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WATER STRESS EFFECT ON THE FACTORS OF PRODUCTION OF IRRIGATED RICE IN NORTHWEST REGIONS OF BANGLADESH

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ABSTRACT

Like all animals, plant growth and productivity depend on water. Water plays an important role in plant vegetation as well as economic gain from the crop plant cultivation. An in-depth analysis is performed to see the impacts of water availability on functional factors of irrigated rice (*Boro*) production and productivity. Primary and secondary data were used to perform the qualitative and quantitative analysis. Primary data were collected from five districts of northwestern regions of Bangladesh considering the severity of groundwater scarcity. A total 643 samples were selected from irrigated rice (*Boro*) producer across the regions to analyze the water stress effect on factors of production and productivity. Severity of water stress has positive relationship with irrigation and pesticide cost, and negative relationship with lease value, labor and seed cost. Remaining two factors of production such as fertilizer and tillage cost shows a volatile indicator in water stressed condition. In the water stressed areas, though irrigation cost is higher, and farmers get lower yield from their land, but the net return is not much lower compared to less water stressed areas because of getting higher price of rice in the water stressed regions. The water stressed effect on irrigated rice production is significant which leads the policy maker to think of factors preventing farmers to adopt less water consuming crop varieties in the drought prone areas of Bangladesh and rice market to reach equilibrium price during the season.

Key words: Water scarcity, irrigated rice, irrigation, production factors, Bangladesh

I. INTRODUCTION

A country with a gross population of 167.47 Million (est.) in 2019, with an agrarian-based economy (BBS 2018), Bangladesh has achieved self-sufficiency in rice production since the year of 2008. Rice is not only the staple food, but also constitutes the major economic activity and a key source of employment and income for the rural population. United States Department of Agriculture (USDA)

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revealed Bangladesh's total rice area and production levels in 2019-20 (May-April) is projected to increase slightly to 11.8 million hectares and 35.3 million metric tons, respectively, assuming good weather and increased yield in 2019-20 market year. This output is higher than 2018-19's 34.9 million MT and the previous market year's (2017-18) 32.6 million MT, thereby largely making Bangladesh self-sufficient in its staple production (Ahmad, 2019). More food will be required in the future because of the increasing population. Decreasing resources (e.g. land, labor, soil health, and water), and increasing climate vulnerability (e.g., drought, salinity, flood, heat and cold) appeared as the great challenges to keep the pace of food production in the background of increasing population. Sufficient rice production is the key to ensure food security in Bangladesh. In fact, 'rice security' is synonymous to 'food security' in Bangladesh as in many other rice-growing countries (Kabir *et al*., 2016).

Like any other crop production system, rice production can be segmented as pre-plantation (input materials collection and preparation), cultivation (sowing, planting, irrigating, inter-culture activities) and post-harvesting stage (harvesting, threshing, winnowing, etc.). Although, Bangladesh is a land surrounded by rivers and most of the agricultural land is wetland; Irrigation is a major condition for dry season rice cultivation. In most of Asia, water is the single most important component for sustainable rice production, especially in the traditional rice growing areas of the region (Mansion, 1999). However, water scarcity in Bangladesh is a recent phenomenon resulted from the geographic condition, climate change, and socio-domestic status of the region (Habiba *et al.*, 2011). Moreover, high demand and insufficient availability of water for irrigation, intervention in trans boundary rivers, unreliable rainfall, and salinity intrusion in coastal rivers, particularly during the pre-monsoon (March to May), cause seasonal water scarcity (Shahid, 2011;Ahammed*et al.*, 2018). Reduced investments in irrigation infrastructure, increased competition for water and large water withdrawals from undergroundwater lower the sustainability of rice production. Despite the constraints of water scarcity, rice production must rise dramatically over the next generation to meet the food needs of Asia's poor. Producing more rice with less water is therefore a formidable challenge for the food, economic, social and water security of the region (Mansion, 1999).

In this region, rice is grown typically in fields where it remains flooded for 7-10 days prior to harvest. Continuous flooding helps in ensuring sufficient water and control weeds. Lowland rice is extremely sensitive to water shortage (below saturation) at the flowering stage. Drought at flowering results in yield loss from increased spikelet sterility, thus fewer grains. So, it requires a lot of water. On average, it takes 1,432 liters of water to produce 1 kg of rice in an irrigated lowland production system (Water management, 2019). It is estimated that there might be an increase in future potential irrigation amount required to satisfy crop evapotranspiration for *Boro* rice production (Acharjee*et al.*, 2017). The agriculture of Bangladesh is basically irrigation based agriculture, study showed that based on a multi-factorial water security very high (0.8–1) water scarcity threat over Bangladesh on a threat scale of 0 (no apparent threat) to 1 (extremely threatened) (Vörösmarty *et al*., 2010).

The geology of northwest Bangladesh does not support for large-scale exploitation of groundwater. Excessive groundwater exploration after the introduction of a groundwater-based irrigation project has caused the lowering of groundwater level in the region (Shwets *et al*., 1995). According to a report of 2005, Bangladesh Agricultural Development Corporation (BADC), the groundwater-based irrigation system in the area has reached a critical phase with croplands in many places going out of the reach of shallow-level aquifer due to fast depleting groundwater. Declination of groundwater level below the operating range of irrigation wells during peak irrigation period is a common problem in the region in the recent years and the situation is worsening gradually (Ahammed *et al.*, 2018). In northern part, if this continues, rice production will face a drastic consequence due to water availability in the future. A minor study related to water stress effect on factors of irrigated rice production was found. Therefore, the aim of this paper is to see the water stress effect on different factors of production as well as yield and return of irrigated rice (*Boro*).

II. MATERIALS AND METHODS

Study area and sampling technique

The study was conducted in five districts namely Rajshahi, Chapainawabganj, Bogura, Dinajpur and Nilphamari of northwestern region in Bangladesh (Figure 1). These five districts were classified into three water stressed areas named as highly water scarcity area (Rajshahi and Chapainawabganj where groundwater level goes 10m depth in winter season), medium water scarcity area (Bogura where groundwater goes 7 to 10m depth during winter season) and low water scarcity area (Dinajpur and Nilphamari where water level goes 5 to 6m depth in winter season. Rajshahi and Chapainawabganj is the Deep Tube-well (DTW) area where groundwater level is well below the suction limit of Shallow Tube-well (STW) and the water level get declined 10m in every winter season. Bogura is a STW region where during the peak month water level goes below the suction limit of the pump, so water is not available for irrigation. The other two districts, Dinajpur and Nilphamari are also STW area but groundwater level does not drop below the suction limit of the pump.

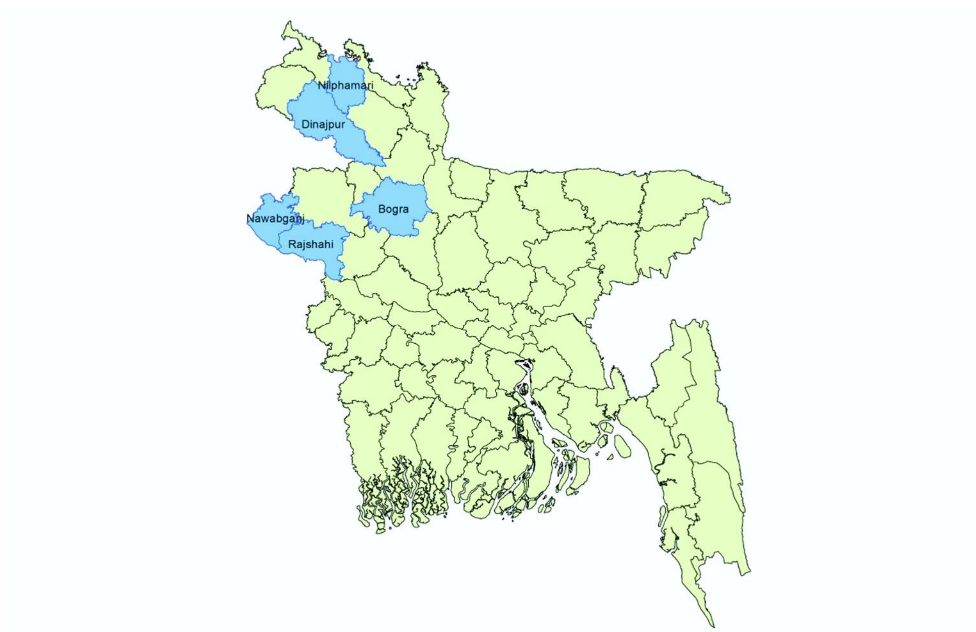


Figure 1: Selected areas of different water stressed level

A total of 132 active groundwater wells are considered for getting the actual picture of water level in the specified water scarce areas among which 48 well was in high water scarce areas, 27 well from medium and 57 well was from low water scarce areas. Groundwater depletion level data was obtained on monthly basis and as per requirement the *Boro* season (October to March) water depletion data are considered. For the cross-sectional survey, a total 643 samples were collected using purposive random sampling method from these three categorized districts of which 232 samples from high water scarcity area, 177 from medium water scarcity area and 234 samples from low water scarcity area. A cross sectional survey method was used using a standard questionnaire which were pre-tested before the final data collection. Finally, data were carefully scrutinized and entered in data analysis software.

Data analysis

The data were analyzed using Tukey-Kramer test for comparing pair wise differences of means. For unequal sample size, Tukey-Kramer test indicates if there exists a significant mean difference in comparable groups or not. The idea behind the Tukey HSD (Honest Significant Difference) test is to focus on the largest value of the difference between two group means. The relevant statistic is:

$$q = \frac{\bar{x}_{max} - \bar{x}_{min}}{s.e.} \quad where\ s.e. = \sqrt{MS_w / n}$$

and n = the size of each of the group samples. The statistic q has a distribution called the studentized range q. The statistic q is related to the usual t statistic by $q = \sqrt{2}t$. Thus, we can use the following t statistic(Zaiontz, 2019b):

$$t = \frac{\bar{x}_{max} - \bar{x}_{min}}{\sqrt{2MS_w / n}}$$

When sample sizes are unequal, the Tukey HSD test can be modified by replacing $\frac{2}{n}$ with $\frac{1}{n_i} + \frac{1}{n_j}$ in the above formulas. In particular, the standard error for the q statistic becomes

$$s.e. = \sqrt{\frac{MS_w}{2}\left(\frac{1}{n_i} + \frac{1}{n_j}\right)}$$

The Real Statistics Tukey HSD data analysis tool actually performs the Tukey-Kramer Test when the sample sizes are unequal (Zaiontz, 2019a). The economic productivity of water was calculated using the income (I, BDT) from crop yield and volume of water applied (measures in monetary value) (Materu*et al.*, 2018) as:

$$\text{Economic productivity of water} = \frac{\text{I}(BDT)}{\text{Water applied (BDT)}}$$

III. RESULTS

Groundwater availability in the study areas

Figure 2, 3 and 4 show the groundwater depletion rate in *Boro* season of low, medium and high water scarcity regions from the year 1985 to 2016. Month-wise groundwater depletion rate is different for three regions, low scarcity regions suffered more in the month of March although all six months in the *Boro* seasons groundwater table is decreasing over the year. Over the year, the groundwater table depletion rate is higher for medium water scarcity regions than that of low scarcity regions and the higher depletion was observed in the month of October and November.

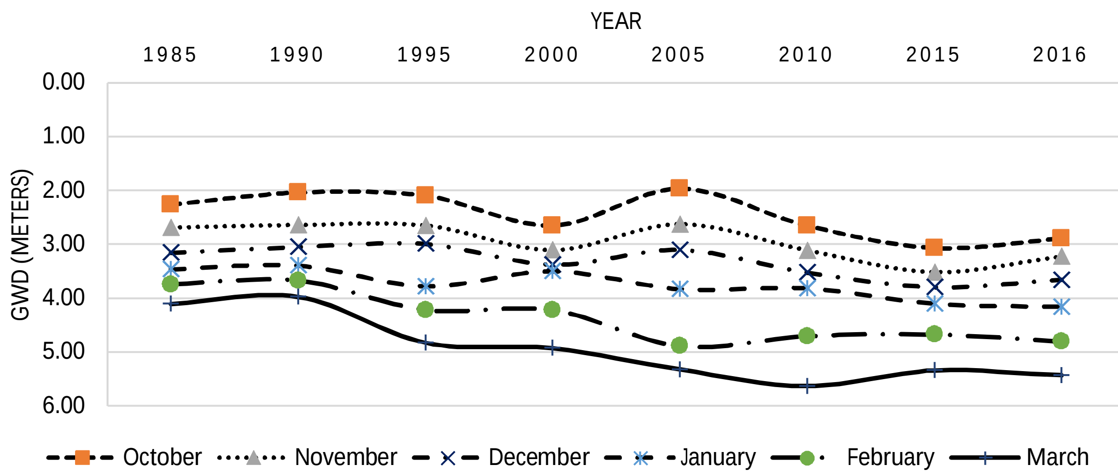


Figure 2: Low water scarce area groundwater depletion (GWD) in *Boro* season

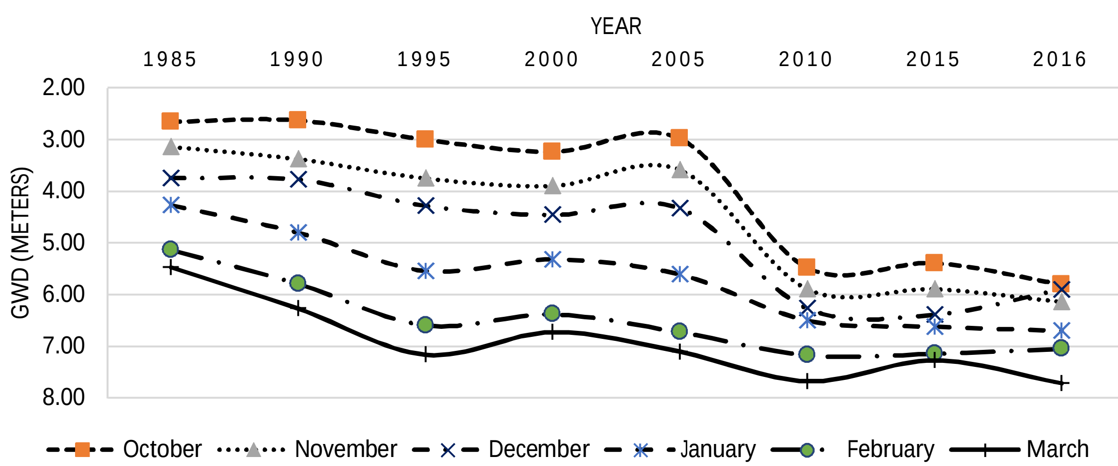


Figure 3: Medium water scarce area groundwater depletion (GWD) in *Boro* season

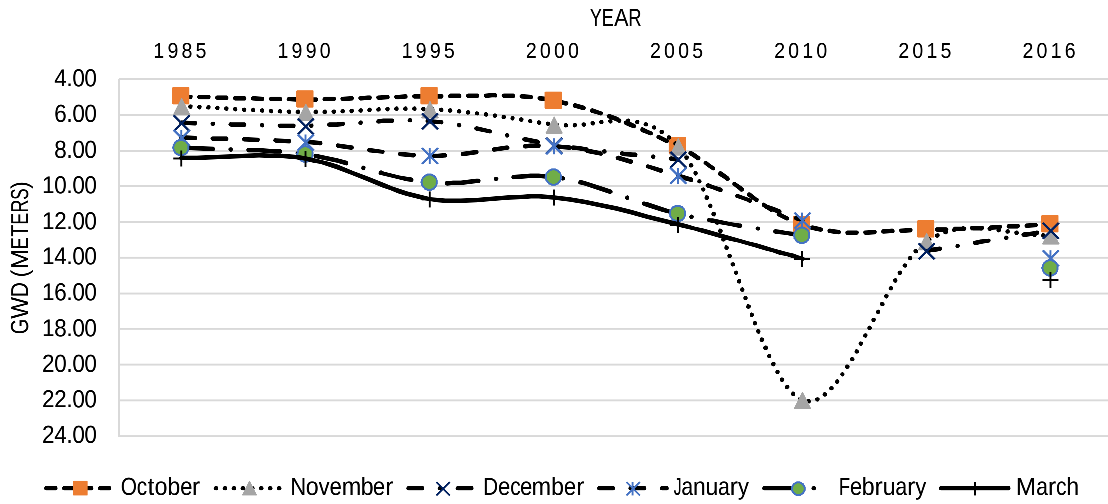


Figure 4: High water scarce area groundwater depletion (GWD) in *Boro* season

Figure 4 shows the groundwater depletion rate in high water scarcity regions (Rajshahi and Chapainawabganj). From the year 1985 to 1990, there was no groundwater depletion, but the situation had changed after 1995 where groundwater table started to go down in the month of January, February and March. The worst situation of water crisis had faced between the period of 2005 to 2015, afterward the water table became stable though it is below the suction limit of hand tube well during *Boro* seasons.

Water markets

In the study area, several water supply institutions are actively working for meeting the demand of water in *Boro* season. Barind Multipurpose Development Authority (BMDA), Bangladesh Agricultural Development Corporation (BADC) are working as government organizations. Rural Development Academy (RDA) acts as community service providing organization. Farmers usually purchase from institutions by considering the price of water per hectare/acre. In some cases, they consider the distance. Water service providers who are close to their field are chosen most of the time. If farmers take service from the individual owner, they need to pay lower amount of money in cash but in addition to the cash payment they must give rice to the owners of the water pump after harvest. Adding up both payment method by considering in monetary unit, this is the costliest payment structure of irrigation in *Boro* season.

The community service providers; in this case Rural Development Academy (RDA), Bogura is the sole organization who provides water supply to *Boro* rice field during the season at the lowest possible cost to the farmers. Bangladesh Agriculture Development Corporation (BADC); a government organization is just after them in case of price. From field survey calculation, it appeared that Barind Multipurpose Development Authority (BMDA) was the first to lead as water supply management organization in water stressed area of Bangladesh but in terms of pricing of water in

Boro season, they charge the highest of all the institutions except personal endeavor exist in water scarce area (Figure 5). This is leading to the situation where farmers are deviating more toward the individually owned water suppliers who charges a higher cost than community service providers and government organization. Rural Development Academy (RDA), a community service provider, has great water pricing to support farmers but they do not have sufficient technical support to provide water supply to all the *Boro* farmers during the season which is main constraint for farmers to get service from them. The same scenario is for BADC too. They are providing the service, but expansion of support areas is now crying need of farmers.

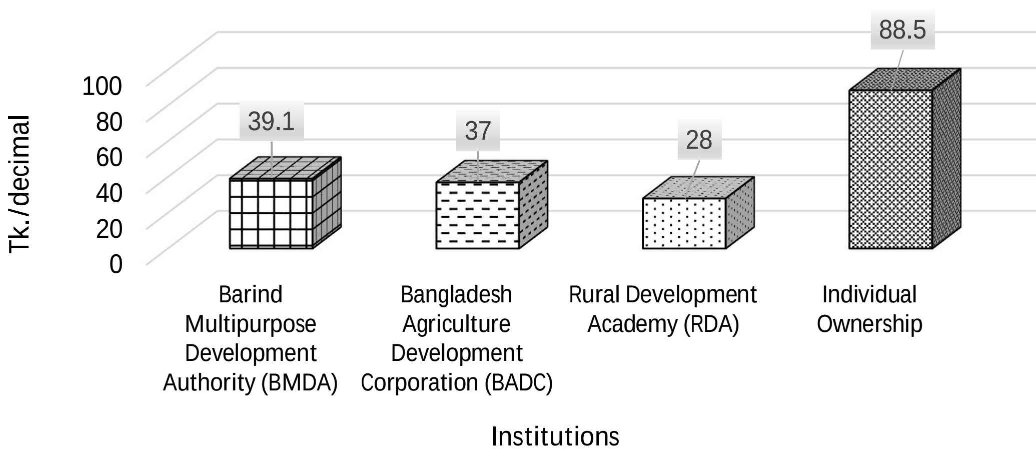


Figure 5: Irrigation cost of different institutions

The same average pricing of water supply (per decimal) is found in both high and low water scarce area. In low water scarce area, the community service providing institution is not present while they have active function both in medium and high-water scarcity areas, Rural Development Academy (RDA) acts as community service provider. Due to their involvement in water supply in these areas; specially in Bogura which is a medium water scarce area, the price of water is very low. BADC sets their water pricing through committee meeting arranged before the *Boro* season. BMDA always fixes price almost same (an average of Tk. 100 per hour while minimum is Tk. 80 and maximum is Tk. 120 per hour) irrespective of season. They are bit costly, and maintenance, technical operation is slower than other institutions. Generally, BADC and RDA only fix price of their water with land measure unit (decimal/acre) but other institutions (BMDA, individually owned) sell water per hour basis.

Water stress effect on the factors of irrigated rice production

The groundwater availability has significant influence over the production of *Boro* rice. Not only it just has impact on its productivity but also the cost associated with the production process is affected and it varies among different water scarcity level area. The costs incurred for rice production includes the cost of leasing land for production, tillage the land, purchasing seed of *Boro* rice, labor use, pesticide and fertilizer purchase and application, providing irrigation, etc. Figure 6 shows the water stress effect on the factors of irrigated rice (*Boro*) production. In areas where water scarcity is high (districts like Chapainawabganj, Rajshahi) the irrigation cost is very high, and the high price fixation is usual as groundwater level is lower than low and medium water scarcity areas. Beside this, in every other cost item in high water scarce area, the cost is either almost equal or higher than other comparable water scarce areas which clearly indicates a straight water stress effect on *Boro* rice production.

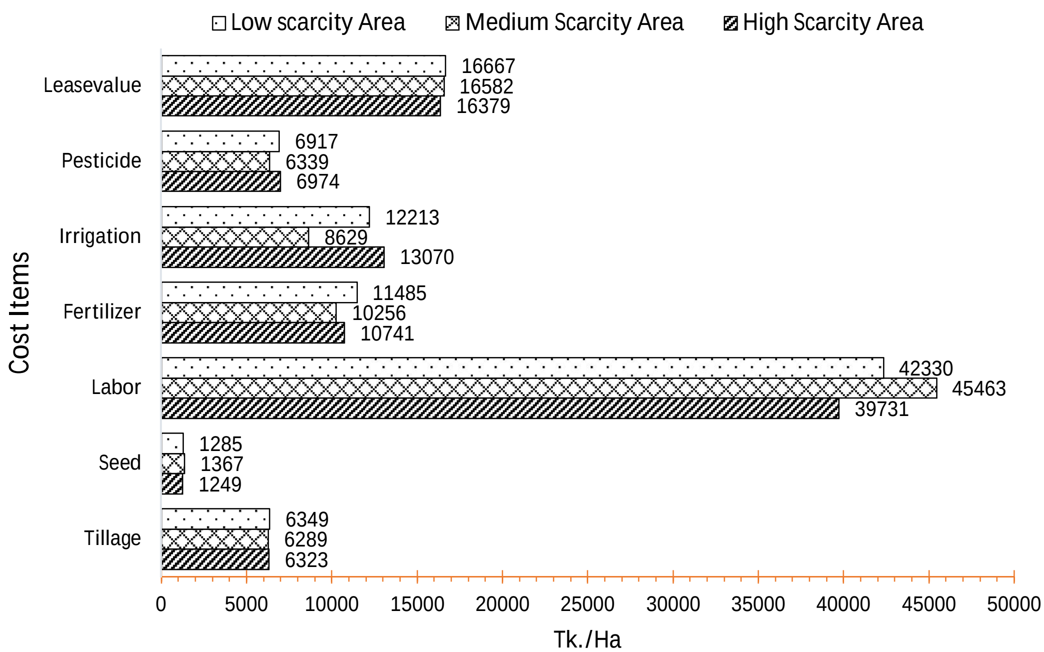


Figure 6: Cost variation in *Boro* rice production in different water stressed area

From this study it was found that, in low water stressed area the cost of tillage for producing *Boro* rice is the highest while in medium water scarce area, it requires minimum for a single hectare of *Boro* land. Although, this cost doesn't vary much due among the districts. Based on the seed used in land, the per hectare average cost of seed was calculated maximum in medium scarcity area while minimum in high water scarcity area, which is Tk. 1367 per hectare and Tk. 1249 per hectare respectively. The labor cost for irrigated rice (*Boro)* includes the cost for both the family labor and hired labor required throughout the season. The involvement of labor exists in the form of either hired or family work force, starting from the land preparation, seedling growing, weeding, fertilizer and manure use, irrigation, harvesting, threshing, winnowing, storing and ends at selling the harvested rice. Family member use cost was calculated as an opportunity cost considering ongoing hired labor cost. This leads to a rise in labor use cost. Likewise, the seed cost, in medium water scarcity area, the labor use cost is maximum and minimum for high water scarcity area while low water scarcity area indicates a medium cost of labor compared to other two areas. This scenario changed in case of fertilizer use cost. In low water scarcity area, this is maximum of average Tk. 11485 per hectare and in medium water scarcity area, this shows minimum cost of Tk. 10256 per hectare. Also, high scarcity area shows little higher fertilizer cost than medium scarcity area but less than low scarcity area which is on average of Tk. 10741 per hectare. Irrigation to the land is a significant cost item in the study areas. It is indicated that, areas where water is highly scarce, average cost is Tk. 13070 per hectare and this is maximum. On the other hand, the minimum irrigation cost is found in medium water scarcity area which is Tk. 8629 per hectare. Most important point here is, in low water scarce areas, the irrigation to land requires a bit higher cost compared to medium water scarce area and this cost is not close to high water scarcity area. An average of Tk. 12213 per hectare is required for *Boro* cultivation.

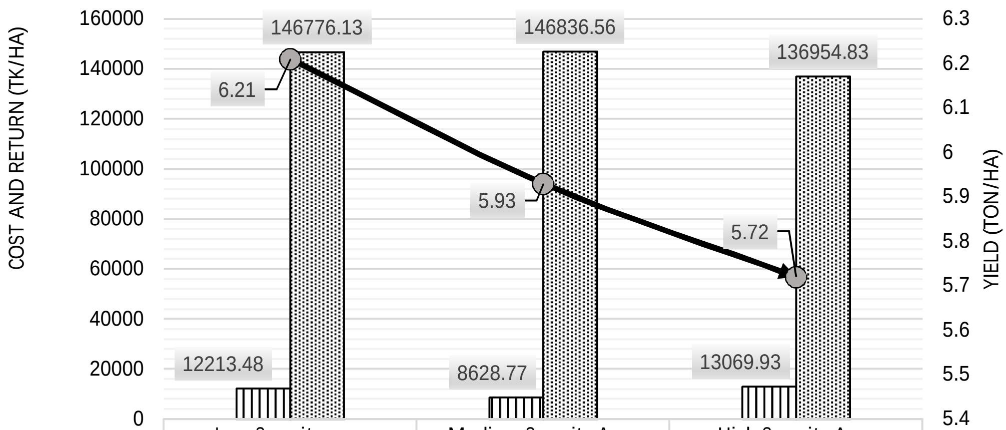
Low and high-water scarce area appears to be more prone to pest attack during *Boro* cultivation compared to medium water scarce area. The average cost for pest management by using pesticides exhibits a total average cost of Tk. 6974 in high water scarce area followed by Tk. 6917 per hectare in low water scarce area. The pesticide cost is minimum in the medium water scarcity area. The lease value for cultivable land in low, medium and high-water scarce area is almost same and it is a major portion of total production cost. In low water scarcity areas, the land lease value is higher than other two areas and it costs an average of Tk. 16667 for a hectare of land. Besides, in medium and high-water scarce areas this cost is Tk. 16582 and Tk. 16379 per hectare where high water scarce land shows the lowest lease value.

In concluding term, it can be mentioned that, different cost items that involve in total *Boro* rice production in Bangladesh, if segmented to areas on the basis of water availability a significant difference is found. The land areas where water availability is high, also known as low water scarcity area the cost of tillage, labor use, fertilizer use and land lease value is higher. But, in this area tillage, labor use, fertilizer use costs were supposed to be low. Also, the irrigation cost is high compared to some other areas due to other factors involved in irrigation practices. On the other hand, in high water scarcity area or area with minimum groundwater availability seed use, labor use cost and land lease value are lower and irrigation, pesticide use cost is higher than other areas. The seed and labor usage cost are very high in medium water scarcity area but other production costs including tillage cost, fertilizer use cost, irrigation cost, pesticide cost is very low than other two categories of land areas.

Relationship among irrigation cost, total return and yield of *Boro* Rice

In low water scarcity area, where water availability is high, irrigation cost is not that low as it supposed to be. But rationality can be found while a comparison graph between irrigation cost, total return and yield is illustrated (Figure 7). The total return in Tk./ha is significantly highest compared to the irrigation cost in low water scarce areas. The total return from *Boro* in high water scarce area decreased by 6.69% and 6.72% respectively than of low and medium water scarce area while in medium water scarce area, the return increased 0.04% of low scarcity area. On the other hand, in medium water scarce area, the cost of irrigation is the lowest (Tk. 8628/ha) while in high scarcity area, this cost is much higher and is maximum of all region. Considering all other associated costs, this ultimately yielded the highest net return for medium water scarce area which is a total of Tk. 51911 per hectare. On the other hand, in high water scarce areas, they faced a 43.5% decreased net return (total 29304 Tk./ha) compared to medium water scarce area where total return was minimum too (Tk. 136954/ha).

While the scenario is compared to irrigation cost and yield per hectare in different water scarce area, it appears a downward trend from low water scarce area to high water scarce area and the per hectare yield is 6.21, 5.93 and 5.72 ton respectively for low, medium and high-water scarcity area. Although the cost of irrigation has risen in high water scarce area but yield decreased. Even in medium water scarce area, the irrigation cost was minimum like other relevant cost items in *Boro* rice production; which might lead to an increase yield but the yield decreased.



	Low Scarcity area	Medium Scarcity Area	High Scarcity Area
Irrigation Cost (Tk./Ha)	12213.48	8628.77	13069.93
Total Return (Tk./Ha)	146776.13	146836.56	136954.83
Yield (Ton/Ha)	6.21	5.93	5.72

Figure 7: Irrigation cost, return and yield variation in different water stressed areas

Since the sample sizes are unequal, the Tukey Kramer test was used to determine which pairwise comparisons are significant. Both table (Table 1 and 2) shows the statistical relationship among irrigation cost, yield and return of irrigated rice (Boro) in the water scarce regions of northwestern regions of Bangladesh. Table 1 shows that there is a significant difference between the groups of irrigation cost and yield of different water scarcity regions (low, medium and high). The irrigation and yield of low, medium and high-water scarcity areas with unequal sample, the p values are less than alpha ($p<0.05$). Also, the standardized q value for group 1 and group 2 ($q>q_{crit}$) shows in above mentioned group a significant mean difference exists. Table 2 shows the mean differences between irrigation and total return among different water scarcity areas (low, medium and high). The Tukey Kramer test identifies which groups has the significant mean differences. Likewise, the ‘irrigation and yield Tukey-Kramer test’, in ‘irrigation and total return Tukey-Kramer test’ shows similar result that standardized $q>q_{crit}$ and p<alpha (0.05). This means significant mean difference exist between irrigation and total return too.

Table 1: Tukey Kramer test for irrigation and yield

Group 1 (Irrigation)	Group 2 (Yield)	Mean	Standard error	q-stat	p-value
Low	Medium	12135.39	94.94	127.82	5.66E-12
Low	High	12135.78	100.00	121.34	5.66E-12
Medium	Low	8622.55	73.53	117.25	5.66E-12
Medium	High	8623.09	72.79	118.45	5.66E-12
High	Low	13024.2	79.96	162.86	5.66E-12
High	Medium	13024.36	72.79	178.92	5.66E-12
F- test statistic		F= 6122.19, P value = 0, F critical = 2.22			

Table 2: Tukey Kramer test for irrigation and total return

Group 1 (Irrigation)	Group 2 (Return)	Mean	Standard error	q-stat	p-value
Low	Medium	133367.9	1732.85	76.96	5.34E-12
Low	High	124514.3	1835.24	67.84	5.34E-12
Medium	Low	138019.2	1342.16	102.83	5.34E-12
Medium	High	128026.9	1342.16	95.38	5.34E-12
High	Low	133617.5	1459.63	91.54	5.34E-12
High	Medium	132478.9	1328.64	99.71	5.34E-12
F- test statistic		F= 2640.75, P value = 0, F critical = 2.22			

IV. DISCUSSION

In Bangladesh, informal water markets for irrigation have developed quickly with the rapid expansion of tube-well irrigation over the last few decades. There is no single rate or uniform method for payment of irrigation water. Per hectare water rates vary not only from one area to another but also depend on the type of tube-well within a particular area (Mandal and Dutta, 1993). In the northern part of Bangladesh where water availability is a crucial matter of concern to both the groundwater supply management body and the farmers who are ultimate user of this groundwater. Different institutional bodies exist in the market to serve farmers with water in *Boro* season. The institutions consist of specific government organizations, community service provider organizations, individually owned water pump who provide water supply on commercial basis and lastly farmers themselves. Except self-ownership of the water supply system, in return to water, farmers mostly pay the suppliers in cash but in some cases (i.e. individual owner providing water commercially) they share the crop with water seller.

Despite of having abundant groundwater sources, staple crop-rice production in Terai plains-lowland region of Himalayan plain, is hindering due to water stress. Erratic monsoon-season precipitation acts as a threat for the rice-based production system that is present in Asian landscape (Turner and Annamalai, 2012; Urfels *et al.*, 2020). The north-eastern region of Bangladesh has similar physiography and cropping pattern like the Terai and eastern Uttar Pradesh, Bihar states of neighboring country, India (Urfels *et al.*, 2020). Study indicates that, as the groundwater level decreased that means, in high water-scarce areas the lease value of land has decreased by 1.73% of low water-scarce areas. This might be because of the difficulties aroused from less groundwater in these areas and farmers find it less productive. Also, producing rice in these areas field requires extra effort than other crops. Less groundwater means continuous irrigation is must for keeping land flooded which is both costly and difficult in high water-scarce areas. To keep land irrigated for the whole *Boro* season, the cost of irrigation increased by 53.47% of low water scarcity and 67.13% of medium water-scarce areas. This results in less natural pest control in the *Boro* rice field and leads to an increased cost of using pesticide which is 0.81% higher in the high water-scarce area compared to the low water-scarce area. As minor studies were found and empirical results suggest rational outcome and indicates real life situation, the findings are considered as appropriate.

On the other hand, the fertilizer use cost has diminished as water level decreased and compared to low water scarcity area, the fertilizer cost is 10.69% and 6.48% less in medium and high water-scarce area respectively. Again, the labor cost in the high water-scarce area is 12.60% less than the medium water-stressed area and it is 6.13% less than low water-stressed area. This is unusual fall in labor use cost in *Boro* rice production in the high water-stressed area. Agriculture labor abundance, lower wage rate for agriculture labor in these areas, lower living standard, lack of the opportunity of other employment in that particular season might be reasoned behind the fall. The same scenario is found in the high water-stressed area for tillage of land. This is related to the labor cost. The per hectare tillage cost of land in high water scarcity area is less than low (0.4%) water scarcity area and only 0.53% higher than medium water scarcity area. Also, the seed use cost in high water scarcity area is minimum than both low and medium water-stressed area diminishing demand of *Boro* seed due to people's tendency of not to produce seems like a possible reason behind the decreased cost. It is found, the seed cost in high water scarce areas is 8.6% less than medium scarcity and 2.78% less than low water scarcity areas.

The most interesting findings is that, the cost of irrigation in medium water scarce areas is lower than low water scarce areas which allows us to estimate a probable rise in the total yield of production and return as well. But in reality, it is different, the per hectare yield of *Boro* rice has decreased drastically and the total return increased although at a non-significant level. From Figure 8 we see, between low and medium water scarcity areas, the yield of *Boro* rice per hectare falls by 4.5% but instead of a fall in total return, it appears an increase in return of 0.04% in medium water scarce areas than of low water scarce areas. Again, between medium and high-water scarce areas, the yield decreased by 3.54% in high stressed areas and it resulted in a 6.69% less return in high water stressed area compared to medium water stressed areas. As we see, between low to medium water scarce area, despite of decreased yield (4.5%), return increased in medium water scarce area, so between medium and high water scarce area, with a less decrease in yield (3.54%) if linear trend was maintained, there wouldn't be any fall in total return in high water scarce area and it was supposed to rise by 3.146% but it did not. So, clearly something else is offsetting the effect of lower yield on total return from rice production in medium water stressed areas. As all other production factors effects are already analyzed earlier for all three different water stressed areas and they are not influencing unusually then, the only possible reason of getting higher return in medium water stressed area is the price of rice.

V. CONCLUSIONS

Though Bangladesh is surrounded by rivers and average sea level alleviation is not more than 10m, irrigation is necessary to cultivate the major staple food grain (rice) of the country. Irrigated rice (*Boro*) plays the major role in the rice bank of Bangladesh, the contribution is more than 60% of total rice production. Any natural calamities such as excessive or lower rainfall and extreme/lesser temperature have negative impact on rice production. Therefore, irrigation is necessary to see the water stress effect on irrigated/winter rice (*Boro*) production in Bangladesh. The result shows availability of groundwater for irrigation have multi-dimensional effect on different factors of rice production which ultimately affect the rice production and return from rice farming in northwestern region of Bangladesh. Groundwater level is decreasing over the years and the severity is increasing in the winter seasons, but the severity is not same across the regions. Therefore, policy maker can make zone-specific customized rationing of more water consuming crops cultivation in the northwestern region of Bangladesh.

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