Bangladesh

Ministry of Water Resources

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

TRAINING MANUAL

WARPO
পানি সম্পদ পরিকল্পনা সংস্থা
Water Resources Planning Organization

Technical Support from
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Training Manual

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

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1. Introduction

Water is one of the most needed and misused natural resource on the planet. Fresh water which is necessary for use by humans for sustaining life, is just near 2% of the total available water and of that 2%, only a negligible potion 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.

One major code for such efficient and equitable allocation is to do so based on how human society value such a resource in alternative uses. Valuing water is therefore a requirement for resourceful and equitable distribution of water across different uses and users. Bangladesh seemingly has a lot of water because of generally high rainfall (though distributed unevenly over space and time). 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 quite inefficiently 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 supplied as a matter of basic human right. Agricultural water demand was 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-exploited and so may be on the verge of depletion. As such, there is a need to understand the value of water in its different uses.

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. Previously, water was never used as an input, which has to be counted for estimating net social benefits in public sector investment decision-making.

Given the importance of valuing water in Bangladesh, Water Resources Planning Organization (WARPO) has assigned the task of developing operational shadow price of water to support investment and policy decision-making processes to Centre for Environmental and Geographic Information services (CEGIS). The study estimated shadow prices for four sectors, 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 & Beverage and Apparel. The estimated shadow prices for water will help in allocating public sector resources for investments in areas or projects where social benefit and social costs of all inputs including natural resources such as water may be used for prioritization. These may be used for operational purposes of revised guidelines for DPPs. Future public investment projects can thus directly benefit from such estimates.

1.1 Objectives

The primary objective of this training manual is to introduce the concept of valuing of water with examples. Water Resources Planning Organization (WARPO) with the technical support from CEGIS has conducted a study on Valuing water and Developing Shadow Prices for 7 sub-sectors under 4 major sectors in Bangladesh. The objective of the study is to estimate the economic value of water as it is being used in these sectors. The sectors are: a) Agriculture, b) Industry, c) Urban Water use; and d) Ecosystems. The 7 sub-sectors are: 1) water used in boro-rice production under Agriculture, 2) water used in the construction sectors; 3) water used in the power sector; 4) water used in the food and beverage industries; 5) water used in the RMG industries; 6) water used in urban supplies of piped water; and 7) water used for ecosystem services such as flood regulation.

The training is expected to be on introductory in nature and is expected to develop an understanding on what does it mean for value of water & Shadow Prices and how it is different from charges levied for use of water (often know as price of water); Framework for developing shadow prices of water; what are the different methods of valuation; and how these methods are used to estimate the value of water in Bangladesh and to identify some of the best practices for valuing water as well as incentive mechanism.

The training is expected to last for two (2) days, and the slides are expected to be used in conjunction with a face-to-face or online lectures.

1.2 Rationale

Water remains an indispensable natural resource. It is used for production purposes such as agriculture, industrial, commercial, forestry, fisheries etc. and 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 worsen 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 sector 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 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.

Water uses in the Industry for production of final products is very common. Huge amount of water used in industry sector, where no water auditing exists. As a result huge misuse of water and occurrences of pollution is a common phenomenon. If appropriate valuation and acceptable pricing of water is exist, it will ultimately help in judicious allocation and uses of water. Thus valuing water is imperative.

In the absence of information about ecosystem values, misallocation of resources may have occurred and gone unrecognized and substantive economic costs may have often arisen. Under-valuation impacts on the status and integrity of natural ecosystems themselves run 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, 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 are not appropriately considered in Bangladesh. This study seeks to develop a framework for valuing water in Bangladesh and estimate the value of water, which can be easily operationalized for informed decision making.

1.3 Shadow Price Means

A shadow price is an "artificial" price assigned to a non-priced asset or accounting entry. Shadow pricing is frequently guided by certain assumptions about costs or value. It is generally a subjective and inexact, or imprecise, endeavor. To make a decision regarding the undertaking of a project or investment, businesses often perform a comparative analysis of the project or investment cost against the projected benefits. Economists will often assign a shadow price to estimate the cost of negative externalities such as the pollution emitted by a firm.

A shadow price is an estimated price for something that is not normally priced or sold in the market. Shadow pricing can provide businesses with a better understanding of the costs and benefits associated with a project. However, shadow pricing is inexact as it relies on subjective assumptions and lacks reliable data to fall back on. It is often used in cost-benefit accounting to value intangible assets, but can also be used to reveal the true price of a money market share, or by economists to put a price tag on externalities. Shadow pricing is also frequently used by economists to determine the value of public infrastructure projects like public parks and transportation.

Shadow pricing is used by analysts and economists to assign a monetary value to non-marketed goods such as production costs and intangible assets. Shadow prices are essential to running an accurate cost-benefit analysis of a project.

1.4 Advantages and Disadvantages of Shadow Pricing

Using of shadow pricing helps to obtain a fuller understanding of its project's real value. It is a necessary part of running a cost-benefit analysis and can assist management in their decisions about various aspects of a project's strategy and scope. Shadow pricing encourages responsible ethical behavior and is a vital tool in accurately evaluating a project.

Shadow pricing provides management with a fuller understanding of the costs and benefits associated with a project. Shadow prices help determine whether or not a public project is worth pursuing. Shadow pricing can save money by demonstrating the appropriate path of action to take.

Shadow pricing quantifies production actions and abstract commodities that aren't normally assigned a numerical value. One common example of an abstract commodity is a public park; shadow pricing assigns a monetary value to the benefit of a park in order to decide how or if to pursue the project.

That being said, there are a number of limitations to shadow pricing. Most notably, shadow pricing is inherently subjective; because the assets it attempts to value are intangible, the shadow price is proof less. Furthermore, because analysts must employ a fair amount of guesswork, there is significant room for bias. This means there is also a good chance the shadow price is not accurate. If the methodology used to create the shadow price is flawed, the business may direct its actions in a way that won't benefit and could discredit the company.

Finally, some critics believe shadow pricing puts too much emphasis on short-term social opportunity costs while ignoring the long-term priorities of the business.

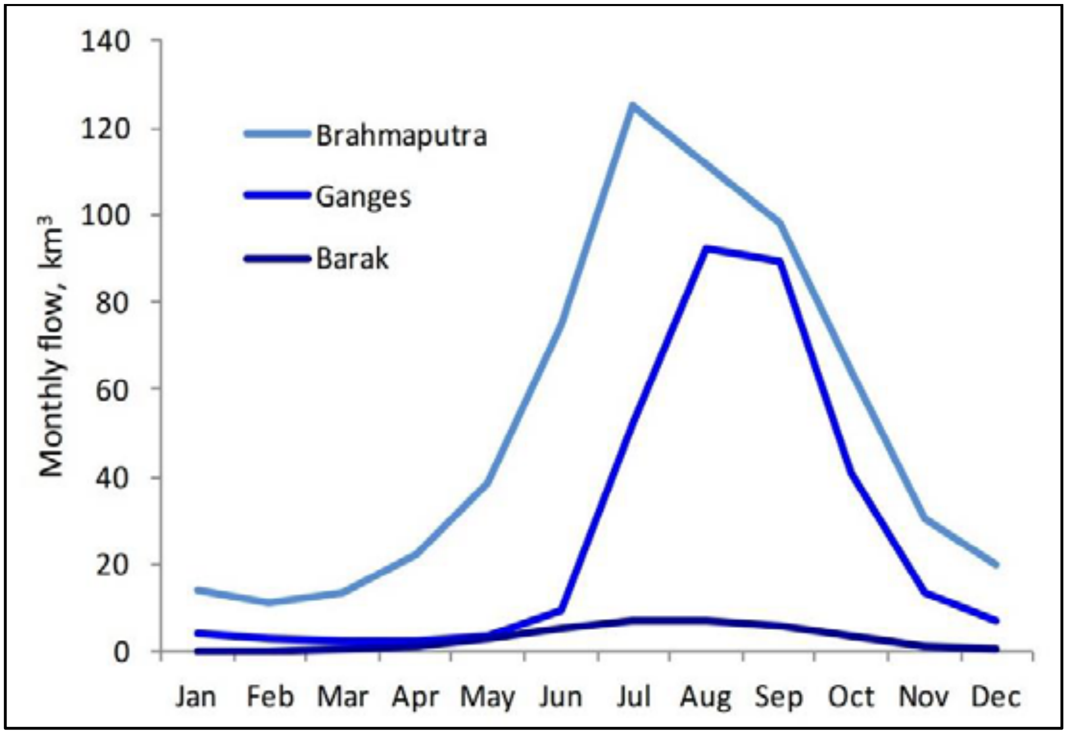
2. Water Resources Management and its Challenges

2.1 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 apple of truth falls very far from the true indeed as a closer look at this water and the associated radical seasonal variation paints a more horrid picture as to the actual condition in prevalence.

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 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 1: Monthly water inflow from the three major transboundary river (WARPO, 2014)

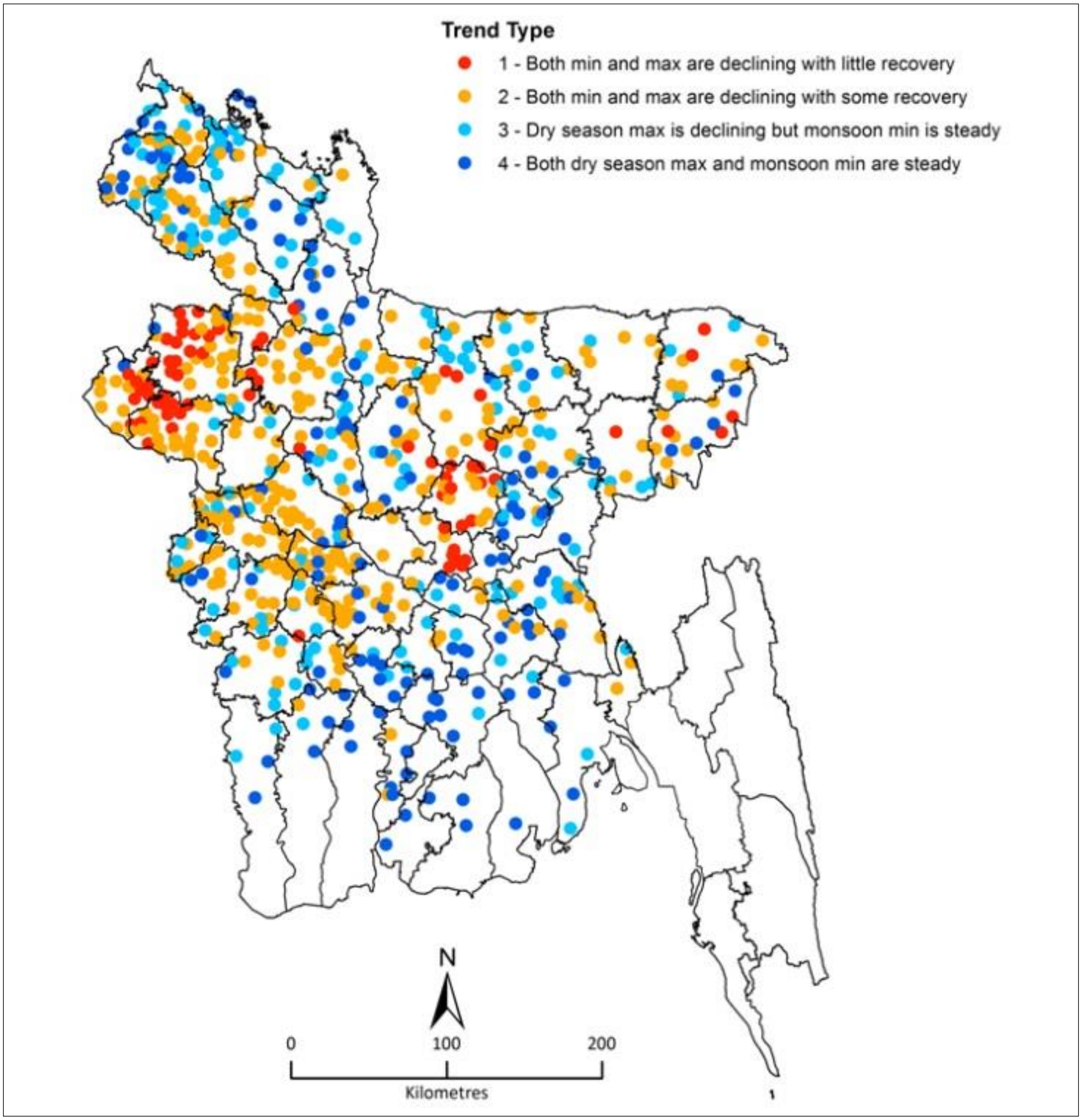


Being the lower most riparian country of the GBM basins, Bangladesh is highly dependent on the cross-border flow which varies greatly in wet and dry season of the country, the exact value of which differs in different literature. However, reduction of dry season flows in Bangladesh due to increasing 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 Southwest region, while about 25% of the country is flooded to varying degrees each year during May through September (Ahmed and Roy, 2007).

2.2 Groundwater Resources

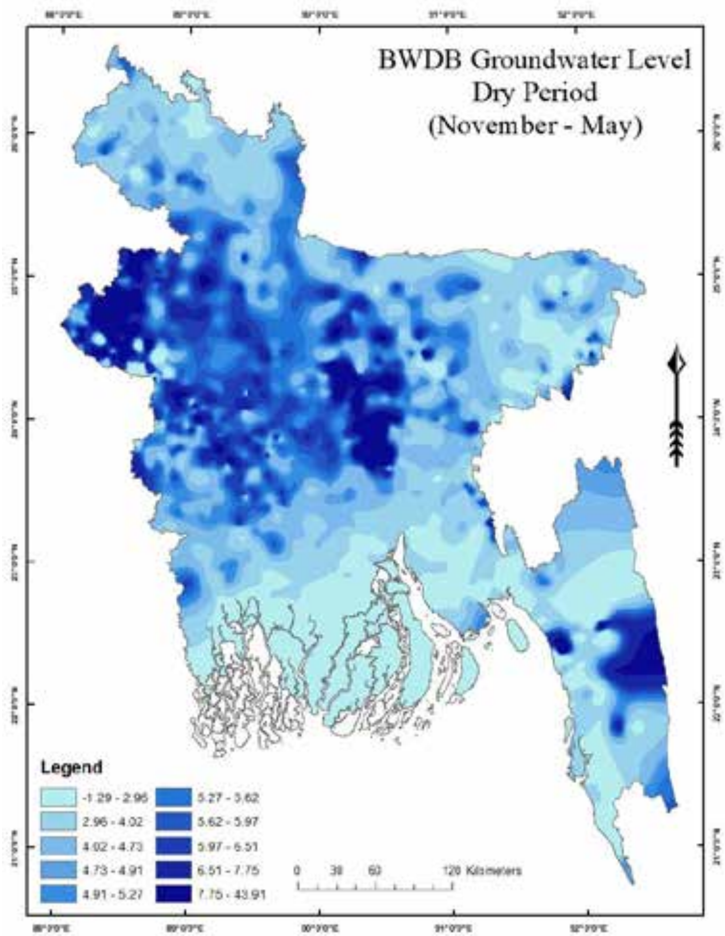
Groundwater is also an important source of water in Bangladesh, especially for agriculture and drinking purposes. Major source of ground water is the recharge from surface water in the unconfined aquifer that is underlying most of the area of the country from the sedimentary alluvial and deltaic deposits 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 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 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 Northwestern region.

Figure 2: Groundwater Level Trends in Bangladesh

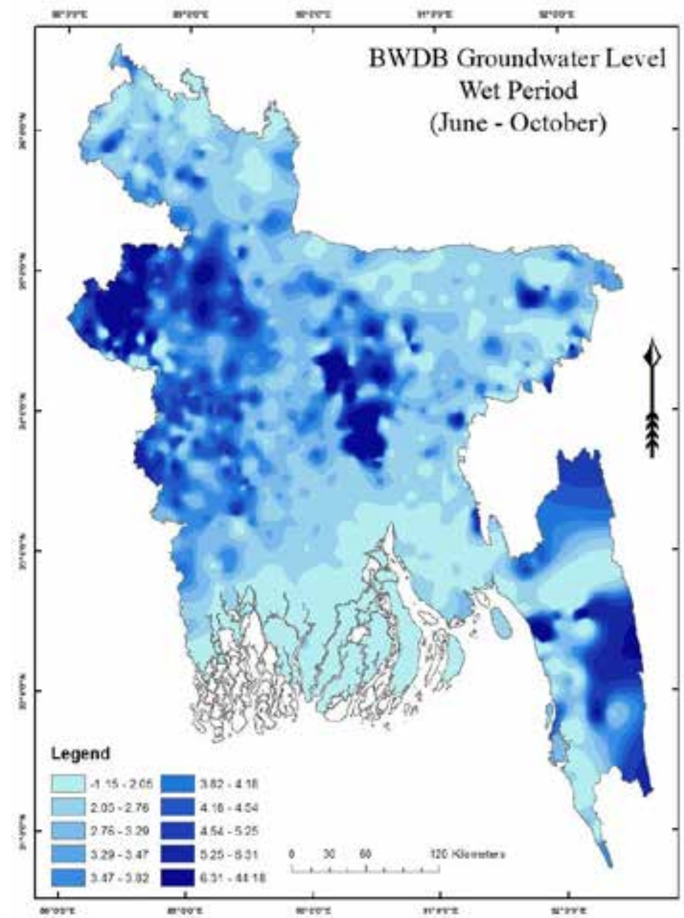


(Source: WARPO, 2014)

Figure 3: BWDB Groundwater Levels



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



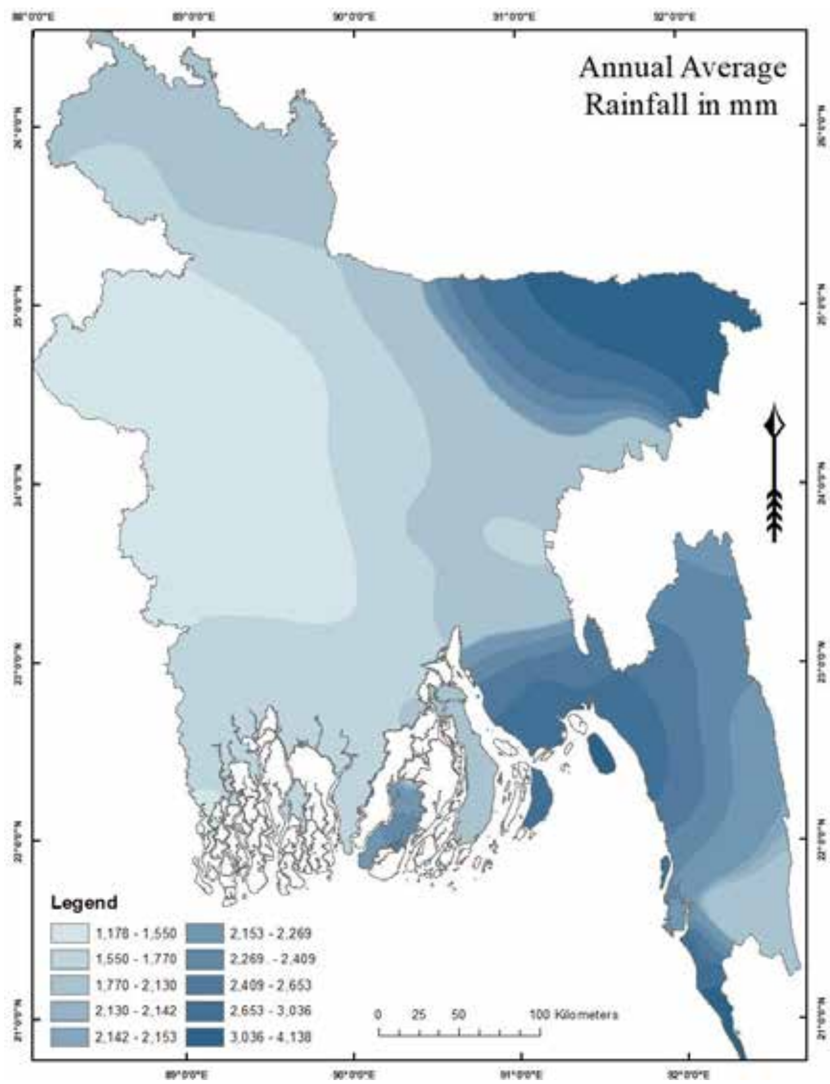
b. BWDB Wet Period GW Levels (Jun-Oct)

(Data Source: NWRD)

Rainfall

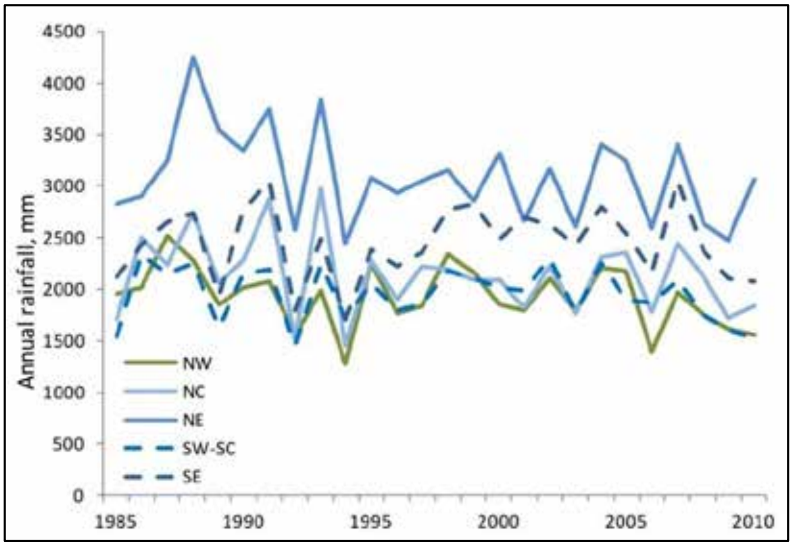
Established as a land of six seasons, the hydrometeorology of Bangladesh is dominated by a pattern of successive dry and wet spells, the other "seasons" being altered variations of the former two. Irrigation practices prevalent in the country is heavily dependent on the seasonal rainfall patterns. During 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 southwest-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 4 illustrates the rainfall distribution pattern throughout the country and Figure 5 portrays the comparison between the regional annual total rainfall.

Figure 4: Variation in Rainfall Distribution in Bangladesh



(Data Source: NWRD)

Figure 5: Annual Total Rainfall for the Hydrological Regions



(Source: WARPO, 2014)

2.3 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 period. 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 in order 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.

2.4 Issues of Valuing Water and Pricing in the Relavent National Policies and Act

2.4.1 Issues of Valuing Water and pricing in National Water Policy, 1999

Section 4.14 Economic and Financial Management of National Water Policy, 1999 States that: Changes are required in the system of prices and other economic incentives affecting water demand and supply in Bangladesh. Unless the users pay a price for water, there will be a tendency to misuse and deplete it under scarcity conditions. Desirable practices such as conjunctive use, water-saving agricultural and industrial technologies, water harvesting, water transfers, and water recycling, both within and between sectors, will emerge only when users perceive the scarcity value of water.

A system of cost recovery, pricing, and economic incentives/disincentives is necessary to balance the supply and demand of water. Cost recovery of services such as flood control, drainage, irrigation, and wastewater treatment has not been considered adequately. Failure to recover O&M cost leads to decline of service quality and deterioration of the system. This, in turn, makes the consumers less willing to pay for the deteriorating services. An important principle, for the long-term, in this regard is that public service agencies should be converted into financially autonomous entities, with effective authority to charge and collect fees. The participation of users in managing and maintaining water facilities and operations is an important element of financial accountability. It is, therefore, the policy of the Government that:

a. Water will be considered an economic resource and priced to convey its scarcity value to all users and provide motivation for its conservation. For the foreseeable future, however, cost recovery for flood control and drainage (FCD) projects is not envisaged in this policy. In case of flood control, drainage, and irrigation (FCDI) projects water rates will be charged for O&M as per Government rules.

b. Relevant public water supply agencies will be gradually given authority to charge for their services.

c. Recovery of O&M cost will, as far as possible, be made through private collection means such as leasing and other financial options. Beneficiaries and other target groups will be given preference for such contracts.

d. The pricing structure will match the goals and needs of the water provider and the population served. Water rates will be lower for basic consumption, increasing with commercial and industrial use. The rates for surface and groundwater will reflect, to the extent possible, their actual cost of delivery.

e. Water charges realised from beneficiaries for O&M in a project would be retained locally for the provision of services within that project.

f. Effective beneficiary participation and commitment to pay for O&M will be realised at the project identification and planning stages by respective public agencies.

g. Appropriate financial incentives will be introduced for water re-use and conservation, responsible use of groundwater, and for preventing overexploitation and pollution.

2.4.2 Issues of Water pricing in Bangladesh Water Act, 2013

Section 8. Power to adopt National Water Policy Bangladesh Water Act, 2013 states that - (1) The Government may, form time to time, subject to the provisions of sub section (2) by notification in the official gazette, adopt a National Water Policy.

(2) The Government may, in order to formulate National Water Policy mentioned in sub section (1), make arrangement for public hearing in the manner prescribed by rules to take opinions of the communities and organizations concerned with water resources, and shall, by taking the considerations of the opinions received in public hearing, finalize the National Water Policy.

(3) In the National Water Policy, the government may include the policies of pricing of water to be determined by the appropriate authorities, and in doing so, the government shall, along with other relevant issues, consider the following issues namely:-

(a) purpose and sectors of water use;
(b) affordability of the water users
(c) actual cost of water abstraction and distribution
(d) financial ability and backwardness of water users or any group thereof;
(e) demand and supply of water ; and
(f) any other issues considered relevant by the government.

(4) Until a National Water Policy is adopted under sub section (1), The National Water Policy, which was adopted by the government immediately before the commencement of this Act, shall remain in force subject to being consistent with the provisions of this Act.

2.4.3 Water allocation and pricing issues in Draft Industrial Water Use Policy, 2019

According to draft Industrial Water Use Policy, 2019 Water allocation and Pricing mechanism should internalize environmental externalities. It is stated in the draft Industrial Water Use Policy that,

- It is important to estimate the full cost of water used in a particular sector considering water as a social and economic good. The full cost of water should include the opportunity cost of water as well as the environmental externalities. The full cost should present the context for setting water prices, effluent charges and incentives for pollution control.
- In estimating the value of water, it is critical to reflect the societal objectives of poverty alleviation and food security, and incorporate the net benefits from return flows and non-irrigation uses of water.

3. Concept of Shadow Prices and 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 for us; 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, ecosystem conservation, 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 or scarcity 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.

3.1 Shadow Price of Water

The literature review on the subject shows that the shadow price of water has many definitions; the shadow price can be computed either based upon the farmer's behavior or based upon the value of alternative use(e.g., different user or different time). Four types of definitions are available in the literature and are relevant to present study are:

(1) First, it may be defined 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 definition of shadow price refers to the price that would need to be paid by farmers 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 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 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).

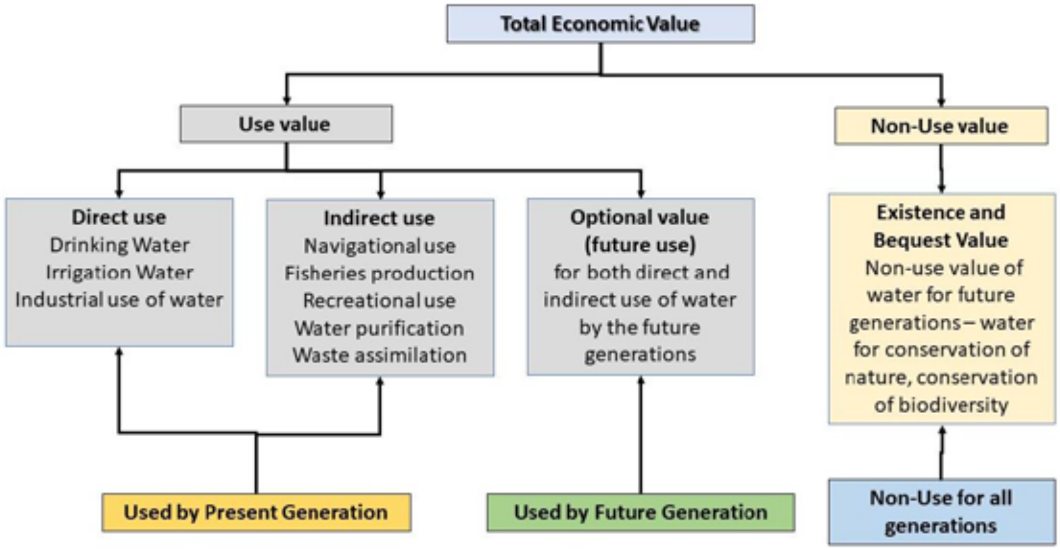
(4) Finally, if farmers do not consider inter-temporal efficiency (they ignore future groundwater use), the shadow price can also be referred to as the current marginal value of water (He et al., 2007; Wang & Lall, 2002; Young & Loomis, 2014). This reflects the value that water has to the farmer, that is, the maximum price the farmer is willing to pay for the last cubic meter of irrigation water consumed. In other words, the shadow price of water reflects the value of crops 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 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 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.



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

Table 1 below shows that Total economic value (TEV) concept can also be generally used to provide a more comprehensive framework for monetary value estimates for non-marketed environmental and social values, to complement market based economics values (WBCSD 2013). Examples of Economic and Environmental and Social uses of water are detailed here.

Table 1: Examples of economic welfare values and other sustainability related values

Dimension of Sustainability	Example of welfare economic values (i.e. contributing to TEV)	Examples of other sustainability values (not additive to TEV)
Economic	• Market values for food, timber, properties, energy and industrial goods produced (reflected in business profits) • Tourism values • Carbon market prices • Flood protection of assets	• Some contributions to GDP • Expenditure in local economics • Contribution to national and local taxes • Number of small business
Environmental	• Conservation/biodiversity value • (non-use values) • Carbon Sequestration	• Ecological values, such as preserving species and evolutionary potential • Intrinsic value of organism
Social	• Flood protection of houses • Recreation • Wild food gathering • Aesthetic values • Impact on health	• Jobs • Household incomes • Good social relations • Gender and age equity • Freedom of choice and action • Spiritual values

Source: (WBCSD 2013)

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.

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 i

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 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 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. Hedonic pricing reflects the contribution of groundwater rights to higher land values, in situations where groundwater access entitlements have not been unbundled from land. This requires that groundwater availability be isolated as the sole source of difference in property prices which, in reality, is not always a practical approach (Deloitte Access Economics ,2013).

10. 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).

11. Contingent Valuation is a method of estimating the value that a person places on a good. The approach asks people to directly report their willingness to pay (WTP) to obtain a specified good, or willingness to accept (WTA) to give up a good, rather than inferring them from observed behaviours in regular marketplaces. Because it creates a hypothetical marketplace in which no actual transactions are made, contingent valuation has been successfully used for commodities that are not exchanged in regular markets, or when it is difficult to observe market transactions under the desired conditions (extractive, non-extractive and option value) is being assessed (Deloitte Access Economics ,2013).

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) apparel 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) In 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 used for the selected study sectors, the operational framework for the study may be summarized as follows:

Table: Operational Framework for Valuing Water[1]

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 , Apparel 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

5. 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

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

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).

5.1 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 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 apparel. 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 to optimize or maximize the production through using less water as less as possible.

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 almost 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 in Bangladesh is also under practices of water efficient uses for its production.

5.2 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 green production.

Promotion of green bond market: Promotion or adoption of a well-developed green bond market, green labelling has helped as incentives. 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 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.

6. Training Slides/Illustration With Explanatory Notes

This training is of Two days duration. It is designed to introduce the concept of valuing water in designing projects and in policy making. Participants for such training are expected to be drawn from the officer of the

- Ministry of Planning
- Ministry of Water resources
- Ministry of Power and Energy
- Ministry of Environment, Forest and Climate Change
- Ministry of Industries
- Ministry of Agriculture, and
- Officers of the various agencies, departments and institutions from relevant ministries.
- Participants from private sectors i.e. WRG 2030, BGMEA,BKMEA, COCA-COLA, Nestle, RMG Factories, NGOs, Public medias, Development Partners,
- Participants from Academic Institutions

The training has three distinct objectives

- Introduce the concepts related to environmental valuation related to use of water and protection of water bodies or conservation of water resources
- Participants will get an insight on various techniques of valuation used to determine the use and non-use value of water.
- Participants will get idea on using the values to determine – a) feasibility of projects, b) to decide on investing in conservation of water and c) to decide on protecting water bodies from being polluted by other investments and d) identify best practice of valuing water

SLIDE 1:
VALUING WATER FOR DEVELOPMENT PROJECTS

It is often said the water is free. However, providing clean water, keeping it safe and ensure that water bodies remain flowing and interconnected is not free. It requires significant investment and hence there is a need to justify such investments. This means that while water has no market price, it does mean that it is not useful. It has many uses and many of these uses are in competition. Water used for irrigation is not available for other use and hence there is a need to understand the value of water in different uses.

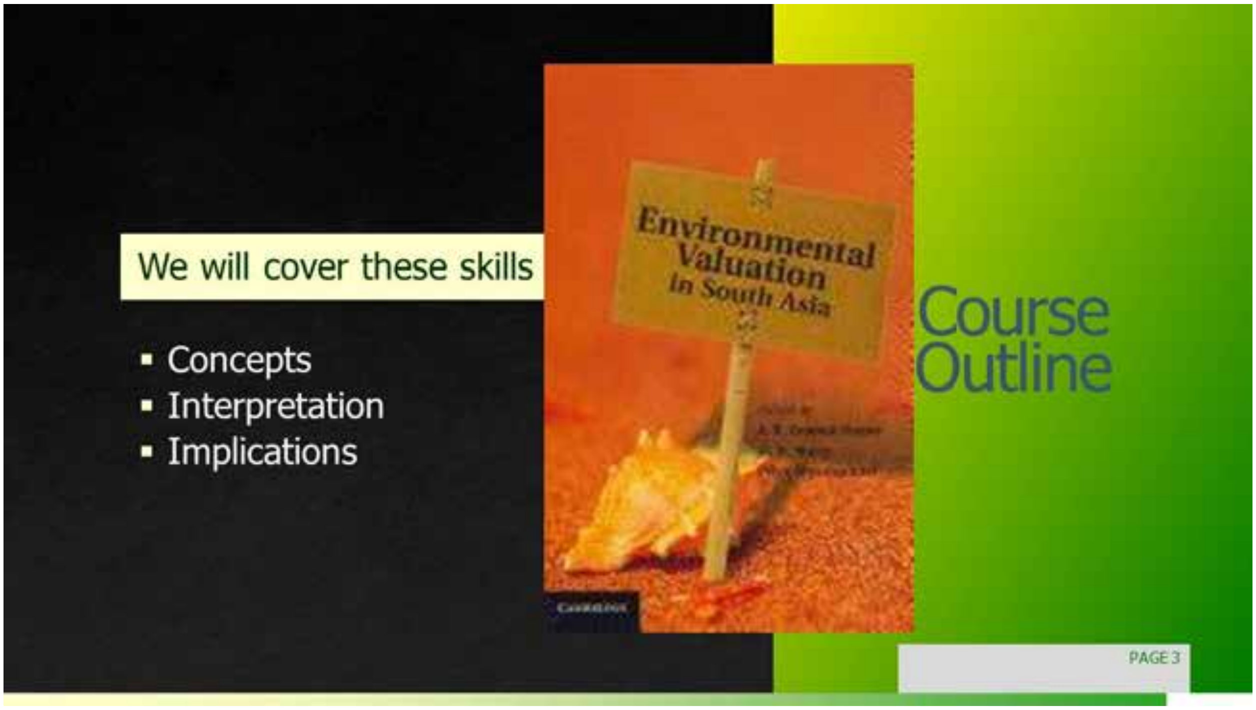
Globally, nearly 5 trillion dollar is required annual to maintain water and wastewater system and to maintain stormwater systems the world spends nearly 6 trillion dollars year. This gives us a clear indication that we need to know the value of productivity of water in order to justify expenditure in the management and maintenance of the water systems.

SLIDE 2:
TRAINING OUTLINE

In this training, we introduce you with the concepts related to economic value of water, explain methods of valuing various environmental goods and services and guide you through several key methods so that you are able to understand why valuing water is necessary for a good decision making.

The term 'value' of a resources in economics is defined as the creative power of the resource and not the market price. This is because markets could be distorted due to various interventions and/or due to the market structure of the resource. For example, if government decides to increase the price of 1KL of water from BDT 10 to BDT12, it does not mean that we have more values for the resources. It will be make a glass of water sweeter or bitter due to this. The inherent productive value remains as it is before and after the price increase. Hence, economists divide the values in two terms – use value and non-use value. Use value refers to the value of water to its users – who use water (directly or indirectly) to produce goods and services. On the other hand, there are non-use of water where no one use water for any specific purpose but they want the water body or the resource to be there for future (who may or may not use it). This means a resource has bequest or existence value.

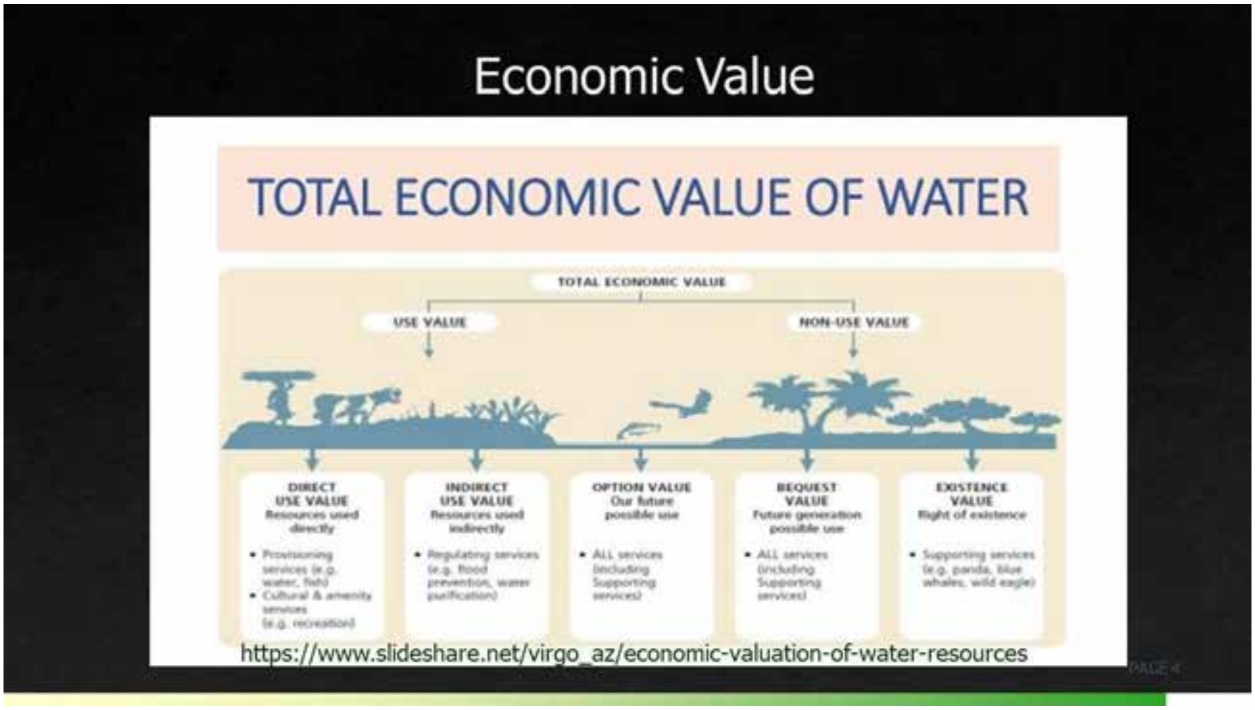
In the next, few slides the concepts are gradually introduced with interpretations in order to provide a clear understanding on the value of water and their implication for public decision making for managing water resources of a country.



While the Total Economic Value (TEV) is the sum of all values of water, it is important to note that such values are not derived to create a trade-off for destruction of water. For example, if estimates show that a river creates 1 billion taka of value in a year then it cannot be used to trade the river for other uses like converting the river into a amusement park, even if the park creates more than 1 billion taka value a year.

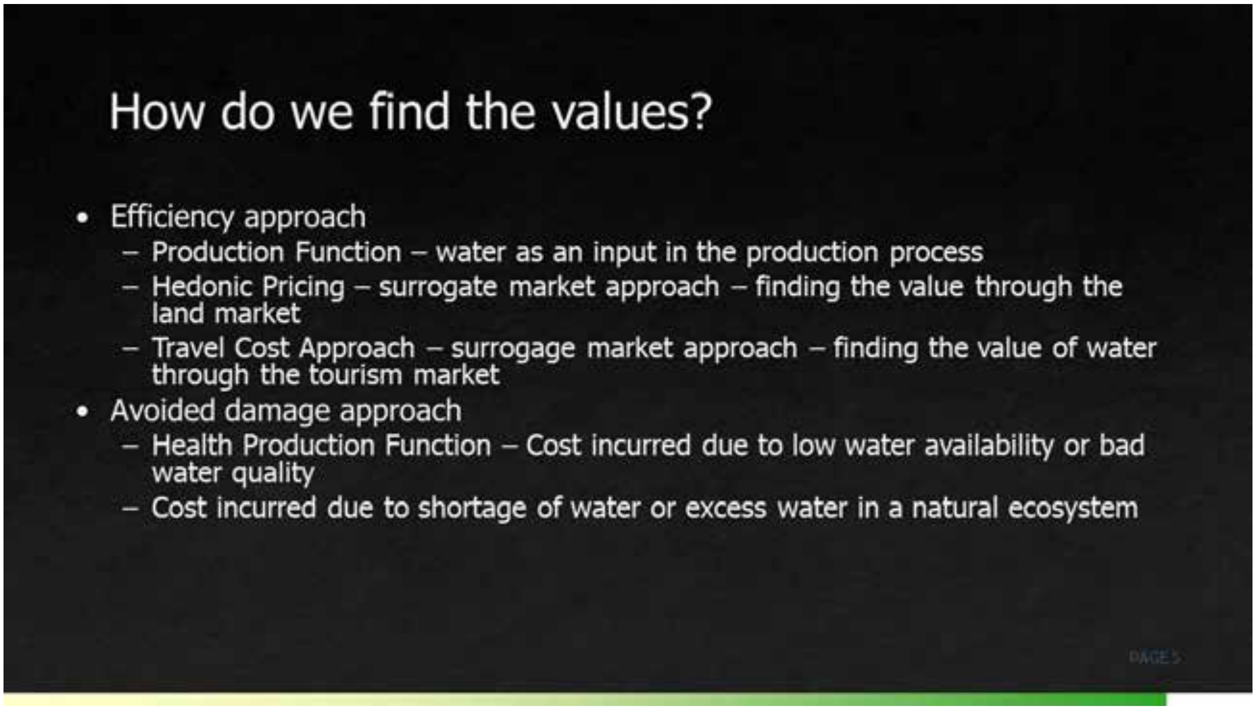
The objective of valuation is to understand the concept of marginal value which means how much will be destroyed if we reduce total water supply by a unit. In this way, economists use the value of environment to understand the impact of a change in resources availability. This is known as the marginal value and it is not constant. The trick is to use the concept of TEV to find the marginal value of resources.

SLIDE 3:
TOTAL ECONOMIC VALUE OF WATER



Water generates many types of ecosystem services. Using the nomenclature of the Millennium Ecosystem Assessments (of UNEP), there are four distinct services that water as a resource creates for humanity. First – the provisioning service – where water is used directly or indirectly to produce goods and services directly for the benefit of human use like fish, navigation service, drinking purpose, irrigation purpose, etc. Second – the regulatory service – whereby water is absorbed by the system to regulate the water cycles in nature so that our natural system survives and provide benefits to humanity. Third – the cultural service – whereby water or waterbodies are pivotal to create a cultural heritage for humanity or it becomes a source knowledge and entertainment for others – tourists and researchers. Finally – the supporting services – in this water and water bodies provide the habitat services for plants and animals which are pivotal for long term existence of humanity.

SLIDE 4:
HOW DO WE FIND VALUE OF WATER?

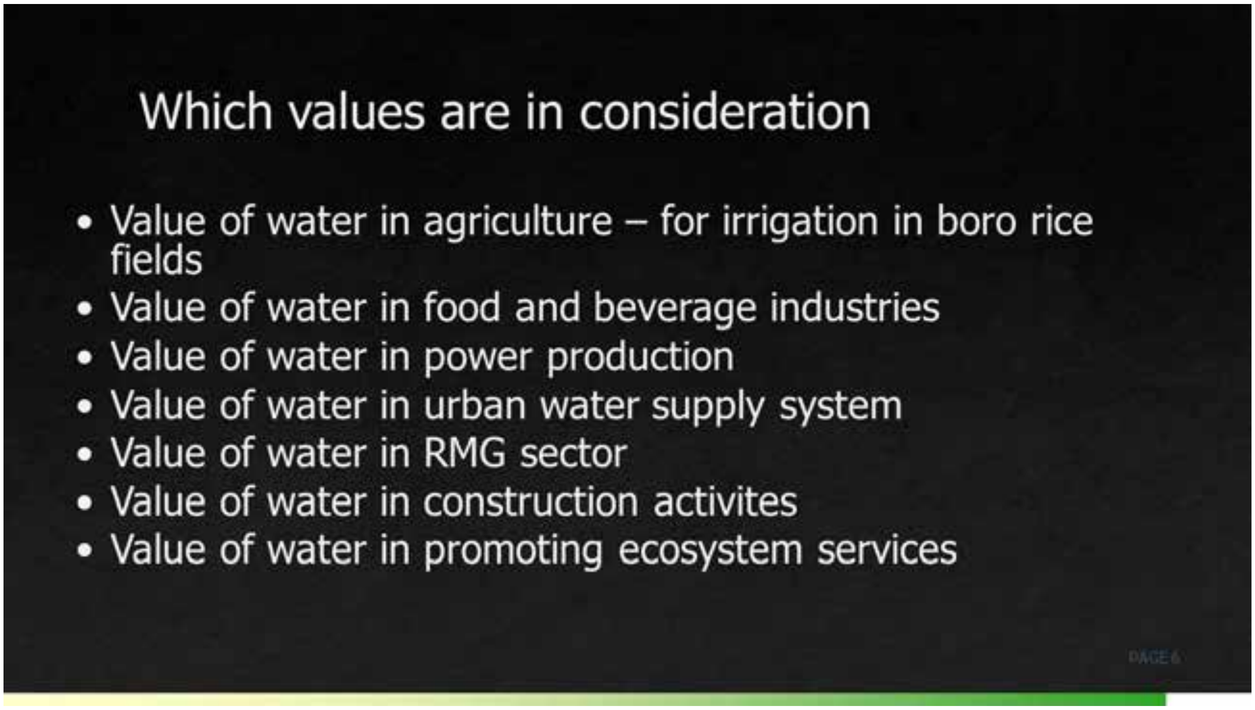


Whether water is sold or bought in the market, it creates value for humanity and it is important that we understand and capture the value of water so that we know how much to invest in it to ensure that the services remain uninterrupted over generations. There are several approaches to find the values. The first set of values are found through measuring the contribution of water in the production of goods and services – know as efficiency approach.

This includes using the concept of a production function in economics which measures technical efficiency from using the inputs. Under this method, economists estimate a production function using field data from producers on output, and other inputs used during the production including the volume of water. All of these inputs and outputs are measured in volumes, so that physical productivity of water can be estimated.

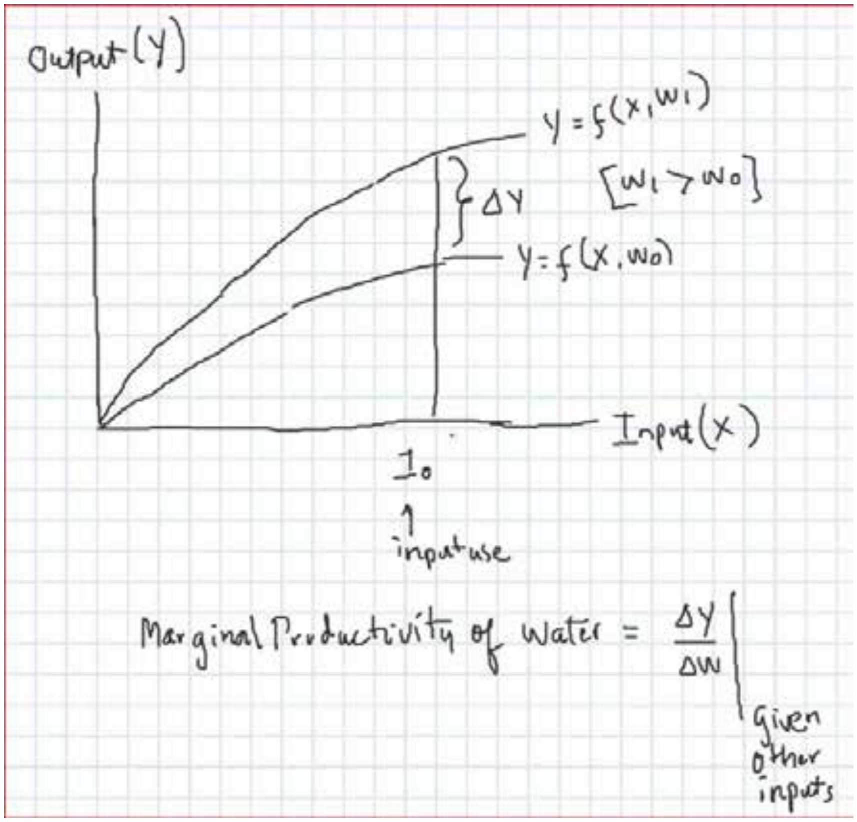
The next method for estimating the value of water is through a surrogate market approach whereby the value of water as a resource is embedded in a different market and economics use econometric concepts to decompose the value of water. This is known as the hedonic pricing method. Here economists use market data from land market, for example, and decompose the proportions of value that is created due to water bodies like lake or river or due availability of water for our use.

SLIDE 5:
HOW DO WE ESTIMATE THE VALUE OF WATER?



In this training we explain how to estimate the value of water used in a) agriculture, b) food and beverage industries, c) electricity production, d) urban water supply, e) the ready-made garment industries, f) the construction sector and g) non-use of water for managing a regulatory and supporting service of nature.

The following slide explains the production function method. A production function illustrates the most efficient input-output relationship between inputs and outputs. In the following diagram, X axis represents an input, Y-axis the output. Assuming a fixed volume of water, the relationship between input and output is illustrated by the convex lines. As water volume changes, the curve moves. Assuming that more water increases output, the curve will rotate up and it is shown in this diagram by Y = f(X, W1) where W1>W0. W's are the volume of water. For the same volume of X, with only a change in water volume, the output increases. This change which is only due to changes in the volume of water is known as the marginal product of water (in terms of its output) and multiplying this with the price of the product provides the value of marginal product for water. This value shows much the economy is going to gain by improving a unit of the supply of water in this production.

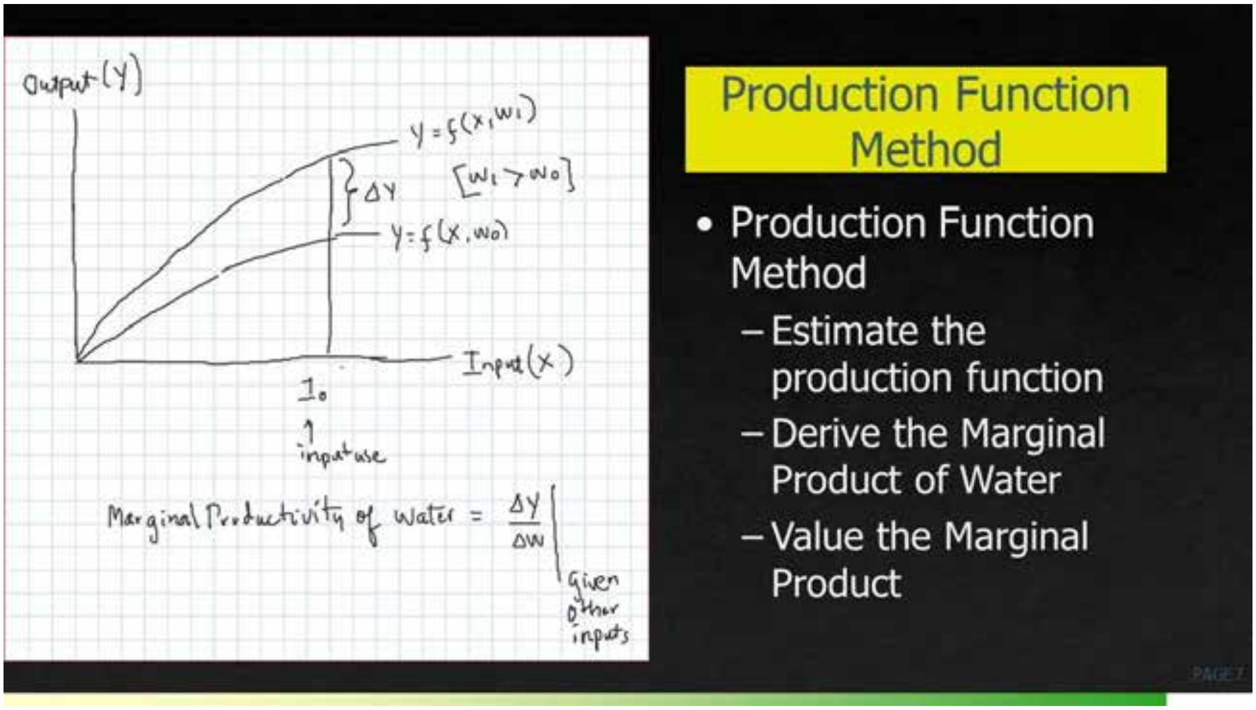


v

The process requires collecting a) field data from producers on output and all different input (in volumetric terms) and that of water; b) estimating the production function using econometric methods; and c) deriving the value of marginal product.

There is, however, a caveat. As we multiply the marginal product with the price of output, it should be clear that the output price is a fair market price – meaning – a competitive market price. Many of the output in this example, however, is not a competitive market price because of many different types of distortions. Hence there is need to use a conversion factor to convert the actual price of an output into an equivalent fair market price. Product markets are often distorted due to a) presence of imperfect market; and b) tax and subsidies on products and inputs.

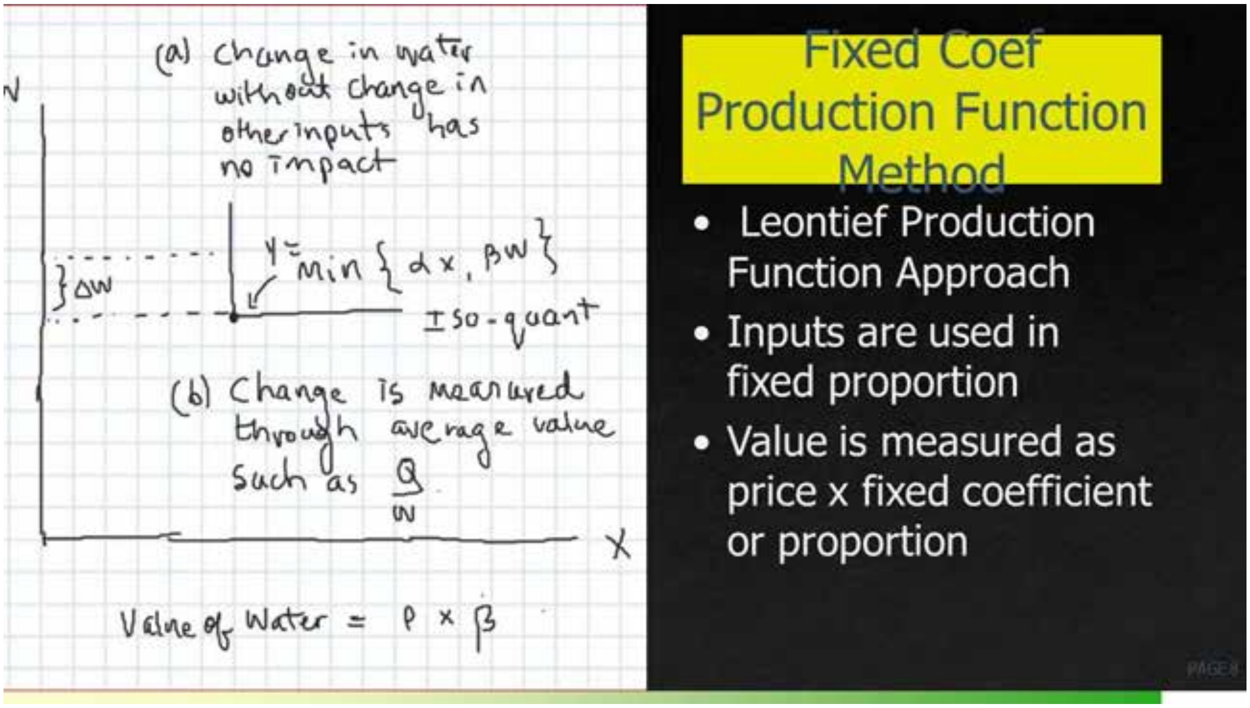
SLIDE 6:
PRODUCTION FUNCTION METHOD



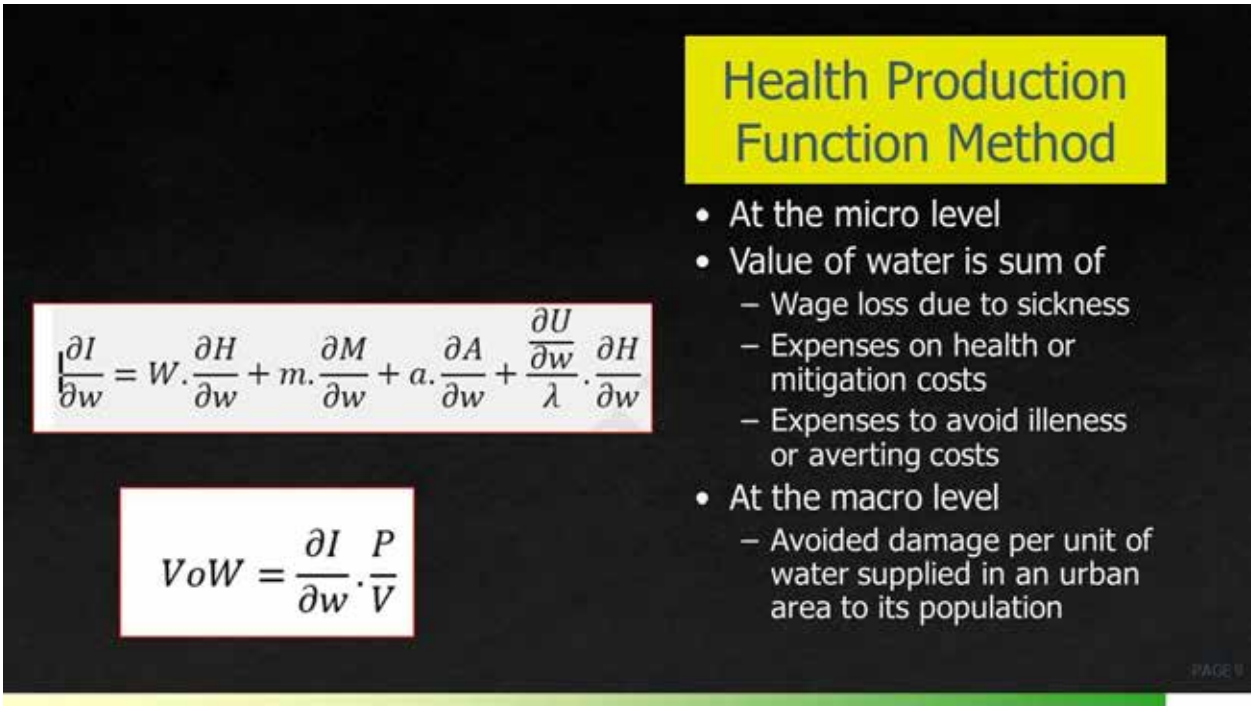
While production relations may not always follow a fixed input-output ratio, there are system of production processes where input-output ratios are fixed under certain conditions. Such a production function is known as the Fixed-Coefficient Production Function or the Leontief Production Function in Economics. For example, in producing a square foot of concrete the ratio of sand, cement and water may be fixed. There are many such processes. In this case, economist numerically estimate the relationship using a Leontief type production function. The fixed coefficient (β) is used to find the value production. This is shown in the following slide.

SLIDE 7:

FIXED PRODUCTION FUNCTION METHOD


(a) Change in water without change in other inputs has no impact
Y = min {αx, βw}
}ΔW
Iso-quant
(b) Change is measured through average value such as Q/W
X
Value of Water = P x β
Fixed Coef Production Function Method
• Leontief Production Function Approach
• Inputs are used in fixed proportion
• Value is measured as price x fixed coefficient or proportion

SLIDE 8:
HEALTH PRODCUTION FUNCTION METHOD

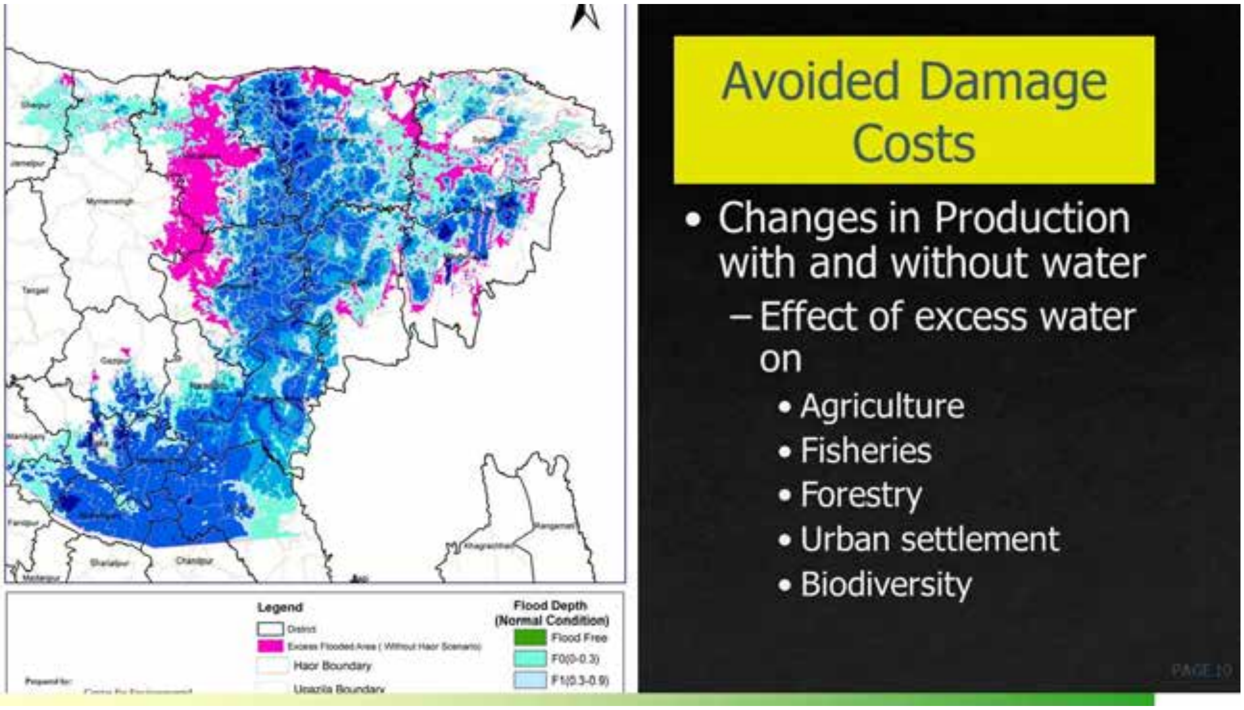


Estimating the value of water that protects human life is a bit tricky because the output is our health status which is difficult to quantity. Economists, therefore, use an indirect method to find the value water when it is used to maintain our health. In case of valuing water for urban water supply, the method is presented in Slide 9. Here the value is decomposed using the health production function approach into four parts. Part 1 – measures the loss in income due the non-availability of water and its consequence on human health in terms of increased incidences of several disease – a) kidney disease, b) skin disease and c) female hygiene related illness. It might be noted that some of the diseases are also due to changes in the quality of water. In this study, we ignore the quality aspect of water.

Part 2 – measures the expenditure a household make to ensure availability of water at ease. This is known as averting behavior meaning how much value a household is willing to spend to ensure that they are not affected by these diseaseS; Part 3 – measures the cost of treatment in case of illness that includes medical costs, hospital costs; doctor's fee and others. Finally, Part 4 is the psychological cost due to illness. Economists are yet to find a reasonable method to estimate such costs.

Therefore, the health cost approach often estimates the first three different costs of water scarcity. Using household level expenditure data on a) illness and loss of working days, b) averting behavior and their costs; c) mitigating costs, economists estimate such costs. This is used to derive the marginal value of water use for urban use.

SLIDE 9:
AVOIDED DAMAGE COSTS

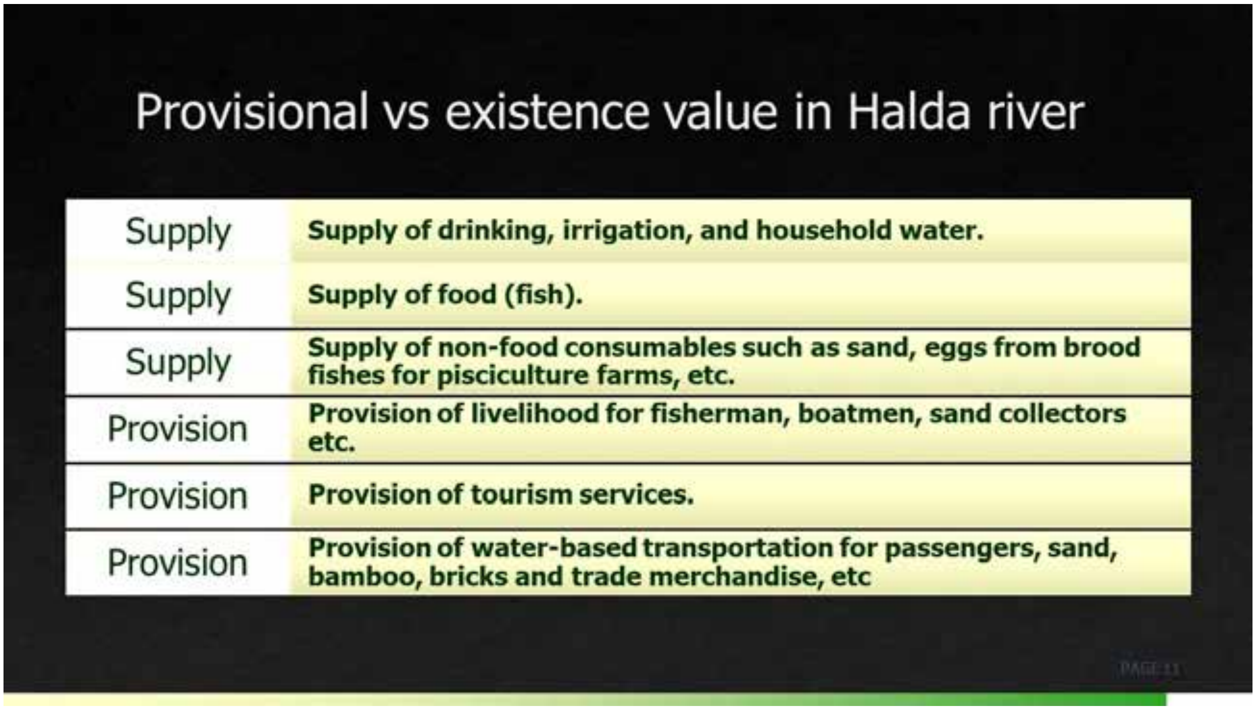


Of the ecological services two important value of water flows are a) flood regulating values of water – as water pours in due to upstream rainfall, it creates flooding in the riparian flood plains causing destruction in the crop production. In Bangladesh, the Haor systems provide a unique service and the gush of water are received in the Haors for a period of time (a natural refuge for incoming water) and let the downstream farmers harvest their crops. However, it has a cost. Farmers using the flood plains within the haor take the hit and their may lose their crops if water flow is untimely for them. There is strong demand from haor people to create temporary structures to protect their crop land until the harvest. This means, haors are will not retain the incoming flood water and so it will create flooding in the surrounding areas adjacent the to haors. Consequently, it appears that there are benefits and costs on both sides. If the value of economic loss to the haor people is higher than building a structure to protect cropland inside haors might be of value. On the other hand, it losses to the farmers outside the haors are bigger than the construction is not worth and in that case it is possible to develop a strategy under which farmers inside the haor may receive a compensation for losses and it is known as 'payment for ecosystem services'.

Valuation is tricky as it is not possible to stop intrusion of water inside the haor and so a simulated scenario was developed using GIS 3D models to find the impact of removing the haor and measure the extent of flooding. The loss due to additional flooding for various land use categories are estimated using national statistics.

The simulation shows that adjacent area currently used for agriculture, forest, fisheries, human settlement and biodiversity in the area will be affected. The values are estimated using national statistics except for estimating the loss of biodiversity which is derived from a meta-analysis.

SLIDE 10:
PROVISIONAL VS EXISTENCE VALUE



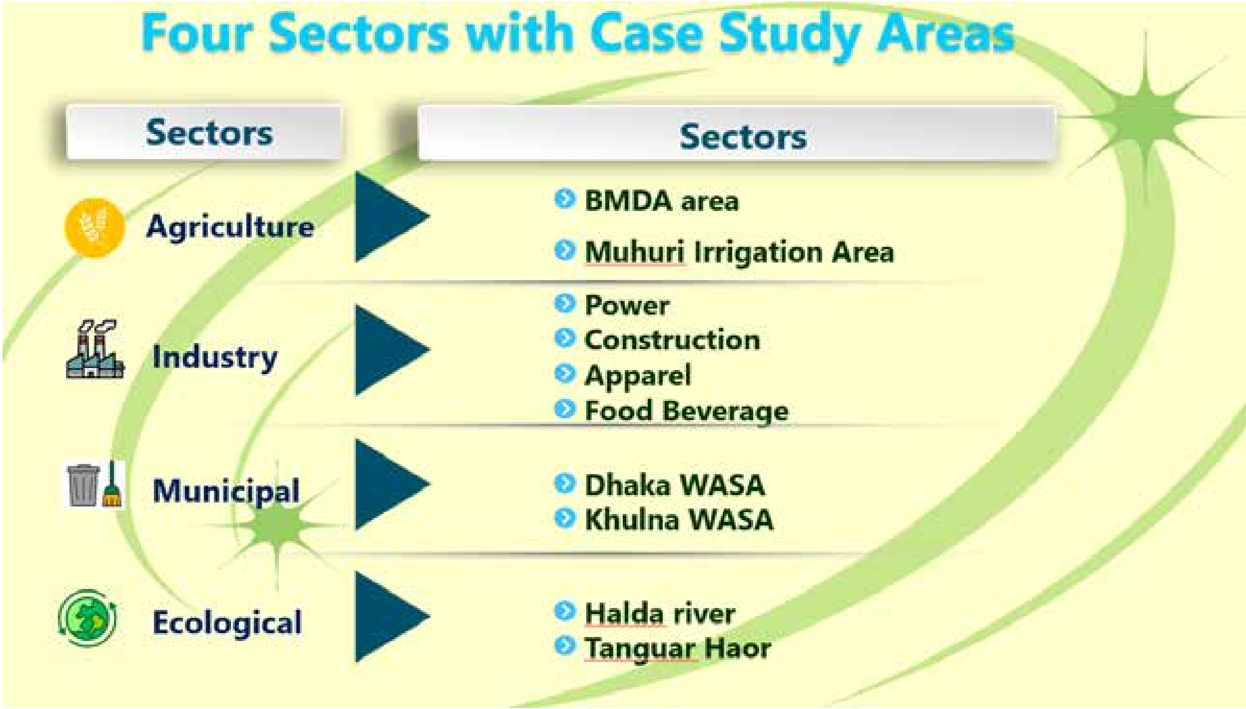
One of the unique services of a flowing river is its supporting services in terms of providing the spawning ground. The Halda river in Chattogram is a unique river which is the spawning ground for Indian carp fishes. The uniqueness lies in the fact that the spawning services is linked to an age-old cultural practice where fishermen collect eggs and hatch them in nearby shores.

Review of literature on this, suggest that the river has many other provisioning services and a few of them are in conflict with the spawning service of the river. Research reports published in journals further suggests that the value of spawning services was very small compared to other services.

We also observed that this service falls more into the non-use value of services because the government has recently declared the site as a heritage site. Hence, we propose that such studies shall be done using the 'contingency valuation' method and for this a nation-wide survey is required. This was not part of plan under this study. However, we reviewed the existing data and understood that estimating the provisioning value of this river water will not be a good tool for decision making.

SLIDE 11:
ESTIMATION OF SHADOW PRICES

Under this study, value of water in four sector and 7 sub-sectors were estimated using different methods explained above. For a detailed understanding of the analysis please refer to the final report.



Case Studies

In this training we explain the case studies used to find the value of water from four sectors of Bangladesh economy: a) Agriculture, b) Industry, c) Municipal Water, and d) ecological use of water. The principal reason for such a study is that water is either free for use or charged at a much lower price that its actual use value to the users. The objective is to understand how much value the users derive from use of water in these sectors.

There are several subsectors where the study has taken examples. In the agriculture sectors, studies were done in

a) The Barind Multi-purpose Development project which is a water scarce area and farmers are provided with irrigation water using a volumetric price scheme. The water is withdrawn mostly from ground water sources.

b) The Muhuri Irrigation project which is a coastal area and surface water is provided to farmers using canals.

In the Industry sector, there are three subsectors where value of water is estimated. These are

a) Power sector – where the power authority draws surface water for both cooling and steaming for electricity generation

b) Ready-made-garment sector – where RMG industries use water for washing and dyeing purposes.

c) Food and Beverage sector – where the food and beverage industries use water for processing food and drinks.

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, cost of water	Primary (field survey) data on boro crops from Northwest and Southeast regions.
Industrial Use – Construction, Power , Apparel Sector, Food and Beverage Sector	Provisioning service of water	Fixed proportion production function method or Input-Output Method	Volume of water use from selected producers, unit cost of production, unit price of output	Key informant interviews from selected producers

In the municipal water use, the value water is estimated for Dhaka (a major metropolitan city) and Khulna (a coastal metropolitan city) dwellers for providing them with supply water at home.

Sectors	Type of Services and Value	Valuation Method	Data need/requirement	Data source
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

Finally, the ecological value of water is estimate for two cases. These are:

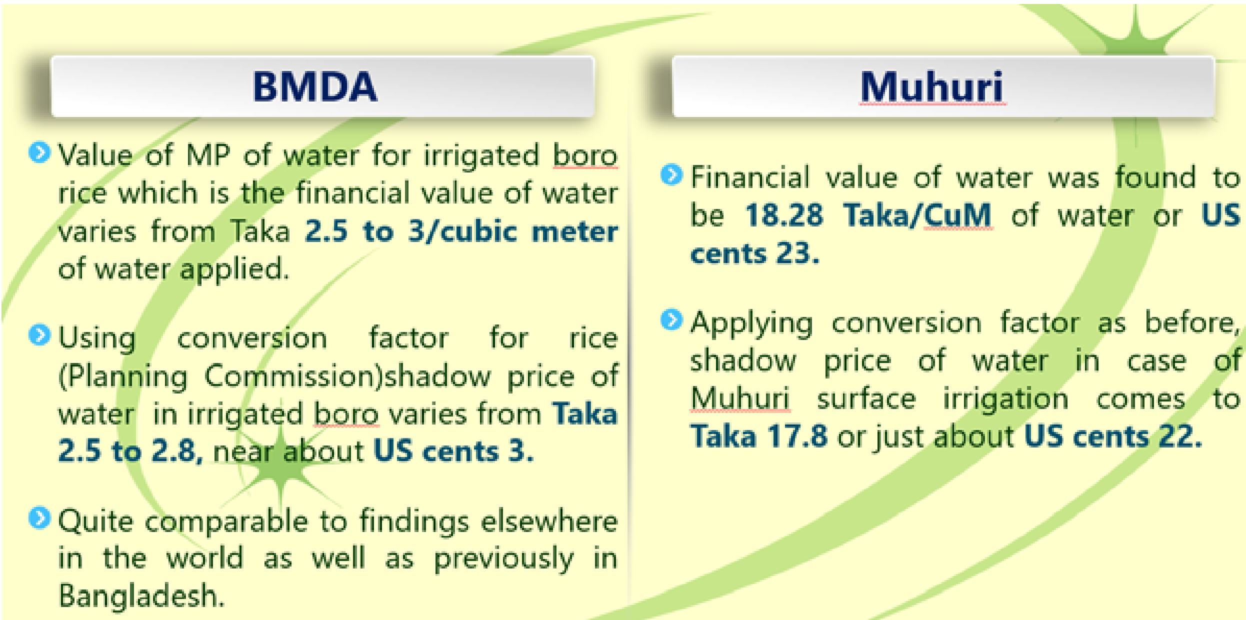
a) Benefit of retention of early monsoon water at the haor system in Sylhet-Sunamgonj districts (north east of Bangladesh)

b) Benefit of water in the Halda river for a special spawning service for various Indian carp fishes.

Sectors	Type of Services and Value	Valuation Method	Data need/requirement	Data source
Ecological Service of Water – Flood Control function of Tanguar haor	Regulatory service of water	Output Change Approach	Extent of inundation with and without haor ecosystem services, agricultural production and cost data	Simulate using GIS models at CEGIS, secondary data from agricultural and other data from BBS
Ecological Service of Water – Spawning ground for fishes in Halda River	Supporting service of water/ Habitat service of a river	Replacement Cost Approach or Productivity Change Approach		

Value of water for irrigation in agriculture

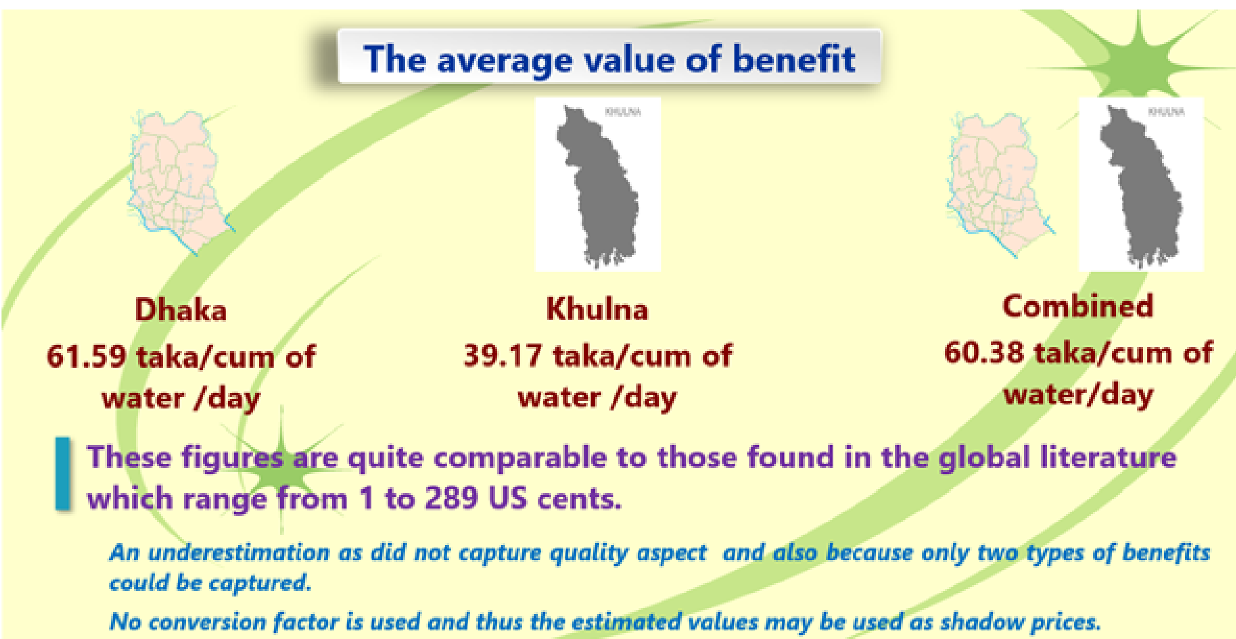
Estimated of Shadow Prices of Water for Irrigation Water



- For detailed analysis please refer to the full report.

Value of water in municipalities (volume of water supply)

Estimated of Shadow Price for Municipal Water Use



- For detailed analysis please refer to the full report.

Value of water in the construction sector

Sector	Result
Construction	• Water usage was found to be 4.30 m^3/ sq meter on average with a range from 1.49 to 6.81 m^3/ sq meter. This is at least 40% higher, if not more than in other countries • Using average output per unit of water (i.e., space constructed) which is same as MP, and the price of space • following financial values were obtained (all in Tk) 396.66, 324.41, 105.78 and 86.51 or an average of just about 225. • Using a conversion factor of 0.75 (based on Planning Commission guideline), the shadow price of water in construction 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.

- For detailed analysis please refer to the Full report

Value of water in power plants under industry sector

Sector	Result
Power	• Water use was 1.15 cum/Mwh • Given MP of water, value of water varied from Taka 500/cum - Taka 1500/cum • No conversion factor for electricity is known • However, given that gas is subsidized for power production and also power sold at subsidized price a conversion factor of 1.25 for electricity price has been assumed . • On that basis, the average shadow price of water may be Tk 600 per cum on average. The maximum may be Tk 1800/cum.

- For detailed analysis please see the Full report.

Value of water in the apparel industries for dyeing and washing

Sector	Result
Apparel	• Value of water (VoW) based on MP before conservation: Tk 71.16 • Value of water(VoW) after conservation: Tk 77.85 • As prices are export prices and likely fob, no conversion factor is used for shadow prices. • Above values, say around Tk 75 are therefore shadow prices of water in RMG industry

- For a detailed analysis please refer to the full report.

Value of water in the beverage industries

Sector	Result
Food & Beverage – Carbonated water and bottled water	• Value of marginal productivity of water at firm gate price comes to 13 to 15 taka/ cum. • No conversion factor was used as apparently no subsidized water was utilized in production; thus, at the prevailing exchange rate, the shadow price varies from US cents 16 to 18 or at most 20.

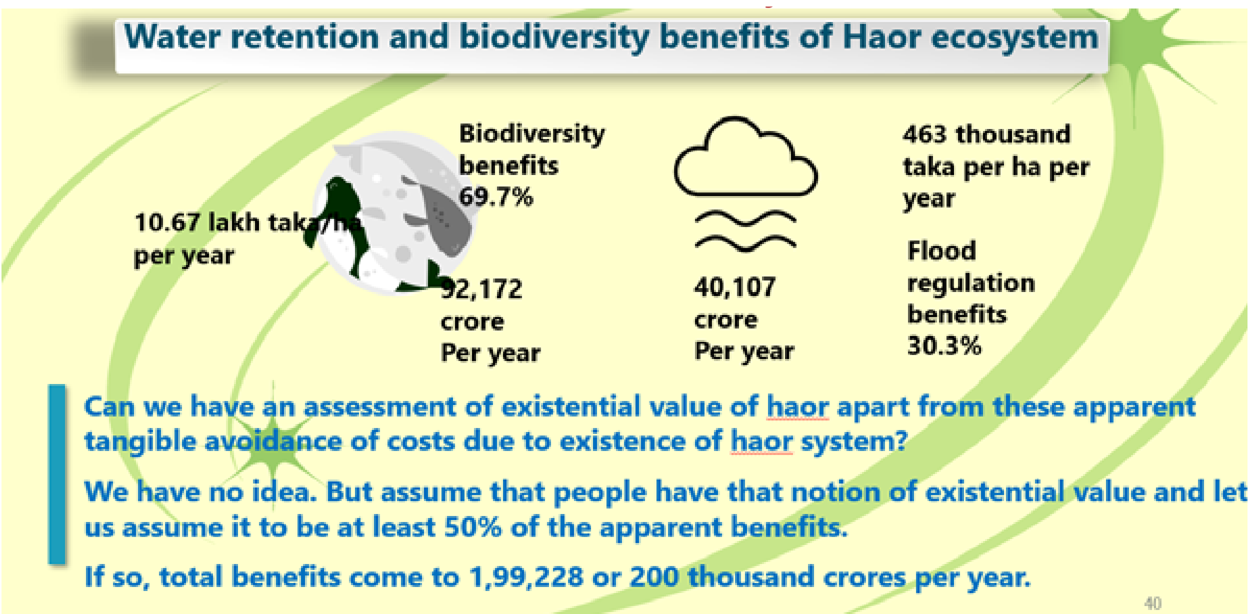
- For a detailed analysis please refer to the full report.

Value of water in the food processing industries

Sector	Result
Food & Beverage Noodles and similar food	• Value of Marginal Productivity of Water ranges ➢ for Noodles: 144/ 1cum of water ➢ for Cerelac-type 230 taka/1cum of water ➢ for both it is 187 taka/1cum water • No conversion factor available for such products, but as these are wheat based, used wheat conversion factor of 0.92 (PC) – shadow price for ➢ Cerelac-type: Tk 212/cum of water ➢ Noodles: Tk 132/ cu m of water – ➢ in US $ 2.58 and 1.61/cu m of water – combined shadow price is just above US$ 2

- For a detailed analysis please refer to the full report.

Value of water retention in the haor system



- For a detailed analysis please refer to the full report.

Summary of the Values

Sector	Sub Sector	Shadow price
Agriculture	BMDA	Taka 2.5 to 2.8, near about US cents 3.
	Muhuri	Taka 17.8
Industry	Construction	Tk 298 to Tk 65 with an average of Tk 169
	Food& Beverage	Carbonated and bottled Water: US cents 16 to 18 Cerelac: Tk 212/cum of water Noodles: Tk 132/ cu m of water
	Power	Tk 600 per cum on average
	Apparel	Tk 75
Municipal Water Use		• Dhaka: 61.59 taka/cum of water /day, • Khulna: 39.17 taka/cum of water /day • Combined: 60.38 taka/cum of water/day.
Ecosystem Services	Tanguar	Total benefits 200 thousand crores/yr
	Halda	

Data limitations

- Team worked under severe data limitations
- For part of agriculture, Muhuri, no volume of use of water available – had to estimate under stringent assumptions
- For industry, only a few data points available and also limited to only output and water use – restricted proper econometric estimation except for power
- For municipality, secondary data source did not include many information needed and had to make assumptions under stringent conditions
- For ecosystem, single haor estimation of ecosystem services not possible. Had to do for haor system as a whole – for Halda major question marks remain – in both cases existential value of the ecosystem could not be estimated due to sevre data limitations

7. Conclusion

Implications for policy decisions

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:

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

Given the above, the recommendations are as follows:

- During CBAs, value of water can be used to value a) saving of water due to an investment, b) destruction of water sources due to an investment, c) conservation of water bodies through an investment, and d) diversion of water due to or because of an investment.
- Do not get hastily into use of the presently estimated values as shadow prices because of the major limitations that these have.
- Need to take initiatives for a broader range study on valuation of water taking into consideration of the findings of the present study.
- 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 analyze under what conditions these may fail or pass the test to be used as a guideline for future actions

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.

- To be more specific, a proposal on the changes to the above specific sections could be proposed to NEC-ECNEC Wing. 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 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 quality", (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.

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

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.

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 related 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 methods 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 out-put. Construction is a point. Just to reiterate within 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, 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 tube wells mostly operated by themselves. In case of Chattogram, the proportion of DTW sourcing is even higher at 71%. Whether such withdrawal of water is under license remains an 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. More details study on shadow price and Mass sensitization on valuing water is imperative.

Conclusions

Concept of valuing water and developing Shadow prices of water are almost new in Bangladesh and very less knowledge is available. Thus capacity building through hands on training in valuing water and developing shadow prices are important to get brief idea about the topics. Participants from relevant ministries, departments, development partners, private sectors, NGOs, Civil Societies as well as academic institution were trained on the topics. A total of hundred Sixty (160) participants were trained on Valuing Water and Developing Shadow prices of Water in eight batch training consisting twenty participants in each batch. It is expected that the trainee further transmit their knowledge in their institution for broader dissemination. More over as the topic is important and vital for water sustainability, the valuing water and developing shadow prices of water may be included in the regular course curriculum of the national training institutes for ensuring sustainability of the issues.

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