue as technical or social. Thus, the theory of intersectionality is proposed in the discussion as either or both technology and the interconnected social stratifications may influence individual's experiences.

3.3 Intersectionality

Intersectionality tries to determine the impact of interlocking systems of power on the vulnerable and discriminated groups in the society (Collins, 2002, Cooper, 2015). There are different types of social stratification in Bangladesh, based on class, gender, religion, ethnicity/caste, age etc. The concept of intersectionality proposes that these social stratifications are inter-related and must be analysed simultaneously (McCall, 2005, Nightingale, 2011). There is correlation between power relations and these social identity differences (Collins, 2010). That is, individual's social experiences may vary depending on these power relations. These concepts are important for analysing who are the beneficiaries of the technology implementation and how the decision of technology implementation can be viewed from the local socio-political milieu.

McCall (2005) proposed three methodological approaches through which different analytical categorisation can be applied to understand complexity of

intersectionality. The first, *anticategorical complexity*, deconstructs the analytical categories on the assumption that social life is highly complex and, otherwise, it may create inequalities in the process. Secondly, the *intercategorical complexity* suggests to follow existing analytical categories to evaluate the inequalities and change in its structure. The last approach, *intracategorical complexity*, stands in between the other two approaches and while rejecting the categories, it strategically uses them. In this research, I have used only the last approach, intracategorical complexity, to analyse the group of people "whose identity crosses the boundaries of traditionally constructed groups" (Dill, 2002) and discussed the complexity of experiences in such groups (McCall, 2005). Since I assume that gender, economic class, religion may intersect to shape the experiences of an individuals in a certain group (STW users or DTW users), the analysis of intracategorical intersectionality may explain the intergroup negotiations in the development of technological frame.

According to the conception of Crenshaw (1991), the black women experience oppression, such as sexism, differently than that of white women in a particular location, whereas, black women facing racism is different than that of black men. Crenshaw (1991) argues that we need to analyse a multiplicative effect of the intersections of these identities to understand the experiences of Black women. According to Thompson (2016), "framing experiences through a single lens such as gender, race, or class distorts and marginalizes those who face multiple intersecting oppressions" (p.1288). Thus, while analysing gender roles, I consider that different social instruments are interconnected which may influence the gender roles.

3.4 Analytical framework

The concepts and theories discussed above can be utilized to build an analytical framework (Figure: 1) to examine social construction of irrigation technology keeping a focus on the adoption process. The groundwater irrigation is the major way of irrigating the lands in Bangladesh. However, the access to the groundwater technologies are not always equal to the farmers in a village. Several social stratifications persist in the society which may also influence the access and control over resources. The concept of intersectionality emphasizes that these social stratifications, based on age, gender, class, religion, etc., are interconnected and needs to be analysed together while discussing the level of accessibility of the technologies. It is crucial to understand how different social markers, such as gender, economic class based on farmers' view and religion, make meaning of these technologies and to what extent these meanings are similar to each other. As stated earlier, SCOT consider that all the individual in a certain group assigns similar set of meaning to an artefact. But analysing intersectionality and SCOT together we can

attempt to investigate similar meaning making and the differences among different social groups (e.g. machine owners, renter, men, women, etc.). Moreover, looking into the role of intersectionality in SCOT's multiparty design process and conflicts would be helpful for critical analysis.

The intersectionality approach should be addressed based on the social norms and institutions of the study sites. As the social norms and institutions set the rules and define the actor's degree of freedom, the discourse of intersectionality may unveil the dynamics at play in the negotiation process in SCOT. Thus, I assume that intersectionality is interconnected with social norms and institutions. When there is a boundary set by the institutions, the intersectional approach needs to be considered in relation with this boundary since it influences individual's experiences within the institution of that particular area. However, the analysis of interlinking social strata would successively show the type of regulation in the institutions and what kind of boundaries that it makes. Besides, understanding these institutions would allow me to build the discussion of the SCOT. Moreover, actors' experiences and expectation constitute in a particular social atmosphere. As the institutions determine the codes of behaviour in the society, the expression of an individual may also be motivated by such regulation. However, the continuous process of SCOT may also evolve the individual experiences and vice-versa while developing the technological frame in such ways. Therefore, I argue that the social construction of irrigation technology is closely related to the farmers experiences.

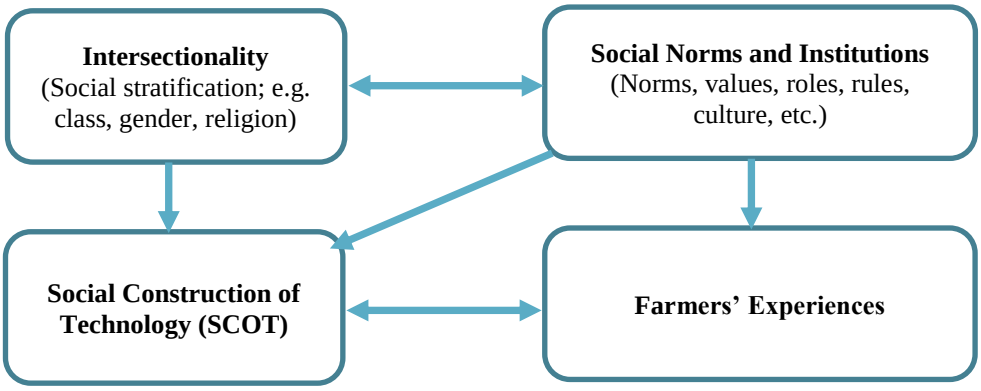

Figure 1: Analytical framework to understand the farmers' experiences and the social construction of technology.
Source: Author

Figure 1 presents the analytical framework outlined by the above-described relationships between intersectionality, social norms and institutions, SCOT, and farmer's experiences. The intersectionality, institutions and farmer's experiences are identified as the determinants of SCOT. Besides, the farmers' experiences and the SCOT are interconnected, whereas, institutions and intersectionality are directly related to each-other.

4 Methodology

The chapter analyses the research approach undertaken and critically argues for the chosen methods. It elaborates the philosophical background, resonates the choice of study sites, discusses the methods of data collection and analysis. The ethical issues and research reliability have also been explained.

4.1 Epistemology and Research Design

The research is based on 'constructivist' worldview which facilitates an in-depth analysis of human experiences and observations (Creswell, 2014). It assumes that historical and cultural surroundings shape individual experiences and it also helps to analyse complex issues involved in the pattern of perception (ibid). Thus, this epistemology helps me to understand how different technology implementation affects farmers' experiences in certain cultural and social context.

The study is designed as a 'case study research design' to analyse in detail and intensively (Bryman, 2012). The rationale behind choosing the case study as a research design is that it enables the researcher to deal with multiple types of data (e.g. documents, interviews, focus group discussion, etc.) into the study. Yin (2017) defines case study by referring (Schramm, 1971) as, "it tries to illuminate a decision or set of decisions: why they were taken, how they were implemented, and with what result" (p.15). According to Bryman (2012), this study can be termed as 'exemplifying case' because it examines key social processes and divulge the implication of technology implementation. As I intend to explain the extent of irrigation technologies in creating inequalities and affecting the social structure, the research follows an explanatory research study. Different theories are employed to analyse and explain the data. The intention here is to incorporate the in-depth explanation and theories during analysis which increase the strength of the study. To simplify, there are two cases depended on the location of the study, Rangpur and

Thakurgaon. It allows me to produce a comparative discussion and ensure the robustness of the research.

4.2 Selection of Study Sites

The research is conducted along with a project, *Improving water use for dry season agriculture by marginal and tenant farmers in the Eastern Gangetic Plains*, led by the University of Southern Queensland (USQ) in collaboration with several other national and international organizations working in Bangladesh, India, and Nepal[4]. The purpose of the project is to "understand the bio-physical, socio-economic and institutional aspects of groundwater irrigation in the northwest region of Bangladesh" (Mainuddin, 2016). According to Bangladesh Rice Research Institute (BRRI) personnel, the study sites of Rangpur and Thakurgaon were purposively chosen by BRRI because of its easy access and diverse cultural settings. There is variation of aquifer levels between the sites It enables to examine how different aquifer levels influence the management of irrigation. Besides, both the study sites accommodate the traditional irrigation machines and the modern machines (Source: BRRI Staff Discussion).

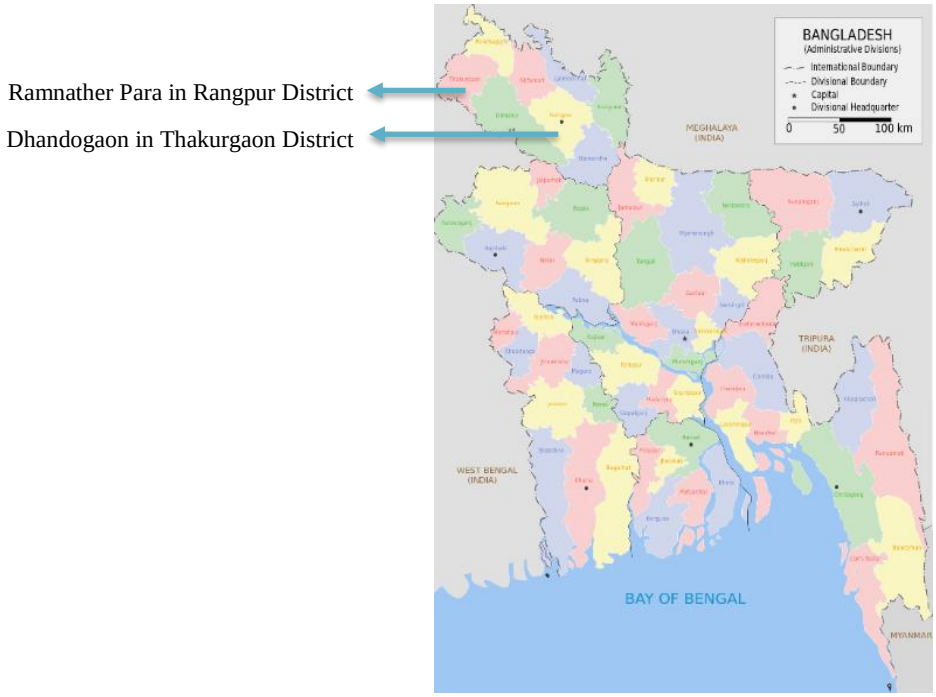

Figure 2: Location of study sites in the map of Bangladesh
Copyright: I, Armanaziz (CC BY-SA 3.0)
Source: https://commons.wikimedia.org/wiki/File:BD_Map_admin.svg

[4] Find details at: https://dsi4mtf.usq.edu.au/about-us/

I collected qualitative data in Ramnatha Para village in Rangpur and Dhondogaon village in Thakurgaon (Figure 2). It helped me to gather data from both users of DTW and users of STW. Besides, it has allowed me to build up a comparative study and analyse if there is any pattern of how the experiences of the farmers has been evolving.

4.3 Qualitative Data Collection

One of the most important tasks of a research project is to obtain reliable and sufficient data. To ensure quality data, several methods of data collection procedures were followed in this research, such as, interviews, focus group discussions (FGD), observations, etc. The data collection started with a transect walk to get an idea of the research sites and identify the locations of the irrigation technologies. I have collected 15 interviews including 5 women in Dhandogaon village, 19 interviews including 6 women in Ramnather Para and 2 FGDs in each of the villages[5]. Each of FGDs was gender separated and had participants between 10-15 persons. During the selection of the participants, an attempt was to contact with a range of people from different religion, sex, ethnicity, age and other social groups to acquire the intersectionality perspective in the thesis. Furthermore, during the FGDs, I conducted 2 Participatory Resource Mapping (PRM) and 2 Wealth Ranking (WR) in each of the villages. The PRM helped me to identify which resources are valuable to the farmers and the WR explained farmers view of different economic class in the villages. The fieldwork was conducted between February and March 2019.

At the beginning, a support from BRRI was acquired to identify key informants in the study sites. To avoid the biasness and identify participants for the FGDs and interviews, the 'snowball sampling' was utilized along with the consultations of the key informants (Silverman, 2015). Attention was to collect gender separated data through interviews and FGD to gather the differences of experiences and perceptions between man and women. I also contacted people from different religion, class and culture to find out the issues of intersectionality. The questions for both interviews and focus group discussions were semi-structured. It kept me focused on the key issues of my research questions and guided me throughout the data collection. The drawback is that unstructured questions enables the researcher to accumulate a wide range of information although there is a risk of losing the track of the conversation. However, the questions were open-ended and flexible to gain respondents' full understanding of the question asked. These were designed to find out respondents' social identities, internal social negotiations around implementation of technology (STW or DTW), experiences of technology,

[5] A data table is included in the appendix

perception of these technologies, their worldview of technology, accessibility, expectation, challenges etc[6]. Observational and interview protocol were maintained during all the interviews and FGDs, conversations were recorded through audiotaping, and notes were taken (Creswell, 2014).

4.4 Data Analysis

I have transcribed the data during the fieldwork and included the notes taken from observations. I have coded the data using a software, Atlas.ti. The codes were assigned to the respondents, different themes, and other interesting factors that emerge during the field work. For example, the codes for the themes were the technology adoption, implementation, gender, economic class, religion, experiences of STW and DTW, etc. The themes were originated from the responses of the interviewees that are aligned with the research questions. As the research was inductive, an analysis of responses after each interview facilitated me to categorize the themes on which the results and discussions are based upon. According to Mayring (2014), "the category system constitutes the central instrument of analysis" (p.40). Besides, the themes were instrumental to analyse through the conceptual framework and build a thick description of the data. My analysis has started by stating a description of the setting and the study area. Then I have discussed the cases according to different themes that appeared through the collected data. My motive was to build an in-depth analysis on each of the themes and connect between the themes. These discussions are written through the theoretical lens and conceptual framework. For example, an attempt was to examine how intersectionality influenced farmers experiences and how the data satisfies different components of SCOT.

4.5 Ethical Considerations

Since the study tries to explore the experiences of the human beings, the ethical challenges should be discussed. I will follow the ethical considerations on different stages of my research according to what (Creswell, 2014) suggested. Primarily, I have contacted BRRI, which is one of the stakeholders of the ongoing project in Rangpur and Thakurgaon. BRRI has provided me local approvals and introduced me with the key informants.

All the participants voluntarily participated in the interviews or FGDs. As I have used coding to all the participants, anonymity of all the participants are ensured. All

[6] Please follow the Appendix for questionnaires.

the information is protected, and the names are not mentioned in the thesis so that no one can be identified. Before taking an interview or an FGD, I asked the consent from the participants, informed them about the research purpose and asked for their involvement. At the end of each session with the participants, I provided them a note to thank them which also included my contact information if they need to contact me later or for any clarifications. Moreover, it also legitimised their participation in the research. While analysing the data, I have refrained myself to put my own idea rather I have discussed from different conceptual perspective and theoretical lens.

4.6 Reflexivity of the Researcher

Doing a research in a familiar place has its own advantages and pitfalls. Thus, a clarification of researcher's roles and biases is important in such qualitative study. Since I grew up in a nearby district of the research study sites, I may have unintended biases and overlooked the little details that influenced the participant's experiences which may affect my interpretation of data. In contrast, this familiarity may also contribute to my understanding of the respondents' experiences which further contributed to the research. It also allowed me to ask follow-up questions and conduct an intensive conversation.

Besides, my field work was supported by a government organization – BRRI which had both positive and negative impact on my fieldwork. A BRRI personnel introduced me to the villages where the farmers often considered me as someone from the government. Their responses may have a bias thinking me as a representative of the government organisation. To eliminate this impression, I approached few people as an independent student researcher, but they were either reluctant to participate or told me that they were busy at that moment. Moreover, my access to women interviewees was not as easier as that of men. When I asked both men and women farmers to introduce me to a woman, they did not seem to be comfortable in doing that. Specially, the Hindu women in Ramnather Para were difficult to reach because they were either shy to talk to me or not interested in participating. Even though I had intention to reach equal number of men and women, I could not do so (see chapter 4.3).

5 Farmers' experiences of irrigation technology adoption in Thakurgaon

This chapter discusses the data collected during the fieldwork at the Dhandogaon village in Thakurgaon. I have focused on the research objective by analysing the qualitative data collected through interviews, focus group discussions, resource mapping and wealth ranking. The discussion is divided into different themes to answer the research questions. Specifically, I have gathered the evidences of how the implementation of different technologies took place in the village and how the farmers adopted these technologies. The findings from Rangpur study site follows this chapter and the discussion of the results in relation with the concepts and theories are presented in a separate chapter.

5.1 Description of Dhandogaon and technology implementation

Dhandogaon is a small village at the eastern side of Thakurgaon district. Most of the habitants in the area follows Hindu religion while others follow Islam religion. The major income source of the habitants in the area is agriculture. The village comprises majority of poor and lower-middle income families. A significant number of farmers use rented lands for cultivation (Maniruzzaman and Mainuddin, 2016). Almost Half of the 15 interviewees asserted that they do not own a land but rent from someone else on different types of contract. The participants' average land holding is between 1.5-2.5 acres either by ownership or rental. In the wealth ranking, farmers opined that those having around 5 acres fall in wealthy families, middle income families have around 2 acres, whereas, poor families do not have any land but rent from other people. The educational attainment is low among the villagers. Only 6 of the 15 respondents had formal education. The interviewed farmers' age group is approximately between 30-40 years. Some people expressed that they had obtained trainings on agricultural activities. However, only a few of the respondent

said that their family members have migrated to other areas for non-farm jobs. Both men and women responded that the income are kept or spent by the male household member. Only one person said that both he and his wife spend the income. Besides, no woman of the participants asserted to have landownership.

Due to unavailability of surface water, the use of STWs is widespread and approximately 100 STWs were in operation before the installation of the DTW (de Silva and Leder, 2016). In recent years, farmers have experienced high costs in using the STWs because of the drawdown of the water level and other climatic variabilities. According to the farmers in the Dhandogaon village, they have been using the STWs for quite a long time until 2014. Barind Multipurpose Development Authority (BMDA), an autonomous organization under the Ministry of Agriculture of the Government of Bangladesh, has introduced a well-manufactured DTWs with smart-card system to increase the water access to the farmers (Figure 3). In Dhandogaon village, BMDA partnered with a group of farmers to implement the DTW. To improve the efficiency of the DTW management, the BMDA took a deposit from the farmers and offered them the authority to operate the DTW.

Figure 3: The DTW operator with smart-card system in Dhandogaon village
Source: Author

By observing the investment potential, a group of three farmers in the village took the initiative to contact with BMDA and convince them to install a DTW in the area. The farmers in the group follow Hindu religion and are comparatively well educated, own a higher amount of lands, well respected and enjoys the platform to have a voice in the community than most other farmers in the village. Besides, they are related to each-other by blood or by marriage, two are brothers and the other one is the son-in-law of one brother. I will refer the group as the group of investor farmers throughout the paper. In an interview with one of the investor farmers it was

found out that the group deposited BDT 1,00,000 (USD 1185) to the BMDA in 2010 for the implementation of the DTW and another investor said that they had to spend BDT 30,000 (USD 356) more to speed up the process and approaching the political leaders to take necessary actions to install the DTW sooner[7]. There were quite a lot of bureaucratic processes to be followed. However, the BMDA installed the DTW in 2014 on one of the investor's land (who now works as the operator) and it serves irrigation to almost 40 acres of lands in the village. The farmers having land outside of the DTW command area use the traditional oil-run STW (Figure 4).

Figure 4: Diesel run STW in Dhandogaon village
Source: Author

From several interviews, it is evident that there was no involvement of the other farmers in the implementation process of the DTW, neither any woman was involved. The farmers who have invested the money is now enjoying the unwritten ownership of the DTW. They were the ones who have decided where the DTW to be installed and where the water outlets be set up while other farmers volunteered by giving up the space to install the water outlets since having a water outlet near to the land is convenient for the farmers.

5.2 Farmers' experiences of different technologies

5.2.1 Variation of expenses

In Dhandogaon village, the farmers outside of the DTW command area use STWs for the irrigation. The major concern of these farmers are the costs of operation and management, labour and time requirement of using the STWs. Almost all the

[7] The exchange rate calculated at 1 USD = 84.36 BDT on 12 May 2019

farmers interviewed opined that the costs of using STW is higher than getting water from DTW. The costs depend on the size of the land, oil price and weather. If a farmer wants to buy a STW, he has to invest a big amount of money. Otherwise, he can rent a STW from other farmers but has to pay a seasonal rent for the access. Nevertheless, the cost of oil needed for the whole season is higher compared to the water cost of using DTW. Several farmers complained that the drilling of bore holes require high cost and it gets damaged frequently. Other machineries also need frequent repair or replacement which increases the total cost. When asked the reasons for frequent damaging of the parts, farmers replied that during dry season the groundwater level goes down and the STW faces difficulties in pulling the water. "*The STW gets damaged frequently, even 2-3 times in a season. If used heavily, gets broken*" (FGD2, 06 March 2019), said the farmers in an FGD.

5.2.2 Time requirements

Moreover, it takes longer than DTW to irrigate the land with STW. Since the STW can pull out less amount of water than the DTW, it takes more time to irrigate the land. The women are the sufferer mostly in such case. Usually, the men start the machine as it needs to pump the water up with the handle first and then the machine is started. When men leave the field, the women oversee the irrigation. Since STW takes long time to irrigate the land, the women are bound to spend more time there. A higher secondary school passed woman woman said, "*I used to spend the whole day irrigating my land, now it takes one hour or so to irrigate the land with DTW*" (Female farmer-GR, interview, 05 March 2019). Moreover, since it takes less time a few farmers claimed that they can work in other's field as labourer or get involved in the non-farm work beside regular agricultural work to increase their income. Another woman, whose family has 5 acres of land, said, "*it was laborious to irrigate with STW, too difficult. Now, there is no problem, very easy (with the DTW)*" (Woman farmer-KB, interview, 05 March 2019). The male farmers have opined the same in an FGD, "*it's very difficult to pull up the water in dry season with STW. It takes only one or two hours to irrigate 1-2 bigha of lands with DTW. The time is a big factor*" (FGD1, 05 March 2019).

5.2.3 Impact of adopting advanced technology

The implementation of DTW has also immense impact on the water availability for the farmers still using the STWs. The DTW is pulling the water with higher pressure that it is affecting the STW's ability to pump the water from the ground. The farmers in an FGD said, "*the DTW is causing problem, the water level is going down. If you got 5 glasses of water before, now you get 2 glasses*" (FGD1, 05 March 2019). While

talking about the difficulties in very hot and dry times, a STW user said, "*I have to go the field in the middle of the night when the DTW stops operating. The flow of water becomes good. When I must need water, I do not care about day or night*" (Male Farmer-DN, interview, 6 March 2019). During an FGD with the female farmers, those who use DTW now have pointed out this case and said, *"…our husbands used to spend the night in the tents (to guard the STW) when there was no DTW in the area. There were so many tents in the fields. But now, they can stay home with peace*" (FGD2, 06 March 2019). It shows that the implementation of DTW has created inequalities between the users of STW and DTW.

On the other hand, the implementation of the DTW has been appeared as an improvement to the irrigation for the agriculture in the Dhandogaon village. The farmers in the DTW command area enjoys the benefit of it. It is not only less expensive but also requires less labour and time to irrigate the land. Even in the dry season, the farmers are getting adequate water for irrigating their lands. A STW user even left a sigh and said, "*if the (water pipe) line went a little bit further, I would have gotten the access to DTW*" (Male Farmer-DN, interview, 6 March 2019). The smart-card system also has a fixed price for the water use and eliminated the uncertainty of the oil prices.

5.2.4 An exceptional case

There is one exceptional case that a farmer cultivates his land with STW in the middle of DTW command area. During the interview, it was found that the farmer took the land as lease contract and the owner of the land is not willing to pay for the DTW access. As the contract is temporary, the farmer is not willing to pay by himself for the DTW access. "*If the owner wanted to share half of the DTW access fee, I would've taken it… I have my own STW, I do not have to pay anyone else, only the oil cost*" (Male farmer-AN, Interview, 07 March 2019). Further, he opined that STW is flexible for him to use as he does not need to take the queue for irrigation and he can irrigate his land whenever he wants. "…*It's a big hassle to get the serial, you have to close one outlet and then open another, you have to run here to there, it becomes a loss*" (Male farmer-AN, Interview, 07 March 2019). However, the DTW operator informed that fields around his land have access to DTW and when these lands are irrigated, the water spills over to that land and benefits the person.

5.3 Management of the technologies

The group of investor farmers charged one-time fee for the access to the DTW from each of the landowners depending on the amount of land one owns. However, the

amount of rent per acre was dubious as different land owner said to give different amount of rent. The operator also acknowledged the issue and explained that not every person is willing to pay the full rent, so he allowed some people the access to DTW with lower amount of rent.

"…they are our own people, people of this community, how many times can I ask for money! So, I let it go. If someone has 3 Bigha (1.5 acre of land), he is supposed to give me 9000 Taka but if he gives me 8000, I accept it and won't ask for money anymore…" (operator, interview, 02 March 2019)

There are also some people who did not pay the one-time fee rather pays a certain amount of money to the operator each year as seasonal access fee. This way of getting access to the water is similar to the rental system of STWs. The farmers who have paid the access fee and own a smart-card which can be re-charged with credit, now, enjoy the water access from the DTW. The operator of the DTW is in charge of giving the queue to farmers who wants the water for irrigation. However, I could not find any major incidence of conflict in queuing or accessing the water.

The operator maintains the queue for the water access on a 'first come, first serve' basis. In the FGD with male farmers, they seem to agree that "*whoever comes first, gets the water first. However, if someone's land is very dry, the operator will consider him first than the one whose land is still wet*" (FGD1, 05 March 2019). The operator also asserted that when there are a lot of people want the irrigation, he maintains the order. However, if there is no pressure or much demand for water, anyone can come and get the water through their smart-card. Several interviews also support that the order of the queue is maintained well. While speaking about the order maintenance, a Hindu male farmer said, "*if queue is not maintained, there would have been fights*" (Male farmer-TN, Interview, 03 March 2019). A Muslim woman on the same issue said, "*everyone gets the water. There was no trouble so far*" (Woman farmer-RN, 6 March 2019). It can be argued that the technology reduced the queuing quarrels as it is faster in water extraction.

5.4 Women farmers and technology adoption

Several interviews with both Hindu and Muslim male farmers found out that men are reluctant to acknowledge that the women work in the field. They prefer to say that the women help them in small works in the fields and their participation is seem negligible. For example, I met a Hindu woman working in the field for irrigating her land (Figure 5) and a moment later, I met her husband. When I asked if his wife works at the field, he replied, "*No my wife does not work at the field. (She) stays home*" (Male farmer-AN, Interview, 07 March 2019). When I followed up asking that I saw her irrigating the land, he replied that he went somewhere else, so his wife

was looking after his work in his absence. When I asked a Muslim farmer if his female family members take part in irrigating the land, his response was, "*No, they do not come for irrigation. They are women*" (Male farmer-CM, Interview, 05 March 2019). Similarly, a male Hindu farmer said that the women did the household works and the works near their home to grow vegetables, whereas, another male farmer mentioned that the irrigation is men's task and they do not need women for the task. When asked if women go to the market if they need anything, a Hindu male farmer replied, "*…when I am alive, if my wife go to the market, does it look good? But if I die and the children cannot do it then she must have to go by herself*" (Male farmer-JD, Interview, 03 March 2019).

Figure 5: A female farmer is irrigating a land with STW
Source: Author

However, it was evident that both men and women works in the field and the burden of work is heavy for women. Seeing a group of men and women working together in the field, I approached the land owner and he said that they are the labourers and there is both Hindu and Muslim men and women in the group working for him to harvest the potatoes. While talking about working together in the field, a women farmer commented, *"the women are now experts, just like the men. Previously, the women were dumb. Now, they can talk against the men. Now, both men and women do not keep silence"* (Female farmer-BR, Interview, 05 March 2019). Almost every woman responded in the interviews that the they take part significantly in both households works and field works. In the FGD with both Muslim and Hindu women, they asserted that the work burden is too much for them as they do all the household works, look after the livestock and also participate in the field works. However, they also pointed out in both interviews and the FGD that after the installation of the DTW, their work burden is now lower than previous.

They spend less time in overseeing the irrigation. In the FGD, the women further stated, "*the work burden is also less for men now. Now, they can spend more time hanging out with friends in the market*" (FGD2, 06 March 2019).

However, in most cases, the women do not hold the money they earn through agriculture. Whatever income they earn, they give it either to their son or husband to lead the family. In the FGD with the women, they asserted that the men maintain the families, so they had to give them the money. The wages are distributed in the market, so the women who works as labourers do not get the money, rather the men go to the market and take it. So, ultimately most of the women do not get to keep the money they earn. Moreover, there is wage disparity between men and women. A woman gets lower payment than the men. When I asked the reason behind it, both men and women responded that the women are physically not as capable as men. It shows a devaluation of women's work as women are often found to get involved in labour intensive works (Leder et al., 2019). A widow woman farmer, who works regularly as labourer, responded saying, *"…the thing is, look at them (pointing men carrying bags full of potatoes), the men are carrying the potatoes, the women won't be able to do that. Now, if the men take one or two hundred Takas more, how could I ask the money?*" (Female farmer-BR, Interview, 05 March 2019). Thus, the farmers think that such differences are the rationale for women's lower wages.

The access to irrigation water for women varies according to situation and technologies. While getting water from a STW, a woman needs help from a man to start the machine since they refer it as a heavy work. Several farmers reported that it takes almost 20 to 30 minutes to pump up the water before starting the STW. On the other hand, both men and women responded that women get privileges in getting the water from DTW. The male farmers in the FGD said, *"if a woman comes for water, we give her the water ahead of others"* (FGD1, 05 March 2019). Agreeing to the fact, a woman farmer in an interview said,

"*I will get the serial ahead of others. If I say, I am a woman, I cannot stay in the night, now the sun is going down. I have to get the water first. You are a man, you can take the water even after evening*" (Female farmer-GR, interview, 05-03-2019)

However, two women also mentioned that they tell their sons to take the serial for the irrigation or start the DTW because they do not know how to operate it. Other women stated that they did not face any issue in accessing the water and they know how to operate the DTW.

5.5 Equality issues based on class

All the farmers hire labourers during the time of heavy works, such as, seedlings plantation and harvesting. Even the tenant farmers reported that they hire labourers

at the time of need. During the interviews, most of the farmers conveyed that only the poor men and women work as labourers to other farmer's field, whereas, the wealthy farmers only look after their own lands. When asked if the Muslim women work as labourer, a Muslim woman replied, "*No, they do not. But the poor (Muslim) women does*" (Female farmer-RN, Interview, 06 March 2019). Several farmers also stated that there is high demand of labourers in the peak time like harvesting and the wages have gone up in the recent year. The farmers think that the economic condition of the labourers have been better than previous. While talking about the poor farmers who get water from STWs, a farmer said, "*maybe some poor people will take water amounts to 50-60 takas instead of 100. If they do not get enough water, then they might come in the night*" (Male Farmer-DN, interview, 6 March 2019). Nevertheless, a few interviews found out that people with larger amounts of lands may be given the queue ahead of those with lesser. A woman farmer said, "*those who need less water are said to take it later as others with bigger amount of land need more water. Those with larger amount of land need more time, so you have to give them earlier*" (Female farmer-GR, interview, 05 March 2019).

5.6 Experiences based on religion

In Dhandogaon village, a number of male and female farmers including Hindu and Muslim conveyed that fewer Muslim women work at the field than the Hindu women. Both Muslim and Hindu poor women go to the field for agricultural work. Some of them even work as labourers in other's fields. When investigated why the Muslim women are seen fewer in the fields, some farmers pointed out that they have better economic condition. However, both Muslim men and women agreed that they did not have to face any troubles in getting the water. Since most of the people in the village follow Hindu religion, to investigate the equality issues, I asked a Muslim male farmer if he faced any difficulties in accessing the DTW, his response was,

"*I never had any problems in getting the water. I call him to know when I should come to get the water. He gives me a time. I never had any trouble. He would say come today or tomorrow. But I never faced any trouble with him. Haven't seen anyone fighting with him.*" (Male farmer-CM, Interview, 05 March 2019)

Whereas, a Muslim woman farmer said:

"They have never made any problems with us. It is running (well). Haven't had any troubles. And we don't make any problems with them, why would they (do)?" (Female farmer-RN, Interview, 06 March 2019)

On the other hand, the STW users have also mentioned that if anyone pays the rent for the machine and bring oil by themselves, then there is no conflict in accessing the water.

6 Farmers' experiences of irrigation technology adoption in Rangpur

The chapter focuses the technology implementation and adoption issues in the Ramnather Para village in Rangpur. I am presenting it as a separate case study which is similar to the chapter 5. All the data collected through interviews, focus group discussions, resource mapping and wealth ranking have been organized into different themes to elaborate and discuss the research questions.

6.1 Description of Ramnather Para and technology implementation

Ramnather Para is at the Mithapukur sub-district in Rangpur. Most of the 19 research participants from Ramnather Para fall into the age group of 35-45 years. Majority of the residents are Muslim and others are Hindu in the area. Although main source of income of the majority of the families is agriculture, a significant number of people are also involved in non-farm work. Almost 12 interviewees of total 19 responded that their family member are either migrated to cities or involved in non-farm work. The overall education level is also better than that of Dhandogaon village. Around 12 farmers reported to have attended formal education to some levels. The people in the village can be categorised as the lower-middle income to middle income families. Only 4 of the total 19 people rented a land from someone else and all the other farmers have their own land. Most of the participants possessed 0.5-2 acres of land. However, in wealth ranking, farmers ranked people having around 20 acres of land as rich, middle income families with 4 acres and poor with half an acre or no land. Moreover, participation in agricultural trainings is very low as only 2 persons said to obtain a training. Notably, 4 out of 6 female farmers said that they can keep the money they earn. However, only the men own the lands here as well.

There are mainly two types of irrigation technologies in operation in the area (Figure 6). These are electric shallow tube wells (E-STW) and diesel run shallow tube wells (D-STW). Usually, the E-STW has the capacity of 5-6 Horse Power (HP), whereas, the D-STW has 3-4 HP. However, there is also a DTW operating at the next village to Ramnather Para which is 20 HP of capacity. According to the wealth ranking, done by the farmers, the high- and middle-income families afford to install an E-STW, whereas, other farmers usually use the D-STW or rent the water from pump owners. The farmers are using D-STW for a long time whereas the E-STWs have been implemented in the recent years as the electricity has become available for irrigation.

DTW

E-STW

D-STW

Figure 6: Irrigation Technologies in Ramnather Para
Source: Author

To get the electricity connection for an E-STW, a farmer has to buy all the machineries including the engine-pump, transformer and all the other necessary equipment and apply for a connection to the Bangladesh Rural Electrification Board, a government organization responsible for providing electricity supply for irrigation. In a casual conversation, an E-STW owner complained that he had so much trouble to get the electricity connection and the authority was not helpful at all. However, he also mentioned that he took all the trouble because he can make profit out of it. Since the E-STWs are powerful than the D-STWs, the water extraction is better, and he can sell the water to other farmers to make profit. Thus,

the E-STW owners usually chose a place to setup the machine where it is easier for his own use and also beneficial for selling the water to other farmers.

On the other hand, to install a D-STW, a farmer needs to buy the machine and setup at a convenient place. Since its capacity is lower, the main purpose of buying it is for own use. However, some D-STW owners also sell the water to the nearby farmers for making some profit out of it. It is also convenient to move from one place to another. The farmers who have lands in different places, they drill the bore holes in both the lands and move the D-STW from one place to another when the irrigation is needed. A farmer with lands in different places in a Hindu majority area said, "*I have my own D-STW. I get water whenever I need …Now every other land has a bore hole. Whenever needed, I bring it there*" (Male farmer-TP, Interview, 13 March 2019). Some farmers also mentioned that D-STW is convenient for them because they can carry it to home after the irrigation is done. It is easier to keep it safe, otherwise, they have to make tents and guard the machine in the night.

The DTW was installed in the 1980s in the area named Kathali which is a village next to Ramnather Para. The type of the machine is different than that of Dhandogaon village. There is no card system, the machine runs by pressing a switch and two operators maintain the irrigation. The DTW was established by the Bangladesh Agricultural Development Corporation (BADC). According to the farmers in that area, at first, the people in the village did not have to pay to the authority for the installation of the machine. After a few years, the BADC sold the machine to a committee formed by the people in the village. The committee was formed spontaneously with the persons who could afford to contribute to the payment for buying the DTW. Since then, the committee is managing the water supply to the farmers in the village. The manager who leads the committee has a lot of lands which he rents to other farmers. The committee is responsible for taking care of the machine and the manager collects the rents from the farmers on behalf of the committee.

6.2 Access to the irrigation technologies

6.2.1 Variation of expenses

The costs of irrigation differ according to the technology a farmer uses. There are high costs involved if a farmer wants to buy an E-STW or D-STW and install it. The approximate cost of installing an E-STW is BDT 50,000 while a D-STW costs around BDT 25,000. When a farmer rents from a pump owner then the cost of the irrigation varies according to the technology. The rent in Boro season to get

irrigation from E-STW is BDT 4000 per acre during enquiry in 2019. To get water from a D-STW, a farmer has to pay a seasonal rent of BDT 1400 per acre for accessing the machine and buy the needed oil by himself/herself. The cost is lowest when a farmer gets water from a DTW which equals to BDT 2800 per acre for a season. "*The expense is minimum to get water from a DTW. The water extraction is also higher, whereas, STW is costly*" (Male farmer-FM, Interview, 12 March 2019), says an D-STW owner. However, if there is any damage to the E-STW and D-STW, the owners are responsible to bear the cost of repairing. But in case of DTW, the beneficiaries have to share the total cost of repair or replacement of any parts. From the cost perspective, the best option for a farmer is to get water from a DTW, whereas, E-STW and D-STW follows respectively.

6.2.2 Machine operation

When a farmer owns a machine, the access is most convenient and easier. A farmer who owns a half acre of land and rents water from an E-STW said, "*It would be good if I had my own machine. Then I could get the water whenever I wanted. I do not need to wait for my serial*" (Male Farmer-AR2, Interview, 13 March 2019). For either of DTW and E-STW, an operator is appointed to look after the lands contracted under that machine. In both cases, the operator was a relative of the owner. The operator is paid by the machine owner and responsible to irrigate the lands adequately. He keeps checking the fields and provides water whenever needed. The usual system is to start irrigating from one side and move to the adjacent fields one by one. When asked a farmer, who rents water from D-STW, about the facilities/downsides of E-STW and D-STW, he said, *"…those who get water from E-STW, they have to wait for the serial. By the time I would get the water, my land gets dry"* (Male Farmer-FM, Interview, 12 March 2019). ADD REASONS HERE At the time of plantation, the operator gives a queue to the farmers for the required irrigation to prepare their lands. After the seedlings are planted, the operator keeps track of the lands and checks when the irrigation is needed. One of the two DTW operators said,

"As far I know, all the lands are (well) irrigated. No one thinks that I will give more water to someone and less to another. The lands are irrigated as much as it needs. Some sandy soil can not hold water. That's a problem. Otherwise, it is irrigated properly" (DTW operator, interview, 16 March 2019)

Since the land quality differs, some fields require irrigation in short interval and some needs in a longer interval. However, if a farmer thinks that he needs water for the land, he can speak to the operator for irrigation and the operator serves the water as needed. As the DTW covers a huge amount of lands, I asked if it is problematic to cover all the lands within short time, the operator replied, "*What could I do if*

there is any problem? There is no solution" (DTW operator, interview, 16 March 2019). It sounded like he also subscribes to the fact that it's difficult to cover this much amount of land with one DTW. He also mentioned that there was more land under the DTW command area before, but now the farmers whose lands are further from DTW are using either E-STW or D-STW. When I asked the reason, he responded that it might be more convenient for them to get water from nearby E-STW or D-STW to have easier access to water and less waiting time.

6.2.3 Women farmers and technology adoption

In Ramanather Para village, women take part in agricultural activities frequently. A considerable number of men are involved directly and indirectly in non-farm works. The women oversee the agriculture in the absence of men. When male persons in a family die or migrate to other places, the woman takes over all the tasks of agriculture along with household works. When I directly asked the men if their female household members work at the field, the first response was 'no' with hesitation. But when I asked if their female household members work with them in the field, they commonly responded that 'they do'. However, investigating further I found out that the burden of work is intense for women. The household chores are mandatory for every woman in the village including cooking, cleaning, looking after the livestock, serving food to the family members. Besides, they also work in the field ranging from weeding, planting, making canals for irrigation to harvesting. But, no woman takes part in applying fertilizers and pesticides which will be explained later. A Hindu woman said, *"women have more responsibilities than men. What do you know! Women have too much of works*" (Female farmer-BT, Interview, 13 March 2019). A woman who owns an D-STW and manages all the agricultural works complained saying,

"Sometimes the bearing (of D-STW) gets damaged, sometimes the filter. I go to the market even being a woman. They (repairmen) give me the token, takes the money. Too much of trouble for a woman." (Female farmer-SB, Interview, 16 March 2019)

Moreover, women have limited decision-making power in this village. Unlike Dhandogaon, some women farmers said that they can keep the income from agriculture and spend it by themselves while some said that they gave it to their husband or son to lead the family. There was also a debate on the issue during the FGD with women. A woman responded saying, *"if the husband orders, they can spend the money. But if he does not order anything, how can I spend the money?*". Another woman objected,

"There is nothing to give orders. Suppose, my husband is away, and I need to apply fertilizers and pesticides, do I need order then or I have to do it by my own?

Now, when I need, I can spend but I will report him later. This is it. The woman has to manage everything." (FGD4, 14 March 2019)

The women also added that not every husband treats their woman same. Some husbands won't say anything if they report the expenses to their husband, but some might beat them. "*Some (women) consult with their husband. If they have money, they can buy. But if the husband is not good, he will beat her. Not everyone is same*" (FGD4, 14 March 2019).

There is a general perception that a woman cannot start a D-STW because it is a heavy work to pump the water up. In several interviews with both men and women, when I asked if a woman can operate STWs, the answer was "no, they do not". They can make the irrigation canals, but they cannot start the D-STW without a help from a man. However, they do lift and carry the machine along with a man to the field but pumping the water up and start the machine are regarded as a heavy work and sought help from men. A farmer said, "*they (women) cannot start the D-STW but they can start an E-STW. They lack the training, they can do it if they are taught the methods*" (Male farmer-SR, Interview, 13 March 2019).

When asked about the access to the irrigation technology, most of the female farmers regardless of any religion responded that they had positive experiences. If they do not own a machine, the women rent the water from another farmer and in most cases, they did not face any difficulties irrigating their lands. A woman, whose husband is migrated to Dhaka, told me that she manages everything related to agriculture by herself. This year, she is renting water from E-STW even though she owns a D-STW. She explained that this is the first time she is doing this, and it is more convenient for her and less expensive than using own D-STW. She says,

"E-STW has more profit. When parts (of D-STW) get damaged, you need 2-3 thousand takas to fix it. Then, there is oil cost. …Now, they (owner of E-STW) are giving me the water. Sometimes I go there to tell them to irrigate this place or that place. I do not have to tell them much, they do it as their responsibility" (Female farmer-SB, Interview, 16 March 2019)

In an interview with an E-STW operator, he said, "*they (women) get water. If they have paid the water fee (rent for the access), they do not have to come to the field. The operator will serve the water by himself"* (E-STW operator, Interview, 14 March 2019). A similar comment was made by a DTW user as well.

6.2.4 Norms, Culture and Religion

Hindu women are more involved in the agriculture than the Muslim women. Hindu women are also more frequent in the group of labourers than the Muslim women. In several interviews, farmers responded that the Muslim women usually do not go to the fields, sometimes they go for weeding but do not work in other's field.

However, a Muslim farmer said, "*Muslim women work in their fields when their male counterpart is migrated to somewhere or do a job … these women take labourers to do the tasks*" (Male Farmer-MU, Interview, 13 March). In an interview, I asked a Muslim male farmer if his female family member works in the field, he replied, *"No, they do not. Women do not come to the field. God said there is no reward in women's work. Women's work means household work*" (Male farmer-FM, Interview, 12 March 2019). Such perception is motivated by the religious understanding that is similar to Naher (2006) argument that religious views set restrictions on individual's role . Furthermore, when a women farmer needs to apply fertilizers and pesticides, they usually seek for men. Even a woman expressed that she cannot cultivate potato because it needs frequent application of pesticides and fertilizers. While searching for the reason, in a casual conversation, a farmer told me that the clothing of the women is not appropriate for the tasks. They need pull up their cloths while doing the task and this is against of the norms and culture of the society. Moreover, according to a farmer's comment, if there is any decision needed on some issues in the community, the committee of the local mosque gather together to make the decision. "*If there is any community work, it is decided in the mosque. The committee of the mosque takes the decision*" (Male farmer-TH, Interview, 12 March 2019). Hence, it can be observed that social norms and cultural barriers are defining the roles of individuals.

6.2.5 Water access for the owner versus renter

In a wealth ranking done by the farmers, they pointed out that the wealthy families own either E-STW or D-STW. When a farmer has his own machine, he can get the irrigation anytime he needs. Otherwise, they have to wait for the queue in case of renting water from someone else. Since the cost of buying a machine is higher, most of the poor farmers rents water from others. Male farmers in an FGD stated that regardless of one's wealth, both poor and rich get the water if they pay the rents for the machine. However, farmers also seem to agree that the operator may also favour someone close to him. When asked a farmer, who owns half an acre of land, if the well-off persons get better treatment than the poor ones, he said, *"…I am poor, so what? If I pay the money, they will check my land and give me water"* (Male Farmer-MU, Interview, 13 March). With a similar question, another farmer said,

"…The only problem is money. Sometimes, it happens that the farmer does not pay the owner. Money amounts to a year's rent is due. Even then he (owner) is giving the water. Because, you cannot damage the plants. The thing is, you have to give me money, give it in instalments or after the harvest. But sometimes, a year goes by, but they do not pay at all. Then the owners do not want to give them any water." (Male Farmer-AR2, Interview, 13 March 2019)

Several interviews also note that there are fewer poor people in the village than in the past. People are getting educated and moving to non-farm jobs. Some farmers said that it was difficult to find labourers and the wages went up in the recent years.

6.3 A comparison between the study sites

Though there are several similarities between Dhandongaon village and Ramnather Para village, the characteristics of the villages are quite different that may influence the differences of opinion of technology adoption. The similarities or dis-similarities mentioned here are based on the data collected during the fieldwork. Majority of the habitants of Dhandogaon village follow Hindu religion, whereas, most people follow Islam religion in Ramnather Para. Besides, the number of people having formal education is comparatively higher in Ramnather Para than Dhandogaon. While agriculture is the major income source for the people in both the villages, more people are involved in non-farm works in Ramnather Para than that of Dhandogaon. According to the BRRI personnel, aquifer level is better in Ramnather Para than that of Dhandogaon. Acknowledging the fact, many farmers in Dhandogaon reported their concern about the groundwater level and the drawdown in the dry season. There is one DTW implemented in Dhandogaon and beyond its command area, the farmers use STWs. The DTW is operated through a smart-card and an operator coordinates the queuing system. In Ramnather Para, farmers adopted E-STW or D-STW according to their capability. There is also a DTW in the village adjacent to the Ramnather Para while few lands in Ramnather Para also get water from the DTW. However, there is no card system in this machine and two operators are appointed to look after the irrigation to the lands in the command area. In both the villages, those who cannot afford to buy a D-STW, they rent the water from a machine owner. Besides, the management of irrigation from D-STW is similar in both the villages.

Results in both the villages shows similarity in the social outlook of women's work. People in both the villages seemed to devalue the women's labour, whereas, the workload of women is quite high in both places. A distinct difference is that all the women respondent in Dhandogaon conveyed that the men kept or spent the income of the family even when the women earned the money, whereas, 4 out of 6 women in Ramnather Para responded that they could keep the income if they want. However, it was clear that the adoption of DTW in Dhandogaon and the adoption of E-STW in Ramnather Para benefitted women by giving them easier access to the irrigation technology. Moreover, the implementation of advance technologies benefitted the machine owners in both the study sites.

7 Discussion

This chapter discusses the empirical data stated in the previous two chapters. It compares and contrasts the data collected in the study sites and connects with the theoretical concepts. The analysis of inequality, social structure and the social construction of technologies have been discussed in this chapter.

7.1 Increasing inequality with the adoption of advanced technology

7.1.1 Uneven access to decision-making power

The findings show that the adoption of an advanced irrigation technology involves significant investment capacity. The involved costs of implementing the advanced technology enables only a few people to afford it and gain the maximum benefits. On the other hand, the poor subsistence farmers are unable to own an advanced technology due to the lower purchasing power. Thus, the inequality between the machine owner and renter are sustaining or may even increasing in light of the introduction of these technologies. It is similar to the findings of Wong (2009) that the rich enjoys more access to financial resource and higher decision-making power.

For the case of Dhandogaon village in Thakurgaon, the partnership with the BMDA involved high amount of financial investment and risks to implement the DTW. Most of the farmers in the village did not take part in it because of the uncertainty involved. As it had been implemented, the investors became the owner of the DTW, whereas, the other farmers became their customers. Even though the implementation of DTW is a project of BMDA, the investor group enjoys the authority over the management of DTW. Such fact establishes an owner-renter relationship and creates a sense of hierarchy among the farmers. However, the differences between a technology owner and a renter has always been there even before the implementation of DTW. But, there was many STW owners from whom

the farmers could rent the water. But in case of DTW, there is a monopoly control of the machine with concentrated decision-making power.

Similarly, case of Ramnather Para in Rangpur presents same scenario for the DTW adoption in a nearby village. However, only the rich or middle-income families could afford to implement an E-STW or D-STW. There is visible variation of benefits between the owner and the renter, whereas, there is also deviation of benefits between the renters of E-STW and D-STW based on time requirement and costs. Besides, the STW owners install the machine where it is most convenient for their own farming and selling water. Since not all the renters have option to choose between D-STW and E-STW, the gain of water access depends on where the STW is located. Thus, the sense of hierarchy is also present in this area which is more spread out than that of Dhandogaon village.

The owners and the operators of the irrigation technologies hold the power to decide the installation of the machine and management of it. The decision-making power to select the place for the technology implementation is totally on the owner's discretion. In Ramnather para, the cost of water access from E-STW and D-STW is fixed by the owners and all the owner take the same price. The water renters have no negotiation power on the prices. For DTW, the water committee in the village decides the rent. Similarly, in Dhandogaon village, the investor farmers determined the access fee for the machine while the rent for the water is fixed by the BMDA. In this case also, the farmers did not have any voice over the water prices (see chapter 5.1). Therefore, an uneven distribution of benefits is visible in both the sites.

Owners of the technology have higher accessibility to the water than the renter. They can irrigate their lands whenever they want, whereas, the renters have to be on the queue to get the water. In both Dhandogaon and Ramnather para villages, the owners enjoy extended benefits. Having the authority over the DTW, the investor farmers are the ones who take all the decisions regarding the machine operation in Dhandogaon village. In Ramnather Para, the operators of the machines also enjoy the power to decide the irrigation system to some extent. It is because some of the farmers acknowledged that the operator may favour someone of his kin (see chapter 6.2.5). Hence, the decision-making power is centralised only to a few people in the society creating a categorisation between the two group, e.g. owners and renters. This categorisation itself shows the presence of social hierarchy. Buchmann (2013) argued that such categorisation places the individuals from rich families at the top and the poor families at the bottom in the social hierarchy.

7.1.2 Variation of benefits based on technological capacity

It is evident from the farmers' expressions and opinions that there are differences in water accessibility among different technologies that the farmers use. Since the

operation cost of D-STW is higher than the E-STW and the waiting time is also less with E-STW due to its higher water extraction capacity than D-STW, there are differences in farmers experiences as well. The experience of DTW users and STW users found to be different as well. The farmers who cannot afford to install a machine by themselves, they rent water from their nearby machines. Since E-STW is faster in irrigating the land than that of D-STW, the renters of E-STW may be better off in such case. Hence, the technological differences shape the farmers' perception about irrigation facilities and may produce uneven benefits among the farmers.

However, having large difference between DTW and STW in Dhandogaon have bigger impact on farmers experiences. The water extraction capability of DTW is much higher than that of STW. Several farmers have even claimed that the operation of DTW affects the capability of STW to pull up the water as the water level goes down. Though a general perception about the DTW is positive in the village, the experiences of STW in not very positive among the farmers. People perceive that whoever got their land in the DTW command area are fortunate. Such differences show that implementation of modern technology may create new lines of hierarchies among the farmers. My argument is that these differences are the reasons for creating a social hierarchy in the community where different groups of people are placed onto different socially identified levels. The process of action and interaction evolve based on these social hierarchy.

7.1.3 Accumulation of social capital

During the data collection, I had taken a closer look on how different community members act and express in their society. It was found that the machine owners have better social stance to raise their voice than the renter. The farmers in Ramnather para respects the owners of irrigation machines. The owners of the machines are comparatively well educated and owns a higher amount of land. They are in the position to decide the location of their machine and to whom they will provide irrigation. They are often treated as the members of 'higher class' in the community and everyone else respect their voice. These wealthy people enjoy higher social capital than that of the poor farmers. Hence, if a farmer gets a chance to upgrade his social status, it gives a satisfaction to him. While talking to an E-STW owner, I could understand his happiness for getting the electricity connection to operate the machine. He even claimed that the life was better with E-STW. Hence, it shows that owning a machine gives a farmer a promotion to the social hierarchy.

On the other hand, the investor farmers in the Dhandogaon village also enjoy the higher social capital due to their authority over the DTW. They are comparatively wealthy and educated than other farmers in the village. It was visible through their

gesture and interaction with other farmers in village. They have addressed the other farmers as ‘tui’ while everyone but a few addressed them as ‘tumi’ or ‘apni’. In Bengali language, the words ‘tui’, ‘tumi’ and ‘apni’ means similar to ‘you’ in English. But the use of it differs according to whom the person is talking to. For example, ‘tui’ is used while talking with close friends, lower class people, someone younger in age, etc. The word ‘tumi’ is used to address someone with same age and same social status but not very close with. And the word ‘apni’ is used for someone older and respected. Hence, it presents that there are prevalence of different social status and people act accordingly. It is clear that the higher-class status is again depended on power accumulated by having higher amount of wealth and education.

7.2 Influence on social structure

7.2.1 Changes in the perception of gender roles

The tradition and the norms have impact on gender roles in the society. With the introduction of advanced technology, these norms are challenged in different ways. It has changed the way irrigation is done and assigned gender roles. Traditionally, irrigating lands has been portrayed as the work of men while women’s participation in agriculture is seen negligible. Kabeer (1994) and Rahman (2000) noted the devaluation of women labour and female seclusion in agriculture in Bangladesh as social and cultural norms. Several interviews found out that the social outlook of women working outside home is not well respected. However, women’s participation in agriculture has been flourishing over the years (Jaim and Hossain, 2011). Along with this trend, the adoption of advanced technology developed the atmosphere for women to participate in agriculture. Previously, irrigating the land was not seen positively as women’s work as it required heavy work. With the adoption of DTW, it is not an issue anymore for women to irrigate their lands. Since it is just ‘press a button and get water’ situation now, women can easily get involved with the irrigation. This is also socially accepted, and no concern is raised.

However, there is indication that the institutions are being challenged on which these norms are based on. By participating in the fields together with men and doing the same job as men, women are realizing their strength and understanding the discrimination they face in everyday life (see chapter 5.4.2). The women’s group in FGDs and several other interviews with women raised the issues that women are low paid and faces different obstacles to conduct their job. Women’s participation in almost every tasks of agriculture proves that the previous stereotypes of women’s work is challenged. Besides, from interviews of both men and women, it was

noticeable that there is acceptance of poor women and widowed women to work in the field. However, women still do not take part in serving pesticides and fertilizers as these tasks are seen as prohibited for women due to cultural obligations. Such issues show Scott's concept of cultural-cognitive institutions that influence the gender roles and other social structures. Scott (2013) asserted that the elements of the institutions are "the shared conceptions that constitute the nature of social reality and create the frames through which meaning is made" (p.67). If a technology can affect the gender roles of irrigation, I want to argue that it may also affect other social system, such as, change in social hierarchy, meaning of economic class, power relations in the society, etc.

7.2.2 Impact on social identities

The technologies have several impacts on the social identities. Examples from both the study sites show that the technology adoption reinforced the prevailing differences of social identities. For instance, in Ramnather Para, the ownership of E-STW display the affordability and richness of the people, whereas, owning no irrigation machine shows the poverty. Moreover, women's access to irrigation technology was limited before, which has been improved after the adoption of advanced technology. With E-STW, both men and women in Ramnather Para do not have to look after their irrigation as it is done by the operator. Thus, the difference in gender identities have been moderate. In contrast, I argue that farmers perception and values may also be motivated by their religious views that influence in assigning gender roles and contributes to the devaluation of women's labour. Similarly, Leder et al. (2019) found that female labourers internalised the devaluation of women's labour due to their dependency on the landowners.

The overall cost of irrigation is lower than previous for those who have adopted the new technologies. It may have increased the capacity of poor or tenant farmers to avail the irrigation water. Since the advanced technology (both DTW and E-STW) takes less time to irrigate, these poor farmers can get the possibility to diversify their income through non-farm works. Besides, they can also work both on their lands and as labourers in other's lands. This gives them opportunity to earn higher income and contribute to their development (see chapter 5.2.2). Several farmers claimed that the demand for labourers is high and those labourers earn good wages to sustain themselves. Some farmers even argued that the poor people are better off by working as labourers. The reason is that the poor can work as labourers, but the middle-income families can not because of their social status. This social perception gives an edge to the poor. However, it is not clear what happens when the poor promotes to the middle-income status. The social norms, thus, have great influence on people's way of action.

7.2.3 Improvement in social relations

The adoption of the modern technology has also improved the social cohesion and harmony. Farmers in the Dhandogaon village stated that there were several occasions of disputes for getting water from STWs previously. But the adoption of DTW has changed the scenario and eliminated the conflicts. The machine operation system appears to be effective for such impact. Similarly, people in Ramnather Para reports that E-STW operation system is convenient and there is trust between the operator and the renters. The eradication of conflicts may have improved the social relations and built trust among the people. Such codes of behaviour shows the influence of institutions in individual's action (Friel, 2017, North, 1991). It also shows the shared implicit perception of the irrigation among the farmers (Friel, 2017). The trust among the people in the community is necessary as (Leder et al., 2019) shows that the trust influences collective benefits in the society.

7.3 SCOT and social stratification

The above discussion clearly explains the inequality due to economic class and gender in the society in different forms and how society accommodates these inequalities. As all the farmers adopted different technologies, either as an owner or a renter, the social construction of these technologies also forms in various ways. Before the discussion of how the technologies are socially constructed, I focus on the norms and intersectionality by reiterating the analytical model as Figure 7.

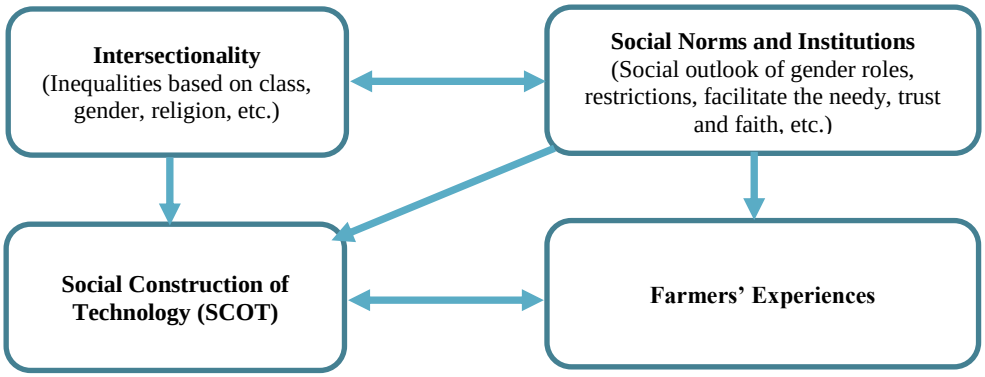

Figure 7: A Model to analyse SCOT in Dhandogaon and Ramnather Para.
Source: Author

As I have argued earlier that the social norms and institutions have influence over intersectionality and vice-versa, my data also conforms similar explanation. The institutions in both the study sites control the perception of gender roles, impose various restrictions, and also establish a sense of trust and faith among the members

of the community. Intersectionality, on the other hand, propose that the restrictions imposed by different social norms and the institutions that controls social strata affect an individual's experience in different ways and it needs to be addressed simultaneously (McCall, 2005, Nightingale, 2011). That is, when a woman faces limitation on accessing irrigation water, it is important to examine, at the same time, if there are any other limitations based on religion, race, class, etc. For example, in Dhandogaon village, woman from wealthy family do not participate in agriculture due to their status, whereas, poor woman works in the field but has limited access to STW. In this case, social institution limits a woman from wealthy family in accessing agriculture while permits poor woman but restricts the poor woman to access an irrigation machine. It is a reflection of how social status intersect with gender under the umbrella of social institutions. McCall (2005) asserts that such complexity in conflicting experiences and complicated power relations demand the analysis of intracategorical identities. Hence, the intertwined discussion of social norms and intersectionality has been undertaken to understand the SCOT.

Another example from Ramnather para shows that the ownership of a technology is facilitating a farmer by acquiring higher social status while marginalising other poor farmers who cannot afford it (see chapter 7.1.3). The higher social status is also offering the machine owner a voice and decision-making power, which in turn, again marginalizes the poor farmers. Here, the owner of the machine is gaining for both being in the higher class and having higher decision-making power, whereas, the renter famer is being worse off due to his/her lower social status and lower decision-making power. Besides, the women in both the study sites do not have any participation in the implementation processes or own lands that leave them with no decision-making power at all. Therefore, it again shows that the access to decision-making power depends on several social factors (e.g. gender, social class, wealth) which reaffirm McCall's idea of intracategorical complexity. Similarly, Nightingale (2011) also opines that class relations significantly intersect with many other indicators of social difference (e.g. gender, caste, etc.) to influence inequalities.

To examine how the social norms and institution facilitate building trust and help the person in need, an example from Dhandogaon village is explained (see chapter 5.4.4). Social norms restrict women's access to the public space after evening. However, it may also try to balance by giving them extra benefits. For instance, a woman reported that she gets the irrigation earlier if she says that she won't be able to irrigate after evening. The operator, in such case, will provide water to the women ahead of other men. Hence, different social norms treat the persons of different social strata differently. According to Thompson (2016), the social complexity and multidimensional experiences of individuals are part of social structure.

A discussion of theoretical components of SCOT would make the ground to show how the irrigation technologies are socially constructed in Dhandogaon

village and Ramnather Para. Klein and Kleinman (2002) emphasized on the background conditions of social relations that affect the interactions between relevant social groups. Hence, starting with the last component, 'the wider context', would be helpful to understand. In Dhandogaon, people have been using the STWs for long since. The implementation of an advanced technology (DTW) by partnering with the influential farmers of the community demand an analysis of sociocultural and political atmosphere. As stated earlier, the investor farmers had been influential in the community due to their position, status and wealth. They may have observed the investment potential and took the risk to gain profit later. As the technology have established, their influence over the community have been increased since they control the irrigation system for a huge amount of land which can also be termed as political gain (REF). Similarly, in case of Ramnather Para, the wealthy farmers could afford to install the E-STWs and became better off than the poor farmers. The implementation of the technology also increased their social status as an owner of E-STW. Therefore, a social relation of owner-renter emerges along with the implementation of the technology that may influence the differences in interaction among the farmers. The ability of a relevant social group to shape an artefact development depends on its access to economic, political and cultural resources (Klein and Kleinman, 2002).

The structural design of the technological frame is open, that is, the meanings assigned to the technology is free to evolve (Klein and Kleinman, 2002). The users' group of different technologies describe the outcome of a technology differently. The DTW users in Dhandogaon stated that the machine has improved their irrigation while the users of STW claimed that their irrigation has been negatively affected due to the implementation of DTW. Similarly, users of E-STW and the users of D-STW in Ramnather para interprets the outcome of the technology differently. The users of E-STW are happy with the water extraction but complains about the longer queue, whereas, the users of D-STW have issues with higher expenses. It shows that each type of technology comes with different meanings to various groups and the interpretations of each of these groups are different. Referring to the above discussion again, it can be observed that an irrigation technology to an owner is a machine to both for irrigating his/her lands and as a business instrument to make profit by selling the water. On the other hand, a renter of the same machine views it from the consumer perspective. Such meaning making of both the groups is depended on the above discussed intracategorical complexity. That is, the interpretations are created based on the intersectionality that is bounded by the social norms and institutions. Such different assignment of meaning from relevant social groups exhibits the interpretative flexibility of SCOT (Howcroft et al., 2004).

The data collected in the study found that the meaning making is somewhat similar in a certain social group as Pinch and Bijker (1987) claimed. For example,

the poor people in both the study sites were mainly concerned with the cost of their irrigation and availability of water, whereas, the owners of the technologies focused on the profits and management of it during the *Boro* season. Besides, the women in both the areas were concerned with the condition of labour intensity related to different technologies, whereas, the male farmers were mainly concerned about the amount of yield. Thus, it is clear that each of the social groups make similar meaning to the technology. However, Klein and Kleinman (2002) states, "simply because a multitude of individuals share a set of meanings does not ensure that they will organize themselves into a group to participate in a design process" (p.37). It emphasizes that the inability to organize a group to negotiate may have impact on the final artefact. This is also noticeable that the inability to organise all the farmers to take the partnership with BMDA left only a few people having the control over DTW and gaining the maximum benefits in Dhandogaon village.

The design process of the technologies involves different social groups and create conflicts. The design processes are debated, and a consensus reaches when all the parties agree. In Dhandogaon, when the BMDA approved the partnership with the investor farmers, investors have contacted with other farmers to get their opinion if the farmers want the access to DTW. They set up a rent as an access free for the machine and the farmers debated on this and there were conflicts over the fees. Several farmers did not pay the full rent as claimed by the operator. However, the renter farmers had little or no power in negotiating the rent. Besides, in Ramnather para, the consensus reaches when the owner of the E-STW agrees with the renter farmer to provide an operator to irrigate all the land within the asked price. But then again, the renter has to take the asked price and do not have any negotiation power over the price. In such situation, the closure and stabilization may have achieved but portrays imbalance of power among different social groups. Klein and Kleinman (2002) argued that a closure should only be interpreted with reference to the power relations among the groups. I want to argue as Portes (2006) discussed that social norms and institutions establish the rules that allocates decision-making power to different group of people differently. Hence, I argue that the closure and consensus may establish a technological frame through interactions but it may also have biases and produce unequal benefits to different relevant social groups while achieving stabilization.

The above discussion provides an illustration of how the irrigation technologies are socially constructed in Dhandogaon village and Ramanther para. According to the model presented in figure 7, the farmers experiences from these technologies shows direct relation to the SCOT and the social norms and institutions.

8 Conclusion

This chapter presents the summary of the study by depicting the main outcomes, details the limitation faced during the research, provides ideas for further studies and suggests some recommendations. All the sections are discussed having focus on the technology in agriculture and development.

8.1 The major findings – the social construction of irrigation technologies

The irrigation technologies are among the major inputs for *Boro* rice cultivation in the north-western region of Bangladesh. Various types of these technologies are socially accommodated, and the meaning of these technologies are socially constructed based on the specific social context, culture and social institutions. With the adoption of advanced technology, the experiences of the farmers about irrigation have been evolved as found in the study conducted in the villages of Dhandogaon in Thakurgaon and Ramnather Para in Rangpur. The technology adoption has varied impact on the accessibility of the technologies to different social groups and increased social acceptance of women's work in the fields. However, the implementation of these technologies is found out to be the dominion of the high-income families and the benefits accumulated from these technologies are also higher for them than the low-income families. The participation of the women or the poor farmers were nearly absent in the implementation processes.

In both the study sites, the farmers perceive that the implementation of the advanced irrigation technology has improved the irrigation system in the area. There is variance of costs in the adoption of different technologies and a farmer tries to adopt the most convenient one with lower costs. The management of the technology varies but each type of technology usually has similar management system in a particular area. However, the management of the technologies is different in between the study sites. The study kept attention on the management system and

how it treats people of different social identities. The findings are that the good management ensures proper distribution of the irrigation water, the wealthy people are better off than the poor in water access, the women enjoys improved access with the advanced technology than the traditional ones, and the religious differences may not have impact on the water access. However, the unequal adoption of different types of technologies created uneven benefits among the farmers. The differences in the capability of different technologies and the inability to adopt particular technology shaped farmers experiences of irrigation for agriculture.

The study also used the intersectionality perspective to analyse the dynamics of social construction of technology in affecting the social institutions and identities. The finding shows the decision-making power whether on the implementation of the technology or the distribution of water is in the control of certain people holding certain social and political status. For example, the investor farmers initiated the implementation of the DTW and control the management of the machine in Dhandogaon village. On the other hand, operators in Ramnather para decides which lands are to be irrigated at what time. Hence, the ordinary farmers hold very little to no decision-making power at all. However, the discrimination seems to be lower among the farmers having land in the DTW command area in the Dhandogaon village. Therefore, I would like to claim that the adoption of a technology can be an instrument to reduce inequality among the farmers in certain social aspects.

The technology adoption also has significant impact on gender roles and women's participation in the agriculture in the study sites. The women who use the latest technologies asserted that the water access have been improved for them although the work burden have increased alongside. Besides, the social barrier that the women used to face while irrigating their lands or taking part in cultivation has been more open now than that of previous. A notion of changes can be found from the expression's men as well. The men and women seem to be more open to work alongside which was not visible in the past. Moreover, previous social norms that restricted women's access to agriculture found to be challenged by the growing acceptance of women and the introduction of simple modes of irrigation in agriculture.

8.2 Limitation of the study

The study lacks the views of the implementing authorities, e.g. BMDA, BADC, due to shortage of time and resources. The observations of the BMDA officials would have been a contribution to analyse the SCOT more rigorously. Besides, the study was targeted to find out the experiences of farmers holding diverse social identities to maintain an intersectionality approach to the study. However, only a small

number of people from different economic class, status, religion, gender, educational background, income group, ethnicity, type of technology they use, etc. could be identified within the scope of this study. Besides, it involves collecting data from a huge number of individuals having different cross-sectional identities. I was, thus, restricted into religion, gender, economic class and the type of technologies the farmers use. A more comprehensive study including diverse types of people could have brought more divisible data to interpret the divergence of experiences. According to the preliminary studies, I came to know that there is both DTW and STW operation in Ramnather Para. But during fieldwork, I found out that DTW is in fact situated in the next village although a few lands in Ramnather para get irrigation from the DTW. I could not collect enough data to make a comprehensive discussion on the influence of DTW in Ramnather Para.

8.3 Reflection on the methodological and theoretical choice

The results of a study depend on the methodological choices and the theoretical approach undertaken. The methodology guides the research and shape the outcome of the research. In this study, the chosen methodologies were well suited to capture the farmers experiences of irrigation technologies. The semi-structured interviews were helpful to address the research question while giving the space to the interviewees to bring in various topics of conversation. It was easier to make follow-up questions to grasp the respondents' views. However, I think unstructured interview could have brought more interesting opinions of the farmers related to the irrigation and technology. Besides, the FGDs were very fruitful to learn the common understanding of the people. It also helped me to verify the information gathered in the interviews. Moreover, the wealth ranking and the participatory resource mapping helped me to analyse the farmers' views of the community and the distribution of resources. However, as I conducted the FGD, wealth ranking and participatory resource mapping together at a time. It took quite a lot of time to conduct and I suspect that the farmers' concentration into the topic was lower by the end of the tasks. I understood that I should have conducted the tasks separately, but I was not able to do so due to limited time resources.

The theories used in the study helpful to analyse and discuss different social identities affecting farmers experiences of irrigation technology. The discussion of the farmers' experiences portrayed how the irrigation technologies are socially constructed in the study sites. However, I couldn't find any literature that have worked with theory of SCOT focusing on irrigation or agriculture. Thus, it was a challenge to make arguments and refer those with relation to other literature. Besides, not having data from the implementing organizations (BMDA, BADC)

limited the discussion of the SCOT as implementers are the parts of the relevant social groups in the theory of SCOT. On the other hand, the theory of intersectionality shaped the approach of methods undertaken for data collection. An attempt was to include people from different religion, economic class and gender in relation to the different technologies they use. It helped to accumulate different perspectives of the people as well as analyse the differences of experiences based on intersectional identities. However, it would have been better if I could include more people of diverse social identities.

8.4 Suggestions for further studies

During the data collection, I have been introduced with wide range of factors that can be analysed and researched in further studies. Such areas of research could follow the themes below:

- Investigation of the dynamics of changes in the social norms due to the factors other than technology (e.g. AES, micro credit, NGO programs) and its relation to the gender division of labour and the control of income.
- A study may explore the impact of technology on the choice of crop selection and the variance of income. An ethnographic research may focus on finding farmers' crop selection processes based on access to different technology.
- Research on the migration decision induced by the implementation of technology in agriculture and its implication on the livelihood diversification.
- An examination of the intensity of groundwater extraction and its impact on the drawdown of the groundwater level would be necessary to measure the sustainability of the advanced technologies.
- Investigating the differences in the volume of water extraction from different technologies and its relation to the amount of yield.

8.5 Recommendations and policy implication

The study discussed the uneven adoption of irrigation technologies and farmers experiences. From the farmers expressions and perceptions, it is visible that they are willing to adopt better mode of technology to improve their irrigation system and agriculture. However, to improve the current state of agriculture, there are various measures that can be necessary in order to ensure equal access to the technology across people from all social identities.

First of all, I think it is important to evaluate if the high powerful updated technology would be sustainable to the agriculture. Since several farmers in both the study sites argued that the action of powerful machines has impact on the

capability of the other machines. Implementation of a technology may benefit a few but the concern raises if that happens with the cost of hurting someone else. Besides, it is also important to understand the characteristics of these technologies in future. As the farmers are highly depended on the groundwater, inadequate recharge of groundwater may affect the farmers with lower end technology immensely. Here you can add the effects on the STW users who have to withdraw water at night after the DTW is turned off

Secondly, the latest technologies implemented should have proper management system with regular monitoring and more participation from community members. It has been observed in this study that the management of the irrigation machines and the authority over it highly affect the equality of water access to the farmers. Thus, if the management system is revised and operation of the machines are given to all the people on a roster may ensure the equality and eliminates the sense of hierarchy. The government approach should also be engaging to the farmers, such as, involving more farmers in the implementation of a particular technology may reduce the polarity created by owning the authorship into a small group. Another step could be reducing the bureaucratic complications in obtaining permission to install an irrigation machine.

There is close relation between the mode of operation of a machine and women's access to the machine. Hence, the design of a technology should consider the social aspects like the institutions that creates barriers for people with certain social identities. If the technology can offer the convenience of operation and improve the accessibility within the social norms such as increased women's access to technology, then the outcome of a technology might be the maximum. Besides, the technology design should also maintain the efficiency in regards to costs and the amount of water withdrawal. Therefore, the designing of the technology needs to accommodate the experience and knowledge of both the farmers and the scientists. The social construction of technology would reach a point of closure and stabilization when all the social groups takes part in the designing process.

Lastly, the agricultural extension services (AES) need to be strengthened and address the issues of social inequality. The extension services can also educate the farmers in using the irrigation water and create awareness not to waste the water or overuse the water. The AES is specially very important to boost up the confidence in women and improve their negotiation power. Various training inclusive of both men and women may create a sense of equality among them. Furthermore, these AES should also be designed in a way so that the excess burden of work for women can be reduced and shared equally by men and women. I think a comprehensive approach would benefit the society most.

References

ADB 2010. Country Gender Assessment Bangladesh. Manila, Philippines Asian Development Bank.

AHMED, A. U., AHMAD, K., CHOU, V., HERNANDEZ, R., MENON, P., NAEEM, F., NAHER, F., QUABILI, W., SRABONI, E. & YU, B. 2013. The status of food security in the Feed the Future Zone and other regions of Bangladesh: Results from the 2011–2012 Bangladesh Integrated Household Survey. *Project report submitted to the US Agency for International Development. International Food Policy Research Institute, Dhaka*.

ALAM, K. 2015. Farmers' adaptation to water scarcity in drought-prone environments: A case study of Rajshahi District, Bangladesh. *Agricultural Water Management,* 148**,** 196-206.

AMARASINGHE, U. A., SHARMA, B. R., MUTHUWATTA, L. & KHAN, Z. H. 2014. *Water for food in Bangladesh: outlook to 2030*, IWMI.

APPLETON, B. & SMOUT, I. 2003. The Gender and Water Development Report 2003: Gender perspectives on policies in the water sector. *Loughborough University*.

ASADUZZAMAN, M. The Next Agricultural Transition in Bangladesh: Which Transition, Why and How? Conference on Understanding the Next Generation in Asia, Bangkok, April, 2010.

ASADUZZAMAN, M., RINGLER, C., THURLOW, J. & ALAM, S. 2012. Investing in crop agriculture in Bangladesh for higher growth and productivity, and adaptation to climate change. *Bangladesh Food Security Investment Forum.*

BELL, A. R., BRYAN, E., RINGLER, C. & AHMED, A. 2015. Rice productivity in Bangladesh: What are the benefits of irrigation? *Land use policy*, 48**,** 1-12.

BIJKER, W. E. 1997. *Of bicycles, bakelites, and bulbs: Toward a theory of sociotechnical change*, MIT press.

BIJKER, W. E. 2009. How is technology made?—That is the question! *Cambridge journal of economics*, 34**,** 63-76.

BRYAN, E., BELL, A. R., RINGLER, C. & AHMED, A. U. 2018. Increasing Crop Production Benefits to Small Producers in Bangladesh. *Asian Journal of Agriculture Development*, 15.

BRYMAN, A. 2012. *Social Research Methods*, OUP Oxford.

BUCHMANN, D. C. 2013. Accountability at the local level in fragile contexts: Bangladesh case study. *IDS Working Papers*, 2013**,** 1-62.

CHOWDHURY, F. D. 2009. Theorising patriarchy: the Bangladesh context. *Asian Journal of Social Science*, 37**,** 599-622.

CHOWDHURY, N. T. 2010. *The relative efficiency of water use in Bangladesh agriculture*, SANDEE.

CLEMENT, F. 2012. Literature review: Gender and water management organisations in Bangladesh.

COLLINS, P. H. 2002. *Black feminist thought: Knowledge, consciousness, and the politics of empowerment*, Routledge.

COLLINS, P. H. 2010. The new politics of community. *American Sociological Review*, 75**,** 7-30.

COOPER, B. 2015. Intersectionality. *The Oxford handbook of feminist theory.*

CRENSHAW, K. 1991. Mapping the Margins: Intersectionality, Identity Politics, and Violence against Women of Color. *Stanford Law Review*, 43**,** 1241-1299.

CRESWELL, J. W. 2014. Research design: qualitative, quantitative, and mixed methods approaches. *SAGE Publications*.

DE SILVA, S. 2012. Structural vulnerability to climate change in Bangladesh: a literature review. *[Project report prepared by IWMI for the CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS) under the project" Water-related Interventions to Reduce Vulnerability to Climate Change: Do they Address the Structural Causes of Gendered Vulnerability in the IGP [Indo Gangetic Plains]"]*.

DE SILVA, S. & LEDER, S. 2016. Agricultural innovations for water security in North West Bangladesh from institutional, gender, food and livelihood security perspectives. *Evaluating groundwater irrigation technology adoption in Rangpur, Thakurgaon and Rajshahi Districts.* ACIAR - Australian Centre for International Agricultural Research.

DEY, N., ALAM, M., SAJJAN, A., BHUIYAN, M., GHOSE, L., IBARAKI, Y. & KARIM, F. 2011. Assessing environmental and health impact of drought in the Northwest Bangladesh. *Journal of Environmental Science and Natural Resources*, 4**,** 89-97.

DEY, N., BALA, S. K., ISLAM, A., RASHID, M. A. & HOSSAIN, M. 2013. Sustainability of groundwater use for irrigation in northwest Bangladesh. Dhaka, Bangladesh: The Food Planning and Monitoring Unit of the Ministry of Food.

DILL, B. T. 2002. Work at the intersections of race, gender, ethnicity, and other dimensions of difference in higher education. *Connections: Newsletter of the consortium on race, gender, ethnicity***,** 5-7.

DOMÈNECH, L. 2015. Improving irrigation access to combat food insecurity and undernutrition: A review. *Global Food Security*, 6**,** 24-33.

DOSS, C. R. & MORRIS, M. L. 2000. How does gender affect the adoption of agricultural innovations? The case of improved maize technology in Ghana. *Agricultural economics*, 25**,** 27-39.

FALKENMARK, M. 2013. Growing water scarcity in agriculture: future challenge to global water security. *Philosophical transactions. Series A, Mathematical, physical, and engineering sciences*, 371**,** 20120410.

FRIEL, D. 2017. Understanding institutions: different paradigms, different conclusions. *Revista de Administração (São Paulo)*, 52**,** 212-214.

FUJITA, K. & HOSSAIN, F. 1995. Role of the groundwater market in agricultural development and income distribution: a case study in a northwest Bangladesh village. *The Developing Economies*, 33**,** 460-463.

HABIBA, U., SHAW, R. & TAKEUCHI, Y. 2011. Drought risk reduction through a socio-economic, institutional and physical approach in the northwestern region of Bangladesh. *Environmental Hazards*, 10**,** 121-138.

HOSSAIN, M. 2009. *The impact of shallow tubewells and boro rice on food security in Bangladesh*, Intl Food Policy Res Inst.

HOSSAIN, M., NAHER, F. & SHAHABUDDIN, Q. 2005. Food security and nutrition in Bangladesh: progress and determinants. *Journal of Agricultural and Development Economics*, 2**,** 103.

HOWCROFT, D., MITEV, N. & WILSON, M. 2004. What we may learn from the social shaping of technology approach. *Social theory and philosophy for information systems***,** 329-371.

HUMPHREYS, L. 2005. Reframing social groups, closure, and stabilization in the social construction of technology. *Social epistemology,* 19**,** 231-253.

JAIM, W. & HOSSAIN, M. Women's participation in agriculture in Bangladesh 1988–2008: Changes and determinants. Preconference event on Dynamics of Rural Livelihoods and Poverty in South Asia, 7th Asian Society of Agricultural Economists (ASAE) International Conference, Hanoi, Vietnam, 2011.

KABEER, N. 1994. *Reversed realities: Gender hierarchies in development thought,* Verso.

KABEER, N. 2009. Conflicts over credit: re-evaluating the empowerment potential of loans to women in rural Bangladesh. *Microfinance.* Routledge.

KATNIK, A. 2002. Religion, Social Class, and Political Tolerance. *International Journal of Sociology,* 32**,** 14-38.

KIRBY, J., AHMAD, M., MAINUDDIN, M., PALASH, W., QUADIR, M., SHAH-NEWAZ, S. & HOSSAIN, M. 2015. The impact of irrigation development on regional groundwater resources in Bangladesh. *Agricultural Water Management,* 159**,** 264-276.

KLEIN, H. K. & KLEINMAN, D. L. 2002. The social construction of technology: Structural considerations. *Science Technology & Human Values,* 27**,** 28-52.

LEDER, S., SUGDEN, F., RAUT, M., RAY, D. & SAIKIA, P. 2019. Ambivalences of collective farming: Feminist political ecologies from the Eastern Gangetic Plains. *International Journal of the Commons,* 13**,** 105-129.

LIPTON, M., LITCHFIELD, J. & FAURÈS, J.-M. 2003. The effects of irrigation on poverty: a framework for analysis. *Water Policy,* 5**,** 413-427.

MACKENZIE, D. A. 1993. *Inventing accuracy: A historical sociology of nuclear missile guidance*, MIT press.

MAINUDDIN, M. 2016. *Monitoring dry season irrigation by groundwater using STW and DTW in the northwest region of Bangladesh* [Online]. Improving water use for dry season agriculture by marginal and tenant farmers in the Eastern Gangetic Plains: dsi4mtf.usq.edu.au. Available: https://dsi4mtf.usq.edu.au/monitoring-dry-season-irrigation-by-groundwater-using-stw-and-dtw-in-the-northwest-region-of-bangladesh/ [Accessed 03-02-2019].

MAJUMDER, S., BALA, B., ARSHAD, F. M., HAQUE, M. & HOSSAIN, M. 2016. Food security through increasing technical efficiency and reducing postharvest losses of rice production systems in Bangladesh. *Food Security,* 8**,** 361-374.

MALLICK, B. & VOGT, J. 2011. Social supremacy and its role in local level disaster mitigation planning in Bangladesh. *Disaster Prevention and Management: An International Journal,* 20**,** 543-556.

MANIRUZZAMAN, M. & MAINUDDIN, M. 2016. *Dhandogaon, Site 1: Thakurgaon Sadar, Thakurgaon (Case Study)* [Online]. Available: https://dsi4mtf.usq.edu.au/dhandogaon-site-1-thakurgaon-sadar-thakurgaon-case-study/ [Accessed].

MAYRING, P. 2014. Qualitative content analysis: theoretical foundation, basic procedures and software solution.

MCCALL, L. 2005. The Complexity of Intersectionality. *Signs,* 30**,** 1771-1800.

MENDOLA, M. 2007. Agricultural technology adoption and poverty reduction: A propensity-score matching analysis for rural Bangladesh. *Food policy,* 32**,** 372-393.

MOA, M. O. A. 2018. Organization Wise Summary of irrigation Equipment Used, Area lrriated and Benefited Farmers Rabi Crops (Boro, Wheat, Potato, Maize and fruits)- 2016-17. Dhaka: Government of Bangladesh.

MOLLAH, M. A. H. 2017. *Groundwater Level Declination in Bangladesh: System dynamics approach to solve irrigation water demand during Boro season.* The University of Bergen.

MONDAL, M. S. & SALEH, A. F. M. 2003. Evaluation of some deep and shallow tubewell irrigated schemes in Bangladesh using performance indicators. *Agricultural Water Management,* 58**,** 193-207.

MOTTALEB, K. A., KRUPNIK, T. J. & ERENSTEIN, O. 2016. Factors associated with small-scale agricultural machinery adoption in Bangladesh: Census findings. *Journal of rural studies,* 46**,** 155-168.

NAHER, A. 2006. *Gender, religion and development in rural Bangladesh.*

NIGHTINGALE, A. J. 2011. Bounding difference: Intersectionality and the material production of gender, caste, class and environment in Nepal. *Geoforum,* 42**,** 153-162.

NJUKI, J., WAITHANJI, E., SAKWA, B., KARIUKI, J., MUKEWA, E. & NGIGE, J. 2014. A qualitative assessment of gender and irrigation technology in Kenya and Tanzania. *Gender, Technology and Development,* 18**,** 303-340.

NORTH, D. C. 1991. Institutions. *Journal of Economic Perspectives,* 5**,** 97-112.

PALMER-JONES, R. Irrigation service markets in Bangladesh: Private provision of local public goods and community regulation. Symposium on managing common resources: what is the solution, 2001. 10-11.

PEARSON, K. A., MILLAR, G. M., NORTON, G. J. & PRICE, A. H. 2018. Alternate wetting and drying in Bangladesh: Water-saving farming practice and the socioeconomic barriers to its adoption. *Food and Energy Security,* 7**,** e00149.

PIESSE, J. & THIRTLE, C. 2010. Agricultural R&D, technology and productivity. *Philosophical Transactions of the Royal Society B: Biological Sciences,* 365**,** 3035-3047.

PINCH, T. J. & BIJKER, W. E. 1987. The Social Construction of facts and Artifacts: Or How the Sociology of Science and the Sociology of Technology of Technology Might Benefit Each Other. *The Social Construction of Technological Systems: New Directions in the Sociology and History of Technology,* 17**,** 1-6.

PITT, M. M. & KHANDKER, S. R. 1996. *Household and intrahousehold impact of the Grameen Bank and similar targeted credit programs in Bangladesh,* The World Bank.

PORTES, A. 2006. Institutions and development: A conceptual reanalysis. *Population and development review,* 32**,** 233-262.

PORTES, A. 2010. *Economic sociology: a systematic inquiry*, Princeton University Press.

PRELL, C. 2009. Rethinking the Social Construction of Technology through 'Following the Actors': A Reappraisal of Technological Frames. *Sociological Research Online,* 14**,** 1-12.

QUISUMBING, A. R., ROY, S., NJUKI, J., TANVIN, K. & WAITHANJI, E. 2013. Can dairy value-chain projects change gender norms in rural Bangladesh? Impacts on assets, gender norms, and time use. International Food Policy Research Institute (IFPRI).

RAHMAN, S. 2000. Women's employment in Bangladesh agriculture: composition, determinants and scope. *Journal of Rural Studies,* 16**,** 497-507.

RAHMAN, S. 2003. Environmental impacts of modern agricultural technology diffusion in Bangladesh: an analysis of farmers' perceptions and their determinants. *Journal of environmental management,* 68**,** 183-191.

RAHMAN, W. & PARVIN, L. 2009. Impact of Irrigation on Food Security in Bangladesh for the Past Three Decades. *Journal of Water Resource and Protection,* Vol.01 No.03**,** 10.

RASUL, G. & THAPA, G. B. 2004. Sustainability of ecological and conventional agricultural systems in Bangladesh: an assessment based on environmental, economic and social perspectives. *Agricultural systems,* 79**,** 327-351.

ROLAND, G. 2004. Understanding institutional change: Fast-moving and slow-moving institutions. *Studies in comparative international development,* 38**,** 109-131.

ROY, K. & SINGH, G. 2008. Agricultural mechanization in Bangladesh. *AMA, Agricultural Mechanization in Asia, Africa and Latin America,* 39**,** 83.

SCHRAMM, W. 1971. Notes on Case Studies of Instructional Media Projects. *Working paper for the Academy for Educational Development*.

SCOTT, W. R. 2013. *Institutions and organizations: Ideas, interests, and identities*, Sage Publications.

SHAH, T., SINGH, O. P. & MUKHERJI, A. 2006. Some aspects of South Asia's groundwater irrigation economy: analyses from a survey in India, Pakistan, Nepal Terai and Bangladesh. *Hydrogeology Journal,* 14**,** 286-309.

SHAHID, S. 2011. Impact of climate change on irrigation water demand of dry season Boro rice in northwest Bangladesh. *Climatic change,* 105**,** 433-453.

SHAHID, S. & BEHRAWAN, H. 2008. Drought risk assessment in the western part of Bangladesh. *Natural Hazards,* 46**,** 391-413.

SHAHID, S. & HAZARIKA, M. K. 2010. Groundwater drought in the northwestern districts of Bangladesh. *Water resources management,* 24**,** 1989-2006.

SHAMSUDDUHA, M., CHANDLER, R., TAYLOR, R. & AHMED, K. 2009. Recent trends in groundwater levels in a highly seasonal hydrological system: the Ganges-Brahmaputra-Meghna Delta. *Hydrol Earth Syst Sc,* 13**,** 2373-2385.

SHITIMA, C. M. 2018. Intersectionality and an Intra-household Analysis of the Freedom to make Decisions on the Use of Household Products: Evidence from Rural Tanzania. *Journal of International Women's Studies,* 19**,** 207-223.

SHONCHOY, A. S. & RABBANI, M. 2015. The Bangladesh gender gap in education: Biased intra-household educational expenditures.

SILVERMAN, D. 2015. *Interpreting qualitative data,* Sage.

STIMIE, C. & CHANCELLOR, F. 1999. South African women's part in rehabilitation and design of irrigation projects. *GRID-Magazine of the IPTRID Network*.

SULTANA, F. 2009. Fluid lives: subjectivities, gender and water in rural Bangladesh. *Gender, Place and Culture,* 16**,** 427-444.

THEIS, S., LEFORE, N., MEINZEN-DICK, R. & BRYAN, E. 2018. What happens after technology adoption? Gendered aspects of small-scale irrigation technologies in Ethiopia, Ghana, and Tanzania. *Agriculture Human Values***,** 1-14.

THOMPSON, J. A. 2016. Intersectionality and water: how social relations intersect with ecological difference. *Gender, Place & Culture,* 23**,** 1286-1301.

WONG, S. 2009. Climate change and sustainable technology: re-linking poverty, gender, and governance. *Gender & Development,* 17**,** 95-108.

YIN, R. K. 2017. *Case study research and applications: Design and methods*, Sage publications.

Appendix

Questionnaire

Participant Name		
Mobile Number		
Sex		
Age		
Household head		
Size of farm		
User of STW/DTW		
Religion/caste		
Years of school education		
Participation in agricultural trainings		
Migration (where, why, for how long?)		
Income/Source/kept by/spent by		
Area of land owned by whom (ID), f/m?		
Area of tenancy by whom (ID), f/m?		

Questions for FGDs

i. What do you think about the irrigation technologies? What do you think about STW and DTW?
ii. How these technologies were implemented? Who has implemented? How was it implemented?
iii. How the farmers get access to the technologies? What are the procedures? What criteria to be filled up? Is there any obstacles to get the access?
iv. What are the difference between STW and DTW? How much are the difference? How does this difference affect the farmers?
v. Do you face any difficulties in accessing the technologies due to your religion/caste/class/Gender? Why? Why not? What instruments are behind it? How can it be improved?
vi. Who manages the technologies? Who distributes the water? Who decides whom should get what?

Questions for farmer's interview (as a guidance for myself)

Ask consent and permission to record

Adoption of the technologies

i. Tell me about your farming. How is it going? What are the challenges you face? What are the things beneficial for farming?
ii. What do you think about the irrigation technologies? What do you think about STW and DTW?
iii. How was the irrigation system before the introduction of technologies? What were the challenges before?
iv. How these technologies were implemented? Who has implemented? How was it implemented?

Access to technologies

v. How the farmers get access to the technologies? What are the procedures? What criteria to be filled up? Is there any obstacles to get the access?
vi. Who has more access to the technology? Who has less? How can the access be improved? What are the barriers?
vii. What are the difference between STW and DTW? How much are the difference? How does this difference affect the farmers?

Norms/culture/Gender

viii. How much involvement of men and women had in the implementation process?
ix. Who are the female farmers got access to the tech? Who are the male farmers?
x. Do you face any difficulties in accessing the technologies due to your religion/caste/class/Gender? Why? Why not? What instruments are behind it? How can it be improved?

Decision making power

xi. Who manages the technologies? Who distributes the water? Who decides whom should get what?
xii. Who took the initiation to implement the technologies? How did they do it? Whom did they take help from?
xiii. Who hold decision making power in the community? Why? How much are their holdings and properties?

Overview of the participants

Dhandogaon Village							
Participants	Sex	Age	Size of farm	User of STW/DTW	Religion	Years of school education	Area of land owned by whom, f/m?
Participant 1	Male	40	1 Acre	STW	Hindu	0	Rented
Participant 2	Female	45	0.5 Acre	DTW	Hindu	0	Own - Male
Participant 3	Male	65	2 Acre	DTW	Islam	0	Rented
Participant 4	Male	46	4 Acre	DTW+STW	Hindu	0	Own+Rented
Participant 5	Male	33	5 Acre	STW	Hindu	0	**
Participant 6	Male	35	1.5 Acre	DTW	Hindu	SSC	Rented
Participant 7	Female	26	2.5 Acre	DTW	Hindu	HSC	Own - Male
Participant 8	Male	35	1.5 Acre	DTW	Hindu	0	Own - Male
Participant 9	Female	40	5 Acre	DTW	Hindu	0	Own - Male
Participant 10	Male	54	4 Acre	DTW	Hindu	SSC	Own - Male
Participant 11	Female	30	4 Acre	DTW	Islam	8	Own+Rented
Participant 12	Male	28	1 Acre	DTW	Hindu	SSC	Own - Male
Participant 13	Male	60	2.5 Acre	STW	Hindu	0	Rented
Participant 14	Female	50	1 Acre	DTW	Islam	0	Rented
Participant 15	Male	43	2 Acre	DTW	Hindu	SSC	Own - Male

** Data not available

Ramnather Para							
Participants	Sex	Age	Size of farm	User of STW/DTW	Religion	Years of school education	Area of land owned by whom?
Participant 1	Male	49	0.5 Acre	STW - E	Islam	Degree	Own - Male
Participant 2	Female	45	1.5 Acre	STW - Oil	Hindu	0	Own - Male
Participant 3	Female	35	1 Acre	STW - E	Islam	0	Rented
Participant 4	Male	37	3 Acre	STW - Oil	Hindu	Inter	Own - Male
Participant 5	Male	35	1.5 Acre	STW - Oil	Islam	0	Own - Male
Participant 6	Male	75	11 Acre	STW - E	Islam	8	Own - Male
Participant 7	Female	40	0.5 Acre	STW - E	Islam	0	Rented
Participant 8	Male	37	0.5 Acre	STW - E	Islam	9	Own - Male
Participant 9	Male	45	0.5 Acre	STW - E	Islam	SSC	Own - Male
Participant 10	Female	38	1.5 Acre	STW - Oil	Islam	SSC	Own - Male
Participant 11	Female	30	0.5 Acre	STW - Oil	Islam	0	Rented
Participant 12	Male	54	7 Acre	STW - oil	Islam	0	Own - Male
Participant 13	Female	35	3 Acre	STW - E	Islam	9	Own - Female
Participant 14	Male	60	2 Acre	STW - Oil	Islam	5	Own - Male
Participant 15	Male	30	2 Acre	STW	Hindu	3	Own - Male
Participant 16	Male	45	1 Acre	DTW + STW	Islam	SSC	Own - Male
Participant 17	Male	24	1 Acre	DTW	Islam	Degree	Own+Rented
Participant 18	Male	65	1.5 Acre	DTW	Islam	5	Own - Male
Participant 19	Male	55	1.5 Acre	DTW	Islam	0	Own - Male