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Implications of Dietary Change on the Next National Water Management Plan (NWMP) of Bangladesh

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Abstract

The first National Water Management Plan (NWMP), framed in 2001 for a 25-year period, is due to be terminated soon, necessitating the formulation of the next NWMP. Since 2001, significant changes in the socio-economic condition of Bangladesh have been reported, including shifting dietary patterns towards more animal-based proteins and less rice. This shift is raising concerns about livestock water footprint (WF), especially the country's water resource constraints during dry seasons and in certain water-scarce regions. This article has attempted to assess the effect of dietary change on future water stress in Bangladesh by employing the WF approach. Findings reveal that while rice consumption has decreased more than anticipated, there has been a rising intake of animal protein, which requires additional fresh water. This additional water demand to support this changed diet could exacerbate water scarcity, particularly in the dry season and northwest region of Bangladesh. As the first NWMP did not account for critical aspects like shifts in dietary patterns in the estimation of the nation's freshwater demand or scarcity, we suggest incorporating the impact of such diet changes in the next NWMP. Policy recommendations for the next NWMP, along with the incorporation of dietary changes into national policies, have been suggested, such as emphasizing fish over livestock for protein needs, reallocating and zoning agricultural practices,

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and prioritizing water-efficient agricultural production. The next NWMP should plan for a detailed analysis of stress on freshwater in each of the nation's hydrologic regions, incorporating existing and projected dietary patterns and socio-economic factors. Incorporating this aspect of diet change will enhance understanding of the nationwide demand for fresh water and ultimately lead towards improved and sustainable water resources management in future Bangladesh.

Keywords: dietary change; water footprint; water stress; national plan; policy

1.1 Introduction

Food security is inextricably linked to water resources due to the highest amount (which is 90%) of freshwater consumption in the agriculture sector (Carr et al., 2015; Hoekstra and Mekonnen, 2012; Oki and Kanae, 2006; Yang et al., 2003). Freshwater consumption for food production exceeds any other sector that consumes freshwater as a resource (Carr and D'Odorico, 2017; Falkenmark and Rockström, 2006).

However, water has become scarce in many parts of the world, negatively impacting food security (Jalava et al., 2014). For example, freshwater scarcity has been reported as a limiting factor for sufficient food production in a larger part of Asia and Africa (Fader et al., 2013; Kummu et al., 2014). Water is scarce due to both supply and demand-side changes (Gain et al., 2016). Water supply changes due to high variability in time and space (Postel et al., 1996). Temporal variation refers to 'too much' water during the wet season and 'too little' water during the dry season, while spatial variation indicates the uneven water distribution resulting from the land-use pattern and climate system (Oki and Kanae, 2006). Climate change is considered one of the main driving forces for supply-side changes in water resources, affecting both the temporal and spatial distribution (Gain and Wada, 2014). Due to climate change, it is expected that there will be wide variability in precipitation and the occurrence of droughts and floods (Coumou and Rahmstorf, 2012; Hertel et al., 2010; Pachauri et al., 2014). Besides supply-side changes, water demand changes due to multiple factors, including population growth, economic development, land use change, changes in food habits, and policy changes (Gain and Giupponi, 2015).

Among the demand-side changes, population growth is important. The world population is growing at a rate of 1.1% per year, yielding an additional 83 million people annually. The current world population is around 7.6 billion, which is expected to reach 8.6 billion in 2030, 9.8 billion in 2050, and 11.2 billion in 2100 (United Nations, 2017). Given

the population growth rate and supply-side changes in water resources, ensuring food security is one of the significant challenges for the future (Carr and D'Odorico, 2017; Sun et al., 2015). Factors like population growth, economic development, land-use change, and changes in international and national policies have major implications on changing water consumption (Sophocleous, 2004). Although scientific literature on multiple factors of supply and demand-side changes in water resources is available, the changes in food habits (more specifically, changes in diet) and their implication on water resources are less explored (Jalava et al., 2014).

Food habits or diet are recognized as an important factor for the sustainable use of natural resources and future food security (Falkenmark and Lannerstad, 2010; Foley et al., 2011; Jalava et al., 2014; Pimentel and Pimentel, 2003; Rockström et al., 2009). Several studies provide valuable evidence regarding the impact of diet change on freshwater resources. Aleksandrowicz et al. (2016), for example, found that a shift in the dietary pattern can reduce more than 70% of greenhouse gas emissions and 50% of water use. By employing an inter-regional input-output model of the world economy, Springer and Duchin (2014) showed that a combination of less resource-intensive diets and improved agricultural productivity could make sustainable use of freshwater resources. By analyzing the Water Footprint (WF) of 13 primary crop and animal products in China, Sun et al. (2015) concluded that adjustments to diet patterns (providing enough calories and nutrition) have significant effects on agricultural water usage and, eventually, the change in diet pattern can potentially alleviate stress on water resources. Liu and Savenije (2008) identified the impact of food consumption patterns on China's already stressed water resources. They reported that due to an increase in the consumption of animal products, the water requirement for food was reported to increase from 255 m3/cap/year in 1961 to 860 m3/cap/year in 2003. A study (Liu et al., 2023) reported that such dietary restructuring increases pressure on water resources. Some recent studies (Hossain, 2010; Mottaleb et al., 2018a; Mottaleb et al., 2018b) assessed the changing food consumption in Bangladesh due to changes in income and urbanization. A recent study (Jia et al., 2023) also investigated the drivers of food consumption patterns in Bangladesh. Mukherjee et al. (2011) assessed that due to a change in food consumption pattern, the total consumptive water use would increase by 33% and 57% in the years 2030 and 2050, respectively, with respect to 2001.

The shift in dietary practice and its impact on water resources is not well recognized in any policy or plan in Bangladesh. Bangladesh prepared a 25-year National Water Management Plan (NWMP) in 2001 (WARPO, 2001). As the next plan is due in 2025, preparatory work for that plan is expected to

start soon. This study aims to assess the impact of observed dietary change on future water stress and provide policy directions to achieve sustainable water resources management in Bangladesh. The results of this study aim to contribute to and support the formulation of the next NWMP.

1.2 Methods

The food we choose is determined by multiple factors such as biological (e.g., hunger, appetite, and taste), economic (e.g., cost, income, availability), physical (access, education, cooking skill, time), social (e.g., culture, family), psychological (e.g., mood, stress), and spiritual (e.g., beliefs) (Leng et al., 2017). In Bangladesh, the primary drivers of dietary changes are population growth, urbanization, and economic development (Waid et al., 2018). We analyze these three drivers' historical trends and future projections based on available data from the Bangladesh Bureau of Statistics (BBS), the World Bank, and the United Nations. Then, we assess the trend of agricultural production by using data from the BBS, Department of Livestock Services (DLS), Department of Fisheries (DOF), and the World Bank.

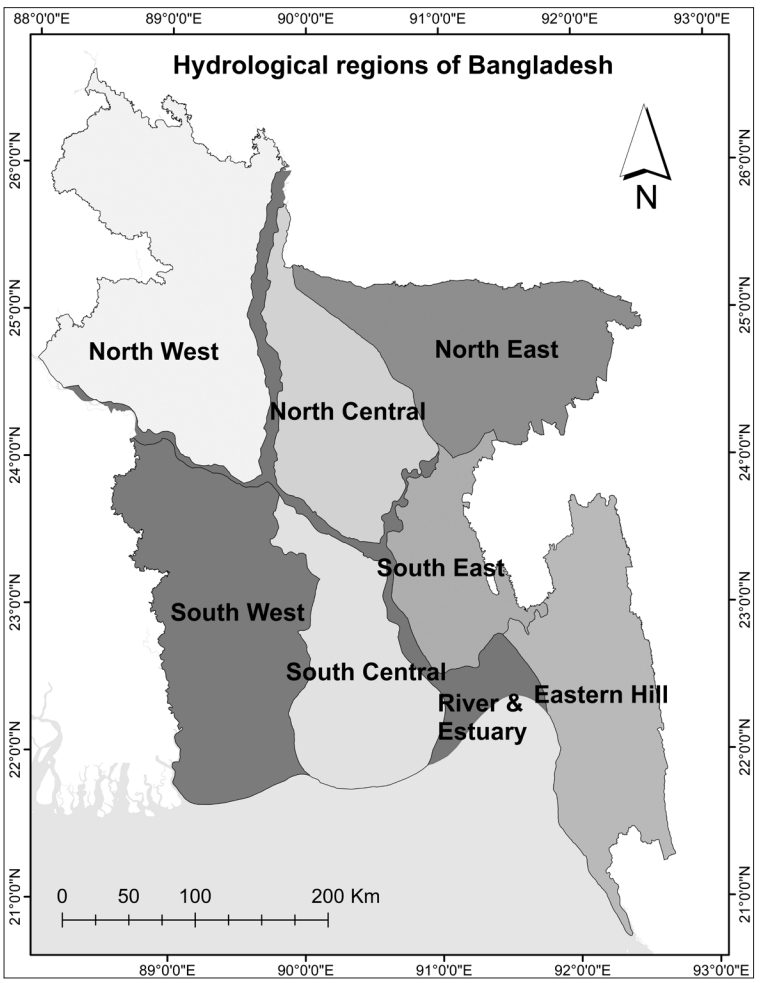
We assess the consumption pattern of major food items in Bangladesh using data from the BBS Household Income and Expenditure Survey (HIES) for the years 1995, 2000, 2005, 2010, 2016, and 2022. To evaluate the impact of dietary change on water stress, we assess the water footprint (Hoekstra and Mekonnen, 2012) for 2001 and 2025, the beginning and the end year of NWMP. The year 2025 is the last year of the current NWMP and, therefore, may be considered the base year for the next plan. We consider two main food items (i.e., rice and meat) for the analysis, as they have the primary water consumption. Based on the projected GDP of Bangladesh, the consumption and water footprint for two major food items (i.e., rice and meat) are projected for the year 2025.

As there is no direct measurement or reported water footprint for different food products in the context of Bangladesh, we adopted the water footprint for rice and meat from published and available national and global datasets. For rice, the water footprint of 3,404 m3/ton was used as per the most recent estimation for Bangladesh from a previous study (Mullick and Das, 2021). The water footprint of meat from beef cattle (15,400 m3/ton as a global average) is much larger than the footprints of meat from sheep (10,400 m3/ton), pig (6,000 m3/ton), goat (5,500 m3/ton) or chicken (4,300 m3/ton) (Chapagain and Hoekstra, 2011). In HIES 2022, per capita per day consumption for beef, mutton, and chicken/duck is 11.66, 1.28, and 26.17 gms, respectively. Thus, the consumption rate for beef,

mutton, and chicken is 29.8%, 3.3%, and 66.9% of total meat consumption. Therefore, WF for meat for Bangladesh can be assumed as (15,400 × 0.298) + (5,500 × 0.0128) + (4300 × 0.669) =7537 m3/ton by combining global and national datasets. Based on these WF and consumption patterns, the changed stress on future water resources management is assessed. The future policy directions are then suggested to ensure sustainable water resources management and the food-secured future of Bangladesh.

The NWMP delineated the country into eight hydrological regions: Northwest (NW), North Central (NC), Northeast (NE), Southeast (SE), South Central (SC), Southwest (SW), Eastern Hills (EH), plus the active floodplains and islands of the Main Rivers and Estuaries (RE) (See Figure 1.1).

Figure 1.1: Hydrological regions of Bangladesh



NWMP carried out water balance for these hydrological zones based on the demand and supply of water resources of each zone. The above-mentioned policy directions are discussed in the context of these hydrological regions.

1.3 Impact of dietary changes on water resources in Bangladesh

Population growth

The total population of Bangladesh was around 170 million in 2022, with an average annual population growth rate of 1.12% (BBS, 2023). There has been a decreasing trend in population growth, and the decreasing trend is expected to continue due to social awareness, economic improvements, and other interventions. The UN projection for the future population for the year 2025 will vary between 174 and 183 million (United Nations, 2017).

Urbanization

While experiencing a decreasing trend in population, Bangladesh has experienced a sharp rise in urbanization in the last few decades. Currently, the urban population is about one-third of the total population (BBS, 2023). According to the UN projection, by 2035-2040, the urban population of Bangladesh will exceed the rural population. This increase in the urban population has a direct implication for future food security and water resources management. NWMP (WARPO, 2001) reported that the urban population tends to consume varied diets, with consumption of 16-23% less rice and more non-food grain items than the rural population. The urban population tends to consume more processed food, livestock, and horticultural products.

Economic development

Bangladesh became a lower middle-income country in 2015. The country has experienced a remarkable improvement in its economy over the last few decades. The per capita income increased from 410 USD in 2001 to 2,688 USD in 2022 (World Bank, 2023). Economic improvements in the population have a direct influence on food consumption. NWMP (WARPO, 2001) reported that with increased income, consumers take more wheat (in the form of bread or noodles) and more livestock products, vegetable oils, and other higher–valued food items.

Agricultural production trend in Bangladesh

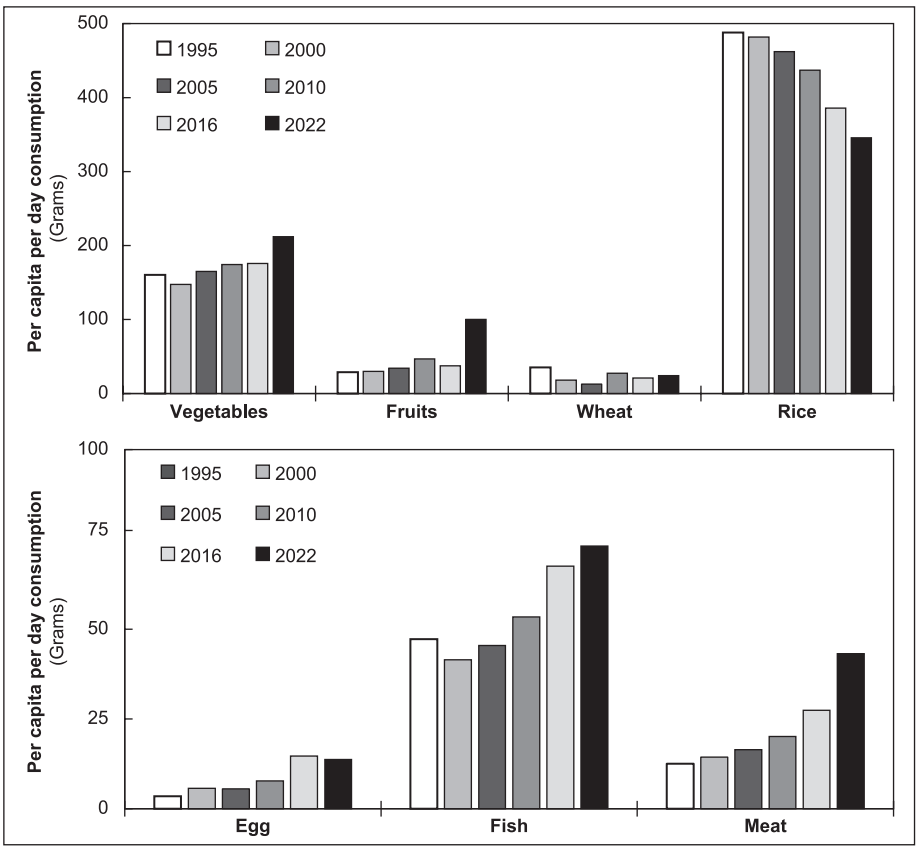
Bangladesh has experienced remarkable progress in the agriculture sector. Though the arable agricultural land is decreasing at an alarming rate of 1% (CSIRO, 2014; Quasem, 2011), the crop yield rate and total production show an increasing trend. There is a potential for further increase in crop yield in the future (CSIRO, 2014). In fishery production, Bangladesh ranked 3rd in inland open-water capture production and 5th in world aquaculture production (FAO, 2022). The fisheries sector contributes 2.41% of the national GDP and 21.52% of the agricultural GDP. During 2021-22, the total fish production increased by 55.4% compared to 2010-11 (MOFL, 2023). Moreover, during 2022-23, meat, milk, and egg production increased by 92.7%, 131%, and 130% compared to 2013-14, and the livestock sector solely contributed to 16.5% of the agricultural GDP (MOFL, 2017; MOFL, 2023). This changed scenario has important implications as the agriculture sector is the principal water user of the country and accounts for 88% of total water use (Rahman and Mondal, 2015). Annual water uses for irrigation vary from 25 to 33 km3, of which 80% is based on groundwater.

Change in food habits in the last few decades in Bangladesh

Due to the population increase, urbanization, and economic improvements, the food habits of the people of Bangladesh have changed dramatically over the last few years. Growth in the country's GDP, more specifically, the increase in household income, has changed the pattern of food intake of the inhabitants of Bangladesh.

The consumption of major food items and protein items is shown in Figure 1.2, which denotes that there is a significant amount of change in food habits in Bangladesh. People are consuming more protein-based food compared to staple foods like rice. Per capita, per day meat consumption has increased from 11.6 gm to 40.0 gm from 1995 to 2022. In contrast, rice consumption (per capita per day) has decreased from 464.3 gm to 328.9 gm from 1995 to 2022.

Figure 1.2: Consumption of major food (top), protein (bottom) items in the last two decades in Bangladesh (Data source: BBS 2023, 2011; WARPO 2000)



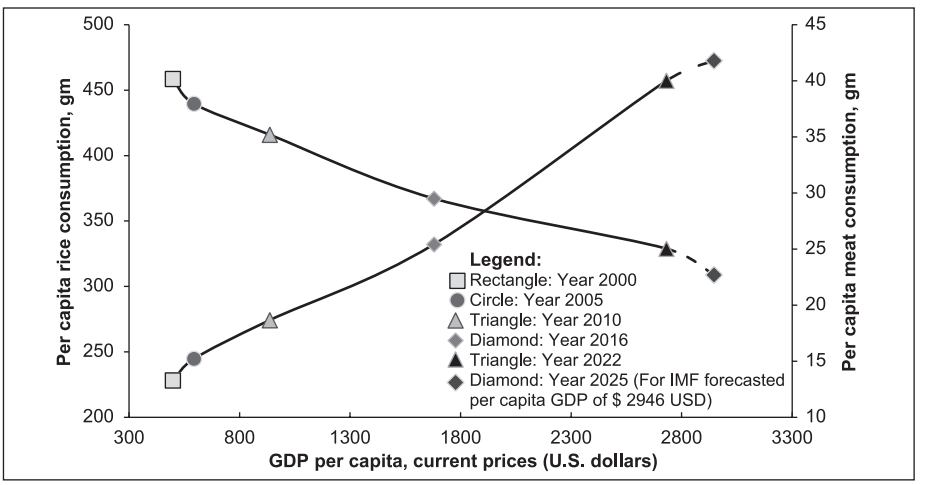
Impact of change in food habits on future water resources

Future population projection, urbanization trend, and economic advancement clearly depict that the ongoing shift in dietary intake will be more pronounced in the near future. Though the NWMP (WARPO, 2001) reported that wheat demand would definitely increase in the future, it stated that there is uncertainty regarding the reduction of rice demand due to the rise in income. However, the recent consumption pattern undoubtedly indicates that rice consumption is decreasing and will follow this trend in the near future. Consumption of animal protein items, such as meat, fish, and eggs, is increasing. This changing dietary pattern has direct implications on water resources management in Bangladesh, where freshwater resources are already reported to be under stress. Such an increase in animal protein consumption trends may put more pressure on water resources. The reason behind this

excess stress on freshwater resources is that one calorie of meat-based food requires 4-10 times more water compared to one calorie of vegetable food (Carr and D'Odorico, 2017; Falkenmark and Rockström, 2004). The global study has reported increased pressure on freshwater resources in the future due to increasing meat consumption. (Hoekstra and Mekonnen, 2012).

To assess the stress on water resources, the consumption rate of two major food items, rice and meat, was calculated for the year 2025. This was done based on the consumption rate over the last few decades and corresponding per capita GDP, as the dietary pattern is largely influenced by the household income. As per the International Monetary Fund (IMF) projection, the per capita GDP for Bangladesh will be around 2,946 USD in 2025. Based on this projection, the projected rice and meat consumption will be about 309 gm/capita/day and 42 gm/capita/day, respectively.

Figure 1.3: GDP and consumption of rice and meat trend in Bangladesh



Considering the projected population of 181 million in 2025, total rice and meat consumption for the year 2025 will be around 20.41 Million Tons (MT) and 2.761 MT, respectively. As per HIES data, rice and meat consumption in 2000 were 458 gm/capita/day and 13.3 gm/capita/day, respectively. For a population of 129 million, the total rice and meat consumption was around 21.73 MT and 0.63 MT, respectively. During the NWMP period (2001-2025), the total consumption of rice will decrease by 1.32 MT, and meat consumption will increase by 2.13 MT. Using the water footprint value as described in the methodology, we calculated the water footprint (WF) for rice and meat in Bangladesh. The change in WF for rice and meat consumption between the years 2001 and 2025 is shown in Table 1.1.

Table 1.1: Change in WF due to change in consumption of two food items between 2001 and 2025

	Total Demand in 2001 (Million Tons)	Total Demand in 2025 (Million Tons)	Per unit water footprint (WF) (m3 water per Ton)	WF in 2001 (× 108m3)	WF in 2025 (× 108m3)	Change in WF between 2001 and 2025 (× 108 m3)
Rice	21.73	20.41	3404	739.5	694.4	45.1
Meat	0.63	2.76	7537	47.3	208.1	-160.7

Note: Here, a positive change in WF value means the water-saving condition in 2025 compared to 2001 and vice versa.

From Table 1.1, it appears that around 45.1 × 10^8 m^3 of water will be saved due to decreased rice consumption, and 161 × 108 m3 of water will be required in excess due to increased meat consumption during 2025 compared to the year 2001. Thus, in this 25-year period, the extra stress on freshwater resources can be as high as 116 × 108 m3 due to the diet change of those two food items.

Based on water demand and supply for A1B and A2 climate scenarios in the Brahmaputra river basin, Gain and Wada (2014) found that during the dry season (November to May), water scarcity is expected to increase in the future years, although the country is one of the water abundant regions of the world. The analysis of Gain and Wada (2014) did not incorporate changes in food consumption patterns. Therefore, the HIES reported that the food consumption pattern would cause additional scarcity compared to the estimated one during dry periods for the Brahmaputra river basin. This remains true for estimated dry season water scarcity for other hydrological basins of Bangladesh and needs to be considered in future assessments.

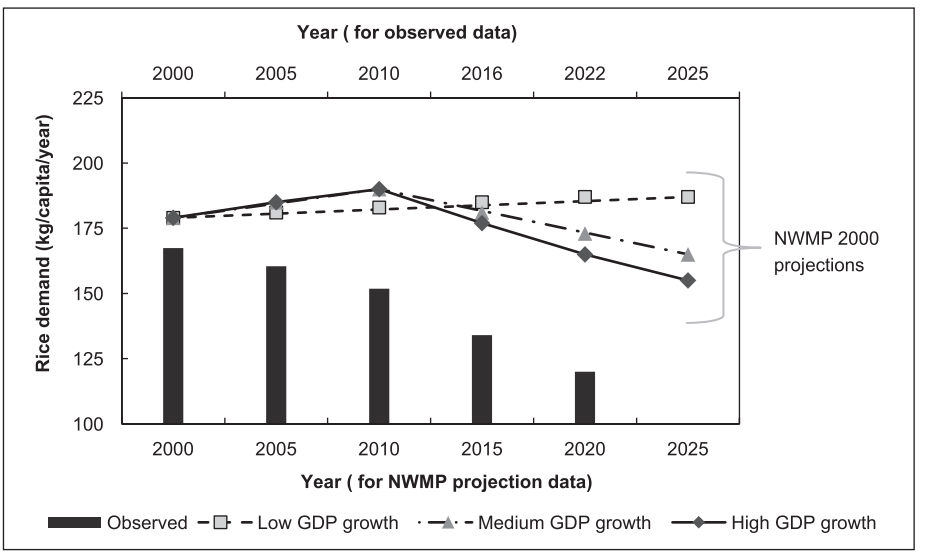
1.4 Policy implication

Incorporation of the impact of food habit change in national water resources planning

NWMP (WARPO, 2001) projected the per capita demand of rice up to the year 2025 for three scenarios of GDP growth, as shown in Figure 1.4. As per the projection, during the year 2025, the per capita rice consumption will vary between 155 and 187 kg per year. However,

the HIES 2022 data reported that the per capita rice consumption had already fallen to 120 kg per year. With the growing economy, the shift towards more protein-based dietary consumption reduces pressure on staple food items such as rice. This dietary change is expected to accelerate in the future and needs to be more accurately addressed in the next NWMP.

Figure 1.4: Observed and NWMP projection regarding per capita annual rice demand



Shifting of agricultural practices (Paddy) from stressed freshwater regions

Dry-season Boro rice cultivation comprises 90% of the total irrigation demand, while dry-season crop cultivation and supplementary wet-season irrigation constitute the rest of the demands (CSIRO, 2014). A study (Kirby et al., 2013) has reported that groundwater-fed irrigation is around 40% in the SW region and nearly 100% in the NW region of Bangladesh. Thus, overexploitation of groundwater (GW) resources is reported in NW Bangladesh (CSIRO, 2014). To preserve the already stressed surface water system, the cropping pattern can be changed. Moreover, the Government has specific plans to reduce the area of Boro in the NW and increase it in the SW and SC regions. Furthermore, there is a plan to increase the wheat cultivation area in the NW (CSIRO, 2014). Implementing such actions can restore the deteriorated GW systems of NW Bangladesh and provide sustainable agricultural water use in Bangladesh.

Prioritizing agricultural production practices based on future demand

Though several past studies (Huang and David, 1993; Ganesh et al., 2012) reported a positive income elasticity for rice in Bangladesh, Mottaleb et al. (2018a) econometrically demonstrated that households are consuming more wheat and less rice with increasing income and urbanization. Our assessment shows the same trend of decreasing rice consumption practices. Bangladesh is now self-sufficient in rice production to meet its local demand, but around 70% of the wheat is imported. As economic improvement and urbanization will be more in the future, wheat cultivation and extension should be prioritized at the policy level, thus creating opportunities to reduce pressure on the water resources system. Otherwise, importing an increasing amount of wheat in future years may not be a sustainable solution to ensuring food security in Bangladesh, which is already evident during the recent global food grain crisis and the consequent pressure on the country's foreign currency reserve. Similarly, there should be a specific plan to enhance the cultivation of other food grains and protein-based food items, as consumption will increase in the future.

Livestock farming in agricultural water surplus regions

For the water resources planning during 2001-2025, the NWMP considered the demand for rice but not the demand for meat, a major water-consuming food item. For the updating of NWMP by 2025, it needs to focus on livestock production and fulfilling the water requirement for livestock production.

NWMP assessed the water availability for different regions of Bangladesh. Regions like SW, NC, SE, and Eastern hilly regions are reported to be water-deficient during the dry season. Regions like SC, NW, and NE were reported to have surplus water during the dry season. However, regions like NW are mostly GW-dependent, and the augmentation of livestock farming is not advised in this region. On the other hand, regions like NE are abundant with freshwater and have vast barren land where agricultural practices like rice and wheat cultivation are not that popular. During the dry season, vast agrarian land remains barren in this region. Despite this, only 9.3% of the total livestock and poultry production takes place in Haor areas (BARC, 2023). The Master Plan of Haor Areas (BHWDB, 2012) has identified that traditional livestock farming is in practice in the NE region, which is suffering from various problems. This master plan also illustrated that commercial livestock

farming had not been developed yet. As there is an increasing trend of consuming protein items, those barren lands can be utilized for large-scale livestock farming using modern scientific techniques to avoid loss due to infectious diseases or others. Moreover, such livestock farming may reconstruct the economy of this region, which is often reported as lagging behind the national development pace.

The water requirement for livestock development is always neglected in the livestock policy of the country, such as in MOFL (2007). The policy also did not mention the region-specific development plan for a sustainable outcome. All sectoral policies and plans need to duly consider the water and land required for sustainable development.

Promoting fish consumption and production

As a Bengali adage goes, Bangalis are mache-bhate bangali (a nation of fish and rice). The country is situated in a delta with large water bodies, including three of the world's largest rivers, namely the Ganges, Brahmaputra, and Meghna, and their floodplains. These water bodies support very high fish production along with many species. The country is self-sufficient in fish production, and 60% of the animal protein intake of its citizens is derived from fish (Planning Commission, 2015). It still has vast potential to increase fish production (WorldFish, 2020). Fish also have a negligible water footprint compared to livestock (Joyce et al., 2019). Moreover, water use for fish is mostly non-consumptive.

On the other hand, the sustainability of livestock production has been a significant concern due to its large water and carbon footprint (Smith, 1996). Various policy instruments are in place in many countries, discouraging the consumption and production of livestock (Mehrabi et al., 2020). Therefore, from a sustainability point of view, it may be beneficial for the country to focus on fish consumption and produc-tion instead of livestock to fulfill most of the animal protein needs of its people.

Required synergies with relevant national policies

In our country, food security has traditionally been synonymous with the security of rice, leading our policies to focus primarily on this staple. However, with rapid socio-economic development, food habits are changing quickly, and our national policies must evolve to reflect this shift. Future policies should aim towards establishing a balanced consumption and sustainable production of rice, fish, and meat.

The relevant policies that need to reflect such a changed narrative are National Food and Nutrition Security (NFNSP) (GoB, 2021), National Agriculture Policy (NAP) (GoB, 2018), National Fisheries Policy (NFP) (GoB, 1998), and National Livestock Development Policy (NLDP) (GoB, 2007). One of the objectives of the NFNSP is to ensure the availability of safe and nutritious food for healthy diets, and it recognizes that livestock and fisheries have multiple roles in food security. The updated versions of other policies must align with the objectives outlined in NFNSP and consider freshwater availability across different regions of Bangladesh. We suggest a few entry points here.

Overall, these policies must acknowledge and address the diverse water availability across the nation's regions. The Agriculture Policy addresses changing food habits and advocates the production of nutritious crops like vegetables, fruits, etc. One of the principal planning tools in this regard is crop zonation. The NAP recommends crop zonation based on soil characteristics; however, integrating water resources consideration in such zoning is equally important. Fisheries policy should emphasize capture fisheries rather than the current focus on aquaculture. The livestock policy should also adopt zonation and encourage free-ranging livestock development in haor areas and char lands to enable enhanced livestock production while considering sustainable use of the nation's water resources.

1.5 Conclusions

With the economic development of Bangladesh, a sharp shift in dietary patterns is being observed. The water footprint for livestock is thus becoming more important due to this dietary change. Though Bangladesh is now self-sufficient in rice production, the current dependency on protein-based food will push toward more animal-based protein production in the near future. However, the extent to which our existing strained freshwater resources will react to such a shift is relatively unknown at the policy level. In this study, we assess the impact of dietary changes on water resources in Bangladesh using a water footprint approach. We found that the consumption of rice decreased more than what NWMP projected, while the consumption of animal protein, which requires more water, is increasing. Due to changes in the dietary pattern, an extra amount of 11,600 million m3 of water may be needed annually by 2025. As the dry season is known for freshwater scarcity in Bangladesh, these dietary changes would cause additional water scarcity, especially in the northwest part of the country.

The issue of changing dietary patterns was not considered when the NWMP was formulated in 2001, although projections were made. In order to address the impact of dietary change, we provide the following policy recommendations for the next NWMP: incorporation of the effects of food habit change in national policies, shifting of agricultural practices from water-stressed regions, prioritizing agricultural production practices based on future demand, livestock farming in water surplus regions and putting more emphasis on fish production than on livestock production for fulfilling protein needs. We suggest incorporating these policy recommendations in the revised NWMP, which is expected to be updated in 2025. The impact of such a diet change must be immediately included in all agriculture and water resources-related policies and plans. Accounting for the effects of change in food habits will help to achieve a future sustainable water resources management plan in Bangladesh.

In this study, we have a few limitations. First, we consider only two main food items, i.e., rice and meat, while assessing dietary changes. For a comprehensive assessment, more food items need to be considered. A detailed assessment of the change in consumption patterns of all major food items is needed to quantify stress on freshwater resources more precisely in the next NWMP, and this can be assessed based on hydrologic regions, as dry season water stress varies across hydrologic regions of Bangladesh. Second, the water footprint assessment for rice and meat is based on global literature rather than Bangladesh-specific values. This implies that the projected water stress based on available studies might vary for Bangladesh. However, we believe this variation will be minor, and still, the projections on future water stress are highly useful for formulating the upcoming National Water Management Plan by 2025. Third, the projection of dietary change and future water stress is limited until 2025 in order to feed the next NWMP. More longer-term projections might be feasible for achieving Sustainable Development Goals and climate change adaptations. However, the calculated value for the long-term period can fluctuate highly due to uncertainty regarding the economy and technological advancement. Through consistent, plausible scenarios of the future economy and technological development, such long-term projections can be accomplished. Considering these limitations, further research is needed to develop sustainable water and agricultural management policies.

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