MINISTRY OF WATER RESOURCES

Study on Developing Operational Shadow Prices for Water to Support Informed Policy and Investment Decision Making Processes

FINAL REPORT

WARPO
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WARPO Bhaban, 72 Green Road, Dhaka-1215

Ministry of Water Resources, Government of the People's Republic of Bangladesh

WARPO Team:

Mr. Md. Delwar Hossain, Director General (Additional Secretary)

Mr. Md. Alamgir Hossain, Director (Planning) and Project Director

Mr. Mohammad Alamgir, Principal Scientific Officer and Deputy Project Director

Mr. Md. Jamal Haider, Scientific Officer and Assistant Project Director

Mr. Ershad Shaik, Scientific Officer and Assistant Project Director

Mr. Md. Mojibur Rahman, Accounts Officer

Key Consultants: CEGIS as lead Consultant

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Abbreviations and Acronyms

ADP	Annual Development Programme
BCAS	Bangladesh Center for Advanced Studies
BMDA	Barind Multipurpose Development Authority
BWDB	Bangladesh Water Development Board
BPDB	Bangladesh Power Development Board
CAPEX	Capital Expenditure
CBA	Cost Benefit analysis
CEGIS	Center for Environmental and Geographic Information Services
DPP	Development Project Proposals
DTW	Deep Tube Well
DWASA	Dhaka Water Supply and Sewerage Authority
KWASA	Khulna Water Supply and Sewerage Authority
ETP	Effluent Treatment Plant
ESs	Ecosystem Services
ECA	Ecologically Critical Area
FOB	Free on Board
FY	Fiscal Year
FYP	Five Year Plan
GIS	Geographic Information System
GPS	Global Positioning System
HIES	Household Income and Expenditure Survey
HLPW	High-level Panel on Water
HL-VWC	High Level Valuing Water Committee
IUCN	International Union for Conservation of Nature
LLP	Low-lift Pumps
PIC	Project Implementation Committee
MAF	Ministry Appraisal Form
MP	Marginal Product
MIP	Muhuri Irrigation Project
MoWR	Ministry of Water Resources
MW	Megawatt
NWMP	National Water Management Plan
NWPo	National Water Policy
NWRD	National Water Resources Database
OECD	Organization for Economic Co-Operation and Development
OPEX	Operational Expenditure
PACT	Partnership for Cleaner Textile
PDB	Power Development Board
PFS	Proforma/Proposal for Feasibility Study/Survey
PSC	Project Steering Comittee
SAF	Sector Appraisal Form
SDG	Sustainable Development Goals
STW	Shallow Tube well
ToR	Terms of Reference
TVWC	Technical Valuing Water Committee
VMP	Value of Marginal Product
WARPO	Water Resources Planning Organization
2030 WRG	World Bank/ 2030 Water Resources Group

Executive Summary

Fresh water which is indispensable for sustaining life, is just close to 2% of the total available water on earth and of that 2%, only a negligible portion is available in liquid form as rainfall, in wetlands, rivers, and underground aquifers. This very small volume is distributed unevenly over space and time- making it a scarce resource in many places and situations. Consequently, it is a must that this scarce resource be allocated among its different uses and groups of users in an equitable and efficient way. SDG6 and its sub-goals capture these issues quite succinctly. However, despite its importance as well as its scarce nature, price of water more often than not is either administered or is very nominal bearing little relationship to its value. For an efficient and equitable allocation of water among competing uses and user groups, one must have an understanding of value of water in different circumstances arising in public and private sector decision-making involving use of water.

The UN initiated a High Level Panel for Water of which the Honorable Prime Minister is a member. Under her direction, the Prime Minister's office initiated a project on estimation of value of water. The task was assigned to the Water Resources Planning Organization (WARPO), under the Ministry of Water Resources. WARPO engaged the Centre for Environmental and Geographic Information services (CEGIS) for providing consultancy services for the project titled as Study on Developing Operational Shadow Prices for Water to Support Informed Policy and Investment Decision Making Process.

The specific objective of the study is to estimate the economic value of water in four sectors, viz., Agriculture, Industry, Municipal Residential water Use and Ecosystems. The industry sector was further divided into four (4) subsectors such as Power Generation, Construction, Food and Beverage and Apparels.

Method and Data

For economic sectors and subsectors in agriculture and industry either a normal production function or a fixed proportion production function method (both with water as an input) was used as appropriate particularly depending on availability of requisite data. Marginal products of water and their values were estimated the latter being the financial value of water. Wherever applicable and available, these were converted into shadow price of water which represent the social (or "true") value of water. For non-economic uses of water as is the case with municipal residential and ecosystem services, other specific methods were used (shown later).

In case of **agriculture**, the emphasis was given on irrigation water use during dry period for producing Boro rice which accounts for bulk of irrigation in crop agriculture. Two areas were chosen, deep well irrigation in BMDA area in the North-west Bangladesh and surface water irrigation in Muhuri Irrigation Project Area in the South-east. In case of BMDA, 179 farmers were surveyed from six upazilas chosen at random after stratification into high, low and eastern Barind areas. In Muhuri area, 227 farmers were surveyed from four (4) upazilas. In both cases, detailed input and output data were collected although in case of Muhuri, water use data were not available and had to be estimated.

For ***power sector,*** data were made available by BPDB for only six (6) power plants. Among the six power plants one was single cycle and the rest gas–based combined cycle plants. Data were obtained for several years, although all types of data were not available as requested. Production function methods were used for estimating the value of water in power generation.

For ***construction sector,*** while several firms were approached, only two provided information but mainly on output (in terms of space constructed) and water use and rates at which water was purchased. No other relevant information was provided. A fixed proportion production function method was used to estimate value of marginal product and the financial value of water.

For ***Food and Beverage,*** data could be obtained from only one firm each. Again, basically only water use and output information were available. The estimation method for both food and beverage were similar to that for construction sector. In case of food. Two products, noodles and cereal, were chosen for analysis. For beverage, it was carbonated water.

For ***Apparels,*** secondary data were obtained from a survey carried out by Bangladesh Centre of Advanced Studies (BCAS) on 80 firms before and after a water conservation measure. The analysis also relied upon a published Masters' thesis on water usage in apparels industry. Again basically only output and water use figures were available and analysis had to depend on fixed coefficient production function method. Moreover PACT data also used for calculating value of water used in apparels production.

For ***municipal water use,*** Household Income and Expenditure Survey (HIES) 2016 data collected by BBS has been used to analyses value of water using the cost of health approach. Various costs (cost of treatment, medicines, hospitalization, days lost in income earning etc) due to impairment of health caused by disease due to inadequate access to safe water were estimated using both HIES and other available national data. Water supply and consumption characteristics in two cities, Dhaka and Khulna were used for analysis.

For ***Ecosystem Services,*** two case studies were attempted, one for Tanguar Haor in the North-east and the Halda River in the South-east part of the country. For the haor, the analytical idea was to add the benefits inside the haor to the flood protection services in surrounding areas due its capacity to contain the flood waters after the Boro crop is harvested. For this, a 3-D model was run to find out the areas surrounding the Tanguar Haor susceptible to such flooding. However, it was found that a single haor model does not provide any meaningful result and so a model for haor system as a whole was done and the areas susceptible to flooding and the possible damages and their monetary values due to the flooding had no haors existed was estimated. The monetization was done based on various national level statistics. That gave the value of the ecosystem service of water. An assumed value to reflect the existence of the haor was added to the above values to find out the indicative total value of water for haor services.

For Halda River, several methods were tried based on the available data and literature. Unfortunately, the results were found to be inconsistent and therefore while the observations were stated, no estimate of value for ecosystem services of Halda River was reported.

Estimated Shadow prices

Agriculture

In BMDA, it was found that the financial value varies from Taka 2.5 to 3. Applying conversion factors used by the Planning Commission, a shadow price of water in irrigation was derived to be Taka 2.5 to 2.8 or around 3 US cents. In case of the Muhuri Irrigation Project, however, the financial value of water turned out to be Tk 18.78, which is nearly US cents 23 which compared to the BMDA results are quite high. In any case, applying the conversion factor as before, the shadow price of water in case of Muhuri comes to Taka 17.8 or just about US cents 22.

Industry

As noted before, for this study, the industry sector consisted with four (4) subsectors namely a) Power, b) Construction, c) Food and Beverages and d) Apparels. The results derived from these subsectors are as follows.

Power

The financial value of water ranges from Taka 500 to Taka 1500/cubic metre. While, the Planning Commission guide does not provide any conversion factor for electricity, considering that gas is subsidized for power production while electricity is also sold at subsidized prices, one can probably safely assume a conversion factor of 1.25 in this case. for electricity price. On that basis, the shadow price of water in power generation with natural gas as the primary fuel ranges from Taka 600 to Taka 1800 per cubic meter.

Construction

For construction sector, the following 4 financial values of water per cubic meter have been estimated (for high and low price of space and high and low productivity of water, all in nearest Taka): 397, 324, 106 and 87, which yielded the average value of Taka 225. Using a conversion factor of 0.75 used by Planning Commission for office buildings, the shadow price ranges from Tk 298 to Tk 65 with an average of Tk 169 which comes to just above $2 per cubic meter.

Food and Beverage

In the beverage industry, value of marginal productivity of water i.e., financial value of water at firm gate price comes to 13 to 15 taka/ cum. No conversion factor was used as there is no clear idea about the value of water that used for beverage production.

As for the food industry, the financial values of water for the two products, noodles and cereal, come to just about Tk 144 and 230 respectively. The average for both comes to just above Tk 187 per cubic meters of water. For these products there is no conversion factors. However, noting that these products are processed using wheat and wheat has a conversion factor of 0.92 (as used by the Planning Commission), the above values has been multiplied by the factor and one comes to shadow prices of Tk 132 for noodles and 212 for cereal. In US dollars, these come to 1.61 for noodles and 2.58 for cereal, the combined figure comes to just above US $ 2.

Apparels

In Apparels subsector, the average productivity of water was found to be 0.0587 kg before and 0.0642 kg after water conservation measures. Valuing outputs at export i.e., competitive world prices, and applying an exchange rate of Tk 85 to US$1, one gets the value of water before conservation at Tk 71.16 and after conservation at Tk 77.85 As prices are export prices and likely FOB, no conversion factor is used for shadow prices. Above values are therefore shadow prices of water in Ready Made Garments (RMG) industry.

Municipal Water use

The average value of benefit of supplying for Dhaka and Khulna combined is 60.38 taka per day for one cubic meter of water. These translate to 75 cents, 48 cents and 74 cents for the respective cities and the average of them. As the global figures range from 1 to 289 US cents, the estimates here are somewhere in the middle of the range and are thus probably acceptable. It may be noted that the issue of quality of water was not considered and had it been taken into consideration, probably the values would have been higher. Furthermore, it should be noted that no conversion factor was used, but given that water is essential for life, probably this may be greater than unity and the values estimated would be somewhere near US$1 per cubic meter. Even then probably this would be an underestimate as the environmental costs of supplying water from the natural sources are not considered.

Ecosystem Services

As stated earlier, the value of ecosystem services of water for Tanguar Haor is actually for the haor system as a whole. The total yearly benefits from services inside haors and outside haors that would have been inundated had there been no haors is estimated to be at least Tk 1325 billion. Much of this is due to in-haor ecosystem services such as biodiversity benefits accounting for nearly 70%. The avoided damage due to protection from flood outside haor (Taka 401 billion) accounts for the rest. It is likely that these are underestimates, particularly the in-haor services as the quantification of the various physical dimensions of the benefits are not completely known. Given this and also that there is also an existential value in itself, the value estimated above be adjusted upwards. On an ad hoc basis, we take the existential value to be at least 50% of the benefits estimated above, the total benefits of the existence of haors and its services may be as much as Tk 1987 billion crore per year or round about Tk 200 thousand crore which is equivalent to US$ 23 billion. Just for comparison it may be noted that this is equivalent to around 35% of this year's national budget.

For Halda river, as already indicated, no estimate could be done with any degree of confidence. This remains a matter for the future detail study.

Summary of Estimation of Shadow Prices and their Implications

The discussion above on the estimates of value of water and corresponding shadow prices may be summed up as follows:

a. Given that there had been major problems with sample units and data availability in most cases with the exception of agriculture, the problems regarding conversion factors (again with the exception of agriculture), the estimates must be taken at best as indicative of the present situation. These must not be taken as definitive exercises and there are ample scopes for improvement in terms of sample size, data on missing variable, particularly inputs in case of economic production activities as well as in case of municipal water supply services and consuming households and most certainly in case of ecosystem services particularly the existential values of the ecosystems.
b. Given the above circumstances the wide range of values that have been obtained, even with a sector or sub-sector. This clearly indicates that even in case of economic production purposes, there may be no one single value for water. However, from literature survey we find a similar picture in many other countries.
c. The estimation of shadow prices was hampered among others by limited number or lack of conversion factors, even for electricity which is now a ubiquitous input into almost any production process. Furthermore, most such conversion factors are several decades old and possibly no longer realistic because of the major changes that have taken place in the economy.

Given the above what are the implications and recommendations for public and private sector decision-making for use of water particularly in production process?

First, public sector investment decision-making:

In public sector decision-making, all costs and benefits have to be valued at their shadow prices. In practice what happens is that the initial costs and benefits are valued at market prices which does not necessarily reflect social perspectives due to various imperfections in the market. In reality, the project appraisal first done the financial cost-benefit analysis, which uses market prices. Then the economic cost-benefit analysis is attempted based on shadow prices. Shadow prices are derived from market prices by multiplying them by conversion factors. Unfortunately, there are no conversion factors for all types of products (as indicated earlier say for electricity) and services as well as for inputs such as water. In such cases either expert judgement has to be used or no adjustment is made at all and certainly no account is taken for unit economic cost (i.e., shadow price) for water usage. Question then is should the estimated values of water be used for economic appraisal of projects which have water as a major input? The answer should be yes, in principle, but no, at least not right away.

Valuing water has been included in the strategy for water resource management in the 8th Five Year Plan of the country. This is expected to allow the use of the social value of water value to be institutionalized and strengthening of the relevant agencies so that water value can be mainstreamed in the regular investment decision making process in terms of project development, appraisal, water use policy etc. Given this, the process of inclusion of shadow price of water is in a sense straightforward. Wherever water usage is mentioned, its volume must be mentioned, and the shadow price should be used to value it and the rest of the process remains as usual.

However, as already indicated the present estimates are at most indicative. More definitive estimates are necessary and for a much wider range of products and services that use water as inputs in some form. This calls for taking larger, more focused study to fully capture the value of water in different scenarios and proceeding accordingly. However, while this goes on two more activities must be taken up alongside. First, all sectors and economic activities where water is a critical input, must keep full records of volume of water used in each stage of process. A kind of water audit must be mandatory in all such cases. Secondly, the Planning Commission will be well advised to revise its conversion factors and widen the scope for is application in case of many other products and services.

Lastly, when if all these are done, there may be no unique shadow price of water. But that will be another matter which will have to be resolved in the future.

How can these values of water and shadow prices be used in the private sector decision-making process. First, as is the case with public sector decision-making, more in-depth and across many types of enterprises are needed for understanding value of water in various kinds of private sector production activities. Given this, perhaps the fact remains that in all case the estimated financial value of water is far greater than the market price that is paid for it. Of course, such a conclusion needs to be tempered by the fact that at least some of the private sector enterprises do get the supply of water they use directly from natural sources either it would be surface water or ground water. In some cases, this may also have to be treated before actual use. All these entail some financial costs. These should be considered in comparing value of water to the cost involved in getting its supply. Question then is if there is a substantial gap, how should this information be used for conservation of water. One way is to simply raise the price as much as possible to transfer the private sector "rent" due to water to the public exchequer. How far this may be possible needs to be carefully studied. No ad hoc decision should be taken in this regard. On the other hand, there must be adequate awareness campaign that water is indeed valuable from private sector point of view, and they should conserve it as well as reuse/recycle as much as possible in which technological advancement may be one possibility. The government may provide specific incentives towards that. Again what these incentives can be needs to be carefully studied keeping in mind that different types of private sectors activities are not the same and thus needs to be treated on a case by case basis.

Issues of Valuing water and its importance, best practices towards valuing water need to pay due attention with intensive dissemination. It needs to be much dissemination for sensitizing the Integrated Water Resources Management Committee formed in the district, upazilla and union parishad level under Bangladesh Water Act 2013. Valuing Water and thus developing shadow prices may recommended to include in academic curriculum specially in secondary and tertiary levels for ensuring the best uses of water. Moreover, issue of valuing water and developing shadow prices of water need to consider for inclusion in annual training curriculum of Bangladesh Public Administration Training Centre (BPATC), Regional Public Administration Training Centre (RPATC) and other institutions.

One final point, which relates to both public and private sector activities, is the externalities involved either in ensuring the supply of water (an issue of quantity) which had been largely considered here in terms of conservation, or the issue of quality, the problems of effluents and the worsening of water quality. How to take the issues of quality of water in to account in latter, remains a major issue in Bangladesh. Finally, more detail study and mass sensitization on valuing water and raising awareness on best uses of water is prerequisite.

1. Introduction

1.1 Background

Water is one of the most needed (and also misused) natural resource on the planet. Fresh water which is necessary for use by humans for sustaining life, is just about 2% of the total available water and of that 2%, only a negligible portion is available in liquid form as rainfall, in wet bodies and rivers, and water underground. This very small volume is distributed unevenly over space and time (between and within years) making it a scarce resource in most places and situations. Therefore, it is imperative that this scarce resource be allocated among its different uses and groups of users in an equitable and efficient way. This aspect of allocation of water is stated explicitly in SDG 6 on water and its sub-goals (United Nations 2015).

One major guide for such efficient and equitable allocation is to do so based on how human society perceive the value of such a resource in alternative uses and contexts. Understanding the value of water in its various uses is, therefore, a requirement for its efficient and equitable distribution across different uses and users. One needs real life estimates of value of water for the purpose.

Bangladesh seemingly is endowed with a lot of water because of generally high rainfall (though distributed unevenly over space and time) as well being in the downstream of some of the major rivers of the world. Yet, it already suffers from scarcity of water- the intensity of which varies from place to place. Much of it is used for agriculture, and in most cases such uses high inefficiency leads to major wastage. Certain industries are water-intensive for either industrial processes or cooling purposes. Many depend on their own arrangements for sourcing water- mainly from underground reservoirs, a common property resource and thus suffer from the oft-repeated problem of “tragedy of the commons” (Hardin and Garrett, 1968 and Frischmann, Marciano, and Ramello, 2019). On the other hand, there is at best limited information on the quantum and sources of such uses. Lastly, water is used for drinking and other residential purposes, which must be available as a matter of basic human right. Agricultural water demand has been estimated to be 33km3/year and the corresponding figures for domestic and industry demand were estimated to be 2.7 km3 and 2.9 km3 in 2011 (Rahman 2016).

Efficient allocation of resources is indicated by the absence of both overuse and misuse and for this, we need to know the price of such a resource. Since water is not priced through the market and is accessible for use by various users free either of charge or at a minimum nominal price (like water supplies in cities), it is likely that the resource is over-used and consequently over-exploited and so may face depletion which unless checked and regulated may be severe. As such, there is a need to understand such over-use and misuse and how actual prices paid for water differ from its values in such cases.

The estimated value of water in this study serves two purposes. First, this may be used as a guide towards pricing of water for different purposes, which may take value as a major element (but not necessarily the only one) for making such decisions. Second, the value may be used to estimate a set of shadow prices for water in its different types of use. Till now water use in various public investment projects was not costed using its social value (shadow price) and costs were thus underestimated and inflated benefits compared to actual costs of the project.

The importance of the issue of value of water was pointed out in a report on Economic Policy Incentives under the aegis of the Bangladesh Water Multi-Stakeholder Partnership (BWMSP) action programme of the 2030 Water Resource Group (2030 WRG) under the World Bank group in relation to designing such incentives. Subsequently "valuing water" was chosen as one of its priority areas within its workstream on Water Governance and Sustainability. A High-Level Committee on Valuing Water (HL-VWC) was formed. In a meeting on 12th of August 2018 a Technical Committee(T-VWC) was formed to oversee the process. It was decided that a study be conducted. The Ministry of Water Resources was entrusted with the responsibility which requested the Water Resources Planning Organisation (WARPO) to take appropriate measures.

The WARPO prepared a PFS and after its approval entrusted the job of conducting the study and other related activities to the Centre for Environmental and Geographic Information services (CEGIS). The study envisaged the estimation of shadow prices for water in four sectors viz., Agriculture, Municipal Water Use, Industry, and Ecosystem Services. For each sector, different case studies were undertaken. Under industry sector, four sub sectors were considered, Construction, Power, Food and Beverage, and Apparels. This report describes in detail the estimated shadow prices, the approach and methodology for estimation and how to mainstream them into planning process.

1.2 Objective

The objective of the study is to develop the operational shadow prices for water. The overall objective is to improve allocation of water resources which is also a core activities of Bangladesh Water Act 2013. The study consists of three parts; Part 1 is devoted to the estimation of shadow prices. Part 2 is concerned with mainstreaming shadow prices in public investment decision process while Part 3 found out how shadow prices of water can be used in private sector decision-making and regulatory process. More details are available in Section 1.4 below.

Acknowledging that this study is based on cutting edge research, and as this type of operational shadow prices have not been developed before in this country, it is understood that while the theoretical framework can present a best- case situation, the actual calculation of shadow prices may have to be adjusted to the realities of availability of appropriate data. The idea for the actual calculation of operational shadow prices is to start simple and practical and then move on to further refinement as more and better data are available. This study, therefore, lays a foundation for further sophisticated estimation of shadow prices for water.

1.3 Rationale

Water is a natural resource indispensable for life as well for livelihood of people. It is used for production purposes such as crop agriculture, forestry, fisheries, livestock, industries, and commercial purposes etc. and direct human consumption to sustain life as well as for community services like sanitation. The nation-wide demand for water continues to grow due to several socio-technical drivers such as high demographic changes, rapid urbanization, high sectoral demand (such as agriculture, fisheries, transportation, industries etc.). On the other hand, the essentiality of water for the rich but vulnerable ecosystem of the country and the variability of water availability between years and between dry and wet seasons within a year as well as its uneven geographical distribution within the country complicate the issue of water resources management in Bangladesh. The management of water resources is further complicated by the fact that of the surface water flow within the country which is by and large due to that within the Ganges-Brahmaputra-Meghna basin has 93% of the catchment area outside the country.

While the issue of availability of water is a major concern, no less is that due to its worsening quality. The quality of water has worsened severely in most of the water bodies and are considered at risk of severe environmental degradation due to several factors such as untreated discharge of industrial effluent, heavy use of chemical fertilizer and other chemicals in agriculture resulting in run-offs, untreated sewage discharge from urban areas, and natural process of salinization particularly in the south-west of the country. Such processes are expected to lead to further deterioration of the already bad surface water quality in many places in the country. Such degraded quality is a major threat to human health as well as biodiversity in the country. In fact, many of the activities that have been analysed in this report demand water of a minimum acceptable quality and in some cases need to be treated before use (as in case of many industries). So, meeting the demand of water by various sectors together while maintaining quality of water become crucial.

Valuing water provides the basis for recognizing and considering all costs and benefits provided by water, including their economic, social and ecological dimensions (Bellagio Principles, 2017). The consideration of all benefits and costs related to water provide the foundation for sustainable water management and long-term socio-economic development.

For example, to understand the full impact of e.g. construction of a river barrage, the full costs and benefits need to be considered. These include the obvious consideration of the financial costs (of capital and operations) of the barrage and the benefits to the irrigators. However, further considerations need to be made to provide a full assessment on whether this investment really has the desires socio economic impact. As such, the barrage may have an impact on the fish population and thus an impact on the production and livelihood of the fishermen. Also the captured sediment behind the barrage may have a negative impact on the agricultural land downstream leading to reduced yields, etc.

In the absence of information about ecosystem values, misallocation of resources may occur and go unrecognized and substantive economic costs may often arise. Under-valuation of impacts on the status and integrity of natural ecosystems themselves run the risk of undermining water availability, and sustainable development goals (IUCN 2004).

By considering these conflicting issues and trade-offs, valuing water can help balance multiple uses and services provided by water in a coordinated, sustainable, and equitable manner and help strengthen related institutions and infrastructure. Thus, effective water management presents a transformative opportunity to convert risk to resilience, poverty to well-being, and degrading ecosystems to sustainable ones (Bellagio, 2017).

For Bangladesh, it is of particular importance as it is a densely populated active delta, with multiple and increasing competing water demands, diminishing groundwater aquifers, increasingly polluted surface, and groundwater bodies, with high vulnerability to climate change.

However, currently the costs and benefits of projects/investments related to water, or which has water as a major input are not appropriately considered in Bangladesh. The private financial costs of water is included on the cost side. But on the benefit side no such considerations are made. The availability of shadow price of water helps in estimating social, as opposed to private, benefits and costs of water in appropriate instances when public sector investment decision has to be made. This study seeks to develop a framework for valuing water in Bangladesh and estimate the corresponding shadow prices based on the existing (if available) or assumed (if not) under plausible considerations. As will be discussed in detail in this report, the necessary conversion factors are lacking in quite a few cases. This study on the estimation of value of water and subsequently its shadow price in various contexts will help in appropriate updating of the Green Book (2016) that is widely used in the project planning process.

1.4 Scope of Work

The present study has three major parts.

In Part 1, a set of shadow prices are developed for water across its various uses in several major water-using sectors of Bangladesh along with conversion factors wherever so necessary and refine them as part of case studies. These shadow prices are developed through a multi stakeholder process, as far as practicable under the circumstances, to ensure their acceptance by stakeholders. Since water is not a homogenous resource, for each source of water, there shall be a shadow price based on which it is possible to know whether this particular resource is overused or not. This is explained by the concept of shadow price. The QR Code given here links to a lecture on the value of water and it explains the meaning of the shadow price.[1] It is included here for readers of this document who wish to know more of the details.

Value of water explained

Since water resources are used in many different sectors, it was decided to limit the study to four sectors of the economy which are major users of water. These are: Agriculture (crop, more specifically rice cultivation), Industry, Municipal (residential) and Ecosystem Use of water. Besides, to capture the spatially heterogeneous characteristics of water resources, the study is spread across different regions of Bangladesh. As such the study purports to capture both heterogeneity of water resources and heterogeneity of its users.

The initial question that had to be addressed was if the conceptualisation of value of water is the same across sectors. The answer is yes and no. For clearly recognizable economic production processes, the conceptualisation is the same as for agriculture and industry. Value of municipal water for human consumption and sustenance of life has to be understood differently. Even more different was the valuation of water for ecosystem services. These differences are discussed in more detail later. On the other hand, because of differences in water availability, quality and other heterogeneity, the methodological approach for estimation of shadow prices are very much likely to be different not only between and within sectors but also sometime between resources like surface water, ground water and by ecological zones of the country. Because of these inter and intra-sectoral differences, a harmonized value of water is difficult to conceive and operationalised and may not serve any clear policy purpose. Yet, we keep the option of harmonization open until the empirical estimations are completed. However, for a particular water resource, how competing water use can be modified to ensure efficiency by using its unique shadow price is explained for more advanced reader in this video [please scan the QR code to watch the video]

Use of Shadow price in policy making

1 The QR code scanner can be downloaded from the internet into a mobile phone and then the code can be scanned by using the mobile.

In Part 2, an attempt has been made to mainstream shadow prices of water in policy and decision-making processes. The basic tool for this is the DPP. Capacity development and training were provided to selected public sector officials to operationalize shadow prices in the DPP design and process.

In Part 3, scopes and options for making shadow prices operational for private sector decision-making processes are identified. For this, Illustrative case studies with selected private sector companies have been conducted. Capacity development and training have been provided to the private sector and civil society organizations as appropriate to ensure the integration of the shadow price of water in their decision-making. The details of training and capacity building including the development of a Training Manual are described in a separate volume.

1.5 Structure of the Report

The final report consists of thirteen chapters:

The first chapter which is the present one provides 'Introduction' to the whole exercise, and describes the background of the project, objectives, and scope of works.

The second chapter is titled 'Water Scenario of Bangladesh' which gives an idea about the ground and surface water resources of Bangladesh and the challenges that the country is facing for sustainable water management practices.

The third chapter is 'Literature review' which includes review of different literature on concept of valuing water and shadow prices in theory and practice and their implications for the present exercise.

The fourth chapter is on 'Framework for Valuing Water' which describes the methods used for estimating value of water for agriculture, industry, municipal water services and ecosystem services as well as their data requirements and sources of data.

The fifth chapter named 'Methodology, Case Studies and Data Issues' gives a clear understanding on how to estimate value/shadow price of water for four sectors agriculture, municipal, industry and ecosystem services.

Chapter 6 to Chapter 9 give details on the data source, sample, procedure of estimating shadow price, the estimated values and shadow prices and their interpretation for the four case study sectors.

Chapter 10 is on Best practices of valuing water and Incentive Mechanisms for adoption of appropriate valuing water. Some examples of existing or provable best practices and possible incentive mechanisms are addressed.

Chapter 11 is on 'Use of Shadow Price of Water for Public Investment Decision Making' which describes the guideline of DPP approval process and suggestion on mainstreaming shadow price of water in planning process and discusses issues briefly regarding the use of shadow prices in private sector decision-making.

Chapter 12 and Chapter 13 discusses implications of the results for private sector decision-making while Chapter 13 provides brief summary and reiterates some of the recommendations already made in earlier two chapters.

2. Water Scenario in Bangladesh

2.1 Country Setting

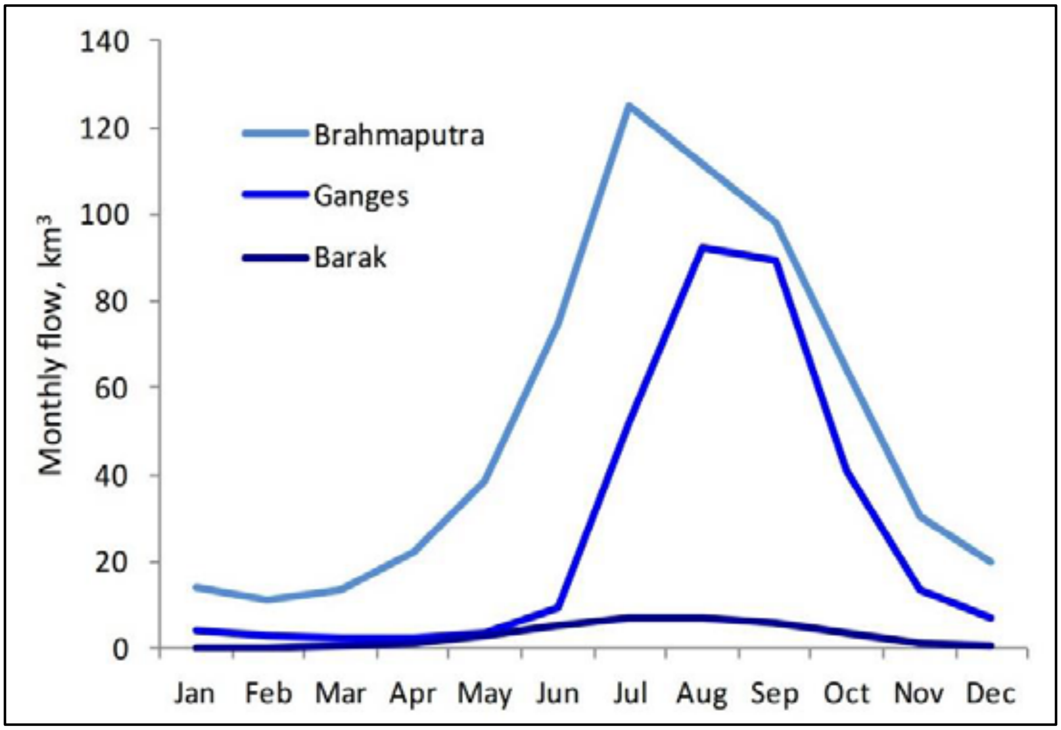
Bangladesh is a deltaic country located at the tail end of the mighty Ganges, Brahmaputra and Meghna (GBM) river systems. Geographically, Bangladesh is bordered by India to the west, north and east and by Myanmar to the southeast. To the south of the country lies the Bay of Bengal. About two-thirds of the country is less than 5m above the Mean Sea Level (MSL) (WB, 2010), which places Bangladesh as one of the most climate vulnerable countries in the world (BCCSAP, 2009). With a large population of approximately 170 million cramped into a land area of 147,570 sq. km., this puts substantial pressure onto any natural resources within the country, and water is no different.

2.2 Surface Water Resources

Bangladesh is crisscrossed by an intricate network of over 400 rivers traversing throughout in a dendritic fashion carrying both water and sediment load into the Bay of Bengal. Being the lowermost riparian of the Ganges-Brahmaputra-Meghna (GBM) systems, Bangladesh shares its trans-boundary water resources with the upper riparian countries like Bhutan, China, India and Nepal. A total of 57 transboundary rivers carry flow into the country with 54 from India and the remaining from Myanmar. Out of a total catchment area of 1.72 million sq. km of the GBM basins, only around 7% basin area falls within the Bangladesh territory (Amarasinghe et al, 2010). With an overall combined flow of 1260 BCM, coupled with an average annual precipitation of approximately 2300 mm, a misplaced notion can be that there is an abundance of available and "ready-made" water resources in the country. But the real picture is quite different. Inter-year, intra-year and spatial variation is some time quite widespread.

The annual cross border river flows entering the river systems are estimated to be 1260 BCM, of which the three main rivers contribute some 981 km^3 (i.e. almost 78% of the total cross border flow), 85% of which enters the country between June and October (Kirby et al, 2014). Out of 981 BCM, some 54% is contributed by the Brahmaputra, 31% by the Ganges, nearly 14% by the tributaries of the (upper) Meghna and 1% is contributed by other minor rivers of the Eastern Hills. Only 15% of the total transboundary flow i.e. 148 BCM is available during the dry season (Kirby et al, 2014) where only 1% (11 BCM) of the total flow is received in the critical month of February (Ahmed and Roy, 2007) showing the vulnerability of the transboundary flow to meet the water demand during dry season. Figure 2.1 shows the monthly water inflow from the three major transboundary river. This 1260 BCM, along with the 113 BCM generated within country puts the total to 1373 BCM flow discharging into the Bay of Bengal (WARPO, 2014).

Figure 2.1: Monthly Water Inflow from the Three Major Trans Boundary River



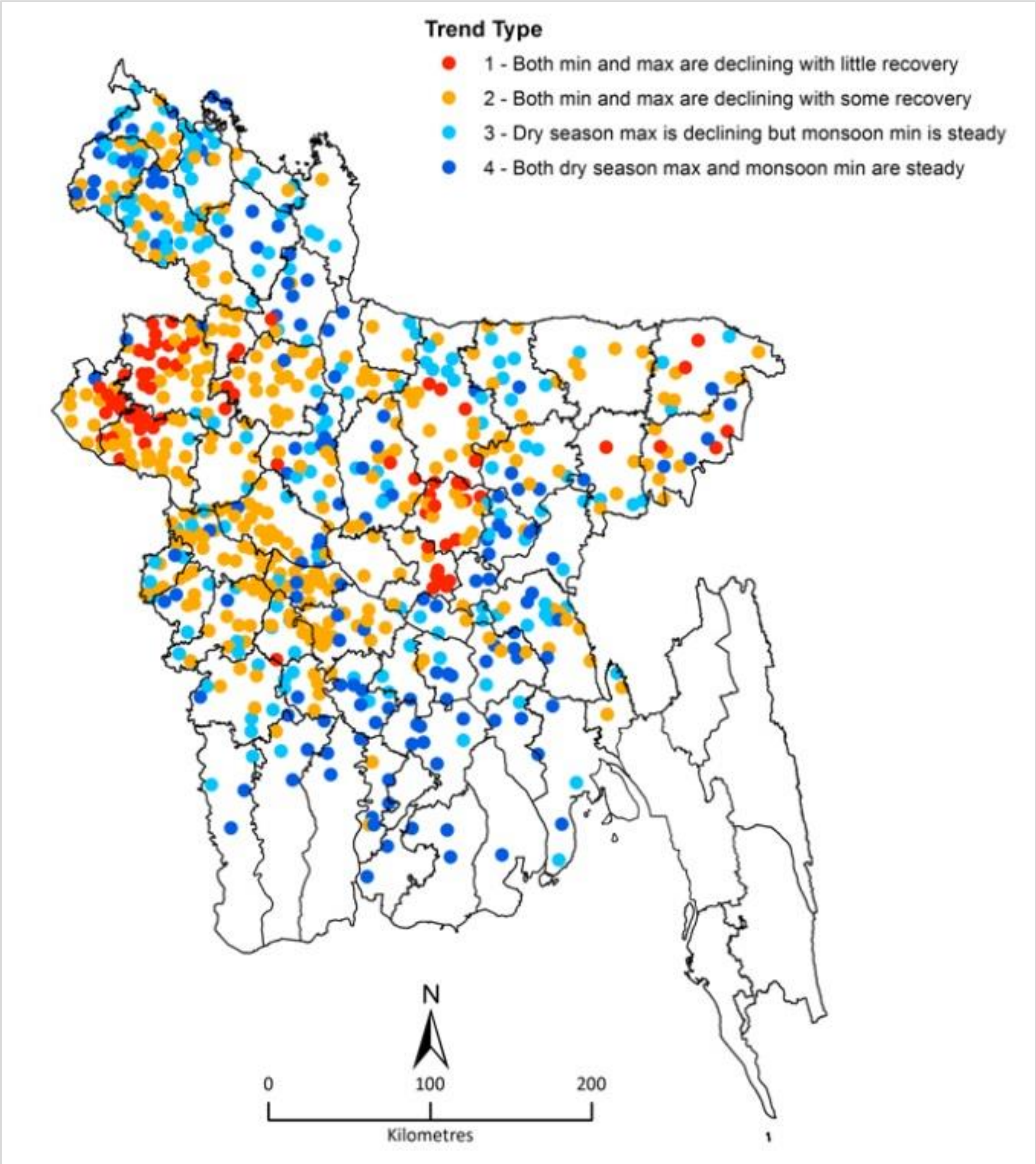
Source: WARPO, 2014

Being the lower most riparian country of the GBM basins, Bangladesh is highly dependent on the cross border flow which varies greatly in wet and dry season of the country, the exact value of which differs in different literature. However, reduction of dry season flows in Bangladesh due to increasing upstream withdrawal is causing severe water stress across the country. The reduced stream flow is also accelerating salinity intrusion and environmental degradation, particularly in the South West region, while about 25% of the country is flooded to varying degrees each year during May through September (Ahmed and Roy, 2007).

2.3 Groundwater Resources

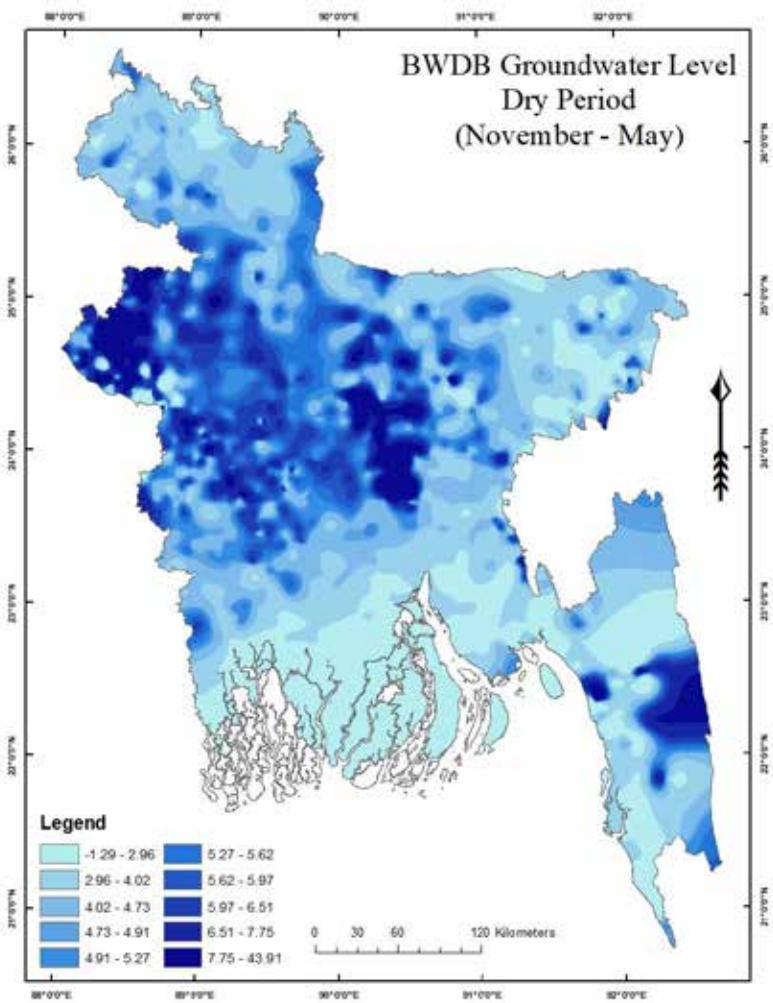
Groundwater is also an important source in Bangladesh, especially for agriculture and drinking purposes. Major source of ground water is the recharge from surface water in the unconfined aquifer that is underlying most of the area of the country from the sedimentary alluvial and deltaic deposits of three major rivers (Ahmed and Roy, 2007). According to the Master Planning Organization (MPO, 1987) an estimated 21 BCM of groundwater resources is produced within the country. Major water usage in Bangladesh comes in the form of agricultural practices, for drinking purposes, industrial usage etc. As majority of this demand is met through extraction of groundwater, water table of underlying aquifers are on the decline. Figure 2.2 shows a resultant representation of this analysis. It shows the declining GW level trend in Barind region and north central region in the vicinity of Dhaka city. Figure 2.3 illustrates the comparative groundwater level trends in Bangladesh. Time series data from BWDB wells all over the country have been used to analyze the prevalent levels in wells. It reveals that there is sharp decline in GW levels in the mid North Western region.

Figure 2.2: Groundwater Level Trends in Bangladesh

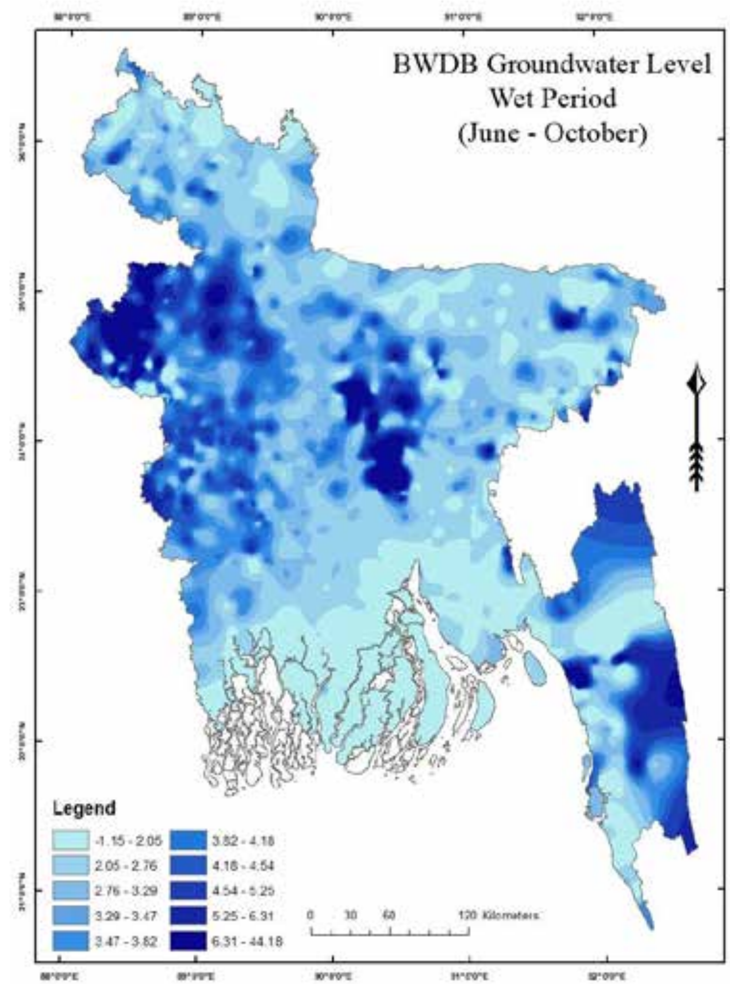


Source: NWRD, WARPO, 2014

Figure 2.3: BWDB Groundwater Levels



a. BWDB Dry Period GW Levels (Nov-May)



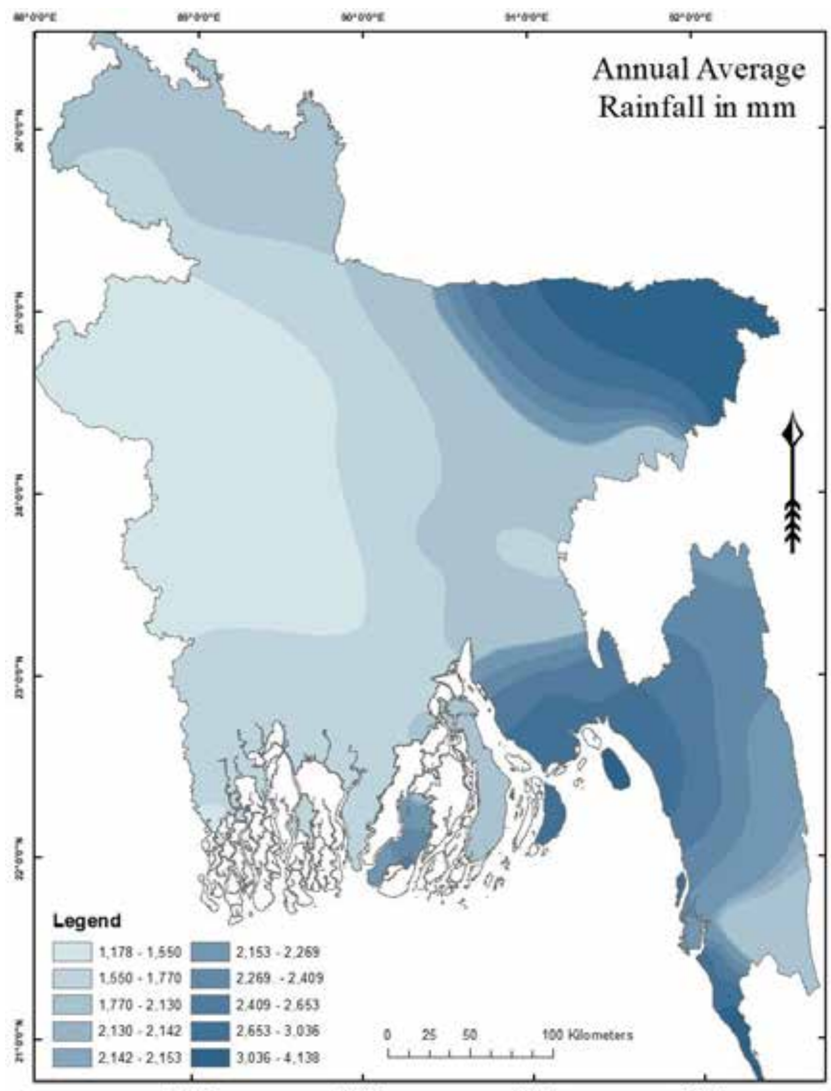
b. BWDB Wet Period GW Levels (Jun-Oct)

Data Source: NWRD, WARPO

Rainfall

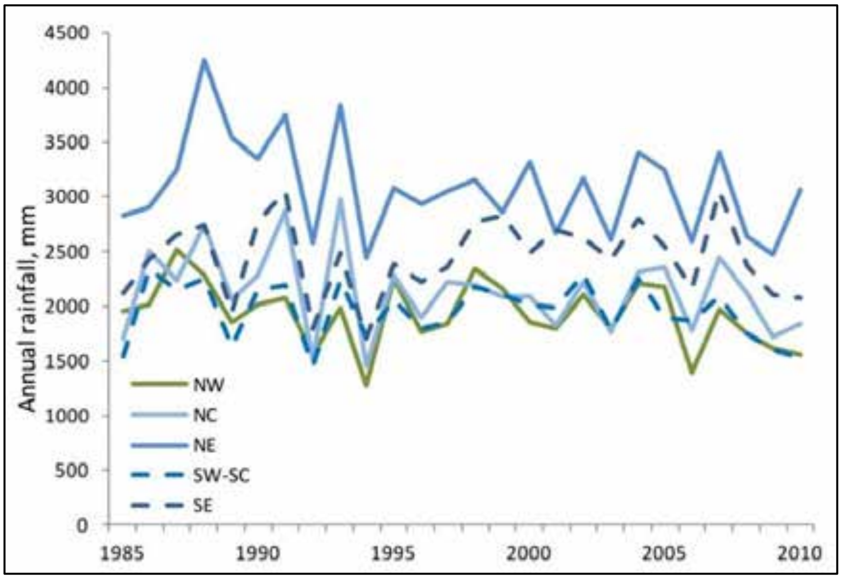
Established as a land of six seasons, the hydro-meteorology of Bangladesh is dominated by a pattern of successive dry and wet spells, the other "seasons" being altered variations of the former two. Irrigation practices prevalent in the country is heavily dependent on the seasonal rainfall patterns. During the monsoon (Ahmed and Roy, 2007), Bangladesh receives about 80% of annual precipitation, averaging 2300 mm, but varying from as little as 1200 mm in the west to 5800 mm in the east (Ahmed and Roy, 2007; Ali, 2006). About only 20% of the average annual rainfall occurs in dry season in northwest region with a highly uneven monthly distribution of rainfall (Ahmed and Roy, 2007). The annual average rainfall varies from 1927 mm in the northwest (NW) region, 1950 mm in the south west-south central (SW-SC), 2133 mm in the north central (NC), 2447 mm in the south-east (SE) and 3091 mm in the north-east (NE) region respectively (WARPO 2014). Figure 2.4 illustrates the rainfall distribution pattern throughout the country and Figure 2.5 portrays the comparison between the regional annual total rainfall.

Figure 2.4: Variation in Rainfall Distribution in Bangladesh



Data Source: NWRD, WARPO

Figure 2.5: Annual Total Rainfall for the Hydrological Regions



Source: NWRD, WARPO, 2014

2.4 Water Resources Management Challenges

The yearly water inflows through transboundary rivers are distributed in a disproportionate manner. The bulk of the flow (85%) is available during monsoon (June –October), only 15% is available during dry season (November-May). This creates problems in both fronts. Bangladesh is unable to capture some of the excess monsoon flow to augment dry season flows due to its flat terrain. The upstream monsoon flow sometimes causes catastrophic flood with coinciding peaks in the Ganges, the Brahmaputra and the Meghna. The country also loses its valuable lands and properties both during onset and receding floods due to erosion along major and medium rivers. On the other hand, low flow in dry season gives rise to water scarcity, especially in the more drought-prone regions as such agricultural activities is severely hampered as well as thriving ecosystems come to a halt.

On the other hand, during dry season between November to May, the country becomes severely water stressed due to low water availability, upstream water withdrawal, unsustainable groundwater use and random contamination (2030 WRG, 2015; Mbugua, 2011; Shahid and Behrawan, 2008). However, compared to floods, drought and water scarcity have not received due attention.

Of the 1373 BCM discharge that flows into the Bay of Bengal, only 15% occurs during dry season when the water is needed the most for agriculture, industrial and domestic use. 90% of this flow (1260 BCM) originates outside the borders of the country. In the absence of adequate regional cooperation, flows reaching the border have reduced drastically. Estimates show a 40% deficit of supply during this season leads to water scarcity and drought in some regions (WARPO, 2014; Mbugua, 2011). Annually, country experiences long dry weather spells during which moderate to severe water scarcity and droughts spread over a region of 5.46 million hectares and 33% of total land acreage falls below the minimum threshold for sustainable cultivation (Habiba et al, 2011). Previous studies show that the land affected by water scarcity was lower, about 2.32 and 1.2 million hectares of cropped land annually during the Kharif (July to October) and Rabi (November to June) seasons, respectively (Ibrahim, 2001).

Freshwater availability is also a function of water quality. Bangladesh is transforming rapidly into a middle-income country, with increasing population density, urbanization, industrialization, higher water, food and energy consumption and waste generation, rural encroachment, and intensification of agriculture, all of this leading to pollution of freshwater resources. Climate change and sea level rise induced salinity intrusion, especially in the coastal region has further reduced the freshwater in the rivers and coastal wetlands (2030 WRG, 2015; WARPO, 2014; Mbugua, 2011; Habiba et al, 2011). While the sources continue to shrink, increasing population and higher living standards means the water requirement in Bangladesh is continuing to increase in all sectors.

Subject to constant gradual formation though millennia of fluvial silt deposit though the mighty GBM systems, Bangladesh has materialized to be one of, if not, the most fertile land in the world. Crop production has increased considerably in Bangladesh over the last few decades; this increase in production can be accredited to greater dependency on irrigation and increased cropping intensity rather than increase in cultivated land. This increase in cropping intensity was driven by the introduction and rapid adoption of shallow tube wells from the 1980s. The number of shallow tube wells increased from 93 thousand (1982-83) to 1.43 million (2009-2010) and the number of deep tube wells more than doubled, whereas growth of surface water irrigation remained almost stagnant in the same period. This has led to the increase in irrigated area from 1.52 million ha in 1982-83 to 5.2 million ha in 2009-10. 95% of this irrigation occurs during the dry season (WARPO, 2014).

The Food and Agriculture Organization of the United Nations estimated that in 2008 the total water withdrawal in Bangladesh was about 36 BCM, of which 31.5 BCM was for irrigation and 3.6 BCM for domestic water use and 0.8 BCM for industry; 79% was sourced from groundwater and 21 % from surface water (FAO, 2014). In future, water demand in the country is likely to be on the rise due to rapid urbanization, high demographic growth, adverse impacts of climate change etc. Due to climate change, irrigation water demand is projected to increase from less than 1% in 2030 in average condition, to maximum 3% in 2050 in dry condition (Mainuddin M et al, 2013). Although agriculture sector is and will likely remain the major water consumer, domestic and industrial uses are on the rise and are likely to grow by 100% and 440% respectively by 2050 (WARPO, 2014).

As Bangladesh faces water stress in dry season with only 15% of flow occurring within this period and a paltry 1% in February, flow in even a lot of the major rivers remain sub-par during this time. Moreover, water abstraction or diversions from these rivers during these period result in further reduction in flow and as a result, the minimal flow for sustenance of riverine and floodplain ecosystems and environment is not possible. Thus, complete assessment pertaining to estimation of shadow water prices demands an evaluation of the environmental flow of these rivers to calculate water value, especially concerning the ecosystems sector. E-flow for critical rivers has to be assessed and evaluated as well as provisions should be suggested regarding regulating and/or minimizing withdrawal of water from these rivers and maintaining standard water quality during dry season, for ecosystems sustenance.

3. Literature Review

3.1 Introduction

The present chapter provides a literature review on conceptual as well as on application aspects of Valuing Water. Literature on concepts like shadow prices, total economic value, full economic cost, and approaches and techniques for valuing water is covered here. Along with that on application of the techniques to different sectors of the economy and existing practices on valuing water, both national and international is also reviewed.

3.2 Concept of Water Valuation

Water valuation means assessing the value (or worth) of water to different stakeholders. Water, unlike other natural resources is used for many purposes and some of them are complementary while others are competing. In general, water resources have many uses and the existing literature has categorized them into four distinct types of use: a) provisioning use of water – where water is used directly or indirectly for production of various goods and services; b) regulatory use of water – where water is used to regulate various ecological functions like precipitation, drought, flooding, etc.; c) cultural use of water – where the ecosystems surrounding water bodies or water sources contribute towards developing non-consumptive use of water like tourism services, cultural heritages, etc.; and d) supporting use of water to continue life over time for both human and plants and animals. These different usages are not necessarily mutually exclusive and so it is hard to find values of water across individual uses. Private sector tends to use the language of finance, while governments often employ concepts from economics using a range of environmental, rights-based, or social-goods for valuing water.

Morgan and Orr (2015) emphasized that all of the stakeholders should have a legitimate claim on water and its use, and so a corporate perspective must both understand and negotiate these different ways of valuing water as a scarce resource. There are others who define value of water differently like Rogers, Bhatia and Huber (1997) consider the value of water to be divided into economic value (i.e Value of water in industrial and agricultural use) and intrinsic value (i.e pure existence value). Whereas, Turner and Postle (1994) consider the economic value of water resources and aquatic ecosystems in terms of four separate components (abstraction of water, fisheries, recreation and biodiversity). De Groot (1992) categorizes the components of ecosystem value according to the impact on welfare, using a broad definition that encompasses environmental, physical and mental health, employment and social contacts as well as material prosperity (FAO 2004).

Moreover, water values may be environmental, social or economic in nature. Many such values can be measured in terms of how much an individual is willing to pay for something. Water valuation studies may be very broad, covering anywhere from one to six categories of water-related value (shown below). The coverage depends on the objective and context of the assessment, and can include the following: (WBCSD 2013)

- Off-stream values: The benefits gained from use of water abstracted or diverted from a Surface- or Groundwater source, and from harvested rainwater and sea water;
- In-stream values: The benefits generated from water that remains within a water body.

- Groundwater values: The benefits provided because of water collecting and flowing underground.
- Hydrological services: The benefits provided by the hydrological functions of habitats that influence Water quantity and quality.
- Non-water impacts: non-water environmental, social or economic impacts related to water delivery and use; and
- Extreme water-related events: Events that can cause significant impact and loss of value, typically related to either droughts or floods.

It may be noted here that in Little Mirlees's (1991) approach, there was social cost of using a resource in developing country that differs widely from the price paid for it. Therefore, there is requirement of shadow pricing to denote the real value of a resource to a society. While valuing water is not equal to pricing of water, it can be a useful tool to determine equitable and incentivized pricing schemes for the resource including water. Internationally, the UN (SDGs) has prioritized valuing water as global action to achieve sustainable water resources management and the World Bank High Level Panel for Water, of which of Bangladesh's Prime Minister is a member. Understanding the total economic value of water, i.e. the value to the economy, society and environment, can provide a basis to find strategic responses to Bangladesh is various water resource challenges.

3.2.1 Shadow Price of Water

The shadow price of a product or service that is marketed may be defined as the price that it will attract if there is no market distortion. Market distortions may be natural like its structure (such as a monopoly which can influence the product price) or may be due to government interventions such as a tax or a subsidy or an administered price. There are cases where in fact there may be no market such as the ecosystem services. In all such cases a shadow price is an artificial construct which indicates its true value to the society.

In case of water, the literature review shows that the shadow price of water may be assessed in several ways. It can be computed either based upon the users' behaviour or based upon the value of alternative use (e.g., different user or different time). Four types of approaches are available in the literature and are relevant to present study are (as the examples are related to use of water in agriculture, in most cases, these are used as illustrations):

1. First, it may be assessed in the context of optimizing groundwater withdrawal over time when groundwater is being depleted because of temporarily extracting more than recharge (Burt, 1964). The goal is to find the optimal or efficient withdrawal rate over time that maximizes the net present value of the groundwater used. It can be shown that this inter-temporal efficiency is achieved if, at every moment in time, the net return (revenue minus costs) from a marginal unit of extracted groundwater is equal to the marginal value of groundwater that remains in the ground. This marginal value is called the shadow price, and it is generally calculated as co-state variable when solving the inter-temporal optimization problem with the water balance of the aquifer as a constraint (Bierkens et al 2018)

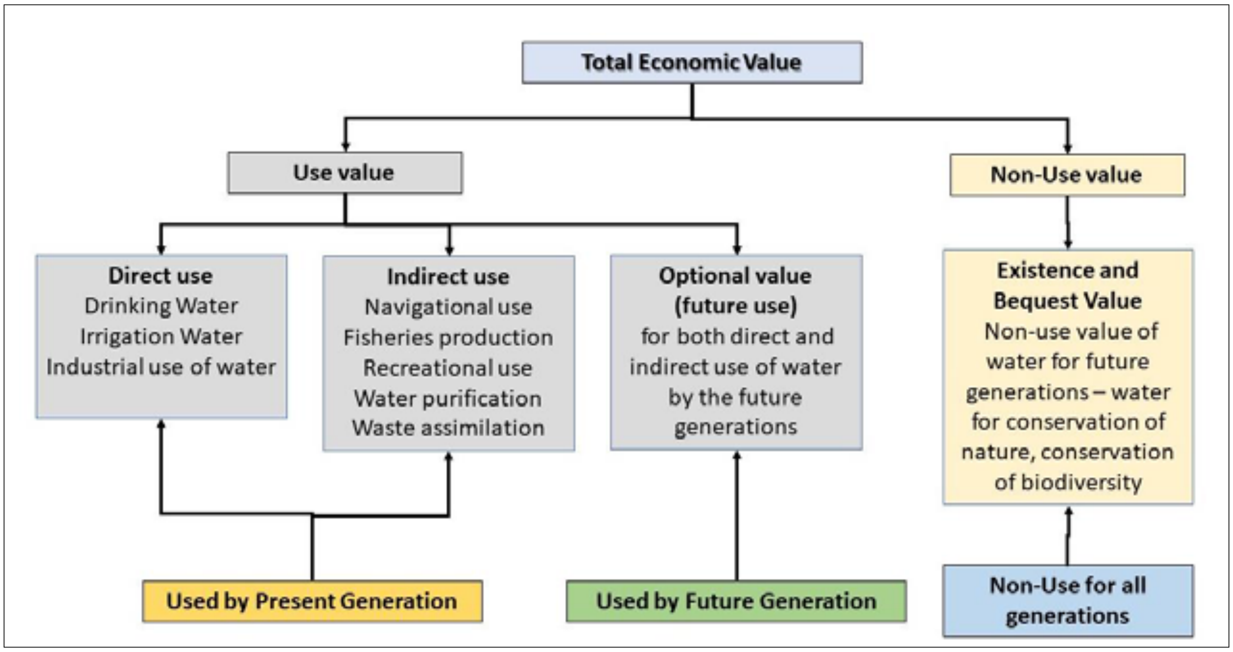
2. An even more extensive approach to the definition of shadow price refers to the price that would need to be paid by users to veritably account for the actual value of water as a scarce resource including all costs (including inter-temporal efficiency, opportunity costs, and environmental and economic externalities).
3. Another approach to definition follows from residual valuation, which is based on the assumption that all inputs (excluding water) are applied according to their (market) price. Here the shadow price of water, for example for irrigation, can be calculated as the ratio between the net returns of crop production and the total amount of water used for irrigating (Bierkens et al 2018).
4. Finally, if users do not consider inter-temporal efficiency (they ignore future groundwater use), the shadow price can also be referred to as the current marginal value of water (He et al., 2007; Wang & Lall, 2002; Young & Loomis, 2014). This reflects the value that water has to the user, that is, the maximum price the he/she is willing to pay for the last cubic meter of water consumed. In other words, the shadow price of water reflects the value of output that can be produced by the marginal unit water consumed, given the quantity of the other inputs (e.g., labor and fertilizer). Applied to irrigation, this means the revenue (production time's market price) produced with the last cubic-meter water consumed. Producers will only employ an input (ceteris paribus) up the point where its price is just equal to the additional value derived by employing an additional unit of input (Williams et al., 2017). By this definition, a low shadow price entails a low revenue per cubic-meter water consumed and, in case of countries or regions with a considerable fraction of irrigation water coming from nonrenewable groundwater, reveals wasteful use of a nonrenewable resource. A low shadow price thus indicates that the application of nonrenewable groundwater can generate higher revenue by using it for crops with a higher shadow price. This definition focuses on the more general issue of nonrenewable groundwater use now and in the future, focusing on the efficient allocation of irrigation water, including nonrenewable groundwater, currently abstracted (Bierkens et al 2018).

3.2.2 Total Economic Value (TEV) Concept

Total economic value (TEV) of water comprises of both direct, indirect use and also future use of water (Figures 3.1). This concept has direct relevance in studying valuation of water in Bangladesh where water has a multifarious use ranging from economic purposes to recreational and ecosystem preservation purposes. Components of TEV are described below:

- Direct use values of water arise out of direct use of water such as water for drinking and irrigation purposes, industrial uses, etc.
- Indirect use values of water are associated with services provided by water resources such as for navigation, fisheries, recreation, drainage, recharge of the aquifers, etc.
- Non-Use values of water are the values of water due to its services like protection of our aquatic biodiversity, conserving human life by protecting species of animals and plants, etc.

Figure 3.1: Economic Value of Water



Source: adapted from Haque, Murty, & Shyamsundar, 2011

Analytically, TEV is estimated for a given quality and quality of resources (here it is for water). This allows economists to find estimates of marginal values which are used to track the benefits or costs of water scarcity or water quality if it is affected by any anthropogenic reasons. As such, using the concept of TEV, economists estimate the marginal value of water when it is affected in terms of either quality or quantity due to economic or other activities by human. This concept, therefore, is pivotal to define compensations or design charges to contain these activities.

3.2.3 Full Economic Costs of Water

Multilateral and international organizations (for example like OECD) use full cost pricing or sustainable cost recovery (OECD, 2009). The concept of full cost pricing is based on the increasingly advocated principles of "user pays" and "polluter pays." This means setting a price for off-stream water use that considers the full economic costs of using water. As shown in Table 2.2 below, the full economic cost of water includes not only the financial costs incurred in obtaining the water, but also other societal costs (i.e., loss of values) associated with using the water. Financial costs should include whole life costs of the project (e.g., capital, operation, maintenance, and decommissioning costs), as well as other administrative costs (such as billing customers and dealing with regulatory requests). Societal costs include various environmental costs (water-related and non-water-related impacts), as well as resource (opportunity) costs from not being able to use the water for other purposes. According to WBCSD (2013), in simple terms, when something gives rise to a value, it can be considered a benefit, whereas when something results in the loss of value, it can be considered a cost. In welfare economics, the costs and benefits of a project are compared using a Benefit Cost Analysis (BCA) to determine an overall net change in value from a societal perspective. In line with review of literatures, simultaneous considerations of Both Benefits and Costs concepts would be made in the present study under consideration.

Table 3.1: Full Economic Costs of Use of Water

<table>
<tr><td rowspan="6">Full Economic Costs</td><td rowspan="3">Social Costs (Externalities)</td><td>Environmental Cost</td><td>Non-water related impacts (1.g., CHGs)</td></tr>
<tr><td rowspan="2">Resource costs</td><td>Water-related impacts (e.g., loss of in-stream values)</td></tr>
<tr><td>Foregone opportunity costs (e.g., other abstraction values lost)</td></tr>
<tr><td colspan="2" rowspan="3">Financial costs (including any internalized environmental or resource costs)</td><td>Administration</td></tr>
<tr><td>Operation & maintenance</td></tr>
<tr><td>Capital</td></tr>
</table>

Source: OECD (2009)

3.3 Methods and Approaches Commonly Used

1. Market Price Method (WBCSD 2013): This approach provides an example water valuation (by a company called Mondi) using actual market prices (water tariffs) that different stakeholder user groups pay for off-stream water consumption in a catchment in South Africa. As shown below, a geographic information system (GIS)-based map was used to help illustrate outputs. Mondi determined that the financial cost to forestry plantation water users is Rand 0.38/m3 x 68.7 million m3/year = Rand 26.1 million/year.

2. Production function method: This approach is based on the notion of regarding water as an input in the production process. Theoretical details of the economic principles based on which such pricing, and hence, the demand and supply curves for water can be derived, have been provided by Tsur et al. (2004: 64-85). A simplified version of the production function approach known as fixed proportions, or residual known as fixed proportions method. The net profit for each hectare of agricultural land is calculated, excluding water costs. The net profit is estimated to reflect the value of water.

3. Mixed Approaches for valuing groundwater: According to National Centre for Groundwater Research and Training in Australia, the valuation methodology for groundwater can be both 'revealed' preference and 'stated' preference techniques. The most commonly used are the deprival value, residual value, market prices and proxy market prices. Other methods such as hedonic pricing benefit transfer and replacement cost or avoidance have not been found in published groundwater case studies, however, are still used in the consideration of groundwater value. However, the most appropriate valuation methodology will vary, depending on the circumstances, data availability and what value.

4.The deprival value represents the cost users would incur to replace groundwater with the next least costly alternative source. This methodology is based on the assumption that if groundwater users were deprived of groundwater, they would be willing to pay up to the value of the next best alternative water source, less groundwater's associated ongoing costs (Marsden Jacob Associates, 2012).

5.The Residual value represents the value of the product that is generated from the use of groundwater. It is calculated by determining the profit (revenue less costs incurred) associated with using groundwater to produce the given product (RM Consulting Group,2008). This methodology is generally assumed to be appropriate

key economic equation: $\pi = \sum \boldsymbol{NiXi}$
π is total net benefit excluding water costs, Ni is the net benefit per hectare excluding water costs for land use I and Xi is the area of land use

when it is not possible or prohibitively costly to replace groundwater with an alternative source. For example, Assessment of economic value of GW for consumptive purposes in Victoria this method has been applied.

6.The proxy market price is revealed not through the market price paid for the resource itself, but through other costs to access (or protect) the resource. Examples might include the costs that groundwater users are willing to incur to access groundwater resources, such as drilling, pumps, pipes and storage or, alternatively, the scale of past investments that have been made to protect the resource (Deloitte Access Economics, 2013).

7. In Productivity method, marginal value-add made possible by groundwater is considered in industries that utilize groundwater as an input to production. In efficient markets this should, in theory, reveal the same value as the market price method (Deloitte Access Economics, 2013).

8. Benefit transfer method is where revealed preferences transfer from one area to another area (adjusted for other variables as needed) (Deloitte Access Economics, 2013).

9. Replacement or damage cost avoidance is the cost that is avoided through groundwater availability eliminating the need to develop an alternative, more expensive source of water, or through avoiding the need to undertake environmental remediation or protection (Deloitte Access Economics,2013).

3.4 Empirical Examples

There is a long list of literature which discusses valuation of water as well as that applicable to agriculture, particularly irrigated agriculture. However, empirical estimates are comparatively fewer, possibly because of data availability. Also, there are several methodological problems that arise depending on circumstances. This leads to problems of comparability. Furthermore, country-contexts are important which also leads to differences in estimates. So what matters most is whether the analytical methods are comparable not so much if the estimates themselves across countries are comparable.

Studies on water use and values in agriculture

One study is by Elame and Doukkali (2012) looks at water valuation in agriculture in the Souss-Massa Basin (Morocco). The study found that water valuation varies depending on water accessibility as this determines what crops to cultivate and how much water may actually be available.

Esmaeili and Shahsavari (2011) used a hedonic price model for valuation of irrigation water in South-western Iran by examining the price of land with irrigation availability. Based on the results from the hedonic model, the value of irrigation water in the region was estimated to be US cents 4.6 per cubic metre of water.

Shen et al. (2017) used a very large data base for the years 2002-12 in various regions in China. While the title of the paper has the word "shadow price", in reality what had been done is estimation of production frontiers with output values in monetary units while water use measurement is not clearly specified. In any case as in China water charges are based on area basis, there are measurement errors in physical quantities of water applied. Given this, there is a wide variation across regions in the estimated "shadow prices" which varies from 2.55 3.88 yuan in 2002 prices or 38.55 58.2 US cents at current exchange rates.

Ren et al. (2018) analysed irrigation water prices (from surface and ground sources) at macro level and micro level. While full cost prices were estimated whether these should be termed value of water remains debatable. Also, several crops were considered. For whatever these are worth, the full cost prices translate to less than a US dollar at present prices. Surface water was almost half of that from ground water sources.

For Bangladesh, at least 3 studies may be mentioned. The most recent one by Mainuddin et al (2020) in fact did not examine marginal productivity but analysed average productivity. Also it must be mentioned that the measurement of quantity of water by volume had certainly been more presumptive than definitive as water prices are by area irrigated, not by volume. In any case, the estimated average productivity based on irrigation water supplied varied from 0.37 kg m3 to 1.47 kg m3 in 2015–16 and 0.63 kg m3 to 1.43 kg m3 in 2016–17. These are in rice terms (husked paddy). While average productivity of water gives no clue regarding its marginal productivity, if just for illustrative purposes we use this as marginal productivity (as happens under fixed coefficient production function). We first transform the rice weight into paddy form by multiplying it by 1.33 (40 kg of rice equivalent to 30 kg of rice). If we use the highest productivity figure above, this comes to jut about 1.92 kg of paddy. Multiplying it by present paddy price per kg (Tk 15 or so), the "value of marginal product" comes to about Taka 28.9 or Tk 30 at most. In US dollars this comes to around 0.35 or 35 cents.

Chowdhury (2013) analysed irrigation water use and tried to estimate value of water by analyzing its marginal productivity. Unfortunately, she used irrigation water cost as the argument, nit volume of water and thus what she found was marginal productivity of a unit cost in Taka of irrigation. It is not exactly value of water. Given this, she found the marginal product of irrigation cost to be 1-3 which she claimed as value of water.

Mullick, Babel and Perret (2011) used the river flow in Teesta River and irrigation water withdrawal to estimate marginal benefits of water per cubic meter of water by converting water depth into volumetric measure. They actually ran a regression to estimate a water production function, apparently for rice and other crops together. The average value of irrigation application (for rice and other crops together) comes to US cents 6. As rice is the main irrigated crop and other crops account for far lower proportion of land as well as irrigation, very likely for rice it would be US cents 4-5. Based on the equation for VMP for water, this may be taken as the value of water for surface water irrigation in the Teesta River basin at 2009 prices.

Industrial use of water and values

Wang et al (2016) has tried to estimate shadow prices of water for industrial output in China. Based on a programming approach, it has evaluated industrial water use and both average and shadow prices of industrial water use across all of its provinces over a period of 2004-12. While the average for one year, say 2012 for shadow price of water is US $ 3.81, the variation across provinces is enormous with arrange from just US$ 0.77 to 16.60. However, just about half of them have a shadow price up to just US$2. Also note that the industries must be of all kinds, small to large and very large as well as some which are far more water intensive than others. One issue that has come up is that the shadow prices are everywhere far above average pieces of water and quite obviously recommendations for raising prices to minimize and more efficiently use water has been made across provinces and across industries as well as water scarce and water abundant regions.

Wang and Lall (2002) estimated marginal value product and their values in Chinese industrial use of water over year 1993.They have reported wide variation in such values. For the industry as a whole they reported a value of industrial water usage per cubic metre to be 2.45 yuan or 42.7 US cents at the exchange rate of that time. For industries of our immediate interest the values of water were Food and beverage:15.6, Textiles;200, Power generation: .009 and construction: 96, all in US cents equivalent.

Agarwal and Kumar (2011) reports citing Kumar (2006) on shadow prices of water in different industries in India. Kumar used a programming approach to estimate the prices. His estimates for industries showed wide variation from less than US 1 cent to just short of 40 cents with an average of 9.4 cents per cubic metre.

Revollo-Fernándeza, Rodríguez-Tapiab and Morales-Novelob (2020) studies Mexican industrial use of water and estimated value of water using a translog production function. The information on cost of water, but not volume was available. To transform to volume the expenditure was divided by the rate charged for water by volume. Furthermore, prices were reported in US dollars but whether these are Mexican prices converted into US dollars at prevailing exchange rate or at least for outputs competitive export prices are hardly mentioned. It appears, however, that, the market price of output had been used for valuing marginal product of water. Thus, in strict sense the values so estimated is not economic value of water, but financial value. Be that as it may, while the over-all value estimated with data for 2013 was US$ 19.4 per cubic metre of water, the range was from $2.3 for wood to $28.7 for transport equipment. For food industry it was $3.7 and for textiles $16.5. These values indicate that even if competitive prices were used, probably these would have not been much lower.

Chilean industrial water use has been analyzed recently by Vasquez-Lavín et al (2020). As in case of the Mexican industries a similar analysis has been done although for a much longer period of nearly 20 years. Question remains as to how prices over this period had been averaged or if a constant price was used. However, it appears that water volume data were available. No reuse of water information was used. The economic value here again is basically the financial value of the marginal product. For the industries as a whole, this is US$ 8.07. The range is from 2.24 for leather products to US$ 17.9 for wood products (except furniture). For specific industries of interest here it is for food: US$ 7.08 and for clothing and textiles around US$ 8 all for per cubic meter of water used.

Malarvannan, J. et al (2016) while analyzing water use in construction found that water consumed during the actual construction was 2 cubic meters /Sq m of built space. They did not estimate any value of water.

Han et al (2016) analysed the issue of water management in construction from the view point of life cycle usage of water. Using Chinese data, they estimated that the total embodied water may be as much as 24 times the actual construction phase consumption of water.

Heravi and Abdolvand (2019) in analyzing construction industry in Iran stressed the need for understanding total embodied water in construction, i.e., life cycle consumption. This they stressed is necessary as while the actual onsite consumption (including human use) is at most 3.22 m3/sq meter of space, the indirect use in construction materials is 16.91 m3/sq meter i.e., 5 times the direct use.

Bardhan (2011) like others has looked into embodied water in construction. Actual construction stage water use in 2 m3 while the total embodied water including construction stage is 27.6 m3 both per sq metre of space.

A WRI/IRENA (2018) document on power sector water consumption analyses how to improve water use efficiency in power generation. This shows that the base line (2014) consumption in gas-based recirculating power generation water use on average 1.62 m3 per Mwh of power generation. Even with rising efficiency this may go down a little to 1.17 m3/Mwh generated.

A study on Turkish power plants found that water use intensity varies by primary fuel as well as wet ro dry cooling or once through system (El-Khozondar, Balkess and Merih Aydınalp Koksal: 2017). For Natural gas based system, the average water consumption is 420 cubic meters of water per Gwh or 0.42 cubic metres per Mwh of generation. Wet cooling process uses 0.75, once through 0.38 and dry cooling just 0.0075 cubic meters of water per Mwh of generation.

Water and ecosystem services

Croitoru, Divrak and Xie (2016) have tried to estimate the value of water providing various ecosystem values in Beysehir Lake in Turkey. Using the concept of total economic value, it has estimated the value of services of waters in the Lake for direct use, indirect use and non-use values. However, as often happens, while the direct use values could be estimated quite well, for others either these were not estimated or estimated using methods not so suitable. Given this, the total direct use value is estimated at 2015 prices to be 257 mn Turkish Lira while the combined indirect use values and non-use values are just 14 million Turkish Lira. The total value comes to just above US$ 87 million. At the surface size of the lake is 73 thousand ha, this comes to just short of US$ 1200. As we shall see later, in Bangladesh the ecosystem services (not including non-use values) come to more than US$ 18 thousand.

The above survey of empirical literature leads to a few conclusions. First, there appears to be some confusion regarding value of water and shadow prices. Various authors have used slightly different concepts as well as method of estimation. In most cases, the information on volume of water use appears to be lacking, be it in agriculture or in industry. Particularly in case of agriculture, area-based water pricing seems to be the norm which makes estimation of productivity difficult. This, be it in agriculture, or industry, there seems to be a wide range of values even within the same country and across economic activities. We will see that Bangladesh is no exception to the above findings.

4. Framework for Valuing Water

4.1 Principles of Study Design for Valuing Water

Water is a natural resource, and its availability largely depends on the nature. Too much or too little availability of water cause a serious water management problem. At the same time, when water is underpriced, there is a danger of over-use of water which in turn reduces availability of water in other sectors. To solve this problem, economists often argued for pricing water fairly so that efficient allocation occurs. Actually, shadow price is required for decision making for public sector but can be utilized for efficient and pricing in private sector business, industry and residential house. For example, in case of residential use of water supplied by utilities, the issue of affordability becomes important as one of the SDGs. Thus, shadow price provides the guidance to a fair system of pricing of water. At the same time, there are sectors where water has no market price, like environment and ecosystem, where availability of water is only residual, finding value of water is most challenging. Since there are many different uses of water, the study team agreed, based on government's proposals, on the following principles to select the sectors and sub-sectors for this study.

- Volume of water use: Sectors where most of the water is being used is part of the study. As such, Agriculture, Industry, Human consumptive use, and ecological use of water is selected.
- Human intervention requirements: Upon selection of the sector, the idea is to examine the sub-sectors where human intervention has resulted in the most extraction or use of water. Based on this principle, we have selected i) Boro Rice in the agriculture sector for the study; ii) Food and beverage industry: which is heavily dependent on water extraction either from surface or under-ground source; iii) Power sector: which needs water for producing electricity, a critical input for production; iv) Urban residential sector: Where millions of people depend on city water supply at the household for drinking and other living purposes; v) Construction industry: Another urban sector use of water which has been rising at an annual rate of 8%+ for a decade; vi) Apparels industry: Another urban sector use of water which contributes to 85%+ in our export; vii) Ecological services: Based on this, the team selected to study haor basin which provides flood-regulating services to downstream regions.
- Geographical variations: Given the above selection of sectors and sub-sectors, the team also understood that there is signification variation of water availability across the hydrological regimes in Bangladesh. This means the study should also consider geographical variations while selecting the valuation exercise. Based on this principle, i) Boro crops form north-west (Barind region) and from south-east (Muhuri irrigation project) were included for the study; ii) For industrial uses, significant differences in water use is not expected and so there was no geographical consideration for selection of industries; iii) Among urban uses: It is expected that water quality is an issue for supply of drinking water and so Dhaka (in non-saline zone) and Khulna (in saline zone) were initially selected for the study; and finally iv) On ecological services, one area in the north (Tanguar Haor) and another in the south (Halda River) have been selected.

- In the Proforma/Proposal for Feasibility Study/Survey (PFS) there was an idea of capturing the effects of seasonality and source of water in valuation exercise. However, while source of water has been tried to be captured for agricultural water use and valuation (with irrigation from ground and surface sources), this is immaterial in other cases. On the other hand, seasonality may have implications for supply of water and hence to ecosystem services. However, due to resource and time constraints as well as COVID situation, no such exercise is attempted.

4.2 Operational Framework for Valuing Water

Based on the methodologies for the study sectors, the operational framework for the study may be summarized as follows:

Table 4.1: Operational Framework for Valuing Water[2]

Sectors	Type of Services and Value	Valuation Method	Data need/ requirement	Data source
Agricultural Use – Irrigation	Provisioning service of water	Production function approach	• Crop production (kg); agricultural land; inputs (seeds, fertilizer, energy, labor etc.); • costs of production • water use, price of water	Primary (field survey) data on boro crops from Northwest and Southeast regions.
Industrial Use – Construction, Power , Apparels Sector, Food and Beverage Sector	Provisioning service of water	For power sector production function approach; for rest fixed proportion production function approach.	Volume of water use from selected producers, unit cost of production, unit price of output	Key informant interviews/information from selected producers
Municipal Water Use/ Urban Domestic Use of Water	Provisioning service of water	Health cost approach	Incidence of water borne diseases in urban areas with and without water supply system, Cost of prevention, cost of mitigation, average daily income, no of days lost due to illness in urban areas	Household Income and Expenditure Survey (HIES) 2016 data
Ecological Service of Water – Flood Control function of Tanguar haor	Regulatory service of water	Damage Cost Approach	Extent of inundation with and without haor ecosystem services, agricultural production and cost data	Simulate using GIS models at CEGIS, secondary data from BBS
Ecological Service of Water – Spawning ground for fishes in Halda River	Supporting service of water / Habitat service of a river	Contingent valuation method if non-use value is dominant. Replacement cost method of use value is dominant	Cost of raising hatchlings in hatcheries	Information on various benefits as well hatcheries available in literature or key informants

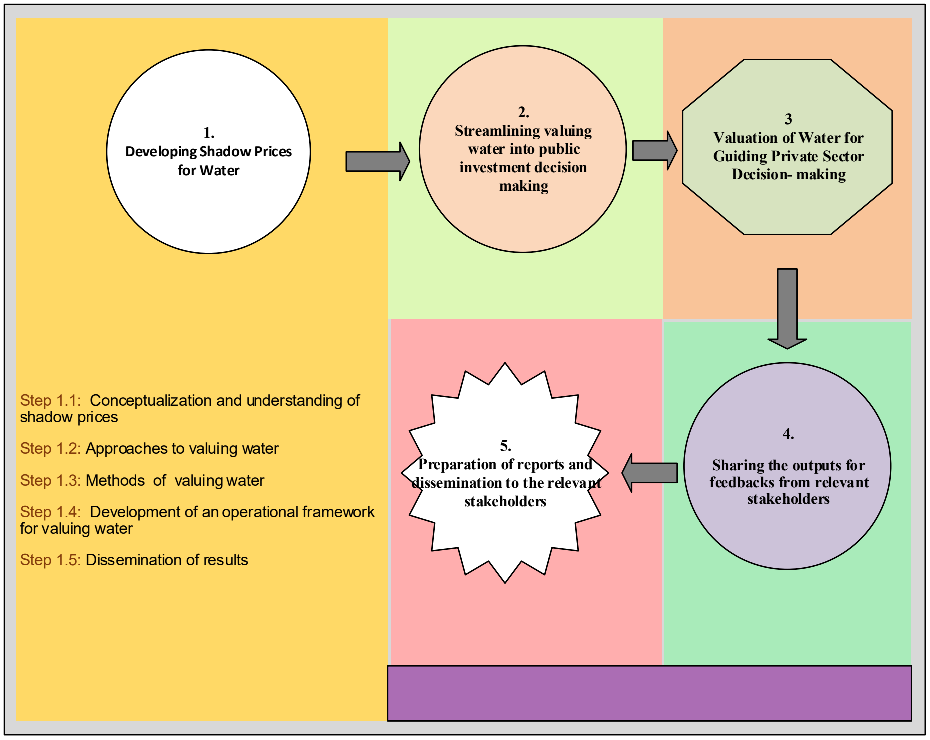
2 This table should be read and understood with explanations provided later how the approaches will be used to avoid repetition of arguments.

5. Methodology, Case Studies and Data Issues

5.1 Introduction

Developing shadow prices of water for the four sectors under case study is not a straightforward task since the economic values of water is expected to be different for different sectors and different uses. Therefore, considering the best practices around the world and contextualizing them as far as practicable in the Bangladesh perspective, this study plans to develop the shadow prices of water for these sectors. The following diagram encapsulates the whole process of estimation of shadow prices and their integration into a policy framework for its use. The details follow in the subsequent sub-sections.

Figure 5.1: Methodology of the Study



5.2 Conceptualization and Understanding of Shadow Prices

Shadow prices of a resource (like water, for example) are used while considering the cost-benefit of projects. Since water is not priced properly, if an investment project reduces availability of water or damages the quality of water, the loss in terms of the economy cannot be measured properly when its price either does not exist or is distorted due to ad hoc setting of prices through an administrative decision. Under this situation, economic loss due to damage or reduction in availability of water in alternative usages cannot be truly accounted. Similarly, if an investment improves water availability or improves its quality the benefits also cannot be estimated properly. Under these scenarios, economic prices or shadow prices are used to estimate benefits of water conservation or cost of damages to water availability or its quality. As such if 'shadow prices' are known than investment projects to conserve water bodies or to improve water quality can be properly valued in the project feasibility studies.

Generally natural resources have thus not yet been extensively considered in investment decision-making based on their shadow prices. But we do know that in many cases, resources such as land as well as water is scarce, and their social cost should be based on their scarcity value. Valuing water has been prioritized as global action to achieve sustainable water resources management by the UN (SDGs) and the World Bank High Level Panel for Water.

Understanding the total economic value of water, i.e. the value to the economy, society and environment, can provide a basis to find strategic responses to Bangladesh's various water resource challenges. Present practice facilitates investment decisions based on the Development Project Proforma/ Proposals (DPP), following the guidelines provided by the Planning Commission of the Ministry of Planning of the GoB. Both financial and economic analyses are required to examine the feasibility of a project in the views of the sponsoring agency and holistically for the whole economy, respectively. Shadow Price Conversion Factors (SCF) prescribed by the Planning Commission are used to arrive at economic prices which are expected to reflect true scarcity value of the particular resource or inputs. As it happens, such conversion factors are not available in all cases and the Study Team had assumed such factors based on plausible criterion.

5.2.1 Use of Shadow Price of Water in Planning

The Planning Commission presently use shadow prices and conversion factors for translating market based financial prices to economic (or social prices) in DPPs. However, no such shadow prices or social scarcity value is used in case of natural resources. In designing projects that would preserve water bodies, or reduce misuse of water or in similar projects, benefits are in terms of volume of water and in situation where water is under-priced, they are underestimated and hence often makes such projects less attractive in terms of economic rate of return. Shadow prices can be used to measure true benefits of these type of projects. Similarly, if any private investment or a privately financed economic activity destroy the water sources or damages the quality of water, there is a need to find the economic cost of this activities. This can also be estimated with information on shadow prices of water.

As indicated earlier, total economic value comprises of its use and non-use values. In most cases, such as use of water for economic purposes (production and consumption), use values are generally prominent. Non-use values are more prominent in case of say ecosystem services. Hence while data availability will dictate which kinds of values are being used, we tried to explore in the field if there are non-use values in case of economic use of water or use values of water where non-use values are more prominent. So, as much as possible we tried to incorporate both types of values in the aggregate estimate of value. question has been raised whether the set of shadow prices so estimated should be harmonised over different sectors, uses, region and social groups. If a certain investment project may destroy, for example, a spawning ground we need to know, in that case, the cost of such loss for destruction of the spawning ground only. Alternatively, if an investment in an industrial zone pollutes water sources of a city, the loss should be estimated from the economic cost of such damage. Economic price in a saline region may thus be higher than that in a region where fresh water is readily available.

The divergent nature of water use by sector has been brought out in earlier discussion of this study. This also highlights that a harmonized shadow price may not be possible or be even irrelevant in the context of Bangladesh.

Detailed review and analysis of relevant national and international policy documents were summarized based on their indicative directives on valuing water.

5.3 Methods of Valuing Water

Water usages in agriculture, industry and in urban areas represent use value of water, whereas water usage in haor and in Halda river illustrates more of non-use value of water. As such, the study in its current form considered eliciting both use and non-use value of water. Earlier Table 4.1 has shown in summary the methods to be used for estimation of value of water and subsequently shadow price of water. Here we discuss the issues of sampling and data sources.

5.3.1 Samples and Data Sources

Several sub sectors from four sectors are identified to estimate shadow price;

1. Agricultural use of water: a) North-West region, and b) South-East Region.
2. Industrial use of water: i.e. use of water in a) power sector, b) construction sector, c) food and beverage sector, and d) Apparels sector.
3. Urban residential use of water: a) in south-west region and b) in central region of Bangladesh.
4. Environmental or Ecological use of water a) in Halda River: a precious spawning ground and d) in Haors or wetlands: which conserve water in pre-monsoon period and prevents early floods in the riparian region and allow boro harvests in these regions as well as conserve mother fisheries: thereby ensure sustainable supply of freshwater fish species in Bangladesh.

Thus, the study broadly covers the north-east, north-west, south-east, south-west and the central region of Bangladesh. Specifically, in case of agricultural use of water, the study team undertook the BMDA project (in the North-west), and the Muhuri River Project (in the South-east). In case of urban domestic use of water, the study considered examining a city in the Southwest region (prone to saline intrusion) and Dhaka WASA. Furthermore, for ecological use of water – haor regions in the North East (the Tanguar Haor in Sunamgonj) and the Halda River in Feni (South East) are studied. Thus, the study has spread its geographical reach into various regions of Bangladesh, and it covers four major water-using sectors of Bangladesh.

Primary data were collected for the agricultural sector to estimate the production function in two areas – Barind area and Coastal area. Primary water use data were also collected from the electricity generation companies for estimating the fixed coefficient production function. In addition, available secondary data were used for RMG or the Apparels sector, the Construction Sector, and for Urban water use. For valuing ecological services, a GIS based simulation model was used to understand the cost of flooding in Haor regions in Sunamgonj, and secondary data from the fisheries department and estimates from various secondary studies were used to estimate ecological benefits of water in terms of spawning function in the Halda river in Chattogram. Details of data sources, methods and data characteristics are discussed in Chapters 6 to 9.

5.4 Streamlining Valuing Water into Public Investment Decision Making

After finalizing, the shadow prices will be mainstreamed into both public and private investment/ decision making process and policies. A Project Proforma (PP) can take three forms. They are:

- Development Project Proforma /Proposal (DPP) (For Aided Project)
- Development Project Proforma /Proposal (DPP) (For wholly GOB financed project)
- Technical Assistance Project Proforma/Proposal (TPP)

Therefore, the Planning Commission was consulted on how to incorporate the shadow price of water into the DPP format. Based on their opinion the relevant part of the DPP may be updated. Once it is finalized, the relevant parts of the DPP manual will be updated which will attempt to explain, step by step, how to use the shadow price of water for investment appraisal under different circumstances. For endorsement of the proposed changes to be made in manual and DPP by the Planning Commission a stakeholder consultation was conducted with following stakeholders.

- Ministry of Planning including all divisions of the Planning Commission and Planning Division;
- Prime Minister's Office
- Ministry of Water Resources;
- Ministry of Local Government, Rural Development and Cooperatives;
- Ministry of Industries;
- Ministry of Agriculture;
- Ministry of Environment, Forest and Climate Change;
- Ministry of Fishery and Livestock;
- Ministry of Housing and Public Works;
- Ministry of Power, Energy and Mineral Resources;
- Ministry of Textiles and Jute;
- Ministry of Commerce;
- Ministry of Chattogram Hill Tracts Affairs;
- Private sector associations, such as BGMEA;
- National and multi-national private sector companies and
- Civil society

5.5 Valuation of Water for Guiding Private Sector Decision- making

All the relevant private sector was kept informed about the results and analysis through workshops. In addition, the estimated value of water and the background framework may also be used to guide use of water by the private sector from various sources. Moreover soft copies of the report also share with all the stakehoders. The final report also distributed to the key stakehoders.

5.6 Sharing the Outputs for Feedbacks from Relevant Stakeholders

During the study, all results and the feedback from both public and private sectors was disseminated among the stakeholders who are from the very beginning (from inception phase) are involved.

5.7 Preparation of Reports and Dissemination to the Relevant Stakeholders

After preparing report, it was disseminated among the stakeholders from both public, private organizations that are working in sectors, agriculture, domestic, industry and ecosystem services and national and international experts on valuing water. Besides this, the study output also shared to academia, civil society representatives, NGOs for mass sensitization and to ensure the best uses of water.

6. Value of Water for Agriculture

6.1 Introduction

Agriculture's contribution to Bangladesh GDP at present is the smallest among its 3 broad components, agriculture, industry and services, only 13-14% at best and it had been falling over time However, this hides the fact that agriculture is absolutely essential for food and nutrition security and more importantly that the country is now basically self-sufficient in the production of rice, the main staple. This had been possible mainly due to the increasing reliance on irrigated boro rice in largely dry period from January to April. While Aman production during the largely rain-fed but also partly dependent on supplementary irrigation has also increased, according to latest official estimates, boro accounts for nearly 55% of rice production while aman's share is just short of 40% the rest being contributed by the completely rain-fed aus rice.1

Of all the sectoral uses of water, agriculture comes at the top accounting for an estimated 75-80% of total water use in the country for such purposes. Again much of it goes for irrigated rice. Irrigation is more or less mechanized in the country. Again much of the irrigation is ground water based, a small part is contributed by surface water irrigation using low-lift pumps. Gravity irrigation is minimal.

For valuing water in agricultural use, we have therefore examined the practices by farmers in boro rice cultivation underground water-based and surface water-based irrigation. Underground water irrigation, there are two basic mechanisms, use of deep tube-wells (DTW) and of shallow tube-wells (STW). By and large in North Bengal which is largely under the jurisdiction of the Barendra Multipurpose Development Authority (BMDA) and which is major boro rice growing area, irrigation is mostly with DTWs and farmers are expected to pay price of water by volume of usage which is controlled through smart cards. It is expected that as volume of water is a main variable of interest in the present analysis, it would be easier to get such information. On the other hand, in case of shallow tube-wells, the water is bought and sold by area served and there is no record of water volume. Thus, getting information on volume of water used becomes extremely difficult and that is why for the present exercise, we have concentrated only on DTW irrigation. Surface water irrigation is generally paid for by area. However, the Muhuri Irrigation Project run with surface water from Muhuri river has recently introduced smart cards for pricing water use by volume. Therefore, we also use also data from Muhuri irrigation project.

6.2 Irrigation Practices in Bangladesh

Agriculture is one of the most water intensive sectors contributing to our national GDP. Bangladesh is a lower riparian country in the flood plains of three great rivers- the Ganges, the Brahmaputra, and the Meghna and their tributaries and distributaries. Fifty-three rivers drain 1.72 million square kilometers in Bangladesh, Bhutan, China, India, and Nepal. Only 8 percent of the catchment area is in Bangladesh. The country has about 25,000 kilometers of waterway stretching across 4.3 million hectares (MoL 2001), or almost 40 percent of the country's net cultivated area. This also includes wetlands and permanent water bodies that have a major impact on agricultural production and bio-diversity conservation in the country.

Rice (paddy) is the largest irrigation user with about 86% of the total irrigated area devoted to its cultivation. In Bangladesh, irrigation is accomplished by: i) Major irrigation schemes using canal/gravity irrigation with surface water, ii) Minor irrigation schemes using groundwater from Deep Tube-wells (DTWs), Shallow Tube-wells (STWs), Force Mode Tube-wells (FMTWs) and also surface water using Low-Lift Pumps (LLPs).

6.3 Barind Multipurpose Development Authority (BMDA)

6.3.1 Analytical Method for Irrigation Water Use under BMDA

The basic method for finding the value of water in irrigated agriculture is to estimate the value of marginal product of water. For this we estimate a production function. A general production function may be written as

$$Q = f(K, L, W, Z) \text{ .... } (1)$$

Where

Q = crop output;

K = service of capital;

L = labour input;

W = volume of water used for irrigating the crop;

Z = a set of various other inputs.

The actual equation used is described later. Suffice to say here that we tried both a Cobb-Douglas production function and a linear function which have the following form:

$$\text{Cobb-Douglas : } Q = AK^{\alpha} L^{\beta} W^{\gamma} Z^{\delta} \text{ ...... } (2)$$

$$\text{Linear: } Q = A + \alpha K + \beta L + \gamma W + \delta Z \text{.........} (3)$$

Where α, β, γ, and δ are estimated parameters, K, L, W and Z are as defined earlier while A is a constant. The Cobb-Douglas production function can be linearized using log transformation.

The marginal product of water can be found simply by partially differentiating Q with respect to W. Multiplying this value by price of output per unit provides the value of marginal product of water or, rather the value water.

In actual econometric estimation, we further elaborated Z and also used interaction terms as shown later and also added an error term at the end as is the normal practice.

6.3.2 Sample

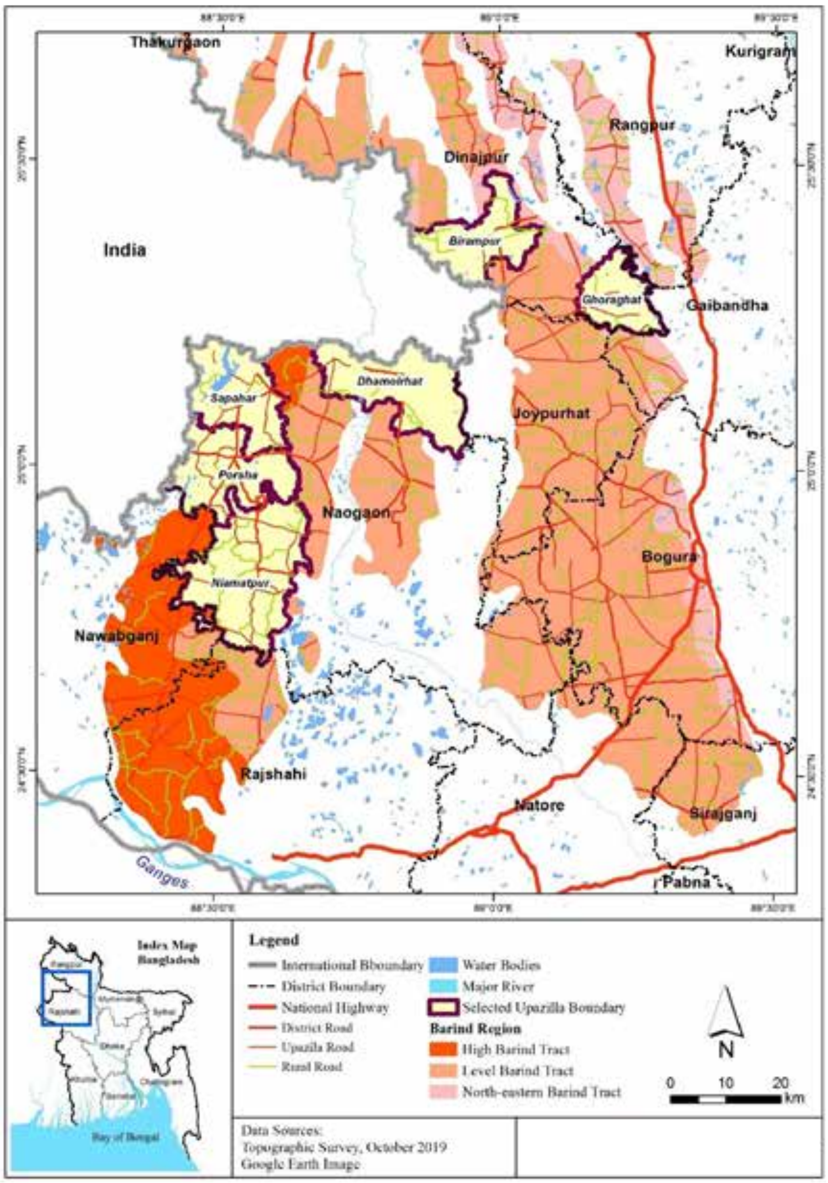
One hundred and seventy-nine farmers were ultimately surveyed although a higher number was targeted from 6 upazilas in North Bengal from Naogaon and Dinajpur districts. In fact, the random selection of the upazilas were based on first stratifying the Barind area in 3 zones, high barind, level Barind and eastern Barind. The upazilas were selected based on these categorizations.

Two thirds of farmers were small in size (1-2.5 acres of operational holding) while a quarter were medium-sized (25-7.5 acres). Fully three-quarter of farmers tilled only their own land while owner-tenants accounted for only 22%. Family size was a maximum of 5 in three-quarter cases while family members in farming were just 1 in 60% cases and 2 in a further 24% cases indicating that labour availability may be a problem during harvesting when labour market becomes quite tight. While all farmers are dependent on irrigation, and most have smart cards (80%), some 20% do not own such cards and are thus dependent on sales of water from others or other means.

Table 6.1: Sample Upazilas of BMDA Area for Data Collection (Agriculture)

Division	Districts	Name of Upazila	No of farmers interviewed
Rajshahi	Naogaon	Niamatpur	30
		Porsa	31
		Sapahar	30
Rangpur	Dinajpur	Dhamurhat	30
		Birampur	30
		Ghoraghat	28
		Total	**179**

Figure 6.1: Selected Upazilas under BMDA Area for Data Collection (Agriculture)



6.3.3 Results

Dependent variable: Maunds of paddy/acre

Explanatory variables (all on per acre basis):

- Capital assets value (in Taka) (K);
- Labour in man-days(L);
- Water in cubic meters (W);
- Fertilsier in taka(F);
- Manure in kg (M).

In actual estimation we have also used one interaction term between capital and labour; one interaction term of water and labour; and one square of water use, and upazila dummies with Birampur as the reference upazila. Initially we used Barind categories as dummies which returned similar results. In any case, the equations we estimated may be expressed as

$$Q= \beta_0 + \beta_1 K + \beta_2 L + \beta_3 L*K + \beta_4 W + \beta_5 W2 + \beta_6 W*L + \beta_7 F + \beta_8 M + \Sigma \gamma (UZD) \text{ .... (4)}$$

where F- fertilizer, M= manure and UZDs are 6 upazila dummies and others are as described earlier, β and γ s are regression coefficients to be estimated.

From eq (4), we get marginal product of water (MPW) as

$$MPW= \delta Q/\delta W = \beta_4 + 2 \beta_5 W + \beta_6 L \text{ ..... (5)}$$

Value of marginal product (VMP) or value of water then becomes

$$VMP = P * (\beta_4 + 2 \beta_5 W + \beta_6 L) \text{ ... (6)}$$

where P is price of output (paddy/maund).

The equations are shown in Table 6.2.

Table 6.2: Boro Paddy Production Functions

	Equation 1	Equation 2	Equation 3	Equation 4
Dependent Variable >>>>	q	q	Ln(q)	q
Explanatory Variables				
Labor (L)	0.214	0.504*		0.0547
	(0.77)	(1.74)		(0.41)
Labor x Capital (L x K)	-0.0000276	-0.0000292*		-0.000025
	(-1.65)	(-1.80)		(-1.55)
Manure (M)	0.0783***	0.0705**		0.0697**
	(2.81)	(2.58)		(2.53)
Capital (K)	0.000322	0.000340*		0.000291

	Equation 1	Equation 2	Equation 3	Equation 4
	(1.6)	(1.75)		(1.5)
Fertilizer (F)	0.000782	0.000797		0.000959
	(0.33)	(0.34)		(0.41)
Water vol (m3)	0.00530**	0.0107***		0.00690***
	(2.31)	(3.6)		(3.4)
Square of (Water Vol)	-0.000000871***	-0.00000149***		-0.00000140***
	(-3.10)	(-4.60)		(-4.34)
Water x labor (W x L)	-0.000153	-0.000252*		
	(-1.08)	(-1.75)		
UZ.Birampur (base)		.	.	.
UZ.Dhamoirhat	13.71***	12.66***	0.801***	12.40***
	(8.33)	(7.74)	(4.79)	(7.56)
UZ.Ghoraghat	3.109**	3.579**	0.392**	4.083***
	(2.43)	(2.29)	(2.61)	(2.64)
UZ.Niamatpur		6.264***	-0.142	5.493***
		(3.18)	(-0.64)	(2.84)
UZ.Porsha		0.924	-0.105	0.758
		(0.63)	(-0.68)	(0.51)
UZ.Sapahar		7.568***	-0.0921	6.728***
		(3.82)	(-0.43)	(3.48)
Ln(labor)			-0.0216	
			(-0.16)	
Ln(capital)			0.0461**	
			(2.16)	
Ln(Manure)			0.211***	
			(2.64)	
Ln(Water vol (m3))			-0.614***	
			(-3.62)	
Ln (Wat volume x Labor)			.	
			.	
Ln(Fertilizer)			0.08	
			(0.77)	
Constant	9.393**	0.215	6.047***	6.885*
	(2.28)	(0.04)	(4.21)	(1.86)
Observations	153	153	123	153
Adjusted *R2*	0.41	0.46	0.28	0.45

Note: t statistics in parentheses and * p< .1, ** p< .05, *** p< .01

Several different specifications of the production functions were estimated using STATA and finally, the Equation 4 is found to have been consistent both in terms of the theory and with the highest value of R-square. The Equation (1) is in the linear form,and the Equation (3) is the Cobb-Douglas form of the production function. The latter is found to be inconsistent with our data (as the coefficient of lab is negative) and with much lower value of R-square. Moreover, due to zero value in some of the inputs for a few farmers, in the C-D production function 30 observations were dropped from the estimation.

The analysis in this research, therefore, used Equations (2) and (4) in which coefficients are consistent with theory and the R-squares are also very similar. We further tried an equation with interaction of water volume with upazilas but the coefficients are not consistent with the theory. Inconsistencies are generally due to multicollinearity in input variables.

Coefficient of the Water variable is statistically highly significant and positive impact on yield of boro rice. However, we also find the coefficient of the square of water usage to have a negative value and is statistically highly significant indicating that excessive use of water leads to reduction in its marginal products. In other words, lowering water use will raise its marginal productivity.

We also find that the upazilas do vary in terms of their productivity in contrast to the reference upazila, i.e., Birampur. All of them with the exception of Porsha has significant and positive coefficients. For example, take Dhamoirhat, everything remaining the same a farmer in Dhamoirhat reaps around 12.5 maunds of paddy per acre compared to a Birampur farmer. When we used a similar dummy for categories of barind, with respect to Eastern Barind, both high Barind and level Barind farmers had higher and statistically significant productivity (not shown).

Coming back to the marginal productivity of water and using equation b in Table 6.2 above, for example, we find the marginal product of water (taking into account the coefficients of water, water-sq (interaction term of labour and water is insignificant and hence not counted), it is found to be

$$0.0069 - 2 * 0.0000014 * \text{water volume} \; \ldots \; (7)$$

The mean volume of water use has been found to be varying from 800 to 2000 cubic metres with an average of 1735 cubic metres across all. Applying this average water usage gives the marginal product of water as 0.0048 maunds. Multiplying this by average price of paddy which was Tk 615/maund, we get the

$$\text{value of marginal product of water (VMP)} = \text{Tk } 615 \times 0.0048 = \text{Taka } 2.98 \; \ldots\ldots \; (8)$$

which is the value of water per cubic metre. This is equal to 3.36 cents (at Tk 82 to $ 1). For comparison elsewhere in the world the modal value appears to be very similar at 3 cents/cubic metre *(Aylward et al 2010)*. Bangladesh therefore has similar value of water on average as elsewhere.

This value is, of course, the value that the farmer gets which is dependent on the financial price he/she pays for water and the financial price received for paddy. Question may arise if we should use the conversion factor for price of paddy for translating this into shadow price for water in agricultural use for irrigation. The DPP manual of the Planning Commission of the Government has shown the conversion factor for boro paddy at 0.95. Multiplying the above value of marginal product of water by 0.95 we get Taka 2.83 as the shadow price of water per cubic metre for irrigated rice under boro season in BMDA area. This comes to just about 3.5 cents per cubic metre of water.

If we use the other equation (Equation 2) in the table above, we get a value of water to be (using similar calculations)

0.011 – 2* 0.0000015 * Water volume - 0.00015* Labour usage … (9)

Applying means of water and labour usage (for labour average of 11.56 mandays/acre, we get marginal product of water to be 0.00406 maunds per cubic metre of water. Multiplying by average price of paddy, we get the

Value of marginal product of water = Tk 2.50/cubic metre. In US cents it is just above 3.

Using the conversion factor of 0.95 *the shadow price of water now comes to Tk 2.37* or US cents 2.9.

6.3.4 Conclusion

We have tried to estimate the value of water in irrigated boro season in BMDA area and found that the financial value varies from Taka 2.5 to 3. Applying conversion factors used by the Planning Commission we arrive at shadow price of water in irrigation to be Taka 2.5 to 2.8. As noted these figures are quite comparable to what has been found elsewhere in the world (Aylward et al: 2010) as well as previously in Bangladesh. (Chowdhury, 2010)[3]

6.4 The Muhuri Irrigation Project

6.4.1 Introduction

The Muhuri river basin is located in the middle reach of the southeastern region of Bangladesh and near the confluence of Feni river, Muhuri river and Kalidas-Pahalia river in the coastal belt facing the Bay of Bengal. The basin in Bangladesh spreads over Feni Sadar, Sonagazi, Chagalnaiya and Parshuram Upazilla of Feni district and Mirersarai Upazilla of Chittagong district and covers a gross area of 40,080 ha with cultivable area of 27,125 ha and irrigable area of 23,076 ha. The combined flow drains to the Bay of Bengal. Until 1985, tidal flooding and salinity intrusion had been a regular phenomenon in this area and drainage was dependent on low tide. In order to cope with the problem and to boost up production a closure and a regulator was built near the outfall of the Feni river in 1985 to facilitate improved water management in the Muhuri river basin.

The Muhuri Irrigation Project, consisting of a closure dam and a 20-vent regulator, was completed by Bangladesh in 1986 to provide irrigation facilities and to check the inflow of saline water into the river from the Bay of Bengal. The Muhuri empties into the Feni at the reservoir formed by the building of the closure dam from where water is taken out through irrigation canals. The project has helped develop inland fisheries, curbed incursion of saline water upriver and kept upstream areas safe from storm surges following cyclones. (BWDB, 2001. Brochure on Muhuri Irrigation Project)

3 Note that for irrigation in Asia the minimum values begin from US cents 1.7. See Aylward, B., Seely, H., Hartwell, R., & Dengel, J. (2010). The economic value of water for agricultural, domestic and industrial uses: A global compilation of economic studies and market prices. *Ecosystem economics.* For the Bangladesh case study see,
Chowdhury, Nasima Tanveer, 2010. "The relative efficiency of water use in Bangladesh agriculture," Quarterly Journal of International Agriculture, Humboldt-Universitaat zu Berlin, vol. 49(2), pages 1-18.

6.4.2 Current Scene

The Muhuri irrigation project in Bangladesh has tried to replicate the lessons of the BMDA smart card system for payment for irrigation services. Despite being told that smart card has begun to be used, we found this not to be the case. Very few farmers have adopted it – old practice of water sale and payment by area continued. No clear idea of how much water is used, neither local officials nor farmers could pinpoint. We had to make some assumptions based on farmers' information as to how to measure water used. That means, there are likely to be major errors in measurement.

6.4.3 Sampling Methods

Four upazilas under Muhuri Irrigation Project randomly to get information from local farmers and Deep Tube Wells (DTWs) operators. operators. The selected Upazilas were Feni sadar, Chagalnaiya, Fulgazi and Sonagazi. Four LLP (FSD13-Feni Sadar upazila, FGZ22-Fulgazi upazila, SON01 and SON03- Sonagazi upazila) where smart cards had been introduced were selected at random. A total of 12 LLPs were studied under this project. Unfortunately, there were only 12 smart card holders among 227 farmers sampled as shown by upazila. And even they did not use it andrather continued old practice of sale of and payment for water by area.

Table 6.3: No. of Repsondents from Different Upazilla

Upazilla	Respondents
Fulgazi	55
Feni Sadar	59
Chhagalnaiya	52
Sonagazi	61
Total	**227**

6.4.4 Methodology

To estimate the value of water in the Muhuri Irrigation Project Area, a production function was estimated. The function is as follows:

Q = f (L, K, L*K, W, W2, Hybrid[0,1], Farmsize[0,1,2,3])

Where

L, Labor = Number of workers (family + hired)

K, Capital = Value of Capital Asset

W = Volume of water

W2 = Square of W

Hybrid= 0 for HYV Boro, 1 for Hybrid boro

Farm size = 0 for landless sharecropper, 1 for small farm, 2 medium farm, and 3 for large farm

6.4.5 Results

The estimated equation is shown in the following table. Data collection on Muhuri irrigation projects were collected during the pandemic months and thus have observed many inconsistencies in the data including the fact that volume of water used by farmers did not exist and farmers continued to pay for water in terms of area under cultivation. Given the situation, effort to estimate a good production function has been failed. The best function that could estimate is the following which is a linear production function. At the same time, the primary objective is to understand how water and yield is related. The following table provides the best function consistent in terms of sign of the coefficients and their goodness of fit.

Dep Var : Output/bigha	Coef.	Std. Err.	t	P>t
Explanatory Variables				
Labor (Number)	0.120***	0.0266219	4.51	0
Capital (K in value)	0.00015**	0.0000685	2.27	0.024
Labor x Capital	-1.47E-06***	5.63E-07	-2.61	0.01
Water volume (m3)	1.374***	0.2344008	5.86	0
Square (water volume)	-0.0031***	0.0011467	-2.7	0.008
Hibrid = 1, HYV= 0	8.185**	4.0571	2.02	0.045
Farmsize (landless base)				
Small farm	4.58	4.076	1.12	0.262
Medium farm	33.51***	5.678	5.9	0
Large farm	44.52***	12.34523	3.61	0
Constant	8.614**	3.435653	2.51	0.013
N (Sample)	179			
Adj R-squared	0.8249			

Note: * p< .1, ** p< .05, *** p< .01

From the production function, the following values were obtained

MP of water : 1.28 maunds/cubic meter

VMP of water (with price of paddy at 23 taka/kg) at prevailing price : Tk 18.28

The VMP is the financial value water which is nearly US cents 23. Compared to BMDA results, this is quite high. It should have been lower as the water use is higher in Muhuri. Note that estimation of water volume was very problematic in this case as water sale and purchase was by area. On the other hand, it has been found that the Asian average is US cents 31 or thereabout. In that sense this is acceptable, but we still need to refine our methodology and calculative approaches-which may be done in the future. Applying the conversion factors as before, the shadow price of water in case of Muhuri comes to Taka 17.8 or just about US cents 22.

6.4.6 Conclusion

The estimated value of water in Muhuri must be treated with caution as there were major problems with estimation of volume of water. Given this, the value of water as found still seems to be within the bounds of such values elsewhere in Asia.

7. Value of Water in Industry

7.1 Introduction

As statd before for industry sector, four industries were chosen:

- Power
- Construction
- Apparels
- Food and Beverage

In this section the estimate value of water for each sub sector has been described. But before that a few issues related to valuation of industrial use of water including the analytical method that had been used need to be described.

7.2 General Method for Estimation of Value of water (VoW) used in Industries

Industrial data are difficult to find in public space. The CMI/SMI data should be the ideal place. However, these data do not report water usage while private industries are often reluctant to share them with anyone outside the regulators. Hoever, management level officials the industries were part of the committee that monitored the study at the Ministry of Water Resources and so it was possible to pursue them and through them a few others to provide water and other related data needed for estimating the value of water. Note that within any industry, there are likely to be differences in technology in use and therefore the input-output relationships including water usage. In such a case, estimation of a production function is the preferred methd to find out an average situation.

Unfortunately, it is not easy to get all the necessary information in case of industries. A detailed set of data on output, capital asset by categories, labor force by categories, volume of water used etc. would have been ideal for estimating a production function. Such a detailed set of would have been ideal for estimating a CD or similar production function. Even if these were available, time did not permit during the Covid pandemic to collect information from a requisite number (say 25 to 30) of firms. Indeed, for food and beverage we could collect data from only two firms and in case of construction about five (5) construction firms. In such a situation the only way we could get an estimate is to use the fixed-coefficient production function (known as Leontief Production Function) to estimate the value of water. The derivation is shown below.

Let Q_i to production of industry i, and the production function is given as:

$$Q_i = \min\{ \alpha_i I_i, \beta_i W_i \}$$

Where I is the amount all other inputs used in production, W is amount of water used in the production and α and β are output-input ratios with respect to I and W respectively. Using standard derivation, it can be shown that the cost function is linear and the marginal cost of water is constant.

Therefore, $Q_i = \beta_i \overline{W_i}$ or $\beta_I = \overline{Q_i}/\overline{W_i}$ is the average output per unit of water produced from water in the ith industry. On the other hand, we can estimate the economic value of water for the i th industry = $P_i \cdot \beta_i$

where P is the average price of output, β is the estimated fixed coefficient based on average unit of output producer per unit of water for each industry and i = power, RMG, food and construction.

In case of power sector, the price of electricity is regulated below the competitive market equilibrium and hence the study team adjusted the output price (electricity price) with equivalent international price using a conversion factor.

7.3 Water Valuation in Power Sector

Water is used in power generation plants for both generation of steam and cooling purposes depending on the technology and primary fuel used for power generation. We first provide some ideas of power generation capacity by fuel and technology in the country and then go on to the estimation of water use and its valuation.

7.3.1 Generation Capacity, Technology and Fuel Use

Generation Capacity

The total installed capacity for power generation in the country in 2019-20 was 19223 MW. Another 1,160 MW was imported. The total domestic capacity included 9,717 MW Public (50.5%) and 7,332 MW (38.1%) IPP/SIPP. The rest was smaller capacities of 622 MW (3.2%) JV, 1,301 MW (6.8%) Rental Power Plant, 251 MW (1.3%) under REB (for PBS). As rental power plants are also privately owned the proportion of such installed generation capacity is just about 45%.

The installed capacity by plant-type and primary fuel type are shown in Table 1 below. It may be noted that just two types of plant, combined cycle and reciprocating engines account of nearly 80% of total generation capacity. On the other hand, in terms of primary fuel, natural gas accounts for 57% of primary fuel used while furnace oil accounts for nearly 29% the two accounting for a total of just about 86 percent of primary fuel for power generation.

Table 7.1: Domestic Installed Capacity (in MW) by Plant Type and Primary Fuel

By type of Plant		By type of Fuel	
Hydro	230 (1.2)	Hydro	230 (1.2)
Steam Turbine	2,966 (15.4)	Gas	10,979 (57.1)
Gas Turbine	851 (4.4)	Furnace Oil	5540 (28.8)
Combined Cycle	7330 (38.1)	Diesel	1,290 (6.7)
Reciprocating Engine	7808 (40.6)	Coal	1146 (6.0)
Solar PV	38 (0.2)	Solar PV	38 (0.2)
Total	**19,223**	**Total**	**19,223**

Note: Figures in parentheses indicate percentage of the column total

7.4 Energy Generation

Total net energy generation in FY 2019 -20 was 71,419 GWh in the country. Net energy generation in the public sector was 35,316 GWh and 29,429 GWh in the private sector (including REB). Another 6,674 GWh was imported from India. The total net energy generated in public and private sector power plants by type of fuel are shown in Table 7.2. It is interesting to note that while natural gas is the primary fuel for power plants with 57% of domestic installed capacity, its share in generation is far higher while the furnace oil, the second most important primary fuel for installed capacity, the proportion in actual generation is half of that.

Table 7.2: Energy Generation by Fuel in FY 19-20 (GWH)

Fuel	Generation
Hydro	825 (1.3)
Natural Gas	51290 (79.2)
Furnace Oil	9461 (14.6)
Diesel	139 (0.2)
Coal	2968 (4.6)
Renewable Energy	62 (0.1)
Total	**64745**

Note: Figures in parentheses indicate percentage of the column total

7.4.1 Technologies of Power Generation Plants

A power plant is an industrial facility that generates electricity from primary energy. Most power plants use one or more generators that convert mechanical energy into electrical energy. There are two types of power plant: simple cycle and combined cycle power plant. Simple cycle gas plants are a type of natural gas power plant which operate by propelling hot gas through a turbine, in order to generate electricity. In a combined cycle plant or combined cycle gas turbine, a gas turbine generator generates electricity, and the waste heat is used to make steam to generate additional electricity via a steam turbine. Combined cycle technology allows a power plant to generate 50 percent more electricity from its fuel than it could with a simple cycle power plant.

7.4.2 Water Use in Power Generation

Water is a non-consumable input in the production of electricity from power plants. Water requirement for production of electricity can be divided in two parts, first, for construction of the power plant itself and secondly in actual power generation. It is the second part that this study considers.

In this case, water is used for two purposes. One part is where water is heated up to turn into steam to turn the turbine. The other part is used to cool the system so as to condense the steam and recycle it. As the steam condenses back to water, the surplus (waste) heat which is removed from it needs to be discharged by transfer to the air or to a body of water. This cooling function to condense the steam may be done in one of following two ways:

Direct or "once-through" cooling. If the power plant is next to the sea, a big river, or large inland water body it may be done simply by running a large amount of water through the condensers in a single pass and discharging it back into the sea, lake or river a few degrees warmer and without much loss from the amount withdrawn.

Recirculating or indirect cooling. If the power plant does not have access to abundant water, cooling may be done by passing the steam through the condenser and then using a cooling tower, where an up draught of air through water droplets cools the water. Sometimes an on-site pond or canal may be sufficient for cooling the water. The cooling tower evaporates up to 5% of the flow and the cooled water is then returned to the power plant's condenser. The 3 to 5% or so is effectively consumed and must be continually replaced. This is the main type of recirculating or indirect cooling (World Nuclear Association 2020).

7.4.3 Real Life Water Consumption in Power Plants

Primary fuel, technology of power production and cooling technology in use (once through, recirculating etc) all these affect actual water use. The other factor that may influence water use is the cost of water whether bought or pumped in from surface or underground sources and treated, if necessary, before use. Quite obviously if water use is higher for the same amount of power produced, the productivity of water will be lower and for the same price of output, i.e., power generated, the value of water will be low. Water use per unit of power generated is thus a major factor in valuing water in power generation.

Below we show the use of water per unit of power generated in several countries (Table 3). The figures are in cubic metres of blue water per Mwh of power generated using natural gas and combined cycle technology and closed loop or recirculating cooling system. We find that the maximum is 1.1 – 1.2 cubic metres per Mwh of power. The lowest seems to be in USA where the minimum is 0.1 cubic metres while the maximum is not far above India's or the global one while in Turkey also this is lower, 0.75 cubic metres. Overall it may be concluded that more or less 1 cubic metre of water usage per Mwh of power generated is the global norm. We will see in a while where Bangladesh stands in comparison to this country specific or global average.

Table 7.3: Water Use for Power Generation

Country	m^3/Mwh
India	1.2
India	1.1
Turkey	0.75
USA	0.1-1.5
Global	1.1

7.4.4 Estimation of Value of Water

Data on power generation

BPDB was approached for information related to water use by type of plant and fuel. Data were requested for 5 years so that one could obtain a time series for cross-section. Information, however, for only 6 plants were obtained, all gas based combined cycle except one single cycle plant. While power generation figures were given for all years, water volume were missing for some years for one other plant. The analysis of data had to exclude that information.

The water use was found to be 1.15 cubic meter/Mwh production. Thus, while the sample size is highly restricted, the average water use was at par with the global norm. Note that all the plants in the sample were gas based. What would happen when coal-fired or other types of technology are used, may not be guessed from this figure.

In this study, a Cobb-Dauglas type production function has been used for the power sector with megawatt hours of electricity produced in each of the power plant over a year against the key input of water measured in cubic meter. Both variables are in log-form. However, since data on capital and other key inputs were absent, we have used capacity (measured in MW) as a proxy for capital. There are two types of technology for production of electricity in the sample – combined cycle and single cycle which are also used as a dummy variable in the model. The estimated equation is presented in the following table. There are three models used for estimating the value of water among them and the model 3 has been used to estimate the value of marginal product of water in the power sector.

The equations are shown in Table 7. 4 below:

Table 7.4: Estimated Production Functions for Power Generation

(Dependent variable Gross power generated in ln Mwh)

Explanatory variables	Model 1	Model 2	Model 3
Capacity	0.011 *** (5)	0.012*** (6.49)	0.0086*** (5.14)
Ln W(water in m3)	0.065 (1.3)	0.197** (2.64)	- 0.35** (2.5)
Techdum (Technology dummy :combined cycle =1, else = 0]	0.239 (0.95)		2.86*** (4.25)
Techdum (0)x water		0.00007*** (2.97)	0.00015*** (5.43)
Techdum (1) x water		1.10E-07 (1.42)	3.61E-07*** (2.91)
Constant	11.077*** (20.85)	8.93*** (8.78)	13.66*** (10.26)
Adj R-sq	0.714	0.797	0.896
N	23	23	23

Note: Figures in parentheses are t-statistics. *** and ** indicate statistical significance at 1% and 5% levels

Techdum: Single cycle = 0; combined cycle = 1

In model 1, the sign of technical dummy is negative indicating that combined cycle has lower productivity than single cycle which is contrary to expectation. On the other hand, however, the coefficient is insignificant. Furthermore, the adjusted R-sq although high is lowest of the 3 models. Because the tech dummy variable is showing negative coefficient, we have tried model 2 in which the Techdum variable has been dropped but its interaction with water has been introduced instead. There had been some improvement in adjusted R-sq while all the coefficients were as expected showed positive signs and except for combined cycle interaction with water, all coefficients tuned out to be significant at 1% or 5% levels.

Model 3 introduced Techdum variable again along with its interaction terms. This time, the adjusted R-sq showed very substantial improvement to nearly 90% meaning the explanatory variables explained 90% of variation in power generation across plants. However, the coefficient for water was unexpectedly negative, possibly meaning that there may be some overuse of water given the state of technology. On the whole we may say that despite substantial data problems, the experiment with production function has yielded some good results and future exercises of similar nature may be extended to various vintage of (and thus technological changes in) power generation as well as types of primary fuels used in such generation.

For estimating value of water, the next step was to calculate the Marginal Price (MP) of water and Value of Marginal Products (VMP), its value at the market prices. The MPs and VMPs based on the three (3) models are as follows (Table 7.5);

Table 7.5: MPs and VMPs of Water from Three Models

Model	Technology	MP (Mwh/M³ water)	VMP	
			At BD price (Tk)	At US price (Taka)
Model 1	All technologies	0.05	480.43	644.70
Model 2	Single cycle	0.17	1459.73	1958.84
	Combined cycle	0.17	1459.13	1958.04
Model 3	Single cycle	-0.31	-2573.64	-3453.63
	Combined cycle	-0.30	-3455.35	-3455.35

The minimum value of water as estimated above is somewhat lower than Taka 500/cubic meter. The higher figures (at BD prices) are nearly Taka 1500/cubic meter. These figures are way above what is found in the literature. In China, for example, an estimate shows it to be 0.05 yuan/ton or US cents 0.75. If the Chinese case is typical of a developing country, Bangladesh value of water in power generation is far higher than in other countries. On the other hand, if the Model 3 results are used, water has a negative value and if correct, must mean excessive use of water than is necessary.

Note that we have not used any conversion factor to convert the above value to shadow price. This is because the Planning Commission has no such conversion factor for electricity. However, given that gas is subsidized for power production while the consumers also receive subsidy as BPDB sells below its production cost, one can perhaps safely assume a conversion factor of 1.25 for electricity price. On that basis the average shadow price of water becomes 1.25 times of what has been stated above. More precisely, the figures may be Tk 600 per cubic meter taking the lower value stated above. The maximum may be Tk 1800/cubic meter. One can, based on these estimates safely assume it to be at least Taka 1000/cubic meter.

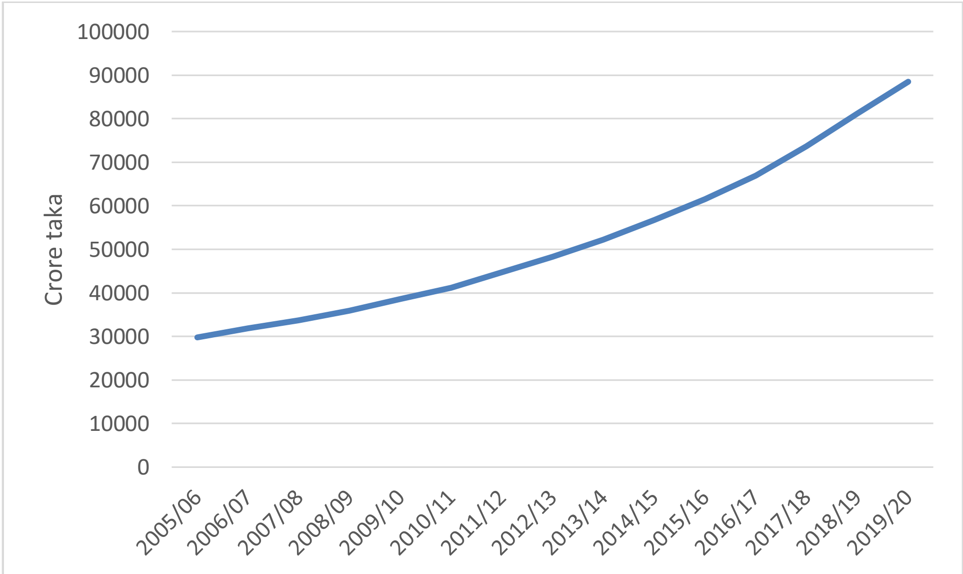
The implication of the above results is obvious. In power generation, water is a very valuable resource. No effort should be spared to conserve it as much as possible. One implication is that direct or once through cooling method should be avoided. On the other hand, if a negative value is accepted, that also means that water conservation must be practiced to the hilt.

7.5 Water Valuation in Construction Sector

7.5.1 Introduction

The construction sector of Bangladesh is playing an increasingly vital role in the economy amid continued urbanization and an array of large infrastructure projects undertaken by the government. Over 2005/06 to 209/20, the sectors contribution to GDP (at constant prices of 2005/06) has risen three-fold from a mere Taka 298 billion to Taka 885 billion (see Fig 7.1 below).

Figure 7.1: Contribution of Construction Sector to GDP (at 2005/06 Constant Prices)



Source: Based on MoF, Economic Review 2019-20

Apart from its direct role as a contributor to GDP, it has a major backward linkage because of its dependence on various construction raw materials such as cement, bricks etc. On the other hand, it is also a major consumer of water, electricity as well as land, all scarce resources. It is therefore imperative that these resources be used most judiciously to conserve them, particularly water. In this exercise, we first provide some information related to water use in such construction activities and then how such uses may be valued for investment decision purposes. It is necessary to point out here that we focus here on only construction of buildings, not other infrastructures like roads and highways. We begin with a description of water use practices in such construction.

7.5.2 Different Stages of Construction Process and Water Use

A high rise building construction comprises the following stages and water is required almost at every stages;

a. Site preparation/ design phase

b. Implementation Phase

- Preparation of site
- Foundation
- Foundation Casting
- Colum casting
- Grade beam casting
- Stair casting
- Column casting (ground floor)
- Floor beam and slab casting

c. Construction of the Columns

- Rod binding
- Shuttering arrangements
- Concrete pouring

d. Curing

e. Construction of Lintels

f. Finishing of Curing

g. Wall construction

h. Plastering

i. Construction of sanitary pits and laying of underground R.C.C pipe

j. Ground Floor Preparation

k. Soling is prepared upon compacted sand filled trenches for ground floor:

l. Tiles laying

m. Construction of boundary wall

n. Construction of entrance road and collapsible gate fitting

o. Finishing Work: Fittings of kitchen, Windows and door, pan/commode, shower and basin in the bathroom, electrical ducts, wires and cables and fixing electrical fittings etc.

7.5.3 Water Use in Different Stages of Construction

Water is used in various stages and operations of construction which are the following:

- Concrete mixing & curing
- Brick Soaking
- Sub- Grade Stabilization
- Dust Control
- Water line testing & cleaning
- Brick work and curing
- Plastering and curing
- Soaking Stones
- Making mortar for setting tiles and curing
- Bathing, Cooking by construction laborers etc.

7.5.4 Water Use Experience in Other Countries

Water use in construction should be based on standard engineering practice although, the actual use may differ due to technology. delays in construction, low price of water leading to overuse where technical standards may not apply (as in case of water for personal hygiene and related other personal uses) as well as laxity in application of standard practices. There are not many examples that could be found for water use practices in construction of buildings. However, at least examples from India might be useful. Note that in such cases two types of water use figures have been used. One is the embodied water in all construction material. Here, however, we are examining only the water use in actual construction and related other water use.

The data are from construction in around Kolkata and in Pune. In Kolkata, the water use per sq meter of built area was 2 m3. In Pune, apparently there were two extreme cases due to very long period of construction. Taking all the 12 sample cases into account the ideal standard use of water should have been 3.1 while the actual use was 6.1 m3/ sq meter. Excluding the extreme cases does not change the respective values much and these become 2.9 and 5.4 m3/ sq meter. However, when we examine the individual cases, among the 10 non-extreme cases, six were around 2.4-2.5 m3/ sq meter. Another study using Iranian data employed both embedded and construction water application in case of of residential buildings. It came up with a figure of 3.05 m3/ sq meter. On the whole therefore the use of water apparently varies between 2.5 to 3 m3/ sq meter.

7.5.5 Methodology of Investigation and Rationale

The above indicates that while there may be some variation in water use during construction of buildings, it may not be very much mainly due to the engineering principles given a specific technology. Yet, there are some variations. On the other hand, it has been found that water use is some what standardized across countries and there is not much variation. We have therefore used a fixed coefficient production function as described in sub-section 7.2 in detail.

In this case, the average productivity of water which is the ratio of sq meters of space constructed and cubic meter of water used is also the marginal product of water. Multiplying this by the price of water gives us the value of marginal product or the value of water. This is, however, the private value of water. To transform this into social value or shadow price of water, we need to multiply it by the conversion factor for a building which we did (see later). Data was collected using a checklist for output, water usage and its detail including sources and pricing and costs

7.5.6 Results

Water usage by enterprises

The water usage average was found to be 4.30 m3/ sq meter with a range from 1.49 to 6.81 m3/ sq meter. Thus, the usage appears to be at least 40% higher, if not more than in other countries. However, it appears that when the water bill paid by the enterprises is divided by the rate of water charge, the water volumes become somewhat lower. This time the average comes down to 3.51 m3/ sq meter, still higher but 22-23% lower than the earlier figure. Compared to a high value of 3 m3/ sq meter elsewhere, this is only 17% higher.

Using those above values and applying the price of output (i.e., price of space per sq meter) the following four (4) values of water (for high and low price of space and high and low productivity of water, all in Taka) have been obtained as 396.66, 324.41, 105.78 and 86.51. Thus the average value comes to Taka 224.84.

It has been found that the Planning Commission uses a conversion factor of 0.75 for office buildings in project appraisal. Using, therefore, a conversion factor of 0.75, the shadow price ranges from Tk 298 to Tk 65 with an average of Tk 169 which comes to just above $2 per cubic meter. This is higher than say in China where it is just less than $1.

We find that the usage of water is higher than in other countries and yet, the value comes out to be higher if China is a typical case. What does this mean? Water is used excessively? If so, why the productivity and value is higher. We believe that the problem lies in under-pricing for water as well as over pricing of space. These issues need to be looked at more closely in future analysis.

7.6 Water Valuation in Food and Beverage Industry

7.6.1 Introduction

The current information on manufacturing industries including food and beverage is not known with certainty as the last SMI was in 2019 although little by way of results have been published so far. The previous surveys were in 2012-13 since when there had been major growth in the economy which must have also resulted in changes in the food and beverage industries. However, the Economic Review of the Ministry of finance indicate that food industry had a major growth over years. The quantum index of the food industry (with 2005/06 as the base year) indicated that in 2007/08, it stood at 109.52, doubled to 219.1 by 2189.81 and since then by 2018/19 to 272.74012/13 and again more than doubled by 2018/19 to 562.70. That means over the last 14 years, the output of the industry has increased to 5 times its level in the beginning. The beverage industry had a less vigorous growth. Between 2007/08 and 2012/13, the quantum index of production rose from 115.84 to 189.81 and then by 2018/19 to 272.74. That means over the last 14 years it had its output roughly doubled.

Quite naturally, such changes mean that there must have been rise of enterprises specializing in such activities and with that also employment. We have however no recent information of such changes. The industries under discussion here are water intensive industries and their expansion over years mean that there had been rise in consumption of water by these industries including discharge of industrial effluents impacting environment including water resources. To give just some understanding of how, a beverage industry may impact on water resources, we provide some information from global literature in the next sub-section.

7.6.2 Water Consumption and Value of Water in Food and Beverage Industry

For the present study, we have collected water use data from two selected food and beverage industries, one from each category. The following section states the methodology, data analysis and results of the investigation. Water Use in these industry analyzed it only for the production process and does not include the lifecycle of water of the products of the food and the beverage industries in Bangladesh.

7.6.3 Results

Beverages

In the beverage industry, the consumption of water varied between years. It ranged from 1.34 to 1.54litres of water usage from each litre of beverage produced. As we are using the fixed coefficient production method here, its inverse is the marginal productivity of water which comes therefore ranges from 0.65 to 0.75. Using the firm gate price of output, the value of marginal productivity comes to 13 to 15 taka/ cum which is the financial value of water in beverage industry.

The water in the particular beverage industry is sourced through own operated tube wells and water treatment is done while effluents are discharged as claimed after treatment. On the other hand, however, there are two other aspects one of which is the environmental impact on ground water reserve as well as health considerations due to consumption of sugar-based carbonated water. If these are major issues, there should be a conversion factor less than 1 to convert the above financial values into social value of or shadow price of water. As we do not have definitive information on these issues, we do not make such adjustment to the financial value above.

Food

Only two products, noodles and instant cereal, were examined for valuing water as these were the most water intensive products as stated by the manufacturer. Data were obtained for 3 years, 2017. 2018 and 2019. The data for water consumption and output of these two products are shown in Table 7.6.

The table indicates that for the years 2017-2019, noodles production used on an average 12,114 cubic meters of water while producing on an average 13,183 tons of giving an average of 1.1 kg of noodles per litre of water which translates to less than a litre of water per kg of noodles produced. For Instant cereal the respective figures were: 5406 cubic meters, 3828 tons and 0.7 kg per litre of water indicating water use of 1.4 litres per kg of output. Instant cereals therefore more water intensive than noodles.

Table 7.6: Output and water use for noddles and Instant cereal (year-wise)

Product	Year	Output (ton)	Water use (kl/ton)	Output/water (ton/cub meter)	Output value (BDT)
Noodle	2017	11704	13125	0.89	16,03,898
	2018	13256	11404	1.16	16,94,876
	2019	14589	11814	1.23	18,84,579
Instant cereal	2017	3849	4962	0.78	12,18,946
	2018	3909	5406	0.72	12,63,339
	2019	3726	5850	0.64	12,36,524

From the values of output provided by the manufacturer we arrived at an average price of around Tk131 per ton for noodles and Tk 324 per tons of instant cereal. Using these prices and noting that as we are using a fixed-coefficient production function, average product per unit of water is also the marginal productivity, we apply the above prices to value them. The financial values of water for the two products thus come to just about Tk 144 for noodles and 230 for instant cereal. The average for both comes to just above Tk 187 per cubic meters of water.

For these products there is no conversion factors. However noting that these products are processed using wheat and wheat has a conversion factor of 0.92 (as used by the Planning Commission), the above values have been multiplied by the factor and we come to shadow prices of Tk 132 for noodles and 212 for instant cereal. In US dollars, these come to 1.61 for noodles and 2.58 for instant cereal, the combined figure comes to just above US $ 2.

7.7 Water Valuation in the Apparels Industry

7.7.1 Introduction

The readymade garment industry is the largest export earner and contributes about 83% to total export earnings of the country (Table 7.7). The Apparels industry of Bangladesh started its journey in the 1980s and contributed over $27.9 billion worth of exports in 2019-20 financial year (Ministry of Finance, Economic Review, 2020). Currently, there are more than 4,000 RMG firms in Bangladesh. Both woven products (shirts, jackets and trousers) and knitwear (undergarments, socks, stockings, T-shirts and other casual and soft garments) are exported with woven products slightly outweighing knit products (Fig. 7.2).

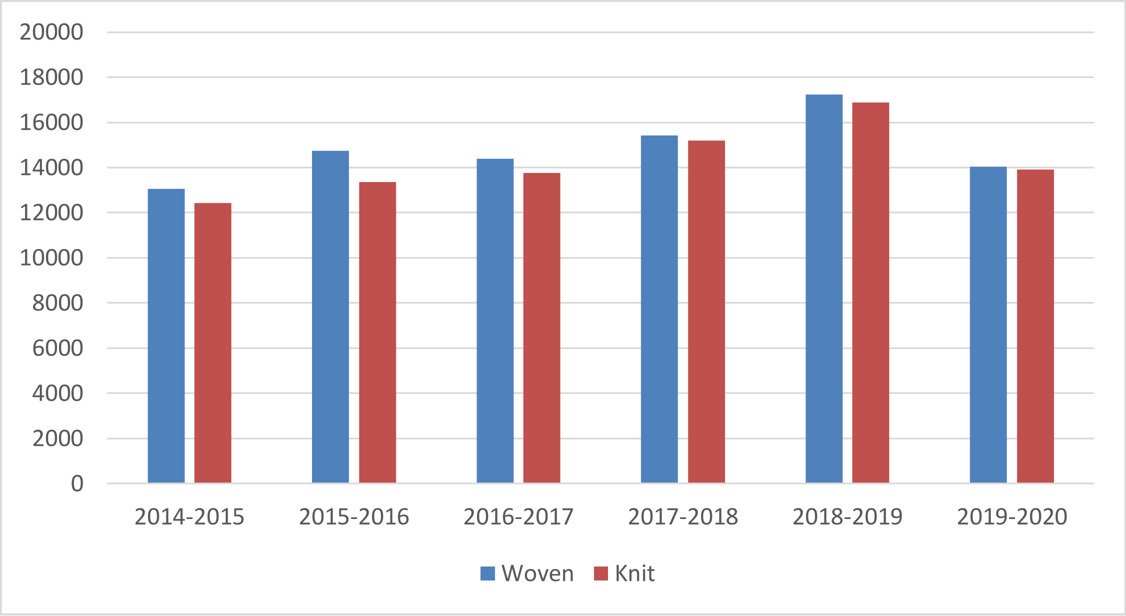
Table 7.7: Export of RMG (Woven and Knitwear) & Total Export of Bangladesh (Value in Million USD)

Year	Export of RMG	Total Export of Bangladesh	% of RMG's to Total Export
2015-16	28094.16	34257.18	82.01
2016-17	28149.84	34655.90	81.23
2017-18	30614.76	36668.17	83.49
2018-19	34133.27	40535.04	84.21
2019-20	27949.19	33674.09	83.00

Table 7.8: Main Apparels Items Exported From Bangladesh (Export Value in Million USD)

Year	Shirts	Trousers	Jackets	T-Shirt	Sweater
2015-2016	2317.09	6319.00	3774.08	6118.53	3182.47
2016-2017	2108.38	6026.69	3546.88	5861.98	3361.53
2017-2018	2063.57	6389.38	3978.47	6292.25	3674.70
2018-2019	2324.85	6939.61	4384.81	7011.26	4255.91
2019-2020	1783.14	5447.13	3514.21	5614.00	3597.68

Figure 7.2: Apparels Export from Bangladesh
(Export Value in Million USD)



RMG (both knit and woven) are major water using industry particularly in processes such as washing and dyeing. Recently the BGMEA has set on a target to reach $50 billion of export for textile sector by 2021 which is projected to $82.5 billion by 2030. To meet this ambitious target, the industry will need among others huge inputs of water. Between 2012 and 2016, the water usage by knit products increased by 20% and for woven products by 23%. By 2016, this resulted in around 232 million m3 of groundwater extraction. If this rate of growth in usage continues, by 2030, the demand for water will be huge and therefore, one must be cautious in water use in Apparels industry. This should also be kept in mind that the industry releases tremendous amount of grey water i.e., effluents which create major environmental and health problems which should be factored in while understanding the impact of water usage in this industry as well as while converting financial value of water into shadow prices.

7.7.2 Water Use in Apparels Industry

How much water is used in the apparels industry? The answer depends on whether one uses a life cycle analysis or only a process analysis. In the present exercise, only the process part is considered. Water is used throughout all processing operations like dyeing, finishing, fabric preparation steps, including desizing, scouring, bleaching and mercerizing, etc. Approximately 85% of the water is used and discharged from factories is in the so-called wet processing stage, as shown in Figure 7.3. Figure 7.4 shows the proportion of water used in the various operations in apparels production in Bangladesh.

Figure 7.3: Wet Processing Stages where Water is Used

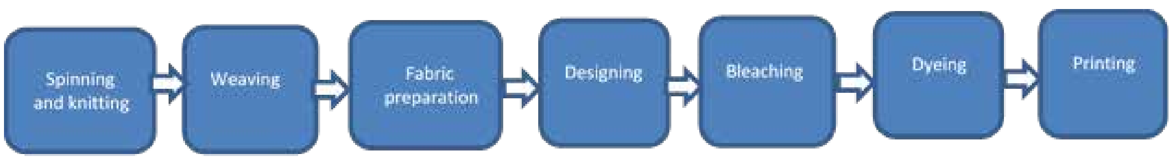
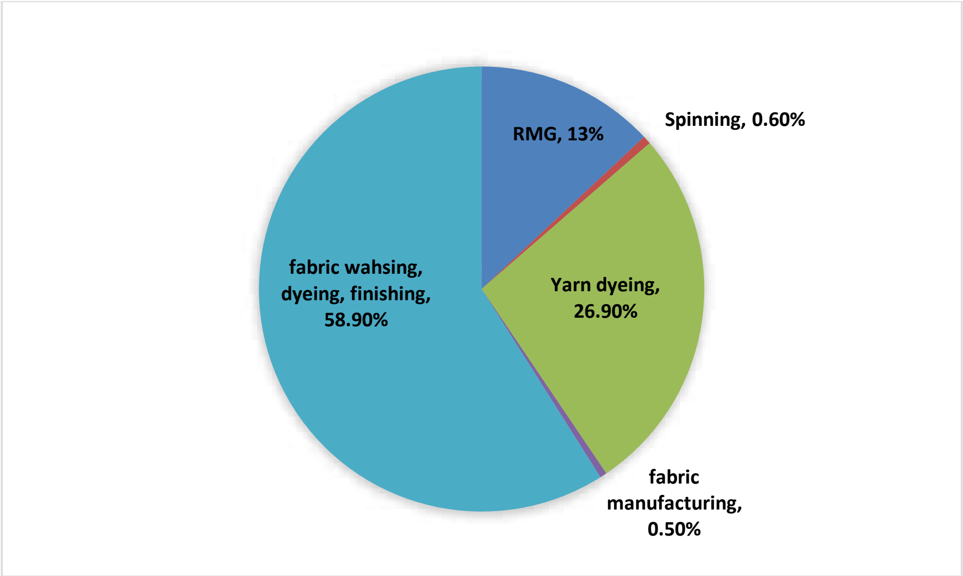


Figure 7.4: Distribution of Water Footprint by Different Stages in Apparels Industry

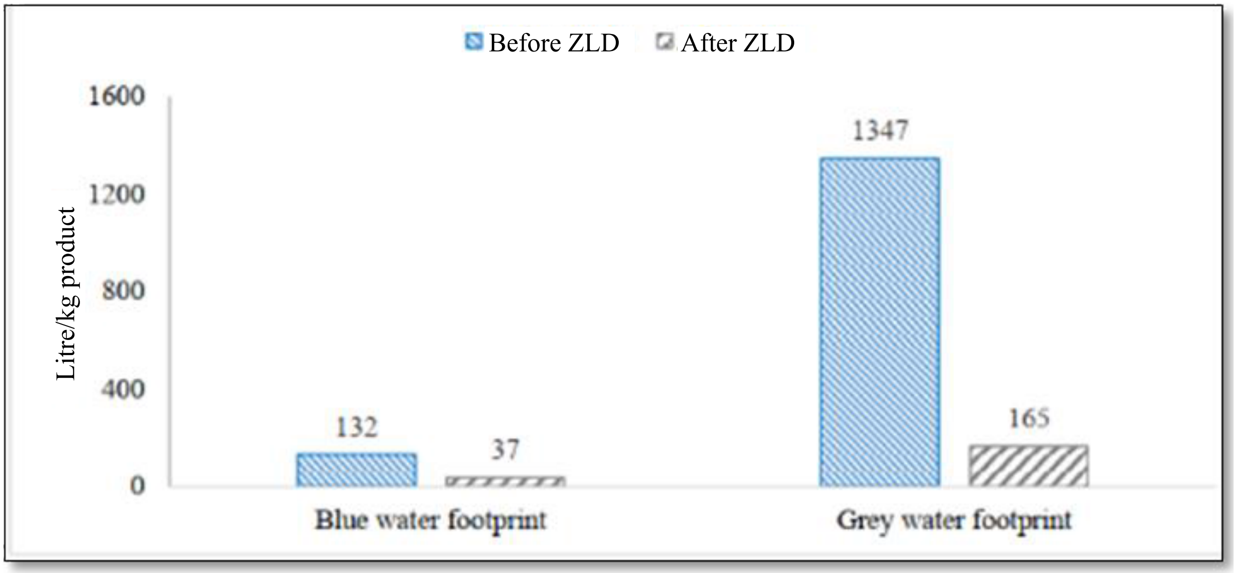


Source: Hossain L 2017

The average RMG factory water consumption in Bangladesh is estimated to be around 250 to 300 litres of water per kilogram of Apparels produced. On average, an estimated 100- 150 litres of water is needed to process 1 kilogram of fabric material. Approximately 28 billion kilograms of textiles are dyed per annum in the Apparels industry using over 5 trillion litres of water.

Bangladesh DoE has recently issued the Zero Liquid Discharge (ZLD) Regulation to deal with the effluent discharge and, requiring all textile/RMG mills to install zero liquid discharge effluent treatment plant (ZLD-ETP) systems. Such a system may substantially cut down water usage and effluent discharge as shown in Figure 7.5.

Figure 7.5: Water Footprint for Per kg Fabric Before and After ZLD



Note: Blue water: Use of groundwater or surface water; Grey water: Pollution of water.
Source: Hossain L 2017

7.7.3 Water Footprints of Different RMG Products

Available literature indicates that blue water foot print on the whole may not have risen much over the last few years for knit products (Table 7.9). However, for woven products, it has risen comparatively more in recent years (Table 7.10). This has been mainly due to the fact that dyeing of fabric for knit products has hardly changed over years and that the usage per mt has remained around 145 m3/mt of fabric for knit. In contrast while usage per mt of woven products also has remained roughly constant, although at a somewhat higher level of 163 m3, the quantity of fabric for dyeing has increased by nearly a third over 2012-2016.

Table 7.9: Blue Water Footprint of Fabric Dyeing (Internal Water Footprint) for Knit Products

Year	Fabric, metric ton	Fabric dyed, metric ton	Blue water footprint, m^3
2012	661471	299837	43444479
2013	692106	310559	45056830
2014	708082	318613	46208690
2015	803505	359160	52133873
2016	820401	368147	43444479

Source: Hossain L 2017

Table 7.10: Blue Water Footprint of Fabric Dyeing (Internal Water Footprint) for Woven Products

Year	Fabric, metric ton	Fabric dyed, metric ton	Blue water footprint, m^3
2012	718209	368801	60292573
2013	760409	395668	64714902
2014	801450	422855	69072034
2015	880162	458397	75008099
2016	924575	487564	79672388

Source: Hossain L 2017

It should be noted that in recent years there had been some attempts at cutting down water usage in Apparelss industry. As this has implications for future directions as also indicated by our own analysis, this needs some brief discussion as shown in next sub-section.

7.7.4 Actions for Efficient Water Use and Sustainable Water Footprint in Bangladesh

IFC -ed Advisory Partnership for Cleaner Textile (PaCT) is a program to support the entire textile value chain – spinning, weaving, wet processing for final processing in garment factories for adopting Cleaner Production practices to ensure environmental sustainability. This program was launched in 2013 and by implementing their recommendation for cleaner production, 29 PaCT factories successfully reduced around 27% of their average water consumption.

7.7.5 Method and Results

For Apparels sector, secondary data on water use of woven and knit products in washing, dyeing and finishing were used for analysis. The main data set was obtained from a survey of 80 factories which were supported by PaCT. Using the data. the following water uses in different stages as derives are shown in Table 7.11.

Table 7.11: Water Uses in RMG

Indicators	Only washing	Only dyeing	Dyeing & washing	Dyeing & finishing	All dyeing	Whole sample	Per kg of finished RMG product
Water (m3)/Kg of output (before)	10.34	8.12	7.98	6.14	6.68	8.75	17.02
Water (m3)/kg of output (after)	9.61	7.49	7.97	5.21	5.95	8.02	15.56
Water saving/kg of output (percent)	-7.0%	-7.8%	-0.2%	-15.1%	-11.0%	-8.4%	-18.1%
Water saving per Kg (m3)	0.73	0.63	0.01	0.93	0.74	0.73	1.46

Source: Calculated based on data from 80 Firms supplied by BCAS
Note: Before means, prior to intervention for lowering water use; after means after such interventions

The table merits some discussion. It is found that in all operations and as a whole, there had been some (not very substantial though) fall in water use per unit of product processed at various stages and as a whole. Yet, it is not insignificant, as a whole it comes to nearly 20%.

Now, using a fixed coefficient production function method and the above set of data, the following results were obtained

The water use figures as stated in Table 7.9 mean that the average productivity (which is also the marginal productivity) of water is

1/17.02 or 0.0587 kg before and
1/15.56 or 0.0642 kg after water conservation measures.

The prices are by units of Apparels, not by weight while all the above information related to water use is by weight of fabric. To get the price by weight, conversion had to be made from numbers to weights. From literature it was found that

Knit shirt weight: 250 gm/piece- price of a knit shirt is US$ 4 which means a kg of knit shirt has a price tag of US$ 16.
Similarly, Woven weight: 400 gms/piece - price in US$/piece is 5 or per kg is 12.5
Average price per kg of Apparels is US$14.25.

Applying the export prices and weights of products as above and an exchange rate of US$1= Tk 85, on the MPs as shown earlier:

Value of water (VoW) before conservation: Tk 71.16

Value of water (VoW) after conservation: Tk 77.85

As the prices are competitive export prices, no conversion factor needs to be used to convert them into shadow prices.

Thus the above values are the shadow prices of water in RMG.

Note that as discussed earlier, the disutility due to industrial effluents as well as other environmental costs could not been integrated. Adding these will perhaps lower the value of water as in such a case a conversion factor less than 1 may have to be used. However, as these sues have not been or could not be considered due to the nature of the available data, this remains a matter for future research.

8. Value of Municipal Water Supply for Residential Use

8.1 Introduction

Life cannot sustain without water. SDG 6 has as its first priority as safe and affordable supply of drinking water. Supply of safe water for drinking and other residential purposes is therefore a major issue for the Government of Bangladesh. In rural areas the thrust is on supply using tubewells while in the urban areas the emphasis is on supply of piped water. Consequently, supply of water by local agencies, like WASA or municipalities in Bangladesh, have become a norm. Despite such efforts, according to the MICS 2019 report, less than one-half, about 48.8 percent, of population in urban areas in Bangladesh has access to safe drinking water in Bangladesh. This signifies the importance of major efforts for supplying clean and safe water in urban areas. This chapter discusses and analyses the value of such water particularly from the angle of what benefits households with supply of clean water gets in contrast to those who do not. This also means increasing rate of extraction of water to meet the demand for water.

According to a Bangladesh Water Development Board report, the average rate of annual groundwater decline in different parts of the city was 0.17 metre to 0.6 metre from 1970 to 1980; 0.15 metre to 0.69 metre from 1980 to 1990; 0.56 metre to 2.26 metre from 1990 to 2000 and 1.24 metres to 3 metres since 2000. (Alam, 2018). As a result, the Government of Bangladesh has already prioritized use of surface water throughout the country.

There are two different aspects of water in urban water supply: the quantity of water and the quality of water. Shortage of water supply like not making water available 24 hours a day, or not giving access to water to each and every household, leads to less hygienic conditions of living. Incidence of female-diseases, kidney diseases, and skin diseases are linked to inadequacy of availability of water in a house while there are many other diseases linked to quality of water supplied to a house. In this report, we concentrate on the issue of supply of adequate volume of water (as the ToR of study stressed the issue of scarcity value of water) and hence, the valuation exercise uses the quantity of water related disease and would like to answer the cost saving (benefits) due to supply of water to a house. Of course, this means that the estimates that are made here are likely to be underestimates of the value of water.

8.2 Conceptualising Cost of Health for Valuing Water

The value of water for household use (quantity) may be measured using the productivity of water in terms of reducing incidences of water scarcity related illness using the cost of health approach. Cost of illness were assessed by comparing households with adequate supply of water (connected to piped water supply) and without piped water supply connections. The costs included a) cost of treatment, b) cost of doctors/hospitalization, and c) workdays and consequently income lost between these two types of households.

More formally, one can estimate a health production function from which the the following equation may be derived to estimate the value of water (note that δ indicates change, in this case between those with adequate water supply and those without) ¨.

$$\frac{\partial I}{\partial w} = W.\frac{\partial H}{\partial w} + m.\frac{\partial M}{\partial w} + a.\frac{\partial A}{\partial w} + \frac{\frac{\partial U}{\partial w}}{\lambda}.\frac{\partial H}{\partial w} \ (1)$$

Where I is the damages due to sickness from lack of availability of water, w is the availability of water, H is health impact from shortage of water measured as sick days, M is the health cost (medical costs) due to water-shortage related sickness, A is the cost of water purification at the household and U is the utility or level of satisfaction and so $(\partial U/\partial w)$ measures loss of satisfaction due to water shortage, λ marginal utility of money, and so $\{(\partial U/\partial w)\lambda.(\partial H/\partial w)\}$ measures the cost of dissatisfaction due to sickness; W is the average wage per day, m is the average cost of mitigation or health cost in a household, a is the average cost of water purification in a household (adapted from Haque, Murty and Shyamsundar, 2011).

In practice, the psychological costs or the cost of dissatisfaction are hard to find and so any typical valuation studies only concentrate on the first three part of the above equation indicating that the estimate here may be an underestimate Estimation of this also requires household level data.

Using the above equation, value of water or productivity water can be found as

$$VoW = \frac{\partial I}{\partial w}.\frac{P}{V} \ (2)$$

Where P is number of households serve dand V is the volume of water used by the population and VoW is the Value of Water per unit of water.

We assume that in the municipality there are two groups of residence, those with municipal supplied water and those not. Further we assume that the municipal supplied water is of quality deemed safe for human consumption. Opposite is the case of those without access to municipal water which is likely to be less safe and thus because various diseases related to water (gastro-enteric). Due to such disease, an affected person (if adult), loses income due to morbidity, has to make expenditure for medical attention and treatment, make preventive expenses for not catching a disease and suffers from disutility. It is assumed that families with access to municipal supplied water will have lower values for each of these components. In any case the difference between the two may be said to reflect the value of municipal water to the residences supplied with municipal water. Thus, this becomes an avoided health cost approach. Thus, from theory, value of water for residential and personal use (from whichever source) can be defined as:

Average value of water for human consumptive use (Freeman, 2003; Haque et al., 2011)[4]

= Value of lost wages due to illness (A) + Mitigating expenditure during sickness (B) + Averting expenditure due to illness (C) + Cost of disutility due to sickness (D).

This is quite similar to what we have shown in mathematical form earlier

These relate to each of the groups mentioned earlier. The difference in these values for the two groups provide the “true” value of water from municipal sources to those access to it.

It should be reiterated here that the components A, B and C all are related to use of water and thus relevant only for water borne or gastro- intestinal diseases.

4 Freeman, A. M. (2003). The measurement of environmental and resource values: Theory and methods (2nd ed). Resources for the Future.
Haque, A. K. E., Murty, M. N., & Shyamsundar, P. (Eds.). (2011). Environmental valuation in South Asia. Cambridge University Press.

It is possible to get some information on components A, B and C above, but not so easy to get any idea regarding component D. It is possible to find the components A, B and C of the above equation from HIES data.[5] However, since these are marginal values, there is a need to understand the quality of water which is not available in HIES data. As such, the estimated value may be only an approximation and can be interpreted as the cost of using water at its current quality. It should be interpreted with caution because the marginal cost of supply germ-free water at the water-taps at the household level is probably going to be much higher because it would require a real overhauling of the water supply systems.

8.2.1 Health Issues

To determine the health costs on water-scarcity related diseases, there is a need to identify the major diseases that can be attributed to water shortages in the house or linked to supply of tap water. We used tap water supply as a proxy to measure the water scarcity issue. This means that households with piped-water supply does not have any scarcity at home as they can use water as and when needed. On the other hand, households not connected to piped-water supply will face a degree of scarcity because they need to put extra effort to fetch water for household daily use.

Sontrop et al. (2013) in their study has linked water supply with kidney diseases. Their study reveals that there is no association between low water intake and CKD but suggests a potentially protective effect of higher total water intake on the kidney.

Howard et al. (2020) study is a report published by WHO that identifies water quantity and health problems. This study cited many other studies and linked access to water supply with reduction of pain, injury and musculoskeletal disorder among children and women (who are engaged in fetching water), benefits in terms of reducing uptake of antenatal care, reduction in child deaths (under 5). Similarly, the Solidarity International in their report has listed cholera, diarrhea, dengue, malaria, malnutrition, onchocerciasis, scabies, schistosomiasis, trachoma, typhoid and paratyphoid fevers as the major water related diseases. Clearly, there is a mix-up of diseases between water quality and water quantity issues. Since this study would like to see the benefit from piped water supply in urban (using surface or ground water sources), we would only include diseases linked to availability of water.

8.2.2 Data Sources

For estimation of value of water for municipal residential use, the initial idea was to collect health expenditure data from households as well as from local governments on costs for supply of water. With COVID-19 pandemic, it was not possible to collect data on health expenditure directly from households. Since the study is concerned on water related issues – it was decided to use Household Income and Expenditure Survey (HIES) data of 2016 (the latest published set of data on household expenditures and income) as an alternative source of information to estimate and analyse value of water. The HIES 2016 is a randomized household survey data that includes among others the sources of supply of water for residential purposes including drinking as well as lists of diseases the members of the household are suffering, and the cost of treatment. As decided by the study sponsors, two cities were to be chosen for analysis – Dhaka and Khulna. Dhaka was selected as it is the major metropolitan hub of the country, and a megacity and Khulna

5 Section 6 in HIES 16 has information on sources of water, municipal piped or otherwise. Section 3 has details on health-related incidence and costs of treatment and related other costs. There is no direct information on days of suffering due to illness (though hospital stay length is available). However, based on other available information one can find out days without work which can be translated into income lost.

was selected to see whether the situation is different in a coastal city because average water salinity level is higher in Khulna city.

HIES 2016 dataset includes 46,083 households from 64 districts of Bangladesh of them 1440 households are from Dhaka and Khulna districts. Table 8.1 shows that average monthly financial expenditure due to water scarcity related health diseases is about 46 taka varying from is 168 taka in Dhaka and it is one-fourth in Khulna.

Table 8.1: Summary Statistcies from HIES Data, 2016

Indicators	Dhaka	Khulna	Total
Household size	3.69	3.96	3.81
Presence of arsenic in supply water	0%	0.68%	0.30%
Household with piped water	95.54%	7.05%	56.60%
Average water Related health costs (monthly in taka) per household	168.46	46.01	114.59

Source: Estimated based on HIES 2016 data

8.2.3 List of Diseases

HIES data include a set of information on the diseases suffered by household members. The list is long though by no means exhaustive. These are shown in Table 8.2.

Table 8.2: List of Disease in HIES Data

Diarrhea	Malaria
Fever	Jaundice
Dysentery	Female Diseases
Pain	Pregnancy related
Injury/Accident	Cancer
Blood Pressure	Mental Health
Heart Disease	Paralysis
Respiratory disease/Asthma/Bronchitis	Epilepsy
Weakness	Scabies/Skin Disease
Dizziness	Liver Disease
Pneumonia	Ear/ENT problems
Typhoid	Eye problems
Tuberculosis	Others(Specify)

Source: HIES 2016 Questionnaire

While these 27 types of illness are listed for all members, it is evident that all of them are not linked to water. Hence, a subset of diseases related to inadequate water availability and consumption was created for households living in cities of Dhaka and Khulna.

Based on this list, the study team included a) female /pregnancy related diseases (not including delivery related issues), b) scabies/ skin diseases, c) kidney disease as the health issues related to inadequate water availability or piped water supply at the household. Health related cost data includes hospital costs, medicine costs, related transport costs, tips (if any), etc. were identified from the HIES data for each household against these diseases. The average expenditure per household on these items has already been reported in Table 8.1.

8.3 Estimation of Value of Water

The primary objective of the estimation is to develop the attribution of tap water supply on the family health cost. This means an understanding of how much of the average costs of 168 takas, for example, is attributable to availability of water (measured as in-house piped water supply). Table 8.1 shows that 53.7% of the households in Dhaka and Khulna together in the HIES dataset had tap water. It is 92% in Dhaka and 6% in Khulna respectably. However, only a few data were reported as health costs related to water-access related three diseases available in the survey. Only 16 of the 1160 households reported health cost data related to these diseases. The average of their cost is around 3497 takas per month.

Therefore, with such a small set of reported health cost it is difficult to implement a simple regression model to isolated the impact of tap water supply on health costs. It may, however, be noted that health cost data are also count variables as they are all reported in taka without decimals. Count data are discrete and non-negative values. In this analysis, health expenditure data are in discrete numbers and they are non-negative. Secondly, the number of reported cost information is very few (16/1160) and so we used Poisson function which is more suitable for both for cases with discrete numbers and for events with low probability. Initially a Truncated Regression model was also attempted but because of the better suitability of the Poisson, only the results of the Poisson egression is reported here.

The estimated results are shown in Table 8.3. Results show that on average households' cost of health reduces by 82 taka (the marginal impact) per month if the household is connected to a tap water supply. However, it only the estimate of $(m.\partial M/\partial w)$ value as in equation 1. It may be noted that the marginal value is higher than the average which is possible, at least in theory.

Table 8.3: Marginal Benefit of Water Supply in Urban Areas

	Coeff	S.E.	t value	P > | z |	Marginal impact
Household size	0.10	0.0037	27.38	0.00	
Average age in the household	0.07	0.00028	274.82	0.00	
Tap Water Supply (dummy)	-1.85	0.0147	-125.74	0.00	-81.82
Khulna (dummy)	-1.45	0.0113	-128.97	0.00	-92.29
Metropolitan City (dummy)	-1.34	0.0107	-124.22	0.00	-70.78
Constant	3.04	0.0240	126.46	0.00	

To estimate the cost of workday loss or $W.\partial H/\partial w$ as in equation 1, we need two estimates from the HIES data: a) average wages and b) no of workdays lost due to illness related to these diseases. Unfortunately, HIES data did not provide any estimate of H or workday loss due to these sicknesses. Same is true for the third component $a.\partial A/\partial w$. This number, however, is very small and most of the avertive behaviour is linked to quality of water and not quantity of water. The only quantity related avertive expenditure is the cost of overhead and underground tanks for storage of water. This is however, linked to the policy of WASA which has not yet developed a strategy for 24-hour supply of water in their distribution lines. As such, it is not estimated in this study.

8.4 Marginal Benefit of Water Supply in Urban Areas

As indicated, HIES data did not collect information on number of sick days due to any disease and the first component on effect of income loss due to water shortages cannot be estimated from the data. However, to ensure that we have some estimate on this, we have used the standard 'casual leave' provisions in the salary structure in offices in Bangladesh. In general, there are 15 days of leave entitlement for a person per year. There are also Medical Leave provisions in the pay structure in Bangladesh. We, therefore, assumed that individual may take a leave of 1.25 days per month for sickness.[6] We have used this to estimate for loss for sick days at the minimum.

8.5 Value of Water Calculation

To estimate the value of water, we, therefore, used the following formula

$$VoW/mo/hh = \left(\frac{1.25}{30}\right) \times \overline{W} + \partial HC/\partial w (3)$$

Where 1.25 = no of working days lost per month, $\overline{W}$ is the average daily income, HC is the health cost in the Poisson regression function and w is 0 for no tap water and 1 for houses connected with tap water.

In developing countries such as Bangladesh, people employed, particularly in the informal sectors which is the main employment avenue in urban areas, often do not leave work unless they are forced to and in any case, the HIES 2016 this was never asked. As such we used this Heuristic assumption.

According to the HIES 2016 data, average monthly income of an urban household is 22,600 takas per month and an average household size of 3.81(see Table 8.4).

Dhaka WASA's production capacity of water is around 2550 million litres a day and is serving nearly 17 million individuals or 4.4 million households (Rahman & Islam, 2019).

Based on the above estimates, value of water per m3 of water is shown in Table 8.4.

Table 8.4: Value of Water for Municipal Water Use

Description	Dhaka	Khulna	Both cities
Urban average income [monthly – HIES data]	22600	22600	22600
Average daily income per day (taka)	753.33	753.33	753.33
Marginal effect on monthly health cost from supplying tap water (taka /hh) [regression model Table 8.3]	81.82	81.82	81.82
No of sick days lost per month per household (per month) [heuristic assumption]	1.25	1.25	1.25
Marginal benefits from supply of tap water per day per hh household (taka) [based on Marginal Effect, # of household connected, daily supply of water]	4.92	3.13	4.83
Household size [HIES data]	3.69	3.96	3.81
Per HH per day benefits in Taka from urban tap water use (due to ease of use or availability and no loss of income due sickness) [calculated using equation 3]	36.31	34.52	36.22
Number of Households served per day (by WASA)	4,603,482	167,619	4,771,101
Production Capacity per day (WASA) in cubic meter [WASA data]	2,550,000	146,000	2,696,000
Daily benefit per day per cubic meter per household (in taka)	65.55	39.63	64.09
Daily benefit per day per cubic meter per household (in dollar)	0.77	0.47	0.75

Source: Estimated. Note: * Assumed 1 working person per household

6 In developing countries such as Bangladesh, people employed, particularly in the informal sectors which is the main employment avenue in urban areas, often do not leave work unless they are forced to and in any case, the HIES 2016 this was never asked. As such we used this Heuristic assumption.

Table 8.4 shows benefits from urban supply of water that reduces water scarcity at the household level. The study has taken information from two cities which are different in terms of their size of population and capacity of water supply. Our estimates show that value of benefit per household per day is 64.09 taka per day that includes benefits for not falling sick from water scarcity related diseases and benefits in terms of not losing the workdays due to such sickness.

We have combined the regression estimates with other information to find the value of water per household per day for supplying of piped water supply (quantity aspect of water). Dhaka WASA supplies 2550 MLD and Khulna WASA supplies 146 MLD to the households living in the city.

Based on these, estimates show that in Dhaka city protecting a surface water source that holds a cubic meter of water per day would generate an economic benefit equivalent of 65.55 taka a day and in Khulna city it is around 39.63 taka. This shows that value of water varies across cities and so the protection effort to protect surface water sources will also vary. In any case, the benefits translate to 77 cents, 47 cents and 75 cents for the average and the respective cities. These figures are quite comparable to those found in the global literature which range from 1 to 289 US cents.

8.6 Conclusion

An attempt has been made here, under severe data constraints, to estimate in two urban centres the benefits or rather the avoidance of damages to health as well as loss of income due to sickness for those households with adequate residential supply and consumption of water as reflected in being connected piped water supply as opposed to those who are not so connected. The results appear to vary by cities. More importantly, the over-all benefits compared to household income appears to be rather marginal. Apart from data inadequacy, there is also the problem of the issue of water quality which has not been taken into consideration. While as already pointed out the present results are within the range of values found elsewhere, we believe these will remain underestimates even if somehow the issue of quality could be considered.

Value of water is estimated to understand how much the society will sacrifice if the source of water is destroyed or damaged. As we know that urban water supply will increasingly come from surface water sources as in many areas underground water able is known to be falling due to high extraction rates. With rapid urbanization there will be increased demand for water, and thus increasing pressure on surface water sources and thus calls for protection of surface water sources across the country. However, water bodies are under threat because of its alternative use. For example, water bodies are encroached to convert into housing, or for other use. Any disbenefit due to these issues need to be factored in for properly understanding the value of water. The similar is the case with value of water for meeting residential demand for water.

The estimates made here are dependent on a lot of assumptions because of lack of many of the requisite information in the data set that we were forced to use for not being able to conduct field surveys due to the pandemic. Furthermore, the estimates we show do not fully capture the benefits of safe water supply on two counts. First, we have not been able to include the quality aspects as such while on the quantitative supply benefits, only two types of benefits could be included and even then under strong assumptions which need to be further validated in future. The present ones are thus underestimates of benefits and thus value of water for household supply for human consumption. Yet, these estimates are well within the range of water values found in other studies across the world as indicated earlier.

9. Value of Water for Ecosystem Services

9.1 Ecosystem Services of Tanguar Haor

Haors are one of the major natural ecosystems of Bangladesh. These are bowl shaped flood plain depression located in North-eastern region of Bangladesh. There are 373 haors in Bangladesh covering an area of about 859,000 ha (Table 9.1). They provide different ecosystem services upon which many people are dependent for their livelihood. A non-exhaustive list of these services include:

- Cultivation particularly of boro rice
- Fisheries production and conservation of mother fishes
- Conservation of the biodiversity of the haor system
- Conserve a unique ecosystem with potential for tourism
- Provide refuge to migratory birds during winter

Table 9.1: Haors of Bangladesh

District	Haor Area (ha)	No. of Haor
Sunamganj	268,531	95
Sylhet	189,909	105
Habiganj	109,514	14
Maulvibazar	47,602	3
Netrakona	79,345	52
Kishoreganj	133,943	97
Brahmanbaria	29,616	7
Total	**858,460**	**373**

Source: Haor Master Plan

While the above are the direct benefits from haors, there is also a not so apparent benefit. Note that had the haors not existed and the flood waters which are now stored in the haors would have flowed unimpeded, it would have flooded the surrounding land would have damaged or destroyed property, crops, and displayed people and adversely affected their livelihood. It should also be noted that the flood waters normally enter the haors after or is held back up to the time the boro rice crop is harvested. Thus the above listed benefits and the hidden benefits of avoidance of damage and destruction around the haor areas due to retention of flood water in their constitute the total use values. It has therefore been decided to study the value of the existing flood regulation services of the haors as it retains early monsoon flood water. A non-exhaustive list of such avoided damage due to existence of haors and their flood regulating services may read like the following:

- Protect agriculture in surrounding lower riparian land from the onslaught of and damages from flash flooding by storing water.
- Protect riparian waterbodies and the floodplains from damages by sand deposits
- Provide protection to various infrastructure like roads and housing and other properties
- Provide protection to other ecological resources

While the types of benefits of the haor services inside the haors are known even if not always so quantified, we need to know what area outside the haors would have been flooded had there been no flood water retention. To understand this, a 3D GIS simulation models for the Haors in Sunamgonj in order to get an estimate of the inundation impact of such diversion. The models begin with the normal practice of allowing flood waters to enter the haors so that the general ecosystem services of the haors, remain unaffected.

The initial modelling was only for the Tanguar Haor. But it was found to have no effect on flooding outside the particular haor as apparent "excess" water of the haor was simply redistributed to other haors. In the second stage therefore, we ran the model for the haors as a whole rather than only for the Tanguar Haor. Once the haor system modelling was done, the next task was to find out exactly which areas were flooded and to what level had the haors not existed Based on this scenario, and using secondary data from the Department of Agriculture and other sources estimate was made of the value of crop saved and the properties and infrastructure for which damage is avoided in the non-haor surroundings due to the existence of the haors.

Since we are considering valuing the flood-regulating benefits of the haor ecosystem and assessing the changes in the productivity of land, the value of avoided damages is what would have happened had the haors did not exist minus the value of the excess water flow, if the haors did not exist, can be found from the following equation:

Value of net avoided damage = Value of Water =Net savings from the holding of water by the Haor ecosystem in early months

$$= \pi \times \frac{[DA_{Downsream} - DI_{Haor}]}{W}$$

Where π is the probability of flooding, DA is damage avoided, DI is damage incurred in haor areas and W is the volume of water retained by the haor system.

9.1.1 GIS Model- based Simulations: Model 1

As already stated, a GIS model has been done for the Tanguar Haor Ecosystem based on current flooding pattern using 2D and 3D models. It simulated the water retention impact assuming that Tanguar Haor will remain protected during the first two weeks of flooding so that farmers within the haor area can harvest their crops and then the water will flow out to surrounding flood plains. we tried both a Cobb-Douglas production function

An alternative model including the whole haor system has been considered for estimating the total ecosystem services.

9.1.2 GIS Model- based Simulations: Model 2

In the next step, we modelled all the adjacent haors together in the Tanguar Haor area based on their current flooding patterns using 2D and 3D models. These models simulated the water retention impact in haors assuming that as a result of allowing flood water from upstream to enter the haor system results in possible damage of boro crops in the haors whereas by disallowing the water inflow into the haor system, the model predicted the 'new' flooded area outside the haors. As such, if haors do not keep upstream early flood water inside, the model predicted changes in the flooding pattern outside the haors and hence results in changes in the flooding pattern on

- Agricultural land
- Urban infrastructure
- Forest Land
- River and in other Waterbodies

The value of modelled lost output and damaged properties etc on these lands are the benefits of flood regulation services of the water retained by the haors. Note that if the haors do not exist theoretically there would also be changes within the haor system and thus changes in the patterns of use of land and other existing present benefits. In other words, we measure the benefits of flood regulating services of early monsoon water is equal to the value of damages on land outside the haor zone due to floods plus the changes in the existing benefits within the haor area. Here we assume that the present cultivation pattern of boro rice will remain unaffected provided the flooding does not come before the harvests. In fact, farmers do have their knowledge about the flooding times and cultivate their lands accordingly. In any case, the results of the simulation exercise are shown below.

9.1.3 Impact of Water Retained Inside the Haor

The simulation exercise under Model 2 used two distinct scenarios: Scenario 1 represents the normal condition if the early monsoon rainwater is retained inside the haor; Scenario 2 represents a simulated condition under which haors do not exist or keep the early monsoon rainwater and so it flows into the adjacent floodplains.

Figure 9.1 shows the normal condition of flooding within the haor areas. Figure 9.2 shows the normal flooding outside the haor areas at present. Figure 9.3 shows the modelled flood conditions both outside and inside the haor areas had the water retention by haors did not exist. The flooding impact outside is shown in pink colour.

Figure 9.1: Flood Extent for Model 2 Domain in Scenario 01 (Normal Condition with Haor)

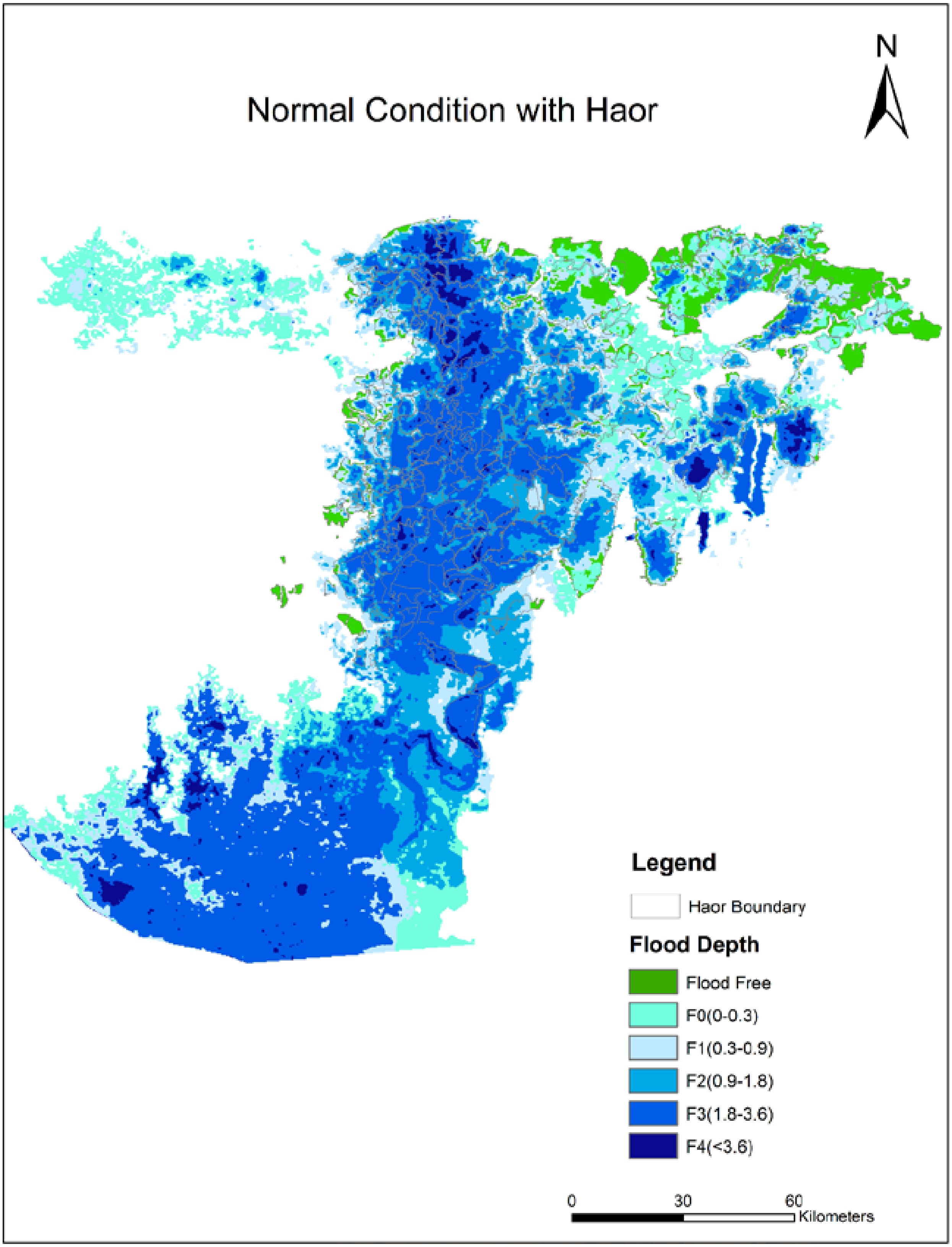


Figure 9.2: Flood Extent for Full Model Domain in Scenario 02 (Normal flooding outside haor area)

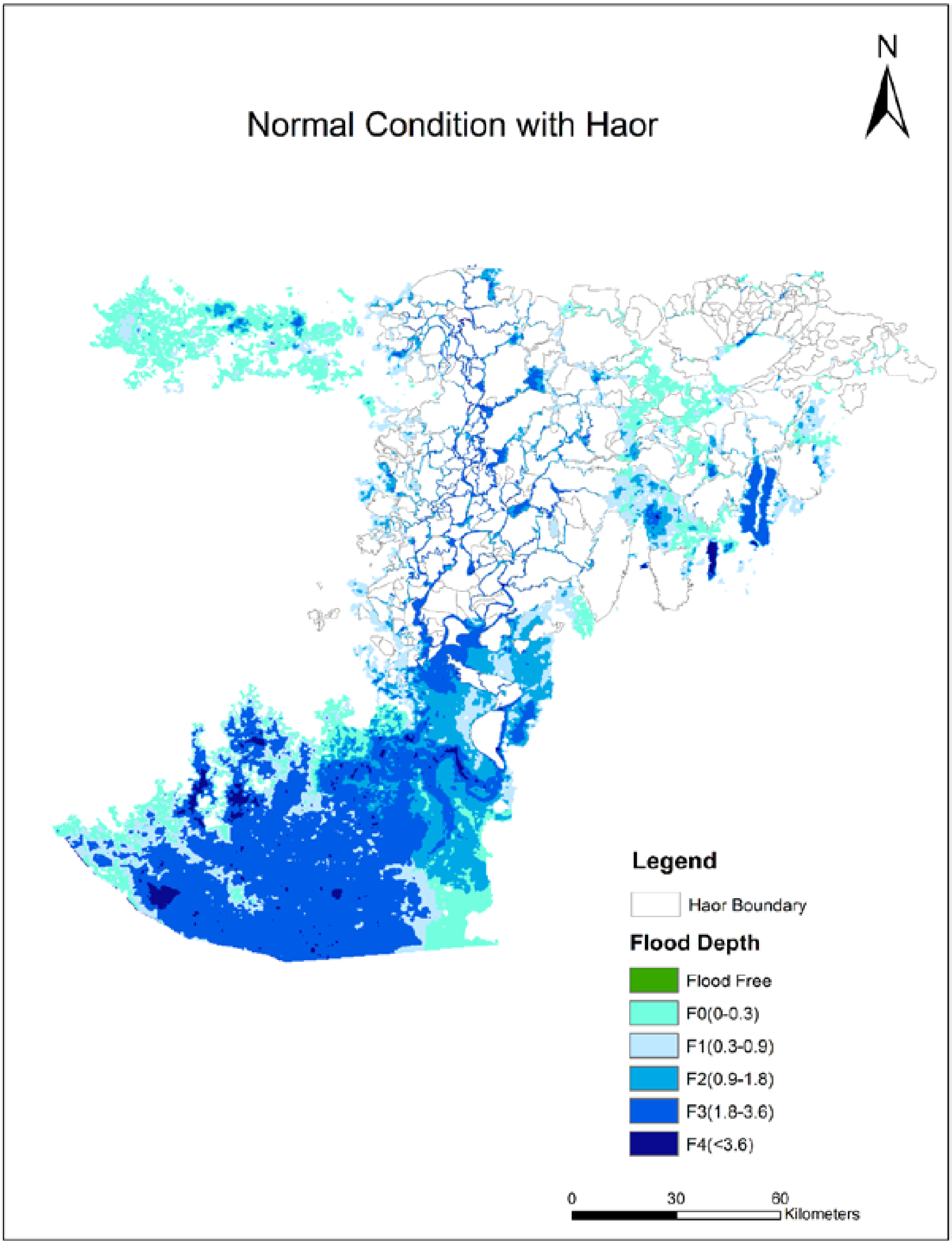


Table 9.2 provides the summary of the simulation exercise. Changes between two scenarios is the impact of flooding if it is not regulated by the haors and hence is the benefit of flood regulating services of the haor in early monsoon period.

Figure 9.3: Impact on Flooding Pattern if Haors do not Hold Early Monsoon Floodwaters

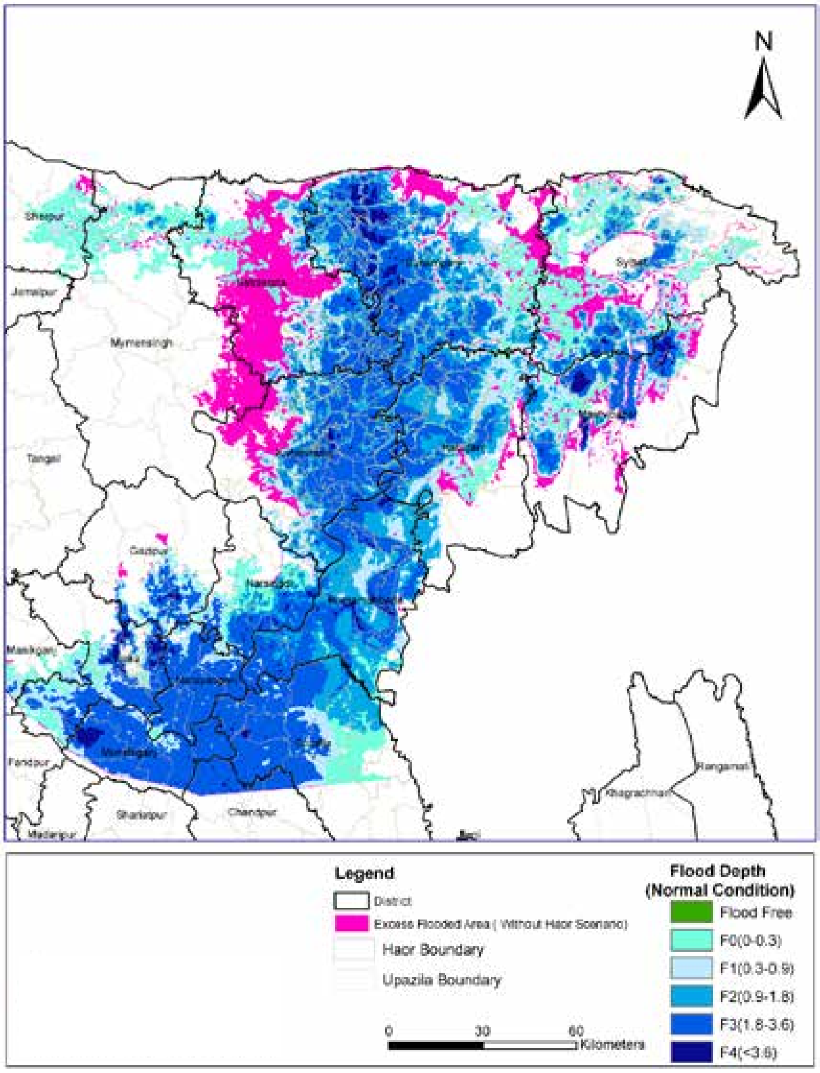


Table 9.2 shows the impacts in terms of land classes based on modelling. It shows that changes in the flooding pattern in haors and outside haors if the haors did not exist or not retained the flooding water. It shows that flooding on F0 type of land will rise by 51%, on F1 type land will rise by 47%, on F2 it will drop by 5%, on F3 type of land it will be up by 38% and on F4 type of land it will be up by 76%.

Table 9.2: Summary of Model Outcome for Full Model Domain (without haor)

Land Class	Range of Depth (m)	Scenario 1			Change in Scenario 2 from Scenario 1		
		Avg. Flood Depth (m)	Flooded Area (ha)	Volume (ha-m)	Avg. Flood Depth (m)	Area (ha)	Volume (ha-m)
F0	>0.3	0.02	288270	58	0.00	+145791 (+51%)	+29.16 (+51%)
F1	0.3 to 0.9	0.60	357624	2151	-0.06	+168705 (+47%)	+686.74 (+32%)
F2	0.9 to 1.8	1.44	371169	5340	-0.08	-17919 (-5%)	-531.94 (-10%)
F3	1.8 to 3.6	2.60	800289	20785	-0.03	-302184 (-38%)	-8004.38 (-39%)
F4	>3.6	4.43	51831	2297	0.38	+39573 (+76%)	+2100.28 (+91%)

Table 9.3 rearrange these land flood depth changes in terms of changes in land use classes. It shows that given the current pattern of land use on these land classes, the damages due to floods will be on agricultural land (hence loss in agricultural output), on forest land, on urban settlement areas, on rivers and on waterbodies. It further shows that depending on land class the impact will be both positive and negative in area flooded under a particular flood depth.

Table 9.3: Change in Land Use by Land Type with No Retention of Water in Haors

	Changes in Land by Flood Type (ha)				
Land Class	**Agriculture**	**Forest**	**River**	**Settlement**	**Waterbodies**
F0	(61,149)	(126)	(1,177)	(29,008)	(764)
F1	52,888	2,092	(649)	27,871	(525)
F2	54,225	29	7,553	31,130	(561)
F3	18,129	(282)	(6,411)	1,602	756
F4	33,517	1,509	521	6,102	1,873

Source: CEGIS 2021
Note: Figures in parentheses indicate reduction from the base model (scenario 1)

The changes in land use classification by depth quite naturally also means that the land use changes will be there and that these changes will also mean changes in the output from these lands. The value of benefit from this system is calculated using average gross value addition of these land to the economy of Bangladesh using national accounting statistics published by the Bureau of Statistics and the Ministry of Finance. This is shown in Table 9.4.

Table 9.4: Productivity/Benefit Estimates: Agriculture, Forest and River System

Agricultural Productivity Benefits (National)[1]	176,692.82/ha
Cropping Intensity (national)[2]	1.73
Cropping Intensity (Haor)[3]	1.00
Forest Productivity Benefits (National)[4]	125,284.62/ ha
River System Productivity[5] **includes river transport and inland fisheries (28.5%)**	77276828.85/ha
Human Settlement Area Benefits[6]	974,257,450.31/ha
Inland waterbodies productivity benefits[7]	20,888,218.82 / ha
Biodiversity Benefits[8] **[from a global meta-analysis]**	21,35,030/ **ha (avg)**
	2,13,435/ **ha (min)**
	85,00,000/ **ha(max)**

Note: [1] includes value of agricultural value addition from the Bangladesh Economic Review (BER 2020) of the Ministry of Finance data, Agricultural land area from the Statistical Year Book (SYB) 2020.
2 SYB 2019.
3 Field Data from haor area.
4 Data on Forest Area from National Conservation Strategy (NCS) of IUCN Bangladesh, Data on Value addition from BER 2020.
5 Value addition from Water Transportation and Capture fisheries (BER, 2020), River land area from SYB 2019, and data on % of capture fisheries from SYB 2019.
6 Productivity of urban settlements are calculated using Urban Settlement Report – vol 3 (for area), and value addition data from BER 2020 which includes value addition from industry (Small and Medium), utility services (gas, electricity, water), public services, social works and health services, and financial service.
7 Productivity of water bodies include value addition from inland fisheries (except riverine fishing) from BER 2020 and SYB2019, and area data from Haor Master Plan 2012.
8 Biodiversity benefits data is based on Table 3 of de Groot et al (2012),. Global estimates of the value of ecosystems and their services in monetary units. Ecosystem services, 1(1), 50-61.

There is no national estimate on the value of biodiversity benefits per hectare of wetlands and hence we used the average from 168 global studies from a meta-analysis as mentioned above. Based on these, the benefits of flood regulation is presented in Table 9.5.

Table 9.5: Flood Regulating Service Benefits – Estimate from the Sylhet-Sunamgonj Haor System

Area type	Area(ha)	BDT/ha	Total Tk Crore	%
Within haor area				
Agriculture area		102,348	-	0.0%
Beel area		2,08,88,219	-	0.0%
Non-agricultural land				
Settlement area				
Kanda - fallow land				
Biodiversity benefits	865,296	10,67,515	**92,372**	69.7%
Outside haor	**4,488,270**			
Additional Flooded area	139,145	463,501	40,107	30.3%
Of which:				
Agricultural area	97,609	176,693	1725	1.3%
Forest area	3,222	125,285	40	0.0%
River area	(163)	772,768	(13)	0.0%
Settlement area	37,697	9,742,575	36,727	27.7%
Waterbodies	779	208,88219	1627	1.2%
Total Benefits from water retention in haors	865,296	1531,016	**132,478**	100.0%

Note: It is assumed that the present cropping activities and the beel (i.e., deeper parts of the haors will remain unaffected. So there would be no change in their ecosystem value.

Table 9.5 shows that because of regulating early monsoon water flows by the haor system, there are 5 different types of benefits *(or rather avoided damage)* that are accrued to the economy from land outside the hoar region. This area due to reduced flooding in regions outside the hoar (reduced in the sense that what additional flooding had occurred had the haors not retained the flood waters as these do now). These benefits are in terms of the existing land use pattern.

Of the totality of benefits, nearly 70% of these are biodiversity benefits *inside the present haor area* and the rest are provisioning service benefits. Estimate shows that per hectare of haor land provides an annual benefit of 15.31 lakh taka while the total comes to Tk 132, 478 crore.

Question arises if these are the only benefits of the haors. The existence of haors has a value in itself apart from the direct tangible benefits the nation gets. In fact, we even do not fully know what other direct benefits there as natural resources are so interlinked with each other that the benefits are better known only when these do not exist and negatively impact other resources. Given this and that there is also an existential value in itself, should this value estimated above be adjusted upwards. We think this should be but we do not know what upward adjustment to be done. On an ad hoc basis, we take it to be at least 50% more. In that sense the total benefits of the existence of haors and their benefits may come to Tk 198, 717 crore or round about Tk 200 thousand crore equivalent to US$ 23 billion.

How do these benefits or the value of ecosystem services compare with other national economic figures Just as an indication of the importance of these benefits, it may be noted that this year's (2021-22) national budget is 603.7 bn Taka. The base case benefits of the ecosystem services is just about 22% while the extended benefits including existential values of the haors comes to just one-third of the national budget. As proportions of the GDP these are 3.8% and 5.6% respectively. What all these proportions mean is that the ecosystem services of the haor system which depends entirely on the water retained therein is extremely important not simply from the point of view of ecosystem preservation but that the monetised value of the services of the system is also very high.

9.2 Estimation of Ecosystem Services of Halda River

Halda River is a spawning ground for carp fishes, a function which is under threat due to other uses of the river. Halda has also been declared as a critically endangered protected area. The uniqueness of its spawning function lies due to the fact that it is the only river in the Chattogram region that provides such ground for spawning and that the process requires 'human' interventions to produce hatchlings. The process is at least 100 years old, and it has created a unique culture of collection of fish eggs and production of hatchlings for Indian carp fishes. As such, it is a cultural heritage for Bangladesh.

It was initially thought that a replacement cost or a productivity method may be used to estimate the benefit of this ecosystem services of water in the Halda river system. Of them, the direct method for estimating value of water for ecosystem services in Halda river is by using the production function approach. However, for estimating a production function, one needs data on inputs, costs, as well as quantified output either as a time series for at least 15-20 years for any estimation to be credible. Furthermore, there are many other factors apart from and related to water such as a) water quality, b) turbidity; c) stock of mother fish; etc. to allow for independent effect of water to be identified. Such data do not exist or not easily available.

Alternatively, one needs, at least for a year, production and all necessary inputs data from at least 30-35 fishermen to have a credible estimate of value of water. Due to Covid, the study team could not manage collection of field data. Hence, it was decided to discuss the issues at length with highly knowledgeable researchers regarding the spawning, and egg collection activities and explore the literature and evaluate other studies on valuing the services of the Halda river. Various studies have listed the following services of the Halda river:

- Value of prawn harvests
- Value of post-larvae catching of prawn fish
- Value of spawning services of carp fishes
- Value of sand extraction from Halda river
- Value of water transportation services
- Value of drinking water for Chattogram city.

All these services are part of provisioning services of the river and not necessarily of water alone. Moreover, studies which estimated the values of these services used the gross production value of produces to value the services. Incidentally, many of these services arin conflict with each other. For example, increased collection of sand would be in conflict with production of fish eggs and fish fries in the river. The studies, however, used a horizontal summation to estimate the value of ecosystem services of the Halda river. This is technically incorrect because the values must be estimated in terms of net revenue and values of only mutually exclusive services may be added. In case of conflicting values, a better method is to estimate the interdependent aspects of production to find the value. However, given the paucity of such information we had no other way but at least recognize the problems with such estimation.

Harvest of fish spawns depends on effort levels of fishermen and the gears they use to catch the larvae. Since, these data are not available, we opted for the replacement cost which is the cost of producing the second best – which is using the replacement cost method – measurement of opportunity cost if the natural production does not exist.

Alternatively, the replacement cost is the cost of producing the same spawns using the hatcheries may be taken as a proxy for the value of spawning function of the river. With the replacement cost method, the objective is to know the cost of substituting this unique fishing ground with commercial hatcheries. This estimate, however, is not only likely to be a lower estimate of the value of the Halda River's unique ecosystem services, it also excludes the social cost that would have to be incurred if commercial hatcheries can replace this service.[7] There are some carp hatcheries in the country. Information particularly on costs and revenue of hatcheries can be used to estimate the alternative or replacement costs of the services that the Halda River provides without any investment.

Therefore, the value of water is

> Value of Water[8] = [Annualized cost of investment in hatcheries per larvae + recurring costs per larvae] x [total larvae production in the Halda river system] / [volume of water required to produce the larvae] (3)

9.2.1 Ecosystem Services from Halda River

The notion of ecosystem services (ESs) has arisen as a structuring and manufacturing framework for deciphering ecosystem procedures in terms of human welfare (Sukhdev et al., 2010). The Halda River is a natural spawning ground for carps and one of the primary sources of fries for fish cultivators throughout Bangladesh. The river serves as a fishing ground for homegrown fishermen and provisions drinking water for the population of Chattogram city. Besides, it offers irrigation water to native farmers and meets everyday household water demand for people residing in the locality. The Halda is a popular leisure site (Kabir et al., 2015). The following ecosystem services have been identified from Halda River.

Provisioning Services

- Supply of drinking, irrigation, and household water.
- Supply of food (fish).
- Supply of non-food consumables such as sand, eggs from brood fishes for pisciculture farms, etc.
- Provision of livelihood for fisherman, boatmen, sand collectors etc.
- Provision of tourism services.
- Provision of water-based transportation for passengers, sand, bamboo, bricks and trade merchandise, etc. (Kabir et al., 2015)

Cultural Services

- Scenic landscape offering unique smells, sounds, senses, and atmosphere.
- Sites of cultural and religious significance.
- Indigenous knowledge for egg collection and spawning tools and techniques.

7 Sometime, questions are raised whether replacement cost or damage prevention are proper methods for estimating value of ecosystem services of water. Frankly, these are not theoretically the best possible methods but only an approximation due to various data constraints. Wherever applicable these shortcomings have been mentioned.

8 It is worth noting that water-based ecosystem and water cannot be separated from the nature. Since larvae production is not possible without the river, we estimate the value of this ecosystem service using the river-system, this is also similar to the flood regulating services from the haor ecosystem.

- Characteristic festivity during the egg collection and spawning season.
- The Halda is a source of recreation for adjoining communities and visiting tourists.
- The Halda is an active site for research.
- Origin of cultural icons such as the unique type of boat (Sampan) and unique genre of song by boatmen –Sampanwala. (Kabir et al., 2015)

Regulating Services

- Water purification and assimilation of pollutants and contaminants from different point sources.
- The river provides spawning ground for major Indian carps and regulates their population
- The river stabilizes its banks through retention of soil and addition of sediments.
- It serves as an important component of watershed in the Chittagong region.
- Minimization and colonization of excessive growth of weeds.
- Regulation of ecological and hydrological processes and cycles.
- Minimization of salinity intrusion from the tide off the Bay of Bengal. (Kabir et al., 2015)

Supporting Services

- The river maintains a unique ecosystem to support the brood fishes of major Indian carps and their spawning which gives the river its unique identity.
- The Halda maintains a biodiversity including many aquatic life forms such as Dolphins, rare birds, etc. and serves as a natural gene pool. The sediments carried by this river contribute to soil formation.
- The Halda plays a crucial role in ensuring other ESs through nutrient cycling by carrying sediments from the upstream. (Kabir et al., 2015)

River Halda is of course natural spawning ground. However, recent information from the Department of Fisheries does not indicate that it is a major one in all years as the output seems to be highly variable as the two tables below (Tbale 9.7 and 9.8) show. In 2018, of the total carp hatchling production, natural spawning accounted for only 9280 kg out of a total of 687 thousand kg i.e., natural spawning accounted for only 1.3 percent. Of the natural spawning, Halda accounted for nearly 50%. However, contrast that with the situation in 2019 when Halda produced only 191 kg out of 2496 kg i.e., 7.6%. These indicate that the importance of Halda as a natural spawning ground has been really blown out of proportion. However, what the essential value of the Halda is unknown. We shall come back to this question later on.

Table 9.7: Annual Carp Hatchling Production, 2018

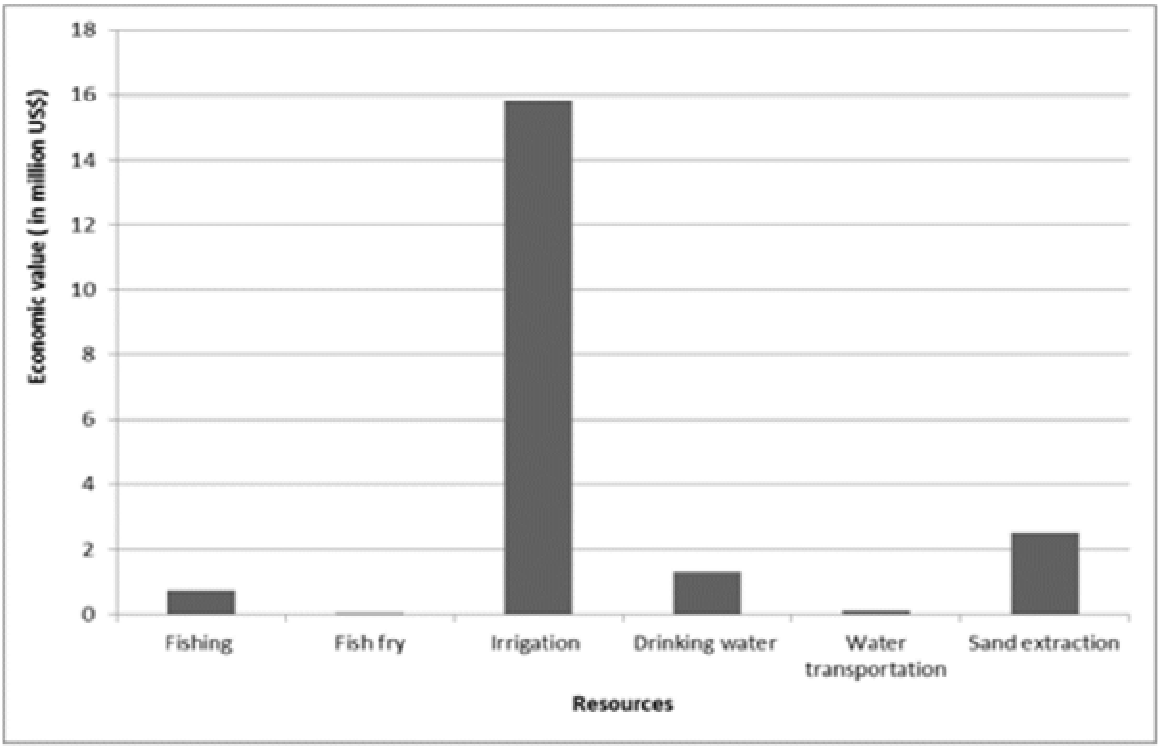
Source of Production	No of Hatchery	Hatchling Production (Kg)	%
***3)* Natural**			
Jamuna River		1767	
Padma River		2049	
Arialkha River		262	
Brahmaputra River		126	
Garai/Madhumati River		561	
Surma		8	
Halda River		4507	
Natural Total		**9280**	***1.35***
***3)* Artificial**			
Govt. Hatchery	102	12059	*2.00*
Private Hatchery	818	666088	*96.66*
Artificial Total	**902**	**678147**	***98.65***
COUNTRY TOTAL	**902**	**687427**	*100.00*

Table 9.8: Annual Carp Hatchling Production, 2019

Source of Production	No. of Hatchery	Hatchling Production (Kg)	%
***1)* Natural**			
Jamuna River	-	952	-
Padma River	-	970	-
Arialkha River	-	175	-
Brahmaputra River	-	50	-
Garai/Madhumati River	-	158	-
Surma	-	0	-
Halda River	-	191	-
Natural Total		**2496**	0.37

Before we go on to ideas regarding carp hatchling vs other benefits from Halda, it would be instructive to have an understanding of the artificial hatcheries and the roles the public and private sectors play. In 2019, private hatcheries produced more than 255 thousand kgs of major carp hatchlings. In the same year, government hatcheries produced only 8492 kgs of major carp hatchlings i.e., private hatcheries produced 97% of the total major carp hatchlings. All these indicate that from provisioning angle, Halda is a small player. Indeed, the unimportance of Halda hatchlings even within the Halda region is exemplified by the figure below.

Figure 9.4: Individual Net Economic Value of Tangible Resources of Halda River



Source: International journal of water research 2013; 1(2); 30-36

The figure shows that fish fry is the least important economic activity in and around Halda. Irrigation has the highests net economic value. The picture relates to 2013 or thereabout. But, as the earlier discussion indicates, the situation may have probably worsened not become better than before. But the important thing is that we have to consider the Heritage value of Halda, which never comparable with any sorts of direct production or financial value.

The question thus arises as to how to value the importance of Halda as a spawning ground. We belive that one must assertain the existential value of Halda. This is only possisble if a proper economic study for the exsitential value is ascertained. Only a future study with clear purposes may perhaps do that.

9.2.2 Conclusion

Till now we do not have any idea about the existential value of haor apart from this apparent tangible avoidance of costs due to existence of haor system. nor for the Halda. In case of haors, we at least have a large tangible provisioning value. For Halda, it is not even that. It is some thing more than the financial value which usually we calculate for benifit cost analysis. Given that if for the haor system, we assume an existential value at least 50% of the provisioning value, the benefits from haor existence come to 1,99,228 or 200 thousand crores per year. In US$ it comes to nearly 23 billion, a really hefty sum.

10. Best Practices in Valuing Water and Possible Incentive Mechanisms

Valuing Water

Since the adoption of the fourth Dublin principle in 1992 at the International Conference on Water and the Environment (ICWE, 1992) there is a formal recognition that water should be considered as an economic good taking into account affordability and equity criteria.

Valuing water means changing the way we think about water by attaching a value to it in all its uses. The value that we give to water will be different depending on who we are and what we are using that water for. When we manage water, our actions should be informed by these diverse – sometimes, divergent – values. Valuing water means optimising the values attached to water as far as possible through management and allocation, noting that this will often mean optimising for multiple criteria, including those related to equity and environmental sustainability. When decision-makers elect to regulate, subsidies or otherwise favor one or more uses or users of water, valuing water simply means understanding the trade-offs involved, and being equipped to communicate them to stakeholders.

Principals of Valuing Water

In April 2016 the United Nations and the World Bank Group convened a High Level Panel on Water (HLPW) to provide the leadership required to champion a comprehensive, inclusive and collaborative way of developing and managing water resources, and improving water and sanitation related services.

In March 2018, the High-Level Panel on Water (HLPW) released its outcome document 'Making Every Drop Count' and recommended that we all understand, value and manage water better. The HLPW defined 5 principles to value water better and triggered the Valuing Water Initiative (VWI) to put these into practice. The agreed principles are:

- **Recognize and embrace water's multiple values** to different groups and interests in all decisions affecting water;
- **Reconcile values and build trust** – conduct all processes to reconcile values in ways that are equitable, transparent and inclusive;
- **Protect the sources,** including watersheds, rivers, aquifers, associated ecosystems, and used water flows for current and future generations;
- **Educate to empower** – promote education and awareness among all stakeholders about the intrinsic value of water and its essential role in all aspects of life;
- **Invest and innovate** – ensure adequate investment in institutions, infrastructure, information and innovation to realize the many benefits derived from water and reduce risks.

Valuing Water and Developing Shadow Prices

The VWI aims to generate experience how to sustainably, efficiently, and inclusively allocate and manage water resources and deliver and price water services accordingly. Valuing water – and developing shadow prices for water - has been prioritized as global action to achieve sustainable water resources management by the UN and the World Bank High Level Panel for Water (HLPW). Valuing water provides the basis for recognizing and considering all costs and benefits provided by water, including their economic, social and ecological dimensions (Bellagio Principles, 2017).

10.1 Examples of best practices of valuing water

Alternate Wet and Dry Method (AwD): Practicing AwD in Agricultural Water Management is one of the good examples of valuing water. It tries to ensure the demand driven water supply. Mass piloting and appropriate application of AwD may play significant role in judicious allocation of water for fulfilling the agricultural water demand. It also ensures the maximum rice production with minimum water use.

Rain Water Harvesting: Rainwater harvesting (RWH) is the collection and storage of rain, rather than allowing it to run off. Rainwater is collected from a roof-like surface and redirected to a tank, cistern, deep pit (well, shaft, or borehole), aquifer, or a reservoir with percolation, so that it seeps down and restores the ground water. Rain Water Harvesting is one of traditional water management practices for valuing water. Bangladesh faces immense rainfall during monsoon. Harvesting of these rain water and use it on non- rain period has ample benefit on ensuring IWRM.

Circular Use of Water: Optimise energy or resource extraction from the water system and maximise their reuse. Optimise value generated in the interfaces of water system with other systems. Maximise environmental flows by reducing consumptive and non-consumptive uses of water. The circular economy is "a regenerative system in which resource input and waste, emission, and energy leakage are minimized by slowing, closing, and narrowing energy and material loops". Water management can contribute to the circular economy by closing water loops, recovering resources from water, and recovering energy from water. Water management covers the whole water cycle, namely: surface water management and groundwater management, drinking water production and transport, and sewerage and wastewater treatment and disposal. All of these elements offer opportunities to realize a circular economy.

Water smart urban development: Water Smart development means the development of urban areas based on demand and sustainable supply of water resources with well-balanced integrated planning. The International Water Associations brought together 17 principles for water-wise urban developments, which are clustered mainly in four areas of policy focus: a) Regenerative water services ; b) Water-sensitive urban design; c) Basin connected cities and d) Water-wise communities. Water smart urban development will be best practice for sustainable water management for urban areas.

Integrated Water Resources Management (IWRM): IWRM is the basis of all best practices in sustainable water management and thus valuing water. Since water is a scarce resources and need to fulfill the competing demands for all sectors so principal of IWRM and its implication is significantly important.

No Waste or Zero Waste: There is a growing concern regarding sustainable waste management in developing economies such as Bangladesh due to the current growth of waste generation in these countries. Several company i.e Coca Cola Bangladesh flagship initiatives, World without Waste was launched in 2018 to resonate with the fundamental principles of circular economy; make-use-recycle. Adoption of a design-collect-partner framework and further developed specific working models that appreciate the closed-loop system so that the wastes like old bottles and cans can be recycled or up-cycled. To concretize this initiative, set the specific goals that give a clear vision of where we want to go in each sector to get No Waste or Zero Waste status.

Polluter Pay Principle: Enforce the "polluter pay" principle in the development of regulatory guidelines for all regulatory actions designed to protect public health and the environment. Provide education and information to the industrial and farming communities on Self-administered pollution control mechanisms and their individual and collective responsibilities for maintaining clean water sources is also important.

Managed Aquifer Resurge (MAR): Managed Aquifer Recharge (MAR) is a promising set of techniques to cope with a variety of water management-related issues. In recent years MAR implementations have witnessed an expansion and greater social acceptance in different countries of the globe. Innovative water management strategies such as the storage of reclaimed water or excess water from different sources in Managed Aquifer Recharge (MAR) schemes can greatly increase water availability and therefore improve water security. MAR seems as a sound, safe and sustainable strategy that can be applied with great confidence and therefore offering a key approach for tackling water scarcity.

Volumetric allocation of Water: Volumetric allocations entitle each water license holder with an annual volume that can be extracted from the aquifer each water use year (1st July to 30th June). Therefore it is fundamental that water users such as industrialists or irrigators or others have a good understanding of volumetric measurement and the water requirements of their enterprise. If volumetric allocation could be ensure the user would be more conscious about uses and thus reduce the mis-use of waters.

Women Empowerment: Women empowerment is one of good practices for valuing water as women's play key role in water management. As per the Global Gender Gap Report 2020, Bangladesh has emerged as the best performer in the region of South Asia and ranked 50th on the global index. Historically, it is the only country in the world where women have had a longer tenure than men at the helm of the state over the past 50 years. The country's performance in closing 72.6% (2006-2020) of its overall gender gap demonstrates a promising future for women in the country. Women empowerment in Bangladesh that supports one of the key goals of the Government's Eighth Five Year Plan, which is focused on women empowerment and works along the lines of the women development objectives set by Bangladesh such as Ensuring full and equal participation of women in the mainstream socio-economic development and Bringing up women as educated and skilled human resources.

Every Drop Matters: Every drop matters is a common slogan for now a day as one of the best practices in awareness rising. Consciously or unconsciously we waste a lot of water in our daily life. The combined value of this water is huge. If we are aware about the value of every drops of water and make maters it in ourselves we can reduce the wastage of huge volume of water in total. So we have to consider the every drops of water and need to care about every drops of water. In water-stressed Barind tract, we have significantly invested since 2017 in a project titled 'Introducing Water-Efficient Irrigation Technologies" by engaging 10,000 smallholder farmers. The focus is on water conservation and enhanced agricultural outputs by introducing water efficient drip irrigation and alternate wetting and drying (AWD) technologies for ultra-high-density mango plantation and water-thirsty boro rice cultivation respectively.

Best Practices in RMG: Daily 410.9 crore litres of water used in readymade garments in Bangladesh (IFC). Every year 1,500 billion litres of water is used to dye and wash the cotton and clothes for the garment industry, according to a study of the International Finance Corporation.

More Water More Pollution: As the inefficient plants draw more water to treat the same quantity of fabrics, they use more chemicals to do the job. More chemicals mean more pollution. If they could cut their water requirement by one fourth, which is very much possible with available technology, they could have substantially cut use of chemicals and thereby pollution too. Also more water needs more gas to heat for the dyeing and finishing of fabrics. Gas is a scarce commodity. Bangladesh is already running short of gas. The inefficient plants are just adding to the crisis. It does not need to use all that water to wash every kg of Apparels. Bangladesh uses 250 litres of water whereas the global standard is 60 to 70 litres . That is four times less than what we use. Experts say this use of water can be further reduced to 13.5 liters.Thus we should concentrate on optimum uses of water with ensuring the reduce, reuse and recycle process.

Adoption of more Cleaner Production: Adoption of more cleaner production will reduces water use from 174 to 52 litres/kg, 70% less use of water in just 2 years. Fakir Apparels Limited of Narayanganj is one of them that adopt clean operation. Before this, it used 24.96 crore litres of water to wash and dye 1,200 tonnes of fabric a month. But after changing technology, it has reduced water use to 6.96 crore litres. This is a saving of 70 percent of water.

Fakir Apparels recovered its investment of $2.65 lakh only in six months. Mondol Fabrics of Gazipur has been able to save 27 percent of water by using new technologies. It needed 120 litres of water to process one kilogramme of fabric. Now it needs 80 litres only. It is working to cut down water use further by putting in more technologies. More industries is also under practices of water efficient uses for its production.

10.2 Incentive Mechanism

To manage and better utilize our water resources, the focus can be on incentive-based solutions that harness the importance of ecosystems as an asset for smart development, economic and social progress, and long-term resilience. To reduce pressure on water resources while encourage and motivate relevant stakeholders/responsible parties and users in supporting water stewardship, an incentive-based instruments for instances –

i) rebates against investment related water stewardship/ pollution management,

ii) technical support from the authority (if applicable),

iii) abstraction fees,

iv) grants for community initiatives,

v) low-interest loans, and

vi) favorable tax treatment can be explored. Some more details incetives mechanism are also illustrated below:

Payment for Ecosystem Services: Payment for ecosystem services is an incentive-based instrument that seeks to monetize the external, non-market values of environmental services – such as removal of pollutants and regulation of precipitation events – that can then be used as financial incentives for local actors to provide such services. In practical terms, they involve a series of payments to a land or resource manager in exchange for a guar-anteed flow of environmental services. Payments are made to the environmental service provider by the beneficiary of those services, e.g. an individual, a community, a company, or a government. Invest in clean-ups and restoration of water ecosystems to ensure sustainable water management.

Direct Financial Incentives: Rebate programs are commonly used to encourage customers to make investments in water conservation and efficiency improvements. Residents and business owners pur-chase new devices as the old devices wear out. While most new standard devices use less water than older models, there are many new high-efficiency devices available that use even less water. While efficient devices are often cheaper over their lifetimes due to lower water, energy, and wastewater bills, users may be put off by the higher up-front costs. As a result, water utilities may provide their customers with a rebate to defray the additional cost of the more efficient device.

Education and Outreach: Education and outreach programs can also be effective for promoting water conservation and efficiency, for example, launching and adoption of Water Sense labeling program to promote water-conserving devices that are 20 percent more efficient than standard products on the market and meet rigorous performance criteria. Educating the people about the importance of water efficiency, including tying performance bonuses or operations based incentives to efficient practices is also important.

Regulations: In addition to financial incentives, acts and regulations are key demand management strategies. Regulations can take a variety of forms, ranging from a prescriptive approach focused on a particular appliance to a performance-based approach for sectoral water use.

Green Adjusted Tax: Green adjusted taxation rates should be applied for promoting water efficient financing. Some industries have high GHG emissions but try to invest in green and water/ energy efficient projects to reduce their carbon surplus and achieve carbon neutrality. Tax therefore needs to be based on adjusted reduction of water use and pollution reduction.

Fiscal Policy Instruments: FPI aimed at filling the water efficient investment gap and incentivising policies such as subsidies and tax exemptions can be highly appreciate. Voluntary agreements can also be efficient tools but need careful planning and monitoring, and their outcomes depend heavily on the stringency of the targets negotiated between governments and the private sector. In case of valuing water , subsidies in other resources uses like Removing energy price subsidies is also way of boosting private sector investments in green and water efficient projects.

Certification of Water Efficient Industries: Promotion of prestigious awards for industries that used to value water and thus reduce, reuse and recycle of water in their own production system. Industries that transparent water auditing system, adequate rain water harvesting, adequate green spaces for nature and ecosystem conservation, adequate use of surface water and adequate treatment facilities may be awarded with certification for encouragement.

Tax Subsidization: Promotion of tax subsidization to support green and water efficient or energy efficient projects or industries to guarantee a higher rate of return of these projects. The after-tax rate of return on green and EE projects would then be much higher, and polluting industries would pay higher taxes. Which encourage the industries for less use of water, less pollution and ensure sustainable green production.

Promotion of Green Bond Market: Promotion or adoption of a well-developed green bond market, green labelling has helped as incentives but is not enough. We therefore need a clear greenness credit rating to identify a precise greenness ratio. Nowadays, since satellite photos show how much CO2 is emitted by companies or projects, it is possible to detect and measure emissions in order to accurately assess greenness.

Promoting Energy and Water Efficient Financing: Adoption or Improvements in energy efficiency (EE) can deliver a "double dividend" by reducing emissions and helping to protect the water & environment. Yet, constraints such as limited access to finance and inadequate policy tools and instruments have placed serious limitations on the promotion of Energy and water efficient financing. Removing energy and water price (if applicable) subsidies is one way of boosting private sector investments in green and EE industries with the consideration of valuing water.

Emission Trading Schemes (ETSs) and cooperative policies can also be used as incentives for water efficient industries. We have to understand that water and energy efficient finance schemes alone will not be sufficient to change markets. Robust policy frameworks with the right economic and regulatory drivers to incentivize and bring about change are required to strengthen the judicious uses of water.

Appropriate Valuing of water is a crucial and timely demand of time because the world is facing serious imbalance in demand and supply in terms of fresh water. The situation will be more worsen in future. It is high time to pay attention on appropriate valuing of water and its sustainable management. Therefore, adoption of best practices for valuing water and provisions for necessary incentives for practicing valuing water is imperative.

11. Use of Shadow Price of Water for Public Investment Decision Making

11.1 Why Valuing Water is Important for Bangladesh

“Valuing water provides the basis for recognizing and considering all benefits provided by water, including their economic, social and ecological dimensions” (Bellagio, 2017).[9] By considering the various trade-offs among irrigation, drinking water, ecosystem services, livelihood, etc. valuing water can help to take decisions for equitable distribution of the water resource for multiple uses and services. Being a densely populated country means that water’s life-sustaining role becomes crucial. On the other hand, as the country is very much prone to natural disasters and also likely to be very vulnerable to climate change these will obviously affect water supply situation particularly as water scarcity and its quality both become major issues.

Valuing of natural resources in any national economy is always a difficult task, and in Bangladesh very challenging, as such practice has not been well established. Researchers have highlighted, for example the value of the Sundarbans to the country, the value of other ecological critical areas, but from the economic perspective, valuing of water is a new exercise. On the other hand, discussion with officials of Planning Commission, and literature review have found that water use is acknowledged as a very important environmental issue but its use as an economic resource, although seen as important in decision making, is not considered in the planning process.

The present study, despite challenging issues like limited availability of data have estimated shadow prices of water in four (4) major water intensive sectors. Question remains as to how to integrate the use of shadow prices for the water in the public investment process, so that the investment decisions undertaken in the key economic sectors can be sustainable and allow for the balanced distribution of the scare resource to the projects and programmes in various sectors (agriculture, transport, health, industry, tourism etc.) and include them under the Annual Development Programme (ADP).The ADP is a tool for the efficient management of the public investment system which is a key driver of economic growth.

The Current Development Framework

The roots of the planned approach for development for Bangladesh lies in Article 15 of the Constitution of the country, where it gives direction for carrying out development activities in a planned manner. Operationally, this has been practised since independence through a five year planning system with some variation over time. The present Government is implementing the 8th Five Year Plan with a vision to promote prosperity and foster inclusiveness. For the first time in the planning systems, valuing water has been included in the strategy for water resource management in the 8th Five Year Plan. This will allow the use of the water value to be institutionalized and strengthening of the relevant agencies so that water value can be mainstreamed in the regular investment decision making process in terms of project development, appraisal, water use policy etc. The 8th FYP is the first plan under the long-term Perspective Plan 2021-41. A positive aspect of the current five-year plan process is that it is aligned with the SDGs and aims for Bangladesh to become a middle income country. Hence the decision to include water values is not a short term issue for Bangladesh, but is expected to be part and parcel of its long term development strategy.

9 In May 2017, the High-Level Panel for Water has drafted the ‘Bellagio Principles on Valuing Water, which seek to provide high-level guidance on the rationale for Valuing Water and on how to implement it in practice.

The Guideline of DPP Approval Process

The Annual Development Programme as the name suggest is the annual operational counterpart of the particular five-year plan under which it operates. It is implemented every fiscal year to meet the targets and goals of the Five Year Plan. The ADP includes the allocations of approved ongoing projects (investment and technical assistance) of the various ministries, divisions, departments, self-financed bodies) and a pipeline of unapproved projects planned for processing for approval.

The ADP of the FY 2021-22 comprises of 15 sectors aligned with budget classification system of the Finance Division. The topmost allocated sectors are Power, Transport, Health and Rural Development. The projects are approved through the DPP approval, appraisal and revision guideline issued by Planning Division in 2016. It is the only guideline available for public sector investment appraisal in Bangladesh. This guideline is followed by the implementing agencies the ministries and the Planning Commission. The current format for investment proposals are given in DPP form which is given in chapter 10.

In all investment projects, financial and economic appraisal is required. Specially for social sector projects (health, education, women affairs, youth etc.) the requirement is to appraise projects in the social sectors. However, in recent times, it has become the practice that the project proposals in this sector have not been appraised. This is not consistent with global best practice. Only in projects of power sector, transport and agriculture, the cost-benefit analysis (CBA) are carried out while in the feasibility stage and appended to the DPP. So the CBA is not properly used uniformly for the investment decision making in all the 15 sectors of ADP.

It may benefit to understand properly as to why the financial and economic analysis are carried out prior to making an investment decision final. The basic purpose of undertaking the cost–benefit analysis of an investment project is to provide information to decision makers as to the contribution of the project to society's welfare. The analysis provides a means to systematically identify, quantify, and wherever possible value all impacts of the project, including (where relevant) its environmental impacts, even in circumstances when these impacts occur over long-time horizons. The role of the economic analysis is to support decision making as it provides information pertaining to the economic efficiency of investment projects, including the economic efficiency of climate proofing investment projects. The economic analysis is not a substitute but an input to decision making.

On the other hand, how environment or natural resources such as water will be impacted or their use will impact on the performance and feasibility of the investment needs to be gauged properly. Water being one of the most important part of our environment proper project financial and economic analysis should include the cost of and benefits due to water during and after implementation (for O&M) of the projects. At present the shadow price of water in such analysis is absent.

The reason for limited practice of CBA in certain sectors is due to the lack of professional training on CBA and knowledge in applying CBA in the decision making in all stages especially at the approval stage. This in turn is due to the difficulty in applying shadow prices to estimation of social benefits to carry out the economic analysis. To improve the situation, Planning Commission has developed simple appraisal tools to support the guideline know as Ministry Appraisal Format (MAF) and Sector Appraisal Format (SAF). However, their wide application is yet to happen.

11.2 Recommendations for Mainstreaming Shadow Price of Water

The problems of estimation of value of water and its shadow price(s) as well their application are beset with several problems. To reiterate the problems are as follows:

a. There is a huge data limitation in terms of their availability, accuracy and proper recording; one needs usage of water by volume and stage of operations which itself needs proper recording of the usage information

b. The estimates because of data limitations could not be done using the best possible estimation methods and thus there are issues related to their consistency and accuracy

c. There is a wide variation across sectors and even within sectors in the estimated values

d. The Planning Commission's conversions factors for translating financial values/prices into shadow prices are available only for a limited number of products and are quite old and need revisions to reflect present economic realities

e. While for many sectors, Cost Benifit Analysis (CBA) is not used, cost effectiveness (both financial and economic) must be looked into and for that shadow prices should be used along with shadow price for water wherever necessary.

Given the above, the recommendations are as follows:

a. Do not get hastily into use of the presently estimated values as shadow prices because of the major limitations that these have

b. Need to initiate a far broader ranging study on valuation of water taking into consideration of the findings of the present study

c. However, in the meantime the Planning Commission may take a pilot study to find out how far projects which have already been approved and are known to use water as a major input may be reappraised to finds out how far these fare against the test of CBA and to analyse under what conditions these may fail or pass the test to be used as a guideline for future actions

d. For social sector projects for which no CBA is done at the moment, the cost effectiveness analysis for some of the approved projects may similarly be undertaken

e. For the future DPP process, the following may be undertaken;

   - Dialogue with the Public Investment Management Unit (PIMU) in Programming Division, Planning Commission and find modality to work with the already formed working groups to roll out the formats.
   - Introduce the shadow price in the training module of CBA and Project Management regularly carried out for Planning Officials,
   - Pilot the identified shadow prices in already approved projects to see how the economic feasibility results any change. Once this is done successfully, the DPP may be changed to take cognizance of the value of water at least in major water consuming projects and sectors. After successful piloting, a set of instructions on the shadow price can be appended to the DPP Approving Guideline which is currently under revision. Also the shadow price terminology has to be incorporated in the main text of the guideline and the section 17, 24 and 31 of the current DPP format (chapter 10).

- To be more specific, a proposal on the changes to the above specific sections could be proposed to NEC-ECNEC Wing of Planning Division of Planning Ministry.
- For section 17: the estimated shadow prices of four sectors can be inserted. The detail of the economic analysis procedure can be issued as a separate guideline to support the Paripatra.In the guideline it will include the assumptions, the calculation method the sources and uses of water such as Domestic use (average domestic water consumption, etc.), Non-domestic use, Non-revenue water (cite examples from the cases under the study), seasonal variation in water use, peak factor, water supply coverage and water demand projection. The findings should give the Expected Internal Rate of Return (EIRR) for the water use /supply to the project
- For section 24.2, the following two points can be inserted.
    - o "What are the Assumptions for Water Demand Analysis for the project"
    - o "What are the potential impact due to the project intervention on the existing water sources and water", (whether it will improve or degrade)
- For section 31, description on risk mitigation on the risks identified on the use/supply of water after the project intervention should be explained,
- Building on the methodologies already developed in this study, the shadow prices for water will be transferred to 'conversion factors. These conversion factors will complement the already existing conversion factors, e.g. for labor, and thus allow for the consideration of the impact on water resources in all investment decisions, in a gradual manner.
- While examining the use and practice of CBA for project development by the 58 Ministries/Divisions, the shadow price concept needs to be given more attention at the DPP development stage. High level seminars need to be carried out with each of the four sector-divisions as each work with different sectors of the ADP.
- Planning Division has issued a comprehensive feasibility study format in January 2021 (see in part B) to be followed by all agencies submitting investment proposals, irrespective of cost. The shadow price for water concept could be included in this format, and for this dialogue is needed with the NEC-ECNEC Wing of Planning Division. Proper feasibility study should be undertaken where detailed financial and economic analysis will be made.

However, all these steps are for the future, right now we reiterate three steps:

i. Re estimate the values with better data and samples
ii. May be piloted in already approved projects with the presently estimated shadow prices and check the sensitivity regarding economic feasibility
iii. From now on instruct all major water using sector that they must keep account of water uses by stages of production/use, sources of water and prices paid or costs incurred in their supply which may be reported with the project proposals even if inclusion of water shadow prices are not possible right now. These proposals should also state clearly if there are alternative technologies or management which might lower water use and the sensitivity analysis due to use of such technologies or management. At least this way, some step will be taken towards conservation of resources.

Annex A: Proforma/Proposal (DPP)

PART-A

Project Summary

1.0	Project Title	:
2.1	Sponsoring Ministry/Division	:
2.2	Implementing Agency (ies)	:
2.3	Concerned Division of Planning Commission	:
3.0	Objectives and Targets (of Beneficiaries) of the Project *(Please specify in quantity and/or in percentage and write in bullet form)*	:
4.0	Project Implementation Period	:
	1. Date of Commencement	:
	2. Date of Completion	:
5.1	Estimated Cost of the Project (Taka in lac)	:
	Total	:
	GOB	:
	PA	:
	Own Fund	:
	Others	:
5.2	Exchange Rate(s) with Date *(Source: Bangladesh Bank)*	:
6.0	Mode of Financing	:
6.1	Mode of Financing with Source	:

(Taka in Lac)

Source / Mode	GOB (FE)	PA (RPA)	Own Fund (FE)	Others (Specify)	PA Source
1	2	3	4	5	6
Loan/credit					
Grant					
Equity					
Others (Specify)					
Total					

6.2 Year wise Estimated Cost:

(Taka in Lac)

Financial Year	GOB (FE)	PA		Own Fund (FE)	Others (Specify)	Total
		RPA	DPA			
1	2	3	4	5	6	7
						Grand Total

7.0 Location of the Project:

Division	District	City Corporation/Pouroshova/ Upazila
1	2	3

(Attach map, where necessary)

8.0 Location wise Cost Breakdown:

9.0 Estimated Cost Summary *(Taka in Lac)*:

Economic Code	Economic Sub-Code	Economic Sub-code wise Item Description	Unit	Quantity	Total Cost*	GOB (FE)	Project Aid				Own Fund (FE)	Others	% of Total Project Cost
							RPA		DPA				
							Through GOB	Special Account**	Through PD	Through DP			
1	2	3	4	5	6	7	8	9	10	11	12	13	14
(a) Revenue:													
Sub Total (Revenue):													
(b) Capital :													
Sub Total (Capital):													
(c) Physical Contingency:													
(d) Price Contingency:													
Grand Total (a + b + c + d):													

*Column 6=(7+8+9+10+11+12+13)
** DOSA, CONTASA, SAFE, Imprest, etc.

10.0 Log Frame:

i) Planned Date for Project Completion:

ii) Date of Log Frame Preparation:

Narrative Summary	Objectively Verifiable Indicators (OVI)	Means of Verifications (MOV)	Important Assumptions (IA)
Goal			
Objective/ Purpose			
Output			
Input			

11.0 Project Management:

11.1 Proposed Project Management Setup

11.2 Implementation Arrangement

12.0 Financial and Procurement Plan:

12.1 Procurement Plan

12.2 Year wise Financial and Physical Target Plan

13.0 After completion, whether the output of the project needs to be transferred to the revenue budget:

13.1 If yes, briefly narrate the institutional arrangement and technical & financial requirement for operation and maintenance.

(To continue the benefits of the projects required yearly costs and personnel should be mentioned)

13.2 If not, briefly narrate the institutional arrangement and financial

requirement for operation and maintenance.

(To continue the benefits of the projects required yearly costs and personnel should be mentioned)

Signature of the Officer(s) Responsible for the Preparation of the DPP with Seal and Date

PART B

Project Details

14.0 Background Information:

14.1 Background with Problem Statement

14.2 Linkages (to Other Projects Institutions)

14.3 Poverty Situation

15.0 Project Description:

15.1 Objectives

15.2 Outcomes

15.3 Outputs

15.4 Activities

15.5 Sex disaggregate d data for target population& constraints faced by women

15.6 Population Coverage

16.0 Whether any pre-appraisal/feasibility study/pre-investment study was done

before formulation of this project? If so, attach summary of findings & recommendations. (If not, mention the causes)

17.0 Financial Analysis:

(Attach Calculation Sheet)

17.1 Net Present Value (NPV)

(considering 15% discount rate)

(i) Financial

(ii Economic

17.2 Benefit-Cost Ratio (BCR)

(considering 15% discount rate)

(i) Financial

(ii) Economic

17.3 Internal Rate of Return (IRR)

(i) Financial

(ii) Economic

conomic Value/Shadow price of water

i. Sector

ii Sub sector

iii. Estimated economic value/shadow price of water

iv. Reference document of shadow price estimation

The shadow price of water of respective sectors should be considered in the above stated financial analysis.

18.0 Lessons Learnt from Similar Nature of Project(s):

18.1 Indicate which issues lead to make project successful

18.2 Indicate which issues did not work well.

19.0 Basis of Item Wise Cost Estimate and Date:

SL	Major Items	Unit	Unit Cost	Basis	Source	Date
1	2	3	4	5	6	7

20.0 Comparative Cost of Major Items of Similar Other Projects:

Sl.	Major Items	Unit	Unit Cost of the Item(Taka in Lac)			Remarks
			Proposed Project	Similar Ongoing Project (*)	Similar Completed Project(**)	
1	2	3	4	5	6	7

* Name of the similar ongoing projects
** Name of the similar completed projects

21.0 Detailed Annual Phasing of Cost

22.0 Specification/Design of Major Items

23.0 Amortization Schedule for Projects having Involvement of Loan from Government

24.0 The effect/impact, adaptation and specific mitigation measures thereof, if any, on (use of water which will be

24.1 other projects/existing installations

24.2 Environmental sustainability like land, water, air, bio-diversity, ecosystem services (If the project is 'Red Category' attach the EIA document)

24.3 future disaster management, climate change

24.4 gender, women, children, person with disability/excluded groups' needs

24.5 employments

24.6 poverty situation

24.7 organizational arrangement/setup

24.8 institutional productivity

24.9 regional disparities

24.10 populations

Here shadow price can be used to supplement water use related policy. Since ground water table is gradually going down and policy suggests to ensure conjunctive use of water or use surface water.

25.0 Whether environmental clearance under the ECA 1995 (Revised 2010) has been obtained? (If yes, attach the certificate. If not, mention the cause)

26.0 Specific linkage with Perspective Plan/Five Years Plan/SDGs/Ministry/ Sector Priority (Mention the pages with clauses of respective document/ attach the relevant pages of those document)

27.1 Contribution of the Project in achieving the Vision, Mission of the Ministry/Division and Implementing Agency.

27.2 Relation of the Project with the Allocation of Business of the Sponsoring Ministry/ Division.

28.0 Whether private sector/local government or NGO's participation is considered? (If yes, describe how they will be involved)

29.0 Major Conditionality (ies) for Foreign Aid:

30.0 Involvement of Compensation, Rehabilitation/ Resettlement:

(Indicate the magnitude and cost, if applicable)

31.0 Risk Analysis and Mitigation Measures:

(Identify risks during implementation& operation)

While identify the risk related to water use or water supply shadow price can be used

32.0 Other Important Details(Technical or otherwise):

32.1 Sustainability of the Project Benefit

32.2 Project Steering Committee (PSC) Formation and TOR

32.3 Project Implementation Committee (PIC) Formation and TOR

32.4 Others, If any.

Signature of the Head of the Executing Agency with Seal and Date

12. Use of Value of Water in Private Sector Decision-Making

All the economic production processes, save for power generation, used as case studies are carried out by the private sector. Of course, if the public sector invests in activities reklated to these production processes, the recommendations given in earlier chapter will apply. Question is, will the rules be the same also for the private sector whose main motive for production is to earn profit.

As has already been pointed out earlier, the estimates suffer from both limited data and also as a result estimation method which are sub-optimal. Also even within the same sector, estimated values vary widely either because of data deficiency and more importantly perhaps because of price differentials of the output . Construction is a point. Just to reiterate with the same city, prices differ by location and even when the technology and use of water are the same or very similar, values of water and therefore shadow prices differed tremendously. Not just that, the values differed by a wide margin from what the enterprises for water. On the other hand, we know that very likely because of low prices, water may have been overused which also has externalities in terms of environmental degradation.

Regarding externalities, it is also common knowledge that particularly in case of industries, grey water or effluents containing toxic materials are released more often than not without treatments and in water bodies degrading the quality of water in those places. While we have not considered this aspect in estimations of values of water and shadow prices, but pointed out that the estimated values in such cases are likely to be overestimates from social point of view.

Against the above findings as well as anecdotal evidence, what policy conclusions should be drawn here?

First, as is the case with public sector decision-making, more in-depth, empirically robust estimates of value of water with detailed information on inputs and outputs and associated data across many types of enterprises are needed for understanding the diversity of value of water in various kinds of private sector production activities. After all, there are hundreds of types of industries of all sizes. To begin with some of the major water using industries may be picked up first at different locations of the country keeping in mind ease or scarcity of water availability as well as quality (for example salinity may be an issue in some places) which may require treatment prior to its use by them. One needs to know if they differ in their usage of water, its volume, technology employed and the chemical nature, volume, treatment if any of grey water released, release points and consequent environmental degradation.

Given all these, perhaps the fact remains that in all such cases the estimated financial value of water is far greater than the market price that is paid for it. Of course, such a conclusion needs to be tempered by the fact that at least some or perhaps many of the private sector enterprises do get the supply of water they use directly from natural sources be it surface water or ground water. A 2016 study by CEGIS sponsored by the Department of Environment found that in Dhaka and its environs, just 23% of enterprises buy water from water utilities while just short of 52% get it from deep tubewells mostly operated by themselves. In case of Chattogram, the proportion of DTW sourcing is even higher at 71%.[10] Whether such withdrawal of water is under license remains an

10 CEGIS, Development of GIS based Industrial Database for the Department of Environment for Chittagong Division, Draft Final Report, 2016, submitted to Department of Environment; and
CEGIS, Development of GIS based Industrial Database for the Department of Environment, Project Completion Report, 2016, submitted to Department of Environment.

open question. In any case, the chances that in such cases water abstraction may be higher than is warranted as much of the cost of pumping water is a sunk cost.

In any case, the cost of such supply of water is unknown and needs to be known with certainty if a proper estimation of value of water is intended as the cost per unit of withdrawal has to be not simply its operation cost but the temporally distributed capital cost as well as any cost of treatment before the water can be used. Almost certainly in food and beverage industries this has to be done to ensure safety of processed food. In case of use of surface water, this is perhaps universal for all industries which may be the reason, enterprises prefer ground water. Given all these the fact remains that all these entail some financial costs. These must be considered in comparing value of water to the cost involved in getting its supply.

Question then is if there is a substantial gap, how should this information be used for conservation of water. One way is to simply raise the price as much as possible to transfer the private sector "rent" due to water to the public exchequer. How far this may be possible needs to be carefully studied. No ad hoc decision should be taken in this regard. However, there must be some regulatory mechanism for industries to source water either from the ground or surface. The Water Act of 2013 and the associated rules should be carefully examined to find out if there is any such mechanism as a guide towards further action.

On the other hand, there must be an awareness campaign that water is indeed valuable from private sector point of view and they should conserve it as much as possible in which technological advancement may be one possibility. The government may provide specific incentives (credit, information etc) towards that. Again what these incentives can be needs to be carefully studied keeping in mind that no two types of private activities are the same and thus needs to be treated on a case by case basis.

Whether for a regulatory point of view or facilitating optimal use of water and maximizing its productivity in private enterprises, the other sin qua non is complete information on water use necessitating keeping of records of sourcing, costs and usage of water by volume. Indeed, water audit must be done for industries on a periodic basis perhaps along with the SMI done by BBS. Indeed we suggest that whenever industries ask for credit from banks or raise capital they should provide such information.

One final point which relates to both public and private sector activities is of course the externalities involved either in ensuring the supply of water (an issue of quantity) which had been largely considered here in terms of conservation, or the issue of quality, the problems of effluence and the worsening of water quality. The latter has implications for estimate of value of water as indicated earlier. How to take account of the latter remains a major issue in Bangladesh.

13. Summary, Conclusions and Recommendations

The discussion above on the estimates of value of water and corresponding shadow prices may be summed up as follows:

a. Given that there had been major problems with sample units and data availability in most cases with the exception of agriculture, the problems regarding conversion factors (again with the exception of agriculture), the estimates must be taken at best as indicative of the present situation. These must not be taken as definitive exercises and there are ample scopes for improvement in terms of sample size, data on missing variable, particularly inputs in case of economic production activities as well as in case of municipal water supply services and consuming households and most certainly in case of ecosystem services particularly the existential values of the ecosystems.
b. Given the above, one sis struck by the wide range of values that have been obtained, even with a sector or sub-sector. This clearly indicates that even in case of economic production purposes, there may be no one single value for water. However, from literature survey we find a similar picture in many other countries.
c. The estimation of shadow prices was hampered among others by limited number or lack of conversion factors, even for electricity which is now a ubiquitous input into almost any production process. Furthermore, most such conversion factors are several decades old and possibly no longer realistic because of the major changes that have taken place in the economy.

Given the above what are the implications and recommendations for public and private sector decision-making for use of water particularly in production process? First, public sector investment decision-making.

In public sector decision-making all costs and benefits have to be valued at their shadow prices. In practice what happens is that the initial costs and benefits are valued at market prices which does not necessarily reflect social perspectives due to various imperfections in the market. In reality, the project appraisal first does the financial cost-benefit analysis which uses market prices. Then the economic cost-benefit analysis is attempted based on shadow prices. Shadow prices are derived from market prices by multiplying them by conversion factors. Unfortunately, there are no conversion factors for all types of products (as indicated earlier say for electricity) and services as well as for inputs such as water. In such cases either expert judgement has to be used or no adjustment is made at all and certainly no account is taken for unit economic cost (i.e., shadow price) for water usage. Question then is should the estimated values of water be used for economic appraisal of projects which have water as a major input? The answer should be yes, in principle, but no, at least not right away.

Valuing water has been included in the strategy for water resource management in the 8th Five Year Plan of the country. This is expected to allow the use of the social value of water value to be institutionalized and strengthening of the relevant agencies so that water value can be mainstreamed in the regular investment decision making process in terms of project development, appraisal, water use policy etc. Given this, the process of inclusion of shadow price of water is in a sense straightforward. Wherever water usage is mentioned, its volume must be mentioned, and the shadow price should be used to value it and the rest of the process remains as usual.

However, as already indicated the present estimates are at most indicative. More definitive estimates are necessary and for a much wider range of products and services that use water as inputs in some form. This calls for taking larger, more focused projects to fully capture the value of water in different scenarios and proceeding accordingly. However, while this goes on two more activities must be taken up alongside. First, all sectors and economic activities where water is a critical input, must keep full records of volume of water used in each stage of process. A kind of water audit must be the mandate in all such cases. Secondly, the Planning Commission will be well advised to revise its conversion factors and widen the scope for its application in case of many other products and services.

Lastly, when if all these are done, there may be no unique shadow price of water. But that will be another matter which will have to be resolved in the future.

How can these values of water and shadow prices be used in the private sector decision-making process. First, as is the case with public sector decision-making, more in-depth and across many types of enterprises are needed for understanding value of water in various kinds of private sector production activities. Given this, perhaps the fact remains that in all case the estimated financial value of water is far greater than the market price that is paid for it. Of course, such a conclusion needs to be tempered by the fact that at least some of the private sector enterprises do get the supply of water they use directly from natural sources either it would be surface water or ground water. In some cases, this may also have to be treated before actual use. All these entail some financial costs. These should be considered in comparing value of water to the cost involved in getting its supply. Question then is if there is a substantial gap, how should this information be used for conservation of water. One way is to simply raise the price as much as possible to transfer the private sector "rent" due to water to the public exchequer. How far this may be possible needs to be carefully studied. No ad hoc decision should be taken in this regard. On the other hand, there must be adequate awareness campaign that water is indeed valuable from private sector point of view, and they should conserve it as well as reuse/recycle as much as possible in which technological advancement may be one possibility. The government may provide specific incentives towards that. Again what these incentives can be needs to be carefully studied keeping in mind that different types of private sectors activities are not the same and thus needs to be treated on a case by case basis.

Issues of Valuing water and its importance, best practices towards valuing water need to pay due attention with intensive dissemination. It needs to be much dissemination for sensitizing the Integrated Water Resources Management Committee formed in the district, upazilla and union parishad level under Bangladesh Water Act 2013. Valuing Water and thus developing shadow prices may recommended to include in academic curriculum specially in secondary and tertiary levels for ensuring the best uses of water. Moreover, issue of valuing water and developing shadow prices of water need to consider for inclusion in annual training curriculum of Bangladesh Public Administration Training Centre (BPATC), Regional Public Administration Training Centre (RPATC) and other institutions.

One final point, which relates to both public and private sector activities, is the externalities involved either in ensuring the supply of water (an issue of quantity) which had been largely considered here in terms of conservation, or the issue of quality, the problems of effluents and the worsening of water quality. How to take the issues of quality of water in to account in latter, remains a major issue in Bangladesh. Finally, more detail study and mass sensitization on valuing water and raising awareness on best uses of water is prerequisite.

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Appendix 1: Terms of Reference

Consultancy Services of
Study on 'Developing Operational Shadow Prices for Water to Support Informed Policy and Investment Decision Making Processes'

1. Introduction of the Project

Background

Internationally, valuing water and thus developing shadow prices for water - has been prioritized as global action to achieve sustainable water resources management by the UN and the World Bank High Level Panel for Water, of which the Hon'ble Prime Minister of Bangladesh is a member.

In policy and investment decisions, the consideration of all benefits and costs related to water provides the foundation for sustainable water management and long-term socio-economic development. The absence of this consideration results in substantial misallocation of resources, which materialises in water resource management challenges which Bangladesh faces, such as localised severe groundwater over-abstraction and water shortages, surface water pollution and flooding.

These misallocations occur, as policy and investment decisions are generally made by comparing the costs against the projected benefits. Due to existing market imperfections, caused by monopoly elements, taxes and subsidies etc., the market price does not measure the social cost or usefulness of a commodity. As a consequence, the market price does not necessarily lead to an optimal allocation of resources. From this realization, it was emphasized early on that a set of hypothetical prices, i.e. shadow prices, rather than market prices are required to evaluate policy and investment decisions.

Valuing water provides the basis for recognizing and considering all costs and benefits provided by water, including their economic, social and ecological dimensions (Bellagio Principles, 2017). In theory, the shadow price for water (or any resource) should capture the value of water, i.e. including its economic, social and ecological dimensions. It needs to be noted, that in practice, shadow prices referred to in literature and guidance documents, may only capture part of the value of the resource - mostly due to operational reasons and data availability.

Bangladesh Water Multi-Stakeholder Partnership (BWMSP) has been formalized with the approval of the Prime Minister, the Government of Bangladesh and includes high-level representatives from the government, private sector, NGOs, civil society and academia. Acknowledging the importance of valuing water for Bangladesh, the BWMSP has chosen Valuing Water as one of its priority areas within its work stream on Water Governance and Sustainability and formed a High-Level Committee on Valuing Water chaired by Mr. Md. Abul Kalam Azad, Principal Coordinator (SDG Affairs), Prime Minister's Office, GoB.

A Position Paper on Valuing Water in Bangladesh was developed, which highlighted that currently investment and policy decision in Bangladesh do not consider the value of water, and thus the impact investment and policy decisions may have on water resources. This results in a misallocation of resources, as described above, and hinders Bangladesh's socio-economic development. The Position Paper provides an overview of best practices on Valuing Water, the applicability of selected methodologies to the Bangladeshi context and presents three pilot studies on Valuing Water in Bangladesh. The Position Paper finds that the consideration of value of water is both – beneficial and possible – for Bangladesh.

The High-Level Committee on Valuing Water requested the Planning Commission to re-examine the use of shadow prices for water in their economic analysis for investment decisions (DPP Manual) and submit a report with its findings to the Valuing Water Committee. It concluded – and thus confirmed the findings of the Position Paper – that while shadow prices were used for other resources, the value of water is currently not considered in investment decisions in Bangladesh. It further outlined the need of determining the value of water and subsequently considers revising the DPP Manual and related assessment formats to integrate this consideration to investment decisions.

Recognizing the need for action, the High-Level Valuing Water Committee (HL-VWC) in its 1st meeting on 12th of August 2018 formed a Technical Committee (T-VWC) led by Dr. Rezaur Rahman, Professor, IWFM, BUET. The T-VWC found the requirement of this proposed study and developed the PFS in cooperation with the Ministry of Water Resources.

1.2 Need and Justification

Need

Water remains an indispensable resource and is used in diversified ways. It is used for production purposes such as, agriculture, industrial, commercial, forestry, fisheries etc., and also for community services like use of water for domestic consumption and sanitation. The nation-wide demand for water is growing every day which is being intensified by several socio-technical drivers such as, high demographic changes, rapid and unplanned urbanization, high sectoral demand (such as agriculture, fisheries, transportation, industries, etc.), climate change, etc. On the other hand, the essentiality of water for the rich but vulnerable ecosystem of the country, and the variability of water availability in dry and wet season complicates the issue of water resources management in Bangladesh. The management of water resources is further complicated by the fact that the flow generated from 93% of the area of the Ganges- the Brahmaputra- the Meghna is lying outside the border of Bangladesh and is drained out to the Bay of Bengal.

There are strong demands of water by the competitive sectors. On the other hand, water quality worsens severely in most of the water bodies are considered at risk of severe environmental degradation. Industrialization, including mechanization of the agriculture sector, urbanization and salinization are expected to lead to further deterioration of surface water quality in the country. So, meeting the demand of water by various sectors together with maintaining quality of water have become crucial.

Valuing water provides the basis for recognizing and considering all benefits provided by water, including their economic, social and ecological dimensions (Bellagio Principles, 2017). The consideration of all benefits and costs related to water provide the foundation for sustainable water management and long-term socio-economic development.

To understand the full impact of, e.g. construction of a river barrage, the full costs and benefits need to be considered. These include the obvious consideration of the financial costs (capex.

opex) of the barrage, and the benefits to the irrigators. However, further considerations need to be made to provide a full assessment on whether this investment really has the desired socio-economic impact. As such, the barrage may have an impact on the fish population, and thus an impact on the production and livelihood of the fishermen. Also, the captured sediment behind the barrage may have a negative impact on the agricultural land downstream leading to reduced yields, etc.

'In the absence of information about ecosystem values, substantial misallocation of resources has occurred and gone unrecognized and immense economic costs have often arisen. Under-valuation impacts on the status and integrity of natural ecosystems themselves, and also runs the risk of undermining water availability, water profits and sustainable development goals' (IUCN, 2004)

By considering these trade-offs, valuing water can help balance multiple uses and services provided by water in a sustainable and equitable manner and strengthen institutions and infrastructure. Thus, effective water management presents a transformative opportunity to convert risk to resilience, poverty to well-being, and degrading ecosystems to sustainable ones (Bellagio, 2017).

For Bangladesh, it is of particular importance as it is a densely populated active delta country, with multiple and increasing competing water demands, diminishing groundwater aquifers, increasingly polluted surface and groundwater bodies, and being vulnerable to climate change.

However, currently the costs and benefits of projects/ investments related to water are not considered in Bangladesh. This study seeks to develop a framework for valuing water in Bangladesh and determine the value of water, which can be easily operationalised for informed decision making.

Justification

The UN and the World Bank High Level Panel for Water, of which the Hon'ble Prime Minister of Bangladesh is a member, have prioritized valuing water as global action to achieve sustainable water resources management.

A Position Paper, requested by the High-Level Valuing Water Committee, chaired by the SDG Coordinator, PMO, highlighted the need for considering the value of water in investment decisions and the absence of this requirement in Bangladesh.

The High-Level Valuing Water Committee further requested the Planning Commission to re-examine the use of shadow prices for water in their economic analysis for investment decisions (DPP Manual). The resultant report confirmed that the value of water was currently not considered, but that the necessity to include it was well understood. The value of water could be included in form of conversion factors to the DPP Manual, which already requires the usage of certain conversion factors, such as for labour, in the economic analysis. However, the report further highlights that the DPP Manual, while published, is currently not mandatory for DPP submissions and approvals. As the Green Book was revised in 2016, the DPP Manual (2014) requires updates before it can be made mandatory to be used. Thus, to ensure the operationalisation of the value of water in public decision-making processes, the DPP Manual also needs to be made operational and mandatory.

1.3 Objectives

The study will develop operational shadow prices for water, so that the value of water can be considered in all policy, project and investment decisions in the public and private sector. This applies to all investment and policy decisions in which water resources are impacted directly, such as for dams, or indirectly, such as for projects requiring water as an input etc. The overall objective is to improve allocation of resources and thus enabling sustainable socio-economic development.

The study consists of three parts:

In Part 1, the study will develop a set of harmonized shadow prices for water for Bangladesh and refine them as part of case studies (action research). These values can be operationalized in investment and policy decisions by the public and private sectors, as well as by civil society. The shadow prices for water will be developed as part of a multi-stakeholder process to ensure their acceptance by stakeholders.

In Part 2, the shadow prices will be mainstreamed in policy and decision-making processes. Capacity development and training will be provided to the public sector to operationalize shadow prices within the DPP process.

In Part 3, options for making shadow prices operational for private sector decision making processes will be identified. Demonstration case studies with selected private sector companies can guide as lighthouse examples on how to operationalize shadow prices for water. Capacity development and training will be provided to the private sector and civil society to ensure the integration of the shadow price of water in their decision making.

Acknowledging that this study is cutting edge research, and as this type of operational shadow prices have not been developed before in any context known to the Committees, it is understood that while the theoretical framework can present a best-case situation, the actual calculation of shadow prices may have to be adjusted to respond to the data situation at hand. The objective for the actual calculation of operational shadow prices is to start simple and practical and then move on to further refine the values. This study, shall lay the foundation for further sophisticated shadow prices.

1.4 Duration of the Project

The approved duration of the project is from January, 2019 to June, 2020

2. Scope of Works

The study builds on the Position Paper developed as part of the BWMSP and High-Level Valuing Water Committee. To develop operational shadow prices for water to support informed policy and investment decision making, the study has three major parts, namely:

- Part 1 – Developing Shadow Prices for Water in Bangladesh
- Part 2 – Streamlining Valuing Water into Public Investment Decision Making
- Part 3 – Identifying and Demonstrating Options to Operationalize the Shadow Price for Water in Private Sector Decision Making

Part 1 aims at developing the conceptual framework around valuing water for Bangladesh and at developing a harmonized set of shadow prices for water. It also provides for capacity building around applying the shadow prices for water in decision making processes for the public and private sectors, as well as for civil society. Part 2 and 3 aim at making these shadow prices for water operational in the public and private decision making processes, respectively. The Technical Valuing Water Committee will support this study and will be an integral part of shaping it during the implementation phase. Each part consists of more detailed tasks, which are specified below.

Part 1 – Developing Shadow Prices for Water in Bangladesh

Overview of best practice methodologies and past and ongoing initiatives on valuing water/ usage of shadow price for water as basis for investment and policy decisions in Bangladesh and around the world

The aforementioned Position Paper contains an overview of best practices/ methodologies for valuing water. It will be provided to the study project team, who can either use it as it is or amend it to further improve it. The study project team will map key past and ongoing initiatives on valuing water/ usage of shadow price for water in Bangladesh and around the world, including, but not limited to, California, Australia, Peru, China and Europe.

Relevant case studies shall be divided into:

- Using the value of water/ shadow price for water as basis for investment and policy decisions by the public sector and private sector (incl. financial institutions);
- Usage of value of water for designing and setting financial and regulatory instruments, such as tariffs, taxes, standards/ benchmarks, polluter pays etc.

Case studies shall cover all relevant sectors, i.e. 1) Agriculture; 2) Industry; 3) Municipality and 4) Environment.

The study project team will develop a framework in which the case studies will be compared, including at least the following criteria: 1) Objective; 2) Sector; 3) Country/ Region; 4) Methodology and data used and 5) Outcomes.

The comparison will be completed by a section on 'Lessons learnt', which can be specifically applied to Bangladesh.

It may be beneficial for the project management team from WARPO and MoWR to attend an exposure visit overseas particularly in the countries having ongoing initiatives on valuing water or usage of operational shadow prices.

Development of a framework for valuing water for Bangladesh

Building on the best practices/ methodologies and lessons learnt, the study project team will develop a conceptual framework on how to value water for Bangladesh and how to derive operational shadow prices from this.

The criteria for this framework include, but are not limited to:

- The shadow prices need to reflect the full value of water, i.e. consider its economic, social and environmental dimensions;

- The shadow prices need to reflect the complexity inherent to water resources, i.e. be differentiated by region, season, sector and source;
- The shadow prices for water shall be derived in a consistent manner across sectors, regions, seasons and sources to allow for comparability;
- Allow for multiple lines of evidence, i.e. the shadow prices for water derived by different methodologies is of similar magnitude;
- Ensure required data sources are available/ could be available in future and are trusted by stakeholders.

Acknowledging challenges around data availability in Bangladesh, the study project team has the option to prepare two frameworks for valuing water, if required by data limitations:

- Best case framework/ methodologies: The ideal framework regardless of data restrictions, however, considering on-ground realities in Bangladesh:
- Practical framework/ methodologies: The framework that can be applied as part of this project subject to data constraints.

In the case that Option A is required, the study project team is requested to provide an overview of data requirements and suggestions how these can be achieved in future.

Demonstration case study (action research)

To test and further refine the valuing water framework developed above, it will be applied in at least four demonstration case studies.

Demonstration case studies (4) should target two critical and two non-critical areas and include each prior mentioned sector, i.e. 1) Agriculture; 2) Industry; 3) Municipality and 4) Environment.

The 'hotspot regions' mentioned in the recently approved Bangladesh Delta Plan (2018) can be selected as 'critical areas'.

Further, the total selection of the demonstration case studies shall reflect the Bangladesh's diversity, i.e. include water scarce, saline and flood prone areas. Finally, the demonstration case studies need to consider the difference in shadow prices in the dry and wet season.

The Steering Committee and Valuing Water Committee will support the study project team in the selection of the demonstration case studies, approve of the final selection and support in the implementation.

Depending on the valuing water framework developed as part of this project, the study project team has the flexibility to first complete the next step (Development of one harmonized set of values for water) and to then undertake the demonstration case study and further refine the framework or use the demonstration case studies to develop the harmonized set of values for water.

Development of one harmonized set of values for water

Applying the valuing water framework, a set of shadow prices for water will be derived. To provide a sense of the range of shadow prices for water, and to provide a better sense of the impact any change of the underlying assumptions may have on the shadow price for water, it is requested to provide a lower, middle and upper set of shadow prices for water.

To operationalize the shadow prices for water, a tabular overview for each scenario (low, middle, high) is preferred.

Methodologies as well as the data used need to be presented in transparent manner. The underlying models form part of the deliverable.

Capacity building / training of trainers on application of values of water

The usage of the resultant shadow prices for water is intended for the public and private sectors, as well as for civil society. As the application of shadow prices for water is new to Bangladesh, capacity building will be required. Since the shadow price is intended to public and private sectors, the professionals of the concerned Ministries and Agencies both in public and private sectors will be trained on the process of determining the shadow price and also the results of the study conducted by the Consultants

The study project team will develop and hold a series of capacity building workshops/training eight (8) nos at different locations with multiple stakeholder , targeted at two main groups:

A. Public sector, including, but not limited to the concerned agencies and organizations, including planning and developing wings, of the following Ministries/ PMO:

- Prime Minister's Office
- Ministry of Planning (All divisions of the Planning Commission and Planning Division);
- Ministry of Water Resources;
- Ministry of Local Government, Rural Development and Cooperatives;
- Ministry of Industries;
- Ministry of Agriculture;
- Ministry of Environment, Forest and Climate Change;
- Ministry of Fishery and Livestock;
- Ministry of Housing and Public Works;
- Ministry of Power, Energy and Mineral Resources;
- Ministry of Textiles and Jute;
- Ministry of Commerce; m. Others.

B. Private sector, including financial institutions, and civil society

- Private sector associations, such as BGMEA etc.;
- National and multi-national private sector companies;
- Civil society;
- Academic Institutions, such as BUET, Dhaka University, BRAC University;
- Commercial, state and developing banks.

The capacity building of the public sector will be started after completion of part 2 of the PFS. Capacity building of the private sector can be done at any time.

Awareness raising campaign on the value of water

Awareness of the value of water is a crucial step to allow for considering the impact of actions on water resources and thus on sustainable socio-economic development. The study project team will prepare an action plan on how to raise awareness on the value of water in the public and private sectors and civil society.

This awareness raising campaign can include a high level conference, workshops across public and private sectors, as well as civil society, but also include media coverage to reach the broader society, including advertisements on radio and TV air time and posters/ banners.

During the project period, ten (10) awareness building workshops including an inception workshop and a final dissemination workshop have been planned.

After consultation with the Technical Valuing Water Committee, the awareness raising campaign will be executed.

Part 2 – Streamlining Valuing Water into Public Investment Decision Making

Currently, public investment decisions in Bangladesh are made based on the Development Project Proforma/ Proposals (DPP), following the guidelines provided by the Planning Commission of the Government of Bangladesh. A financial analysis is required to assess the profitability of the investment, i.e. the revenues, capital, operation and maintenance expenditures. Further, an economic analysis is required to assess the investment's impact on the wider economy, society and environment. However, the proposed approach to this analysis, using specified shadow prices, does not include the impact on water resources.

The above mentioned report submitted by the Planning Commission to the High Level Panel on Valuing Water clarified that the Circular on procedures for preparation, processing, approval, revision and amendment of Development Projects in the Public Sector[11], well known as the 'Green Book', is the key and mandatory document to follow when submitting a DPP. The latest version has been updated and published in 2016. A guidance document on how to develop the DPPs, including information on shadow prices to be used (not considering water), called DPP Manual (Part 1 and 2) has been developed by GED, Planning Commission and published in 2014.

The Planning Commission has stated that to consider the value of water the outlined steps are required after completion of Part 1 of this project.

- Considering inclusion of the shadow prices for water into the DPP Format and revise the DPP Manual accordingly

Building on the methodologies already developed and used for the economic analyses as part of the DPP process, the shadow prices for water will be transferred to 'conversion factors'. These conversion factors will complement the already existing conversion factors, e.g. for labor, and thus allow for the consideration of the impact on water resources in all investment decisions.

The conversion factors for the shadow prices for water will be included in the Annex of the DPP Manual.

11 No. 20.804.014.00.00.014.2012 (Part-1)/204 dated 10 Oct. 2016.

After proper scrutiny by the Planning Division, the DPP format will include a section in which the shadow price of water will be mentioned.

- Endorsement and dissemination of updated DPP Format and DPP Manual across Planning Commission and Line Ministries

As the DPP Manual was published in 2014 and revisions to the Green Book were made in 2016, there are minor inconsistencies between both documents.

The DPP Manual needs to be updated to reflect the structural changes promulgated by the Green Book. An overview of required changes can be seen in the report from the Planning Commission on the 'Usage of shadow prices for water in economic analysis for investment decisions (DPP Manual).

To allow for an endorsement of these changes by the Planning Division, a stakeholder consultation is required. This stakeholder consultation will be coordinated by the Planning Division and GED, and will include, but not be limited to the following stakeholders:

- Ministry of Planning including all divisions of the Planning Commission and Planning Division;
- Prime Minister's Office
- Ministry of Water Resources;
- Ministry of Local Government, Rural Development and Cooperatives;
- Ministry of Industries;
- Ministry of Agriculture;
- Ministry of Environment, Forest and Climate Change;
- Ministry of Fishery and Livestock;
- Ministry of Housing and Public Works;
- Ministry of Power, Energy and Mineral Resources;
- Ministry of Textiles and Jute;
- Ministry of Commerce;
- Ministry of Chattogram Hill Tracts Affairs;
- Private sector associations, such as BGMEA;
- National and multi-national private sector companies and
- Civil society

Once the concept containing the conversion factors for valuing water is well conceived, the Planning Division and the GED will consider revising DPP Format and updating DPP Manual.

Update of the Assessment formats for a DPP submission/ approval

To ensure consideration of the economic analysis, the following assessment formats require an update:

A. Ministry Assessment Format (MAF), which has to be completed by the Planning Wings in the Line Ministry/Division level before submitting the DPP,

B. Sector Appraisal Format (SAF), which is a supplementary document for the Project Evaluation Committee (PEC) and has to be completed by the respective Sector Divisions in the Planning Commission.

The study project team will submit the Report from Part 1, with the tables of harmonized shadow prices for water, to the Ministry of Planning. The Ministry of Planning may then decide to initiate the above mentioned steps in order to streamline the shadow price of water into public decision making.

Part 3 – Identifying and Demonstrating Options to Operationalize the Shadow Price for Water in Private Sector Decision Making

As with public investment decision making, it is crucial that also the private sector understands and considers the impact of its investment decisions on water resources and the resultant implications on its business model.

Understanding and considering the value of water in decision making, allows for improvements in water use efficiency, damage and compensation assessments, conservation actions and offsetting, risk assessments of policy changes, as well as reporting on performance to its stakeholders.

Selected multi-national companies have already started considering the value of water in their investment decisions and have reported the beneficial outcomes. Given the importance of the private sector in addressing Bangladesh's water resources management challenges, it is crucial to identify and promote options for making shadow prices operational for private sector decision making processes.

Identification of best practices on using value of water for investment decision making

The study project team will provide an overview of best practices on how private sector companies have included the value of water in investment decision making.

Case studies shall cover 1) Agriculture; 2) Industry; 3) Municipality and 4) Environment sectors. A focus shall be set on the most relevant sectors for private sector activity in Bangladesh, i.e. food and beverage production and processing, fish production, textile, clothing and ready-made garments, leather tanning, etc.

The study project team will develop a framework in which the case studies will be compared, including at least the following criteria: 1) Objective; 2) Sector; 3) Country/ Region; 4) Methodology and data used; 5) Outcomes, and 6) Business Case. The business case in particular shall provide an understanding on the benefits the company achieved by considering the shadow price for water.

This task considers the private sector, including companies, but also smaller entrepreneurs and farmers.

Demonstration case study (action research) on including shadow prices for water in private decision making

Based on findings above, the study project team will identify which segments of the private sector (sectors, type and size of enterprise etc.) can be considered as 'low hanging fruits', i.e. where the biggest impact on water resources can be made by considering the value of water with least effort.

The study project team will then identify interested private sector stakeholders to pilot, i.e. demonstrate, the operationalization of shadow prices for private sector decision making.

The shadow prices developed under Part 1 of this project will be applied. Particular attention will be given to the question whether these set of harmonized shadow prices for water are sufficient for private sector decision making, or whether more specific shadow prices for water would need to be determined.

There shall be at least three demonstration projects, spanning across three different key sectors, i.e. A) Agriculture, B) Industries, C) Urban and D) Environment, and portraying Bangladesh's diversity of water scarce, saline and flood prone areas.

Awareness raising on the benefit of considering the shadow price for water in private sector decision making

Complementing the awareness campaign presented in Part 1 the study project team shall develop an awareness raising campaign specifically targeted at the private sector.

For this, industry, trade and farmer associations can be involved to reach the targeted private sector stakeholders. All awareness campaigns can be executed jointly.

Design of incentive structure for companies to engage in sustainable water resource management

Based on the shadow price for water, initial ideas for the development of an incentives structure for companies shall be developed. Actions supporting sustainable water resource management, such as increased water use efficiency and reduced water pollution, shall be rewarded. Likewise, actions working against sustainable water resource management, such as wasting water and polluting water resources, shall be penalized.

Further, the study project team shall assess how loan conditionalities from commercial, state and developing banks could be linked to companies' activities towards or against sustainable water resource management. The range of more or less favorable loan conditionalities can be linked to the shadow price of water.

The study team shall provide an outline of suggested ideas on how to set up this incentive structure.

3. Project Organization

Given the novelty of the proposed study project and the specific expertise required to successfully complete the study project, single source procurement under Public Procurement Act (2006) and Public Procurement Rules (2008) is chosen as per procurement plan.

A renowned institution/firm will compile a project study team of consultants, following the qualification and experiences requirements for consultants as outlined in ToR. The institution/ firm will have to hire appropriate professionals to meet the required criteria as mentioned. The study team will develop shadow prices for water and test their application in demonstration case studies, support streamlining the value of water into public decision making and identify and demonstrate options to operationalize the shadow price for water in private investment decision making. Further, the study team will provide training/ capacity development to selected stakeholders from the public and private sectors, as well as from civil society. A public awareness campaign shall disseminate the findings and its applications. The tasks will be performed as per the Terms of Reference.

Project Steering Committee (PSC)

For smooth and proper completion of the project a Steering Committee (PSC) to be chaired by the Secretary, MoWR, will be established. The PSC members will be given an honorarium of BDT 2,000 (Taka Two Thousand only) per meeting. The Committee will be formed comprising the following officials. The Committee will be responsible for overall guidance and inter-ministerial coordination

Officials	Designation
Senior Secretary/Secretary, Ministry of Water Resources	Chairman
Additional Secretary (Development), Ministry of Water Resources	Member
Joint Secretary (Development), Ministry of Water Resources	Member
Joint Chief, Ministry of Water Resources	Member
Representative, Ministry of Agriculture	Member
Representative, Power Division, MoPEMR	Member
Representative, Energy and Mineral Resources Division, MoPEMR	Member
Representative, Ministry of Local Government Division,	Member
Representative, Planning Division, Ministry of Planning	Member
Joint Chief, Irrigation Wing, Planning commission	Member
Representative of GED, Planning Commission	Member
Representative of High Level-VWC	Member
Representative, Ministry of Fishery and Livestock	Member
Director General, WARPO	Member
Representative, Ministry of Textiles and Jute	Member
Representative, Ministry of Commerce	Member
Representative, Ministry of Environment, Forest and Climate Change	Member
Concern Asst. Chief/ Senior Asst. Chief, Ministry of Water Resources	Member
Project Director	Member- Secretary

The Terms of Reference (ToR) of the Committee will be as follows:

- Give overall guidance and monitor smooth implementation of the project (study);
- Monitor the progress of the study;
- Take necessary initiatives for inter-ministerial coordination;
- Review the Reports of the study
- The committee may co-opt members, if necessary.

Project Implementation Committee (PIC)

There will be a Project Implementation Committee (PIC), with DG, WARPO as Chairman. The PIC will meet at least twice in a year, or as and when necessary. The PIC members will be given an honorarium of BDT 2,000 (Taka Two Thousand only). The PIC consists of the following members:

Officials	Designation
Director General, WARPO	Chairman
Concerned Deputy Chief & Desk officer (Planning Wing), MoWR	Member
Concerned Desk Officer (Development Wing), MoWR	Member
Representative of Irrigation Wing of Planning Commission	Member
Representative from Programming Division of Planning Commission	Member
Representative of NEC-ECNEC & Coordination Wing of the Planning Division	Member
Representative from Concerned Sector of IMED	Member
Representative from Finance Division	Member
Representative, Technical Committee on Valuing Water	Member
Representative, Private Sector	Member
Representative, Civil Society	Member
Project Director, Concerned Project	Member
Desk officer (Concerned Officer), WARPO	Member- Secretary

Terms of Reference:

- To give necessary assistance and suggestion for smooth implementation of the project activities
- Provide necessary decision to solve the problem if arises during project implementation.
- The Committee will meet once in every four months.
- The committee may co-opt members, if necessary.

The multi-stakeholder High Level Valuing Water Committee (HL-VWC), chaired by the Principle Secretary SDG Affairs, and the multi-stakeholder Technical Valuing Water Committee (T-VWC**),** chaired by Prof Rezaur Rahman (BUET), were formed in 2018. The HL-VWC and T-VWC assessed the need for this study project, and jointly developed this PFS. The T-VWC will further support the study project team in identifying and gaining access to required data sources, and to demonstration case studies, while also supporting the team in awareness raising. The final report will be presented to the HL-VWC and it can be requested for guidance and appraisal as and when needed.

4. Expected Output, Reports and Workshops

Deliverables and Reports

The deliverables/ milestones are indicated detailed in the table below:

		Month										
Link to Scope of Study		Aug-19	Sep-19	Oct-19	Nov-19	Dec-19	Jan-20	Feb-20	Mar-20	Apr-20	May-20	Jun-20
Part 1	Overview of the best practice methodologies and past and ongoing initiatives on valuing water/usages of shadow price for water as basis for investment and policy decisions around the world											
Part 3	Identifications of the best practices on using value of water for investment decision making											
Part 1	Development of a framework for valuing water/developing shadow price for water for Bangladesh			*1								
Part 1	Demonstration case study (action research) to test and refine the valuing water framework (4 case studies)											
Part 3	Demonstration case study (action research) on including shadow price for water in private decision making (3 case studies)				*2							
Part 1	Development of one harmonized set of values for water					*3						
Part 3	Design of incentive structure for companies to engage in sustainable water resources management											
Part 2	Streamlining valuing water into public investment decision making						*4					
Part 1	Capacity building/training on application								*5			
Part 1 & 3	Awareness raising campaign on the value of water (incl. Specially targeted awareness campaign on private sector							*6	*7		*8	

Deliverables / Milestones (as indicated in the timeline)		Details
*1.	Inception report	Overview and lessons learnt of best practices & methodologies used to value water in Bangladesh and abroad Initial ideas on Valuing Water Framework Outline of suggested 7 demonstration case studies
*2.	Interim Report	Final Valuing Water Framework Outcomes of demonstration case studies
*3.	Shadow prices on water	Table of final set of shadow prices for water Digital data Underlying models/ calculations and assumptions
*4.	Draft updated version of DPP documents	Provided to the Planning Division of Ministry of Planning and GED, incorporating shadow price of water in DPP Format and Manual
*5.	Action Plan for Capacity Development	Materials for Capacity Development Overview of target audience and timeline of concrete capacity building sessions
*6.	Action Plan for Awareness Raising	Awareness Campaign Strategy, incl. modalities and targeted audience
*7.	Draft Final Report	Reporting back on all areas of the project, incl. methodology, data, assumptions, capacity building and awareness raising
*8.	Final Report	Revised version of the Draft Report, incorporating comments from Project Director, Committees, executing agency and MoWR

Workshop

The study project team will hold an inception workshop, with participants from the public and private sectors as well as civil society, at the mid November, 2019. In this inception workshop, the study project team will present their findings of best practices and methodologies in Bangladesh and abroad from the public and private sectors, as well as present initial ideas on the Valuing

Water Framework and related demonstration case studies. The participants will provide ideas and feedback to the study project team. It is planned to hold one small multi-stakeholder workshop (focus group discussion) for each demonstration case study to ensure that diverse opinions are heard and considered, and stakeholders develop ownership. These will take place as and when needed between december,19-february,20 of the study project. After completion of the development of shadow prices of water, a workshop (stakeholder consultation) will take place to allow for comments and verification of the shadow prices at March, 2020. Further, this workshop functions as a consultation for the Ministry of Planning on whether the shadow price for water shall be included in the DPP Format and DPP Manual. The final dissemination workshop shall take place after completion of the final report on May, 2020, while the capacity building and awareness raising campaigns shall continue after the final workshop. Feedback from dissemination workshop/ awareness raising campaigns would be incorporated in the final report.

Sl. No	Overview of planned workshops/ stakeholder consultations	Datelines of the activities
1.	Inception Workshop (Stakeholder Consultation)	Mid of Nov,19
2.	Workshop (focus group discussion) for demonstration case study to test and refine the valuing water framework (4 case studies)	Dec'19-Feb' 20
3.	Workshop (focus group discussion) for demonstration case studies on including shadow price for water in private decision making (3 case studies)	Dec'19-Feb 20
4.	Consultation on the developed shadow price on water and on its incorporation into DPP Manual / DPP Format (hosted by Ministry of Planning)	Mar'20
5	Capacity building training on valuing water	January – April 20
6	Draft final report	April 20
7	Final Dissemination Workshop	May'20
8.	**Final report**	May ,20

Conduct all local training: 8 Nos

Condition for the Study on 'Developing operational shadow prices for water to support informed policy and investment decision making processes'

- The impact study report will be entirely WARPO's knowledge product, which will be made publicly available, and used for public policy making;
- Soft and hard copy of the final report as well as of all underlying models and data will be handed over to WARPO duly;
- The study report/ models/ data of any part cannot be sold, or reproduced in any manner without prior written approval of WARPO;
- No additional money will be given other than what is contracted.

5. Responsibilities

5.1 Consultant's/Consulting firm's/Institution's Responsibilities

The consultant/firm/institution shall carry out the services as detailed in the "Scope of the Study/Survey" under section-2. They will perform the tasks in the best interest of the study with reasonable care, skill and diligence with sound technical administrative and financial practices.

The Consultant/firm/institution will also be responsible for arranging the following facilities:

- Handing over the collected data and study results to WARPO for use and records;
- Providing office space to accommodate members of the study team;
- Carry out workshop, demonstration case studies (action research), collection of data, survey as outline in the scope of Study/Survey and delivering study report in time.
- Arrange all training ,workshop, consultation awareness raising campaign as outlined in the TOR
- Prepare all the necessary report, guideline , manual , PowerPoint, speech, meeting Minutes and others as required
- Others as requested by PD

6. Manning Schedule

The estimated staff requirements for the study are given below in the following table (Provided that the consultants will work in the same rate as per agreement, in case of extension of the project period):

Sl No.	Professional	No. of Person	Person Months
1	Natural Resource Economist (Team Leader)	1	6
2	Water Economist (Deputy Team Leader - Coordinator)	1	9
3	Econometrician (focus Natural Resources)	1	4.5
4	Water Resource Management Expert	1	8
5	Economist (focus Natural Resources)	1	9
6	Regulatory/ Policy Specialist (focus Water)	1	2
7	Sustainable Business Expert	1	3
8	Data Collector	2	10
9	Translator (Bengali/ English)	1	2
	Total	10	**53.5**

7. Financial cost of the consultants

The financial cost for the consultancy services should include the following items

Sl No.	Professional	No. of Person	Person Months	Unit Rate (Taka in BDT)	Total Cost (Taka in BDT
1	2	3	4	5	6
1	Natural Resource Economist (Team Leader)	1	6		
2	Water Economist (Deputy Team Leader - Coordinator)	1	9		
3	Econometrician (focus Natural Resources)	1	4.5		
4	Water Resource Management Expert	1	8		
5	Economist (focus Natural Resources)	1	9		
6	Regulatory/ Policy Specialist (focus Water)	1	2		
7	Sustainable Business Expert	1	3		
8	Data Collector	2	10		
9	Translator (Bengali/ English)	1	2		
	Total	**10**	**53.5**		
Over head cost including social charge, logistic, field trip, accommodation, transportation, stationeries, drafting and reproduction report, FGD, meeting, stakeholder consultation, awareness building campaign, meeting materials					
	Grand Total (Including all Taxes:				
In words:					

8. Requisite Qualifications, Experiences and Responsibilities of the Consultants

Sl	Professional	Educational Qualification	Experiences	Responsibilities
1.	Natural Resource Economist (Team Leader)	He/ She must have a Bachelor's and Master's degree in economics, preferably with a PhD degree in Natural Resource Economics from a well reputed university. A major/ dissertation topic on valuing natural resources (water) is preferred.	He/ She must have more than 20 years of working experience in natural resource economics in developed and/or developing countries. Prior experience in Bangladesh is preferred. He/ She must have substantive prior experience in valuing natural resources (water) and in developing cost-benefit analyses for the public and private sector. Knowledge in econometrics, capacity building and awareness raising campaigns is preferred. Prior experience of working with multi-stakeholder platforms and consultations is preferred. Experience in working with private sector is preferred. He/ She must have at least 10 years of experience as project manager/ team leader in relevant projects. He/ She must be represented by consulting firm. Excellent English skills in speech and writing are required.	His/ Her tasks and responsibilities shall include, but not limited to the following: i. Overall responsibility to guide and coordinate the completion of the project; ii. Full responsibility for all aspects of planning, liaison and reporting; iii. Full responsibility in liaison with Project Committees and (existing) High Level/ Technical Valuing Water Committees; iv. Development of a framework for valuing water for Bangladesh and calculation of shadow prices with inputs from other team members; v. Conceptual design of demonstration case studies (7) with inputs from other team members; vi. Development of capacity building and awareness raising campaigns, with input from other team members; vii. Design of business cases for sustainable water resource management and the usage of shadow price for water in investment decision making for the private sector and development of incentive structures for private companies, based on value of water. viii. Participation on workshops and meetings as and when required. ix. Preparation of reports to a standard acceptable by WARPO.

Sl	Professional	Educational Qualification	Experiences	Responsibilities
2.	Water Economist (Deputy Team Leader and Coordinator)	He/ She must have a Bachelor's and Master's degree, preferably with a PhD degree in Natural Resource Economics or related field with a focus on water from a well reputed university. A major/ dissertation topic or any other academic exposure to valuing natural resources (water) is preferred.	He/ She must have more than 20 years of working experience in natural resource (water) economics in developed and developing countries. Prior experience in Bangladesh is preferred. He/ She must have more than 10 years experience in valuing natural (water) resources and in developing cost-benefit analyses for the public and private sector. Prior experience in capacity building is required. Knowledge in econometrics and awareness raising campaigns is preferred. Prior experience of working with multi-stakeholder platforms and consultations is preferred. He/ She must have at least 10 years of experience in leading international teams. Excellent Bengali and English skills in speech and writing are required.	His/ Her tasks and responsibilities shall include, but not limited to the following: i. Responsibility to guide and coordinate particularly the national consultants, following guidance from Team Leader in overall support to achieve the Team Leader's responsibilities; ii. Support the Team Leader in aspects of planning, liaison and reporting; iii. Liaise with stakeholders in Bangladesh to ensure available information is utilized and built upon, the valuing water framework is adequate and can be utilized and accepted by stakeholders etc; iv. Comparative analysis of best practice methodologies and past ongoing initiatives on valuing water for investment and policy decision making in Bangladesh; v. Lead execution of demonstration case studies (7), under guidance of Team Lead; vi. Support in developing a business case of valuing water for private investment decisions and in developing a framework for incentive system for private sector based on shadow price of water; vii. Lead and execute capacity building and awareness campaign, under guidance of Team Lead; viii. Support Ministry of Planning in understanding shadow price of water, assessing whether they seek to include it in their guidance and (if so) lead support to Ministry of Planning to update DPP Manual, DPP Format and DPP Assessment Formats. ix. Participation on workshops and meetings as and when required.

Sl	Professional	Educational Qualification	Experiences	Responsibilities
3.	Econometrician (focus Natural Resources)	He/ She must have a Bachelor's and Master's degree, preferably with a PhD degree in Natural Resource Economics, Econometrics, Statistics or related field from a well reputed university. A major/ dissertation topic on valuing natural resources (water) is preferred.	He/ She must have more than 10 years of working experience in econometrics (focus natural resources) and/ or natural resource (water) economics in developed and/or developing countries. Knowledge in data quality assurance and how to overcome challenges of low-quality data is required. Prior experience in Bangladesh is preferred. He/ She must have prior experience in valuing natural resources (water) and in developing cost-benefit analyses for the public and private sector. Knowledge in GIS, capacity building and awareness raising campaigns is preferred. Excellent English skills in speech and writing are required. Bengali language skills are preferred.	His/ Her task and responsibilities shall include, but not limited to the following: i. Comparative analysis of international best practice methodologies and past ongoing initiatives on valuing water for investment and policy decision making; ii. Support in developing the valuing water framework from the standpoint of data analysis options, data availability and quality considerations; iii. Support in developing the conceptual framework for demonstration case studies (7) particularly from an econometric/ data analysis point of view. iv. Calculate the shadow price of water in the demonstration case studies, with input from team members, and evaluate the findings. Revise the valuing water framework as required. v. Calculation of harmonized set of values for water, incl. assessment and verification of water availability and quality; vi. Support in developing framework for incentive system for private sector based on shadow price of water; vii. Support in conceptual framework for capacity building and awareness raising campaign, building on international best practice. viii. Participation on workshops and meetings as and when required.

Sl	Professional	Educational Qualification	Experiences	Responsibilities
4.	Water Resource Management Expert	He/ She must have a Bachelor's and Master's degree, preferably with a PhD degree in Water Resources Management, Water Economics or related field from a well reputed university. A major in natural resource economics is preferred. A dissertation topic or any other academic exposure to valuing natural resources (water) is preferred.	He/ She must have more than 15 years of working experience in water resource management in developed and developing countries. Knowledge of economics is required. Cross-sectoral experience, i.e. industrial, agricultural and urban water resource management is required. Prior international experience, as well as experience in Bangladesh is preferred. Experience in water resource modelling and GIS preferred. Experience in developing and executing awareness campaigns is required. Excellent Bengali and English skills in speech and writing are required.	His/ Her task and responsibilities shall include, but not limited to the following: i. Provide support in developing the framework for valuing water, specifically providing expert knowledge related to water resource management; ii. Support the development of demonstration case studies, specifically providing expert knowledge related to water resource management; iii. Support in execution of demonstration case studies; iv. Support the econometrician in calculation of harmonized set of values for water, incl. assessment and verification of data availability and quality; v. Support execution of capacity building and awareness raising campaign. vi. Support in preparing workshops, stakeholder consultations etc; vii. Participation on workshops and meetings as and when required.

Sl	Professional	Educational Qualification	Experiences	Responsibilities
5.	Economist (focus Natural Resources	He/ She must have a Bachelor's and Master's degree, preferably with a PhD degree in Economics or related field with a focus on natural resources (water) from a well reputed university. A major/ dissertation topic or any other academic exposure to valuing natural resources (water) is preferred.	He/ She must have more than 15 years of working experience in economics with a focus on natural resources (water). Previous experience in valuing natural resources (water) and conducting cost-benefit analyses is required. Further, experience in capacity building and awareness raising is required. Experience in econometrics, as well as in working with a wide range of stakeholders, including private and public sector and civil society is preferred. Experience in both developed and developing countries is preferred. Experience of working in Bangladesh is required. Excellent Bengali and English skills in speech and writing are required.	His/ Her task and responsibilities shall include, but not limited to the following: i. Provide support in developing the framework for valuing water; ii. Support in execution of demonstration case studies; iii. Support the econometrician in calculation of harmonized set of values for water, incl. assessment and verification of data availability and quality; iv. Support execution of capacity building and awareness raising campaign; v. Support in preparing workshops, stakeholder consultations etc; vi. Participation on workshops and meetings as and when required.
6.	Regulatory/ Policy Specialist (focus Water)	He/ She must have a Bachelor's and Master's degree, preferably with a PhD degree, in Politics, Law, Business or related field from a well reputed university. Academic experience related to water policy and/ or regulation is required. A major/ dissertation topic on water policy/ regulation is preferred.	He/ She must have more than 15 years of working experience in water policy/ regulation in developed and/or developing countries. Knowledge of the policy and regulatory environment around water resource management is required. Experience in working with the private and public sector, as well as civil society is preferred. Excellent Bengali and English skills in speech and writing are required.	His/ Her task and responsibilities shall include, but not limited to the following: i. Provide guidance on how the shadow price for water can be incorporated in policy, regulation and public decision making; ii. Suggest how identified incentives for the private sector (by the Sustainable Business Expert) can be incorporated in the current policy and regulatory framework; iii. Participation on workshops and meetings as and when required.

Sl	Professional	Educational Qualification	Experiences	Responsibilities
7.	Sustainable Business Expert	He/ She must have a Bachelor's and Master's degree in business or related field. A major in sustainable resource management, sustainable business is preferred.	He/ She must have more than 15 years of working experience in sustainable business practices in developed and/or developing countries. Knowledge of state-of-the-art sustainable business practices with respect to water and experience in incentivizing the private sector to engage in these practices is required. Excellent Bengali and English skills in speech and writing are required.	His/ Her task and responsibilities shall include, but not limited to the following: i. Identify the business case for incorporating the value of water in private decision making; ii. Identify which sectors in which regions, if any, may have the greatest business case and benefit in considering the value of water in decision making; iii. Suggest possible incentives for the private sector to engage in sustainable water resource management (in relation to the value of water)
8.	Data Collector	He/ She must have a Bachelor's degree in water resource engineering, environmental science, statistics, economics or related field.	He/ She must have more than 5 years of working experience in data collection, incl. surveys. Knowledge of existing data sources in Bangladesh across agriculture, urban areas, industry, and environment is required. Further, knowledge of data quality assurance is required. Experience of previous projects in which similar data was successfully collected is preferred. Excellent Bengali and English skills in speech and writing are required.	His/ Her task and responsibilities shall include, but not limited to the following: i. Support the project team in identifying what data is available and thus what can be used to develop the valuing water framework; ii. Analysis and quality assurance of all types of data under guidance of senior professionals in the project team; iii. Collection of data for demonstration case studies, which can also include surveys, and for the assessment of the overall shadow price for water.
9.	Translator (Bengali/ English)	He/ She must have certificates proving excellent command of Bengali and English. Proof of training/ courses on translation is preferred.	He/ She must have at least 10 years of experience of translating from Bengali to English and vice versa. Translation experience in the field of water and environment is required. Experience of simultaneous translation is preferred.	His/ Her task and responsibilities shall include, but not limited to the following: i. Translate required documents from Bengali to English (or vice versa); ii. Provide live translation during meetings/ workshops when necessary; iii. Participation on workshops and meetings as and when required. iv. Translate the final report in Bangla

Appendix 2: Questionnaire for Agriculture Sector (BMDA)

কর্মকর্তার নাম ....

সাক্ষাতের তারিখঃ

দিন		মাস		বছর	

সুপারভাইজারের স্বাক্ষরঃ ....

১. বিভাগঃ ....

২. জেলাঃ ....

৩. উপজেলা/থানাঃ ....

৪. ইউনিয়ন. ....

৫. গ্রামঃ ....

৬. খানা বাড়ীর নম্বরঃ ....

৭. খানা প্রধানের নামঃ ....

৮. কৃষকের জাতীয় পরিচয়পত্র নম্বরঃ ....

৯. মোবাইল নং ....

১০. উত্তর দাতার সাথে কৃষকের সর্ম্পকঃ..

১১. ভূমি মালিকানা শ্রেনীকরণঃ ....

ক্ষুদ্র চাষী=যিনি ০.০৫ থেকে ১.০৫ একর জমির মালিক

মাঝারী/মধ্যম চাষী= যিনি ১.৫১ থেকে ৮.৯৯ একর জমির মালিক

বড় চাষী=যিনি ৫ একর এর উপর জমির মালিক

১২. আপনার কি সেচের জন্য SMART কার্ড আছে? যদি থাকে তবে SMART কার্ড আইডি নং উল্লেখ করুন...................

১৩. স্থানীয় ভূমি পরিমাপের ইউনিট ....কত ডেসিমেল?

১৪. DTW আইডি নং ....এবং ইহার ক্যাপাসিটি (হর্স পাওয়ার এবং কিউসেক)

১. খানার তথ্য

১.১ খানা পরিবারের আকার (পরিবারের সদস্য সংখ্যা)ঃ পুরুষ- মহিলা-

১.২ পুরুষ সদস্য সংখ্যা> ১০ বছরের উপরে মোট=.................. কয়জন কৃষিতে

১.৩ মহিলা সদস্য সংখ্যা> ১০ বছরের উপরে মোট=.................. কয়জন কৃষিতে

১.৫ কৃষি কজের বাইরে কতজন আছে? পুরুষ.................মহিলা.....................

২. খানার সম্পদ

২.১ বর্তমানে খানার সকল জমির মালিকানার ধরন

বর্ননা	আয়তন (স্থানীয়)	আয়তন (ডেসিমেল)	মালিকানার ধরন
১. বসত বাড়ীর উঠানের মধ্যে			
ক. বসতভিটা			
খ. বাঁশঝাড়			
গ. পুকুর			
ঘ. পতিত জমি			
ঙ. অন্যান্য (যদি থাকে)			
২. বসত বাড়ীর বাইরে			
ক. পুকুর			
খ. ফসলী জমি			
গ. ফসলী বাগান			
ঘ. বাঁশঝার			
ঙ. স্থায়ী পতিত জমি			
চ. অন্যান্য (যদি থাকে)			
মোট জমি (১+২)			

মালিকানার ধরন কোড: একক মালিকানা= ১; যৌথ মালিকানা = ২; অন্যান্য = ৩

২.২ খানা/পরিবারের পানীয় জলের উৎস?

উৎস কোড:

১ = পাইপড/সাপ্লাইড; ২ = নলকূপ; ৩ = কূপ/কাঁচা কূপ; ৪ = পুকুর/খাল/নদী; ৫ = ফিল্টার প্লান্ট;
৬ = বৃষ্টির পানি; ৭ = অন্যান্য
সেচের জন্য ব্যবহৃত টিউবওয়েলই কি খাবার পানির উৎস কিনা?
হ্যাঁ / না= যদি হ্যাঁ হয় তখন খাবার পানি এবং সেচের পনির খরচ কিভাবে নির্ধারিত হয়?

২.৩ খানার নিজস্ব কৃষি যন্ত্রপাতির তথ্যাদি

বর্ননা	সংখ্যা	বর্তমান বাজার মূল্য
১. দেশী লাঙ্গল		
২. জোয়াল		
৩. মই		
৪. কোদাল		
৫. পাওয়ার পাম্প		
৬. গভীর নলকূপ		
৭. অগভীর নলকূপ		
৮. ট্রেডল পাম্প/		
৯. হ্যান্ড টিউবওয়েল (বাড়ীর বাইরে থাকলে)		
১০. দোন		
১১. ট্রাক্টর		
১২. কলের লাঙ্গল/পাওয়ার টিলার		
১৩. মাড়াই কল/ধান ভাঙ্গানো মেশিন		
১৪. থ্রেসার		
১৫. স্প্রে মেশিন		
১৬. মেকানিক্যাল রিপার/ধান কাটার যন্ত্র		
১৭. অন্যান্য (যদি থাকে)		

২.৩ খানার নিজস্ব কৃষি যন্ত্রপাতির তথ্যাদি

ভূমি প্রকার/শ্রেনি বিন্যাস	বোরো মৌসুমে চাষকৃত শস্যের নাম	জমি (স্থানীয় ইউনিট)	যান্ত্রিক সেচ চাষের আওতায় জমির পরিমান	গতানুগতিক সেচ চাষের আওতায় জমির পরিমান	তথ্য (নিজ জমি না হলে)			
					সময়	জমির মালিক এবং বর্গা চাষীর ইনপুট শেয়ারিং অনুপাত	কি পরিমানের ফসলের ভাগ/ টাকা দিতে হয়	মূল্য/ পেমেন্ট দেয়া নেয়ার কোড
১. নিজস্ব জমি (সকল জমি/মোট জমি)								
২. নিজস্ব চাষযোগ্য জমি (ফসলি জমি)								
৩. কতটুকু চাষের জমি বর্গা নিয়েছেন								
৩.১ বন্ধক/খয়খালাসি হিসেবে নিয়েছেন								
৩.২ লিজ/ভাড়ায় কতটুকু								
৪. কতটুকু চাষের জমি বর্গা দিয়েছেন								
৪.১ বন্ধক/খয়খালাসি হিসেবে নিয়েছেন								
৪.২ লিজ/ভাড়ায় কতটুকু জমি দিয়েছেন								
মোট ব্যবহৃত জমি (১+সকল নেয়া জমি)-সকল দেয়া জমি								
মোট চাষাবাদযোগ্য ব্যবহৃত জমি (২+সকল নেয়া জমি) সকল দেয়া জমি								

৪. সেচ যন্ত্রপাতি দ্বারা সেচকৃত জমি ও সেচ ব্যয়

শস্যের নাম	সেচ যন্ত্রপাতি দ্বারা সেচকৃত জমি (স্থানীয় ইউনিট) (চলতি বোরো মৌসুম)								
	DTW-ডিজেল	DTW-দ্যুতিক	STW-ডিজেল	STW-দ্যুতিক	LLP-ডিজেল	LLP-দ্যুতিক	খাল (Gravity)	Manual	Rainfed
স্থানীয় বোরো (Local Boro)									
উচ্চ ফলনশীল রোরো (HYV Boro)									
হাইব্রিড বোরো (Hybrid Boro)									

৫. যদি সেচকৃত জমির পরিমান মোট চাষাবাদ যোগ্য জমির চেয়ে কম হয়, কারন ব্যাখ্যা করুন?

কিছু জমি চাস করা হয় সেচ সুবিধা ছাড়া = ১
আশেপাশে কোন সেচ স্কিম নাই = ২
নিজস্ব কোন পাম্প/STW নাই = ৩
দীর্ঘ সময় ধরে পাম্প/ STW/ DTW থেকে বঞ্চিত = ৪
সেচের পানির মূল্য খুবই ব্যয়বহুল = ৫
কোনো প্রয়োজন নাই যেহেতু দেশী পদ্বতিতে *(সেচযোগ্য/দোন)* = ৬
অন্যান্য (স্পেষ্ট করুন) = ৭
প্রযোজ্য নয় = ৮

নোট: সেচ ব্যবস্থা ও খরচ প্রদানের নিয়ম পরিস্কার আনতে হবে। কৃষক ঝগঅজঞ কার্ড সরাসরি ব্যবহার করলে তার খরচ সেই কার্ডের হিসাবে আসবে। যদি অপারেটরের মাধ্যমে সেচ দেয় তবে পানির দাম ও অপারেটরের দেয়া কাটা আলাদা হিসেবে নিবেন।

৬. আপনার নিজস্ব চাষযোগ্য জমি কয়টি উঞড স্কীম এর আওতাভূক্ত রয়েছে? অনুগ্রহপূর্বক নিচে চিহ্নিত করুন

এই স্কীম : .... জমির পরিমান: ....
অন্যান্য স্কীম ১ : .... জমির পরিমান: ....
অন্যান্য স্কীম ২ : .... জমির পরিমান: ....
অন্যান্য স্কীম ৩ : .... জমির পরিমান: ....

(প্রয়োজনে সংযুক্ত করুন)

৭. যদি বোরো ধান চাষের আওতায় বিগত ২০১৯ সাল থেকে ২০২০ সালে জমির পরিমান বেশী হয়, তবে কেন? (একাধিক উত্তর হতে পারে)

কারন সমুহ:

আমন শস্য ক্ষতিগ্রস্থ হয়েছিল = ১
ধানের মূল্য অধিকতর ভাল = ২
নিজের ভোগের জন্য বেশী আবাদ/উৎপাদন = ৩
ঋন পরিশোধের জন্য = ৪
ফলন বেশী = ৫
অন্যান্য (চিহ্নিত করুন) = ৬
প্রযোজ্য নয় = ৭

৮. যদি বোরো ধান চাষের আওতায় বিগত ২০১৯ সাল এর তুলনায় ২০২০ সালে জমির পরিমান কম হয়, কারন ব্যাখ্যা করুন? (একধিক উত্তর হতে পারে) টিক দিন।

কারন সমূহ:

জমি বিক্রয়	= ১
সেচের পানির অভাব	= ২
কৃষি উপকরনের দাম বেশী	= ৩
জমি বর্গা/লিজ/ভাড়া পাওয়া যচ্ছেনা	= ৪
জমি বর্গা/লিজ/ভাড়া দেয়া হয়েছে	= ৫
জমি পানিতে তলাইয়া আছে (Water Logged)	= ৬
সরকার জমি অধিগ্রহন করেছে	= ৭
অন্যান্য উৎপাদন/কৃষি শস্য উৎপাদনে ব্যবহার	= ৮
অন্যান্য (যদি থাকে বলুন)	= ৯
প্রযোজ্য নয়	= ১০

(যদি উত্তর= ৮ হয় তাহলে কোন ফসল?) ....

৯. বিভিন্ন ধরনের শস্যের উৎপাদন, প্রাপ্তি ও ব্যয় Received and Given): (..................... বোরো মৌসুম)

শস্যের নাম	নিজের জমি নিজে চাষ				বর্গা, লিজ, বন্ধকি নেয়া, অন্যান্য ক্ষেত্রে						উপদ্রব্য	
	মোট জমি (স্থানীয় ইউনিট)	সেচকৃত জমি (স্থানীয় ইউনিট)	মোট ফসল (মন*)	ফসল কাটার সময় ফসলের দাম (টাকা/মন)	মোট জমি (স্থানীয় ইউনিট)	সেচকৃত জমি (স্থানীয় ইউনিট)	মোট ফসল (মন*)	নিজের প্রাপ্ত ফসল (মন)	ফসল কাটার সময় ফসলের দাম (টাকা/মন)	বর্গা নেয়া জমির ক্ষেত্রে কৃষক কর্তৃক দেয়া খরচ (টাকা)	সমস্ত জমি থেকে গ্রহন মন/বান্ডেল	মোট মূল্য (টাকা)
১	২	৩	৪	৫	৬	৭	৮	৯	১০	১১	১২	১৩
স্থানীয় বোরো (Local Boro)												
উচ্চ ফলনশীল বোরো (HYV Boro)												
হাইব্রিড বোরো (Hybrid Boro)												

১০. জমি প্রস্তুতকরন ও বীজের দাম (..................... বোরো মৌসুম)

শস্যের নাম	জমি চাষের খরচ (টাকা)		বীজ/চারা ক্রয়/চারা তৈরি খরচ (টাকা	জমি প্রস্তুতের সময় পানির ব্যবহার (হ্যাঁ/না)		মোট শ্রমিক ব্যবহার		মন্তব্য
	বলদ দ্বারা কর্ষণ	যান্ত্রিক (পাওয়ার টিলার)		হ্যাঁ	না	পরিবারিক (সংখ্যা)	ভাড়া শ্রমিক (সংখ্যা)	
স্থানীয় বোরো **(Local Boro)**								
উচ্চ ফলনশীল রোরো (**HYV Boro)**								
হাইব্রিড বোরো **(Hybrid Boro)**								

নোট:
লেভার কস্ট:...
বীজতলা তৈরির সময় জমি চাষ খরচ:...................
বীজতলা তৈরির সময় সেচ খরচ:........................
সিড কস্ট:..
বীজর জাতের নাম...

১১. রাসায়নিক সার ও কীটনাশক ব্যবহারের তথ্য এবং খরচ

শস্যের নাম	রাসায়নিক সার ও কীটনাশক এর ব্যবহার (কেজি)								
	ইউরিয়া	টিএসপি/ এসএসপি	এমপি	ডিএপি	অন্যান্য			কীটনাশক	সবুজ সার গোবর/ অন্যান্য)
স্থানীয় বোরো **(Local Boro)**									
উচ্চ ফলনশীল রোরো **(HYV Boro)**									
হাইব্রিড বোরো **(Hybrid Boro)**									

মূল্য:- ইউরিয়া: টাকা/কেজি, টিএসপি/এসএসপি: টাকা/কেজি, এমপি: টাকা/কেজি, অন্যান্য: টাকা/কেজি, টাকা/কেজি
কীটনাশক: টাকা/কেজি
নোট: কীটনাশকের নাম লিখুন:

১২. সেচ খরচ

শস্যের নাম	সেচের সংখ্যা	সেচ খরচ	সেচ খরচ যদি অন্য ফসলের সাথে শেয়ার করা হয় (টিক চিহ্ন দিন	সেচ করচ যদি অন্য কৃষকের সাথে শেয়ার করা হয় (হ্যাঁ/না)	সেচকৃত শেয়ার করা জমির পরিমান
স্থানীয় বোরো **(Local Boro)**					
উচ্চ ফলনশীল রোরো **(HYV Boro)**					
হাইব্রিড বোরো **(Hybrid Boro)**					

১৩. নিড়নী, ফসল কর্তন ও মাড়ই ব্যয়/খরচ (........................ বোরো/রবি মৌসুমে)

শস্যের নাম	নিড়ানী				ফসল কর্তন				ধরন	মাড়াই (Threshing)			
	ভাড়া শ্রমিক		পরিবারিক		ভাড়া শ্রমিক		পারিবারিক			ভাড়া শ্রমিক		পারিবারিক	
	সংখ্যা	মজুরী/ দৈনিক	সংখ্যা		সংখ্যা	মজুরী/ দৈনিক	সংখ্যা			সংখ্যা	মজুরী/ দৈনিক	সংখ্যা	
স্থানীয় বোরো **(Local Boro)**													
উচ্চ ফলনশীল রোরো **(HYV Boro)**													
হাইব্রিড বোরো **(Hybrid Boro)**													

মাড়াইয়ের ধরণ: বলদ দ্বারা মাড়াই = ১; মানুষ্য দ্বারা = ২; পেডাল থ্রেসিং ৩; যান্ত্রিক = ৪; অন্যান্য = ৫; মাড়াই করা হয়না = ৬

১৪. শস্য হানি/ক্ষতি (..............................বোরো মৌসুম)

শস্যের নাম	ক্ষতির কারন কোড ১-১৫ পর্যন্ত)			ক্ষতি না হলে অতিরিক্ত আউটপুট (মন)
	কারণ-১	কারণ-২	কারণ-৩	
স্থানীয় বোরো (Local Boro)				
উচ্চ ফলনশীল রোরো (HYV Boro)				
হাইব্রিড বোরো (Hybrid Boro)				

ক্ষতির কারণ সমূহ কোড:

১ = বন্যা
২ = অতি বৃষ্টি
৩ = শিলা বৃষ্টি
৪ = ঝড়
৫ = জলাবদ্ধতা
৬ = কচুরীপানা
৭ = পোকা-মাকড়ের আক্রমন
৮ = লবণাক্ততা
৯ = খরা
১০ = রোগ-বারাই
১১ = অপর্যাপ্ত রাসায়নিক সারের ব্যবহার
১২ = রাসায়নিক সারের যথেচ্ছা ব্যবহার
১৩ = অপর্যাপ্ত সেচ প্রদান
১৪ = সেচের পানির প্রাপ্যতা কম (Less pump yield)
১৫ = অন্যান্য (চিহ্নিত করুন)
১৬ = কোন ক্ষতি হয়নি

১৫. অপ্রতুল সেচ ব্যবস্থার জন্য ফসলের ক্ষতি হলে, তার কারন কি কি? (একাধিক উত্তর হতে পারে)

স্থানীয় বাজারে ডিজেল সরবরাহ কম	১
ডিজেল এর বাজার মূল্য বেশী	২
সেচ খরচ অতি বেশী/অতি উচ্চ	৩
সেচকালীন সময় লোড শেডিং বেশী	৪
LLP দ্বারা সেচ প্রদান	৫
পানির উৎস্যস্থল শুকিয়ে যাওয়া/পানির স্তর নীচে নেমে যাওয়া	৬

Appendix 3: Questionnaire for Agriculture Sector (Muhuri Irrigation Project Area)

Name of the Field Officer/ Interviewer: ....

Date of Interview:

Day		Month		Year	

Signature of Field Group Lead from CEGIS:

1. Division:
2. District:
3. Upazila/Thana:
4. Union:
5. Village:
6. Household ID:
7. Name of Household Head (may be Farmer also):
8. Name of the Respondent/ Household Head/ Farmer:
9. Mobile No. of the Respondent:
10. Relation of the Respondent with the Household Head:
11. Local unit of land= How many decimal?

13.1 Do you have smart card in your name for irrigation? Yes ________; No________

13.2 If yes, from which year/month you have the card: Month_________; Year _______

13.3 If yes, smard card ID:

13.4 If no smart card, do you use somebody else's smart card? Yes _____; No______

13.5 If yes, whose card you are using:

- LLP operator,
- neighbor/relative,
- others(specify)

14. Was the last Boro Season had normal rainfall? If not, how much less or more? __________

1. Household Information

1.1 Family Size (No. of family Members): Male above 10 yrs.:______; Male <= 10 yrs):_______

Female, above 10 yrs: ______; Female (<= 10 yrs);______

1.2 No. of family members in own farming (seedling to harvest)? Male:_______; Female: _______

1.3 Highest Education in the family: Male: ____________; Female: ____________

2. Household Asset

2.1 Present land ownership by all the household members

Description	Area (decimal)	Nature of ownership
Within Homestead		
Land under housing structure only		
Bamboo grove		
Pond		
Fallow land		
Homestead garden		
Cow shed		
Others (specify)		
Outside homestead		
Pond/Ditch		
Land for Crop cultivation (seasonal)		
Orchard (perennial)		
Bamboo grove		
Fallow land (permanent)		
Others (specify)		
Total Land (1+2)		

Codes for nature of ownership: Sole ownership = 1; Joint ownership = 2; others = 3

2.2 What is the source of drinking water for the household?

Source Code:

1= Piped; 2 = Tubewell; 3= Well/Katcha Well, 4= Pond//Canal/river; 5= Filter Plant; 6= Rain water; 7= others

2.3 Agricultural Equipment Owned by Household

Description	Number	Present market Value
1. Plough		
2.Joal		
3.Ladder		
4.Spade		
5.Power Pump		
6.Deep Tubewell		
7.Shallow Tubewell		
8.Tradle Pump		
9. HTW (if not in homestead)		
10.Doan		
11.Tractor		
12.Power Tiller		
13.Thresher		
14.Husking Machine		
15.Spray Machine		
16.Mechanical Reaper (diesel/ manual)		
Others (Specify)		

3. Household Operated Agricultural Land and irrigation Facility:

Type of land	Total area (decimal)	Name of crops (last Boro season)	Mechanically irrigated area (decimal) (Duration, on average)	Traditionally irrigated area (decimal)	Information (if not owned)			
					Time length	Input sharing ratio (owner to cultivator)	Money to pay/ receive Taka	Timing of payment (code)
Own land (all land)		NA	NA	NA	NA	NA	NA	NA
2. Own cultivable land(either by self or leased out)		NA	NA	NA	NA	NA	NA	NA
3. Share Cropped in		NA	NA	NA				
3.1 Mortgage/agreement/khaikhalasi in		NA	NA	NA				
3.2 Lease/rented In		NA	NA	NA				
4. Share cropped Out		NA	NA	NA	NA	NA	NA	NA
4.1 Mortgage/agreement/khaikhalasi Out		NA	NA	NA	NA	NA	NA	NA
4.2 Lease/Rented Out		NA	NA	NA	NA	NA	NA	NA
Total operated land(1+all in)-all out		NA	NA	NA				
Total cultivable operated land(2+total in)-total out					NA	NA	NA	NA

Codes and instructions:

Time length:

For this season only = 1; for whole year = 2; For more than a year = 3; Indefinite = 4; N/A = 5

Input sharing:

Write share of owner and share of cultivator. If both pay eaually, it should 1: 1; if landowner pays 1/3 and cultivator payes 2/3 it is 1: 2 etc.

Timing of payment:

Beginning of contract = 1; End of harvest = 2; intermittently = 3; others (specify) = 4

Name of crop:

This should be like HYV Boro BRRI Dhan 28 or say, Mustard local or Mustard improved

4. Information on irrigation coverage with equipment/mechanism

If land is distributed in different places add them together under different irrigation mechanism

Crop name	Area covered by irrigation mechanism (decimal) (last Boro season)									Time required to wet the land for ploughing (in hr)
	LLP – D	LLP-E	Canal-(gravity)	Manual	Rainfed	DTW-D	DTW-E	STW-D	STW-E	
Local Boro										
HYV Boro										
Hybrid Boro										
Wheat										
Maize										
Potato										
Tobacco										
Vegetable										
Oilseeds										
Others(specify)										

4.3 Do you have any land which is not irrigated duirng Boro season? If so, why

Some of the lands are cultivated with crops without irrigation = 1

No nearby irrigation scheme = 2

Have no own pumm/STW = 3

Long way off from the pump/STW/DTW = 4

Irrigation water too costly = 5

No need as can irrigate with deshi method (doan etc.) = 6

Others (specify) = 7

NA = 8

5. Quantity of Various Type of Crops Received and Given (Last one year ending with current Boro season)

Name of Crop	Own land by Self-Cultivation				Share, lease, rent, others in						Byproduct	
	Total Land (Decimal)	Irrigated Land (Decimal)	Total output (Maund*)	Harvest price (Taka)	Total Land (Decimal)	Irrigated Land (Decimal)	Total output (Maund*)	Received outsput (Maund)	Harvest price (Taka/ maund)	Input costs paid by farmer for shared in etc land (Taka)	Received from all lands Maunds/ bundles	Total value
Local Boro												
HYV Boro												
Hybrid Boro												
Wheat												
Maize												
Potato												
Tobacco												
Vegetables												
Oil seeds												
Others												

* Maund= 40 kg.

6. Land preparation and seedling costs current Boro season (first see note below the table)

Crops name	Ploughing cost (Tk/bigha)		Seed / Seedling cost (Tk/ bigha)
	Manual(bullock) plough	Mechanical (power tiller)	
Local Boro			
HYV Boro			
Hybrid Boro			
Wheat			
Maize			
Potato			
Tobacco			
Vegetables			
Oil seeds			
Others			

For ploughing do you use own bullocks? Yes ______; Hired: ______
What is the cost of hiring bullocks for ploughing for one bigha land: Tk ________;
Do you use power tiller of own? Yes _________; No: ______
What is the cost of hiring power tillers for ploughing one bigha of land? Tk _______
Note: If ploughing is with owned bullocks or power tiller, the cost to be equivalent to if it was with hired bullocks or power tiller

7. Information on fertilizers and pesticides use and cost/price

Crops name	Fertiliser and pesticides use (Kg per unit of land)							
	Urea	TSP/SSP	DAP	MP	Zinc	Others	Manure	Pesticide
Local Boro								
HYV Boro								
Hybrid Boro								
Wheat								
Maize								
Potato								
Tobacco								
Vegetables								
Oil seeds								
Others								

Average price: - Urea: Tk/kg, TSP/SSP: Tk/kg, DAP: Tk/kg, MP: Tk/Kg, Zinc: Tk/kg, Others: Tk/kg, Pesticide: Tk/kg (Granular), …. Tk/ml (Liquid)…………, Tk/kg(Powder)………..

8. Irrigation costs in the last Boro season

Crops name	No of irrigation	Average duration per irrigation (in hr)	Cost of irrigation only for yourself	If it is shared with own cultivated other crop (put tick mark)(if yes, name of crop)	Is it shared with other farmer (yes/No)	Area of irrigated land of other farmers with whom cost is shared
Local Boro						
HYV Boro						
Hybrid Boro						
Wheat						
Maize						
Potato						
Tobacco						
Vegetables						
Oil seeds						
Others						

9. Details of payments for irrigation charges:

a. If own smart card holder:
- How card is topped up:
- Charge per cubic feet of water:

b. If smart card jointly with others:
- How card is topped up:
- Charge per cubic feet of water:

c. If paid to operator:
- How card is topped up:
- Charge per cubic feet of water:

d. Payments by area:
- How much per decimal:
- For whole season or for each irrigation:

e. When bullock or power tiller is rented:
- Method of payment:
- For Driver:

- For Machine/bullock:

10. All labour use and cost

Crops name	Sowing of seed /transplanting of seedling					Weeding					Irrigation				
	Hired			Family		Hired			Family		Hired			Family	
	No. day	No labor	Cost/day	No. day	No labor	No. day	No labor	Cost/day	No. day	No labor	No. day	No labor	Cost/day	No. day	No labor
Local Boro															
HYV Boro															
Hybrid Boro															
Wheat															
Maize															
Potato															
Tobacco															
Sugar cane															
Vegetables															
Oil Seed															
Others(specify)															

Crops name	Fertilization					Pesticides					Harvesting					Threshing				
	Hired			Family		Hired			Family		Hired			Family		Hired		Family		
	No. day	No labor	Cost/ day	No. day	No labor	No. day	No labor	Cost/ day	No. day	No labor	No. day	No labor	Cost/ day	No. day	No labor	No. day	No labor	Cost/ day	No. day	No labor
Local Boro																				
HYV Boro																				
Hybrid Boro																				
Wheat																				
Maize																				
Potato																				
Tobacco																				
Sugar cane																				
Vegetables																				
Oil Seed																				
Others(specify)																				

11. Crop Damage (last Boro season)

Name of Crop	Causes of Damage (Code- upto 3)			Additional output if had no damage (maund)
	Cause 1	Cause 2	Cause 3	
L. Boro				
HYV Boro				
Hybrid Boro				
Wheat				
Maize				
Potato				
Tobacco				
Sugar cane				
Vegetables				
Oil seeds				
Others				

Cause of Damage Code:

1 = Flood 2 = Heavy Rainfall 3 = Hail Storm 4 = Storm
5 = Water congestion 6 = Water Hyacinth 7 = Pest Infestation 8 = Salinity
9 = Drought 10 = Diseases 11 = Inadequate application of fertilizer
12 = Unbalanced use of fertilizer 13 = Inadequate Irrigation 14 = others (specify)
15= depletion of water table (less pump yield) **99= No damage**

12. If inadequate irrigation has been cited as a reason for crop damage, why had it been so? (May have multiple answers)

Diesel not available in local market = 1

Diesel was costly = 2

Cost of water too high = 3

Load shedding at time of irrigation need = 4

Water source dried up = 5

Appendix 4: Questionnaire for Construction Sector

Date:……………………………………..

Name of Interviewer / Field Research Officer:

Name of the Company Visited and address:

Name of concerned Official (interviewed) …………………………………………………………….

***Information should be given for recent completed construction work**

1. Location and address of construction site:
2. Type of construction: Residential/Commercial
3. Duration of Construction:
4. Total story of the building:
5. Area per floor (sqm):
6. Total floor area (sqm)
7. Total Water required (Kiloliters):
8. Major construction components:
   8.1 Volume of concrete (m3)
   8.2 Area of brick (m3)
9. Source of Water:
   - If DWASA
     - Per month bill and water used (Kiloliters)
     - Total water used (Kiloliters) (duration of construction X per month used)
   - If Own Source:……………………….
     - Operation Hours /day
     - Capacity of pump
     - Total volume of water lifted during construction period (Kiloliter)
     - Total Energy/Electricity KWh for lifting water

10. Mention only Elements of Construction where water is used (do not mention the volume of water used)

- Concrete mixing & curing
- Brick soaking
- sub-grade stabilization
- dust control
- Water line testing & cleaning
- Brick work and curing
- Plastering and curing

- Soaking Khua/Stones
- Making mortar for setting tiles and curing
- (Mention size of tiles)
- Drinking, bathing, cooking of construction laborers etc.
- Washing cars etc.
- Others, If any (please mention) ………………………..

11. No. of Employees involved in the site Construction period:
12. Total Management cost of construction site:
13. Total cost of construction:

Appendix 5: Questionnaire for Food and Beverage (Beverage)

Study on Developing Operational Shadow Price for Water to Support Informed Policy and Investment Decision Making Processes

1. Name of Enterprise:
2. Head office address and contact person and number:
3. Product manufacturing lines for your enterprise and their jointness

Product	Is this product manufactured under a completely independent process or jointly with others – please include product's brand name	If jointly with others, name those (if it is by-product of a process of producing another product, please mention the name of the other product)
1		
2		
..		
N		

4. Types of products manufactured (last 5 full years), quantity and value at company prices

Product	**Year 1**		**Year 2**		**...**		**Year 5**	
	Qty (with unit)	**Value (mn Tk)**	**Qty (with unit)**	**Value (mn Tk)**	**...**	**...**	**Qty (with unit)**	**Value (mn Tk)**
1								
2								
..								
N								

5. Water use ***in industrial process*** for production by type of product (thousand litres) – ***Please use separate table for each process if possible.***

Process 1: Water need during preparation of the manufacturing unit – like washing, cleaning etc.

Product	**Year 1**			**Year 2**		**...**		**Year 5**	
	Water quantity	**Cost (mn Tk)**	**Do you recycle water? Yes/No**	**Water quantity**	**Cost (mn Tk)**	**...**	**...**	**Water quantity**	**Cost (mn Tk)**
1									
2									
..									
N									

Process 2: water need during preparing raw materials for the product

Product	**Year 1**			**Year 2**		**...**		**Year 5**	
	Water quantity	**Cost (mn Tk)**	**Do you recycle water? Yes/No**	**Water quantity**	**Cost (mn Tk)**	**...**	**...**	**Water quantity**	**Cost (mn Tk)**
1									
2									
..									
N									

Process 3: water need during packaging/bottling etc.

Product	Year 1			Year 2		...		Year 5	
	Water quantity	Cost (mn Tk)	Do you recycle water? Yes/No	Water quantity	Cost (mn Tk)	...	...	Water quantity	Cost (mn Tk)
1									
2									
..									
N									

6. Other ***non-industrial*** (cleaning, personal hygiene, gardens etc) uses of water – percent on average of total water use for the manufacturing plant.

7. Where do you get your supply of water from?

   a. Supplied by WASA/municipality – fully/partly/none;

      If partly, what percentage of total water from this source?

      At what price? ________ Tk/thousand litres

   b. Supplied from own source fully/partly/none

      If fully or partly from own source, what is that? Pump in surface water _____;

      Pump out ground water _____

      If pump in surface water, how many pumps and of what total capacity do you use?

      _______ No; ________ cusec

      If pump ground water, how many DTWs you have?________; What total capacity? ________ cusec

      Do have license for either surface pumps of DTWs? Yes/No

      If yes, how much is the license fee paid per year?

   c. Do you recycle any water? Yes______; No_____

      If yes, what proportion on average gets recycled? _______ percent

   d. Do you discharge any water as effluent? Yes _____; No_____

      If yes, how do you do that?

      Simply discharge water outside to other surface water bodies ______

      Discharge after effluent treatment _______

      If do effluent treatment, what volume of water did you discharge as effluent in last full year? At what cost?

      Year __________; __________ mn cu m; Treatment cost __________ mn Tk

8. Water use details

Year	Volume of water used for industrial process (mn cm)	Volume of water for all other non-industrial purposes (mn cm)	Used water discharged outside(mn cm)	Used water recycled(mn cm)	Effluent treatment cost(mn Tk)
Year 1					
Year 2					
Year 3					
Year4					
Year 5					

9. Capital and labour costs over years (kindly use audited values). If audited values not available, please mention so

Year	Book value of end of year capital (mn Tk)	Capital depreciation cost (mn Tk)	O&M costs (mn Tk)	Enployee (managerial, admin/accounts sections)		Employee (industrial production)	
				Number	Salary cost (mn Tk)	Number	Salary cost (mn Tk)
Yr 1							
Yr 2							
Yr 3							
Yr 4							
Yr 5							

Appendix 6: Questionnaire for Food and Beverage (Food)

Study on Developing Operational Shadow Price for Water to Support Informed Policy and Investment Decision Making Processes

1. Name of enterprise:
2. Head office address and contact person and number:
3. Product manufacturing lines for your enterprise and their jointness

Product	Is this product manufactured under a completely independent process or jointly with others – please include product's brand name	If jointly with others, name those (if it is by-product of a process of producing another product, please mention the name of the other product)
1		
2		
..		
N		

4. Types of products manufactured (last 5 full years), quantity and value at company prices

Product	Year 1		Year 2		...		Year 5	
	Qty (with unit)	Value (mn Tk)	Qty (with unit)	Value (mn Tk)	...	...	Qty (with unit)	Value (mn Tk)
1								
2								
..								
N								

5. Water use in ***industrial process*** for production by type of product (thousand litres) – ***Please use separate table for each process if possible. If not, provide aggregate information***

Process 1: Water use/need during preparation of the manufacturing unit before production process– like washing, cleaning of machines etc.

Product	Year 1		Year 2		...		Year 5	
	Water quantity	Cost (mn Tk)	Water quantity	Cost (mn Tk)	...	...	Water quantity	Cost (mn Tk)
1								
2								
..								
N								
Total								

Process 2: Water use/need during preparing raw materials for the production process

Product	Year 1		Year 2		...		Year 5	
	Water quantity	Cost (mn Tk)	Water quantity	Cost (mn Tk)	...	...	Water quantity	Cost (mn Tk)
1								
2								
..								
N								
Total								

Process 3: Water use/need during post-production packaging/bottling etc.

Product	Year 1		Year 2		...		Year 5	
	Water quan-tity	Cost (mn Tk)	Water quantity	Cost (mn Tk)	...	...	Water quan-tity	Cost (mn Tk)
1								
2								
..								
N								
Total								

6. Other ***non-industrial*** (general cleaning, personal hygiene, gardens etc) uses of water – percent on average of total water use for the manufacturing plant.

7. Where do you get your supply of water from?

a. Supplied by WASA/municipality – fully/partly/none;

If partly, what percentage of total water from this source?

At what price? _________ Tk/thousand litres

b. Supplied from own source fully/partly/none

If fully or partly from own source, what is that? Pump in surface water ______;

Pump out ground water _____

If pump in surface water, how many pumps and of what total capacity do you use?

_______ No; ________ cusec

If pump ground water, how many DTWs you have?________; What total capacity? _______ cusec

Do have license for either surface pumps of DTWs? Yes/No

If yes, how much is the license fee paid per year?

c. Do you recycle any water? Yes______; No_____

If yes, what proportion on average gets recycled? _______ percent

d. Do you discharge any water as effluent? Yes _____; No_____

If yes, how do you do that?

Simply discharge water outside to other surface water bodies ______

Discharge after effluent treatment _______

If do effluent treatment, what volume of water did you discharge as effluent in last full year? At what cost?

Year __________; __________ mn cu m; Treatment cost __________ mn Tk

8. Capital and labour costs over years (kindly use audited values). If audited values not available, please mention so

Year	Book value of end of year capital (mn Tk)	Capital depreciation cost (mn Tk)	O&M costs (mn Tk)	Employee (managerial, admin/accounts sections)		Employee (industrial production)	
				Number	Salary cost (mn Tk)	Number	Salary cost (mn Tk)
Yr 1							
Yr 2							
Yr 3							
Yr 4							
Yr 5							

Appendix 7: Questionnaire for Power Sector

Name of Power Plant	Location	Year of establishment	Technology (CC/ST etc)*	Primary fuel 1	Primary fuel 2	Present net generation Capacity MW

Kindly provide a brief description of technology

Annual Performance

Year	Gross generation GWH	Net generation GWH	Total hours run in year	Qty of primary fuel used for generation (cum for gas, mt for others	Lube oil consumed mt	Auxiliary power consumed MWH
	GWH	GWH				
2019-20						
2018-19						
2017-18						
2016-17						
2015-16						

Value and Cost data

Year	Gross generation value at plant (mn Taka)	Net generation value at plant (mn Taka)	Net generation actual sale value (mn Taka)	Cost of primary fuel used for generation (Mn Taka)	Lube oil consumed cost	Auxiliary power consumed value	Cost of any other raw material used for power generation
2019-20							
2018-19							
2017-18							
2016-17							
2015-16							

Capital and labour costs

Year	Book value of end of year capital	Capital depreciation cost (mn Tk)	O&M cost	Employee no.	Employee no.	Total salaries and wages paid (mn Taka)		Total water volume used (mn Cub metre)	Total cost of water (mn Taka)
	(mn Tk)-based on audit	Based on audit	(mn Tk)	Managerial/ admin/ accounts	Generation	Managerial/ admin/ accounts	Generation		
2019-20									
2018-19									
2017-18									
2016-17									
2015-16									

Details of water supply

Year	Volume of water own underground aquifer (cu m)	Volume of water from WASA/ municipality/ local government authority (cu m)	Volume of water pumped from surface water sources (cu m)	Cost of under ground water pumping (mn Tk)	Total Power consumed -(MWH)	Payments to WASA / municipality/ local government authority (mn Taka)	Cost of surface water pumping (mn Tk)	Cost of Water treatment for generation (mn Tk)
			River/ lake/Beel/ Pond/Others					
2019-20								
2018-19								
2017-18								
2016-17								
2015-16								

Details of water use

Year	Volume of water used for power generation(mn cm)		Volume of water for all other non generation purposes (mn cm)	Used water discharged outside(mn cm)	Used water recycled(mn cm)		Effluent treatment cost(mn Tk)
	For steam	**For cooling**			water for steam	**water for cooling**	
2019-20							
2018-19							
2017-18							
2016-17							
2015-16							

Note: Pleasep provide data Either as shown for some 20 power plants with a mix of technology and age of plant.

Or, provide give data for the most recent year with complete information for as many as possible plants with the characteristics as shown.

It would be very good if you can also provide information as much as possible on some of the IPPS.

Appendix 8: Comments and Response on Draft Final Report

General comments

- Several aspects from the PFS remain missing:
  - o Development of a framework for valuing water for Bangladesh:
    - ▪ "The shadow prices for water shall be derived in a consistent manner across sectors, regions, seasons and sources to allow for comparability" – unclear if these values can be compared
    - ▪ "Allow for multiple lines of evidence" – only one method was used for each value

      Response: *We have explained different methods and used the best method based on data availability and reliability of estimates. There is not value in using multiple methods for valuing it. It would have confused policy makers. Consequently, we thought about different methods however, due to data limitation, time we used one method which has been described in the report.*
    - ▪ "The study project team has the option to prepare two frameworks for valuing water, if required by data limitations: A) Best case framework/ methodologies: The ideal framework regardless of data restrictions, however, considering on-ground realities in Bangladesh and B) Practical framework/ methodologies: The framework that can be applied as part of this project subject to data constraints. only B was completed. No "best case" was offered, nor was guidance provided on how to reach the "best case"
    - ▪ **Response:** Valuing water is an emerging topic and different countries around the world are now trying to estimate value of water. Therefore, we developed a practical framework only. So best case framework is not possible to derive.

      Development of one harmonized set of values for water
    - ▪ Unclear how shadow prices can be used across sectors/ regions
  - o Capacity building / training of trainers on application of values of water
    - ▪ To our knowledge outstanding

Response: *WARPO organized all the capacity building/ToT and awareness raising campaign programs as per ToR and we also submitted report on capacity development. Representatives from all relevant organizations including WRG2030 group were present there.*

  - o Awareness raising campaign on the value of water
    - ▪ To our knowledge outstanding

Response: *It has been done by WARPO with Radio program, Video clips and also through TVs.*

  - o Part 2 – Streamlining Valuing Water into Public Investment Decision Making
    - ▪ To our knowledge outstanding

Response: *This has been done. Please see Chapter 10 on Public Investment Decision-making*

- o Part 3 – Identifying and Demonstrating Options to Operationalize the Shadow Price for Water in Private Sector Decision Making
  - ▪ To our knowledge outstanding

Response: There were two separate training workshop conducted with the Planning commission teams on this issue.

- Structure of the report could be made a lot more concise and reduce repetition – such as the literature review and the framework. Ideas are not necessarily connected but rather just listed leaving the reader a bit confused about why there are so many approaches, what the benefits/ drawbacks are of each – and most importantly what was chosen for this study and why. Chapter 4 in particular misses an explanation why the selected methods were chosen.
- It would be good to present the logic of the shadow price concept more explicitly in the numerical examples. For instance, in the beverage industry, a firm that uses the least water per 100 Taka output has the highest shadow price for water. Hence, it makes sense to either allocate more water towards this firm from a beverage firm with a lower shadow price, or to improve the water productivity of the firm with lower shadow price.

  Response: It has been explained in the training manual.
- The methodology used for ecosystems differs from the other three sectors. P71 "Considering these, the study team has agreed to estimate the flood regulating services of haors". Hence not a shadow price for ecosystems is computed but the value of flood regulating services of haors. Hence the shadow price of water is computed for three sectors (and not for ecosystems).
- P76. "The value of benefit from this system is calculated using average gross value addition of these land". It is not clear whether the average gross value is corrected for the damage due to flooding (in absence of haor system).

  Response: It is not the gross value of land, it was the rental value of calculated from the gross value which is lost in a year and the calculation is based on this. This is a sound method in Economics.
- Typos in the text (e.g. p1. Potion should be portion, p 5 true should be tree), not all reported in this review. Response: Corrected
- The equations are not numbered consecutively. Hence, equation (1) appears multiple times Response: Corrected
- References list is missing. Response: Corrected
- Information stated to be in Annex is not in Annex. Response: Co*rrected*

Comments and Response

Page	Text	Comment	Response
I	Acknowledgements	Please add: • 2030 WRG, as well as High-Level Valuing Water Committee and the Technical Valuing Water Committee under the National Steering Board of the Bangladesh Water Multi-Stakeholder Partnership.	Acknowledgement
P1	Background	Please provide some background on the High-Level Valuing Water Committee and the Technical Valuing Water Committee and how this study request was developed. We can share a paragraph if needed.	Section 1.1
P2	Rationale	Suggest to add rationale of improving public and private investment decision making – and how the shadow price can be integrated into the planning commission processes (DPP) See text in PFS under section 4.2 "Justification" and chapter 3 in the Position Paper	Section 1.2
p3&4	QR codes	Pls also add a link in the footnote for everyone who doesn't know how to use this and/ or would like to watch it on laptop	Section 1.3
P4	As a result, the methodological approach for estimation of shadow prices are very much likely to be different not only between sectors but also sometime between resources like surface water, ground water and by ecological zones of the country.	It should be stressed that the conceptual approach is identical for all sectors, but that the empirical elaboration of the methodology differs between sectors. Hence the estimated shadow prices will differ.	
P4	Capacity development and training were provided to selected public sector officials to operationalize shadow prices in the DPP design and process.	Is this correct and already completed? We are not aware of these trainings with PC?	We completed all and submitted a separate report on it
P14	Literature Review	The entire section would benefit from connecting the ideas discussed, instead of only mentioning them. It also remains unclear what approach and definition is chosen for this study. This is very relevant information and should be added.	The report is not an academic report. It is not supposed to be an academic text either. We have provided the references for inquisitive readers and for a policy document we strongly feel it is redundant.
P14-15	Shadow Price of Water	The list doesn't list definitions, but rather approaches to assess. Suggest to add definition. Also it only focuses on farmers and not on all water uses.	Section 3.2.1
P16	TEV	Doesn't consider option values	Section 3.2.2

Page	Text	Comment	Response
P16	TEV Table 3.1.	Unclear – Conservation/biodiversity value (non-use values) seems same as Ecological values, such as preserving species and evolutionary potential	Section 3.2.2, Table 3.1
P17	Methods and Approaches Commonly Used	Suggest to group methods by their category, such as revealed preference, stated preference or cost-based approaches (see Position paper chapter 6). Suggest to keep this section as an overview of methods. Now it is mixed with case studies (which are discussed in 3.4) "Mixed Approaches for valuing groundwater" – this is not a type of method but a description of how GW was assessed. Suggest to only focus on methods Method 4 and 10 seem to be the same.	For a policy document the report as it is, is good but for academic purpose it is not. We agree to this but this is a policy report and so it would unnecessarily make the report bulky. Interested readers can always read relevant textbooks.
P18	The methods 6-11 from the Deloitte Access Economics	The methods 6-11 (from Deloitte Access Economics ,2013) are identical or overlap with the first five methods and approaches mentioned. For example, method 3 and 9 use hedonic pricing. Method 11 is also included in method 3. Prevent the repetition of methods.	Section 3.3
P19	Empirical Examples	Format/ design of numbering doesn't seem correct	Section 3.4
P19-P21	Empirical Examples	No conclusions are drawn from the empirical examples, It would be preferred if conclusions were drawn from the empirical examples which can be transferred to Bangladesh context.	Section 3.4
P21	For example, in case of residential use of water supplied by utilities, the issue of affordability becomes important as one of the SDGs. Thus, shadow price provides the guidance to a fair system of pricing of water	In the context of affordable price of water for households. The shadow price can be higher than the price paid by households. In that case the government subsidizes water for households.	Affordability and valuation are two different things. The report is primarily for valuing water and so we did not want to venture into this issue. It would require a separate study.
P22		This section misses an explanation why certain methods were chosen	The rational of using certain methods are clearly described in chapter 5
P22	Principles of Valuing Water	Misleading title. Better "scope of study" or "study design"	Section 4.1
P22	PFS	What is meant by PFS	Section 4.2
P22	Agricultural use: cost of water	The costs of water are not necessary in the production function approach	Section 4.2, Table 4.1

Page	Text	Comment	Response
P23	This table should be read and understood with explanations provided in sections earlier how the approaches will be used to avoid repetition of arguments	The link with the section earlier is not evident -> please clarify at page 24 the methods described in the text above	Section 4.2,Table 4.1
P23	Fixed proportion production function method or Input-Output Method	Were both methods used? As the study is completed suggest to be precise. If both were used, pls make two lines stating where which one was used	Section 4.2,Table 4.1
P23	Damage Cost Approach / Average Loss of Output	See above.	Section 4.2,Table 4.1
P24	Figure 5.1: Methodology of the Study	Not all elements of the methodology are reported. E.g. sensitivity analysis	Section 5.1
P24	Conceptualization and Understanding of Shadow Prices	This section is a partial repetition again of previous sections.	Section 5.2
P24	there is a need to know the 'economic' price of water - which is called the 'shadow price'	Please use definition and explanation of shadow price consequently in the report	Section 5.1
P26	Section 5.4 onwards	Unclear about location of these sections. This should be at beginning of report on study design.	Section 5.4
P36	For comparison elsewhere in the world the modal value appears to be very similar at 3 cents/cubic metre.	A reference should be given for the world modal value.	Done
P38	From the production function, we estimated Tk 18.78	Please add the estimation results to the text	Section 6.4.5
P38	Area and found that the financial value is roughly Tk 18.78.	Can you give any explanation why the shadow price is that much higher than in Barind. Is less water used in Muhuri than in Barind?	Section 6.4.5
P39	In case of power sector, the price of electricity is regulated below the competitive market equilibrium and hence the study team adjusted the output price (electricity price) with equivalent international price using a conversion factor	If the power company receives the electricity price, that is the price to use. If the factory also receives subsidy per unit of electricity produced, the subsidy should be included also in the price	Not clear. Shadow prices conceptually take account of all transfer items.
P43	Model 1: MP=0.05	The MP values do not correspond exactly to the estimation results in table 7.4.	Not clear. Probably reviewer has taken regression coefficient as MP which it may not be.

Page	Text	Comment	Response
P41	Water Use in Power Generation	It is not clear in the text whether the water use, applied in the computation of the shadow price is the water which is evaporated (net water use) or the gross water use (includes also water discharged into the river after usage) . In case of gross water use, this may explain partly the high shadow price estimates	Gross water as reported by the plants themselves
P46	(for high and low price of space and high and low productivity of water, all in Taka): 396.66, 324.41, 105.78 and 86.51.	This is difficult to follow for the reader. Please elaborate more on the computation	Section 7.5.6
P49	wet processing stage, as shown in Figure 7.4	The wet processing stage cannot been found in figure 7.4	Done
P52	Method and Results	Unclear what method was used and how results are derived. It seems as if the water productivity is equalled to the value of water?	Section 7.7.5
P57	We, therefore, assumed that individual may take a leave of 1.25 days per month for sickness	This figure is not related to water use. Hence, it cannot be used in this way	It is stated in report section 8.3 'Since this study would like to see the benefit from piped water supply in urban (using surface or ground water sources), we would only include diseases linked to availability of water.' So, when talking about diseases, sick leave must be considered in estimation.
P60	Table 8.4	The heading of the table is missing (Dhaka, Khulna??)	Section 8.5, Table 8.4
P60	For a waterbody that can supply water for the whole year, our estimates show that a hectare of waterbody surrounding Dhaka will generate an economic benefit of 61,589	The assumptions for this analysis are not clear for the reader.	Section 8.5
P61	in this section, we have evaluated the cost of losing a water body that supplies water to a urban cities like Dhaka and Khulna	That is not correct. The value of tap water for households has been analysed	Section 8.6
P64	It appears that other haors will be capable of retaining the excess water and so no impact could be observed on adjacent agricultural or other land.	So only the value of the Tanguar Haor is computed. Which cannot be aggregated directly to other Haors.	Section 9.1.1
P70	Table 9.4: Benefit estimates: Agriculture, Forest and River system	The source of this number and the unit of measurement is not clear in this table	Section 9.1.3, Table 9.4
P70	Table 9.5 Human Settlement Area Benefits	The source of the numbers (what productivity, how computed from National Statistics) and the unit of measurement is not clear in this table	Section 9.1.3, Table 9.5

Page	Text	Comment	Response
P77	Table 9.6 Waterbodies	The benefits for waterbodies are not elaborated in the text. They seem rather high.	Section 9.1.3, Table 9.6
P76	Conclusion	The conclusions do not reflect on shadow prices (addressed	From the very beginning the idea was to estimate value of water in case of haors, not translating that into shadow prices; or for that matter we are not sure whether this can and should be done
P2	we tried both a Cobb-Douglas production function	What are the estimation results of the Cobb Douglas production function? Why is the Cobb-Douglas functional form rejected?	Section 6.3.1
P29	Linear: $Q = A + \alpha K+\beta L+\gamma W+\delta Z$	This linear production function does not satisfy the properties of a production function (concave. Diminishing returns to scale). Normally this is counted for by adding the squared term of all variables. This squared term is used for water input but not or the other ones.	Section 6.3.1
P32	UZDs are 6 upazila dummies	Why are interaction terms of water and upazila dummy not taken into account, to account for differences in shadow price per upazila?	Section 6.3.3
P36	We tried several variations of equations. Of them two equations were found to have relatively better explanatory power.	Which tests have been performed to select the specification presented? How is the explanatory power tested?	Section 6.3.3
P34	while those within parentheses are absolute t statistic. ***, ** and *	It is more informative to present the standard error within the brackets instead of t-value (that is dealt with by the *)	Section 6.3.3
P32	Eq (1) Where I is the income loss due to sickness from lack of availability of water,	In the interim report this equation (1) was presented as the Marginal Value of Water for human consumptive	Section 6.3.3
P32	Where P is population	P should be number of households, as the equation is estimated at household level	Section 6.3.3
P61	Water Related Health Costs	Average Water Related Health Costs per household	Section 8.6
P61	female /pregnancy related diseases	I assume the delivery itself is not part of the pregnancy related diseases	Section 8.6
P57	It may, however, be noted that health cost data are also count variables as they are all reported in taka without decimals	Health cost data as applied in this study (in BDT) are not count data (these dta do not have a discrete nature). The dataset could be transformed into count data, if the expenditures can be converted to number of diseases that involved costs. So the poisson model is not appropriate for the current analysis.	Section 8.3
P57	Results show that on average households' cost of health reduces by 82 taka	This seems to be an unrealistic result, as the average Water Related Health Costs in Khulna (were only small part of the population has tap water) are 46.01 BDT	Section 8.3

Page	Text	Comment	Response
	for use of water for economic production purposes, the general recommendation should be that the productivity of water must rise be it in agriculture or in any industry	Why not first focus on water allocation within a sector, instead of comparing between sectors	No sector is totally dispensable that water may be allocated wholly from one sector to another based on efficiency in use and value of water as converted to shadow price. Rather the first priority option must be to ensure that water use be efficiently done within each sector and the savings may be reallocated to the sector where its value is higher and the use is done efficiently. But note that when one finds value of water, this is financial value and depends on the prices of goods and services of that sector which are not necessarily competitive due to various market imperfections. So, immediate gut feeling of reallocation on the basis of the financial value of water must be resisted.