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**RESEARCH ARTICLE**

# Irrigation Water Requirement Estimation for Wheat by FAO Penman-Monteith Method: A Case Study of Barind Area, Rajshahi, Bangladesh

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## Abstract

The study was focused on analyzing the irrigation water requirement of Wheat in Barind area of Bangladesh. The study was carried out from 2002 to 2011 in nine upazillas of Barind area under Rajshahi district. Reference Evapotranspiration was estimated using FAO Penman-Monteith method. Reference Evapotranspiration and crop coefficient of selected crops were used for estimating crop water requirement. By using estimated effective rainfall and crop water requirement, the irrigation water requirement was determined. The maximum evapotranspiration was estimated in 2004 and minimum was estimated in 2011 during the period of 2002-2011. The irrigation water requirement for Wheat was higher in the vegetative and mid-season stage from December to January and comparatively less irrigation water was required in initial and maturity stage. IWR decreases in the month of March as wheat was in maturity stage. It was also found that irrigation water requirement was less in the maturity stage as compared to the initial stage.



## Introduction

Experts' estimates that demand for food crops will double during the next 50 years with limited land and water resources, farmers need to increase their output from existing cultivated areas to satisfy the food demand of increasing population. The fact that the provision of irrigation facilities can enhance the yield of our crops by large extent to meet future food needs and ensure food security. The irrigation water requirement for crop production is the amount of water, in addition to rainfall, that must be applied to meet a crop's evapotranspiration needs without significant reduction in yield. Estimation of reference crop evapotranspiration ($ET_o$) is an essential prerequisite for efficient planning of irrigated agriculture

Rajshahi City is one of the seven divisional headquarters located in the north-western part of Bangladesh with 787180 people in the total area of 93.47 square kilometers. Population growth rate is about 1.10%. With the increase of population the demand for food is increasing day by day. It is fact that if full irrigation facilities for crops are not developed, the production of food grains shall be reduced, as the yield of different crops will be reduced. And, if sufficient food grains are not available, the people will remain hungry, leading to all round chaos, looting, and economical destruction of the country, hampering its progress & prosperity. In the light of this fact, it can be easily emphasized that irrigation is inevitable at least in every tropical or subtropical country like Bangladesh. Developments in irrigation are often instrumental in achieving high rates of agricultural goals but proper water management must be given due weight age in order to effectively manage water resources. Better management of existing irrigated areas is required for growing the extra food to fulfill the demand of increasing population.(Alam *et* *all.*) However, the irrigation sector must be revitalized to unlock its potential, by introducing innovative management practices and changing the way it is governed.

## Study Area

The part of greater Rajshahi, Dinajpur, Rangpur, And Bogra district of Bangladesh and the Indian territorial Maldah district of west Bengal is geographically identified as Barind tract. The hard red soil of this area is very significant in comparison to the other part of the country (Ref-BMDA). The Rajshahi Barind tact is located in between 24 degree 23 minute to 25 degree 15 minute north latitude and 88 degree 2 minute to 88 degree 57 minute east longitude. The altitude of Rajshahi is 20m.The Barind area is characterized by two district landforms: the Barind Tract- dissected and undulating, and the floodplains. It lies in the catchment of the river Ganges (Padma) with drainage system predominantly of the Atrai, Mahananda, Purnabhaba Rivers and other minor seasonal streams. Except the Padma, all others are seasonal. The physiographic map of the working area shown in Fig.1.1 north-south oriented dome shaped area (20-25 km wide in east-west direction), edged parallel by river valleys demarcate the topography with elevation ranging from 47.0 m in the central part to 11.0 m in the southeast. The slope is with a differential gradient to the west and east (0.79-2-2 m/km).The area enjoys a subtropical monsoon climate characterized mainly by three seasons: winter (November-February) – cool and dry with almost no rainfall; pre monsoon (March-May) –hot and dry; and monsoon (June-October) –rainy. The average annual rainfall for the period from 1964-2010 is 1600 mm, much less than the national average of 2550 mm. Average monthly humidity varies from 62% (in March) to 87% (in July) with a mean annul of 78%. Monthly average temperature ranges from 10ºC (in January) to 33ºC (in May). Sunshine hour varies from 7-8 hr/day (October-May) to 4-5 hr/day (June-September) and wind speed is greater than 3 Nm (April-June) to lower than 1-3 Nm (July-March) (Islam *et all)*

## Material and Methods

Primarily, the existing meteorological data was obtained from Bangladesh Meteorological Department, climate division, Dhaka. The Rainfall data was collected from the zonal office of Barind Multipurpose Development Authority (BMDA), Rajshahi. During the data collection period in the station only actual information have been used. So, the duration of data was 11 years (2002-2011).

The required meteorological monthly data for this study were:

- Mean maximum temperature,
- Mean minimum temperature,
- Sunshine hours,
- Average wind velocity,
- Relative humidity,
- Rainfall data.

Then by using meteorological data, daily potential evapotranspiration was estimated using FAO Penman-Monteith Method as shown below.

$$ET_o = \frac{0.408\,\Delta\,(Rn - G) + \gamma \frac{900}{T+273} u_2\,(e_s - e_a)}{\Delta + \gamma(1 + 0.34 u_2)}$$

Where,

$ET_O$ = Reference evapotranspiration (mm $day^{-1}$)

Rn = Net radiation at the crop surface (MJ $m^{-2}$ $day^{-1}$)

G = Soil heat flux density (MJ $m^{-2}$ $day^{-1}$)

T = Mean daily air temperature at 2 m height (°C)

$u_2$ = Wind speed at 2 m height ($ms^{-1}$)

$e_s$ = Saturation vapor pressure (Kpa)

$e_a$ = Actual vapor pressure (Kpa)

$e_s$-$e_a$ = Saturation vapor pressure deficit (Kpa)

Δ = Slope vapor pressure curve (Kpa $°C^{-1}$)

γ = Psychometric constant (Kpa $°C^{-1}$)

The calculation related to FPM method has been done through *CROPWAT* software in computer. In order to compute the crop water requirement (CWR), crop coefficient ($K_c$) values for the crop were obtained and multiplied with the potential evapotranspiration

$$CWR = K_c * ET_o$$

The Effective Rainfall (ER) and the crop water requirement decide the amount of irrigation water that has to be applied. The effective rainfall is subtracted from the crop water requirement to calculate the irrigation water requirements (IWR).

$$IWR = CWR – ER$$

Effective rainfall is estimated based on FAO approach (Food and Agricultural Organization). The empirical equation given by FAO is as follows,

$$Y = 0.0011x^2+0.4422x$$

Where, y is effective rainfall (ER) in mm and x is total rainfall in mm.

## Results and Discussion

After estimation the amount of potential evapo-transpiration by using FAO Penman-Monteith Method the daily values were aggregated to monthly values for the ten years (2002-2011). Crop water requirement was estimated on a monthly basis by multiplying the potential evapo-transpiration with crop coefficient values. From the CWR and effective rainfall the irrigation water requirement (IWR) is calculated. The graphical representation of irrigation water requirement (IWR) for the wheat crop of Barind area in Rajshahi district is given below.


**Fig.1: Location of study area**

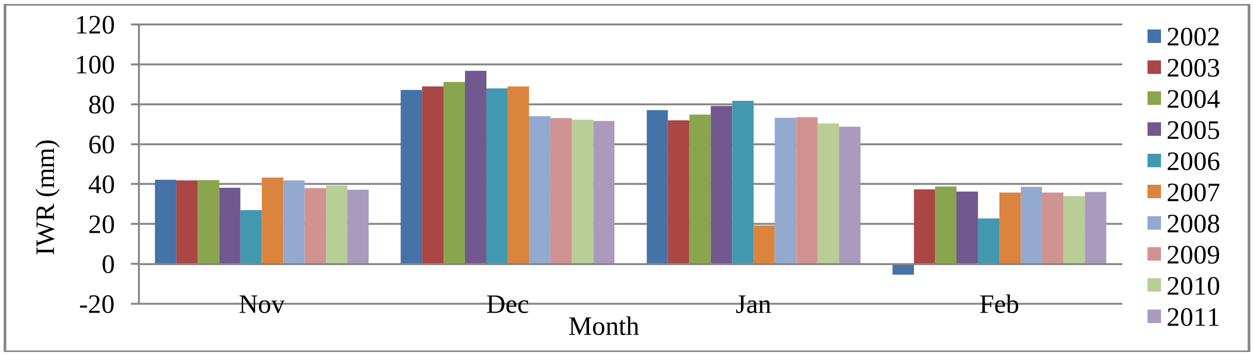


**Figure 1: Monthly variation of IWR at Godagari**

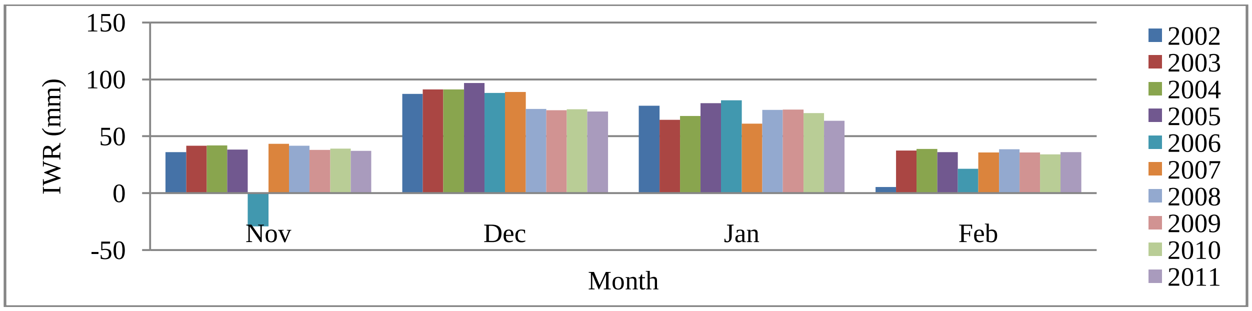


**Figure 2: Monthly variation of IWR at Tanore**

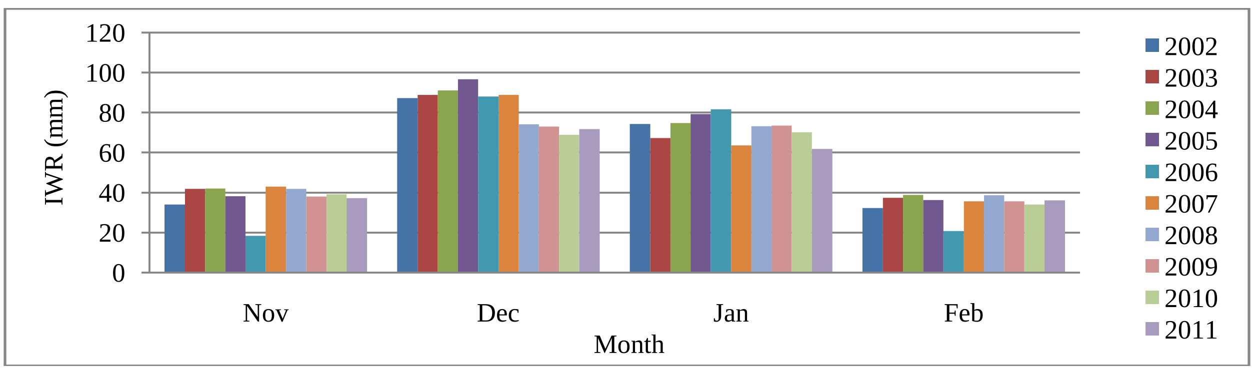


**Figure 3: Monthly variation of IWR at Paba**

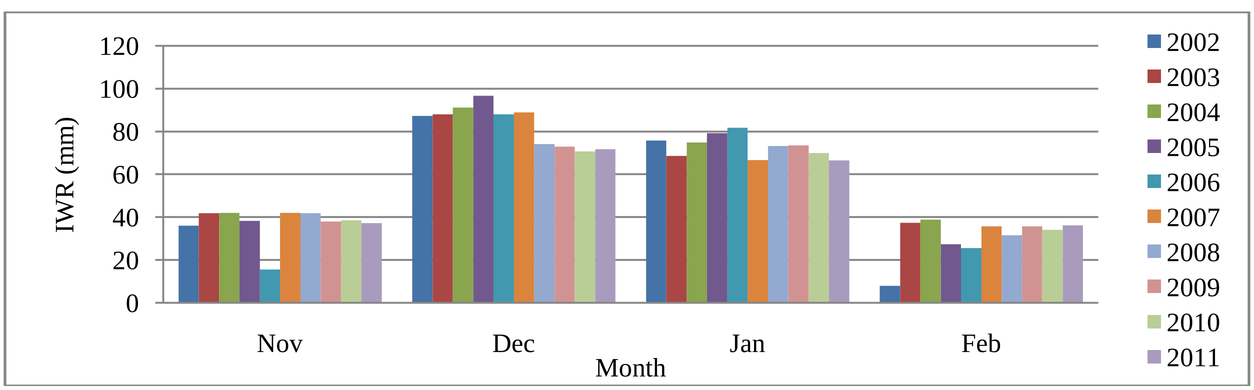


**Figure 4: Monthly variation of IWR at Mahanpur**

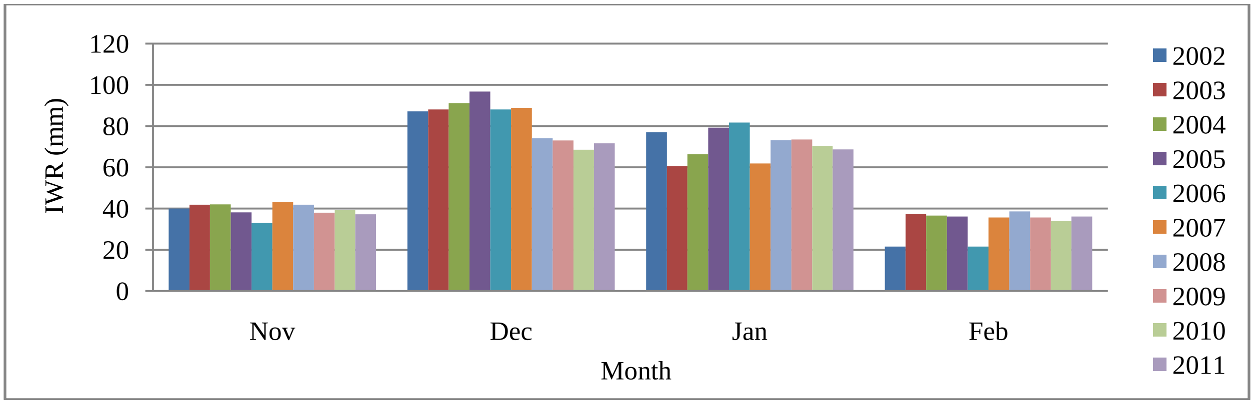


**Figure 5: Monthly variation of IWR at Bagmara**

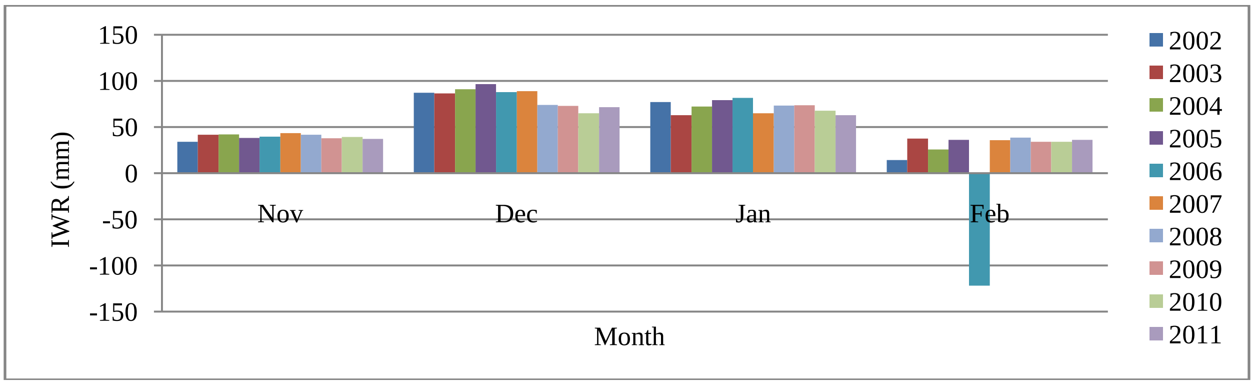


**Figure 6: Monthly variation of IWR at Durgapur**

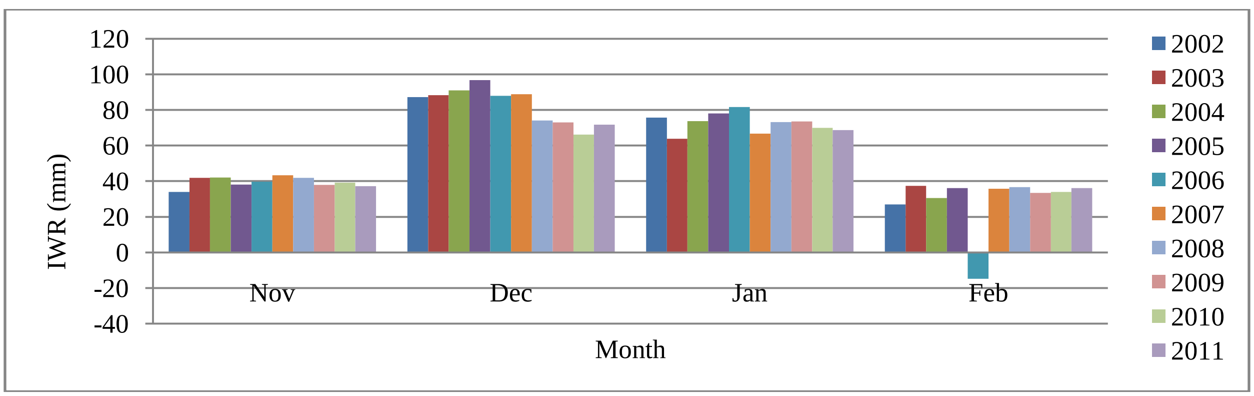


**Figure 7: Monthly variation of IWR at Puthia**

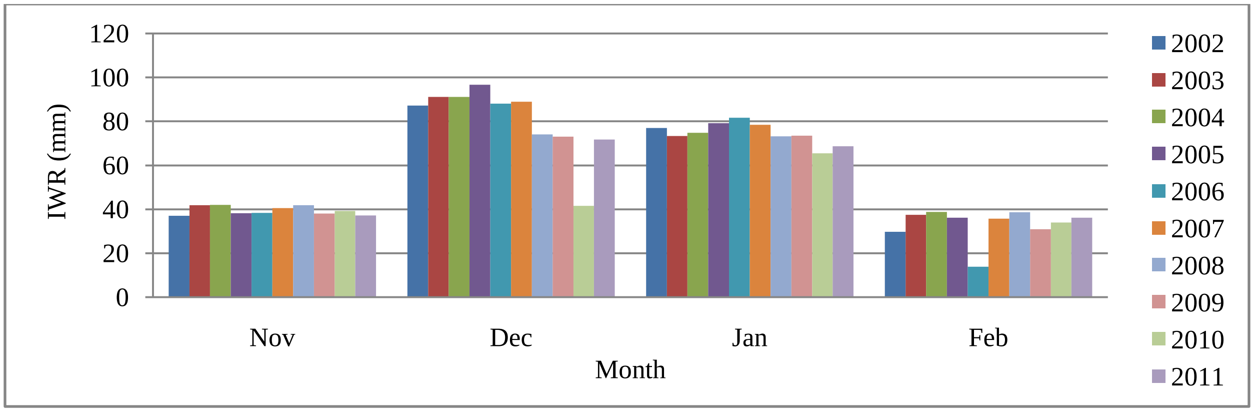


**Figure 8: Monthly variation of IWR at Bagha**

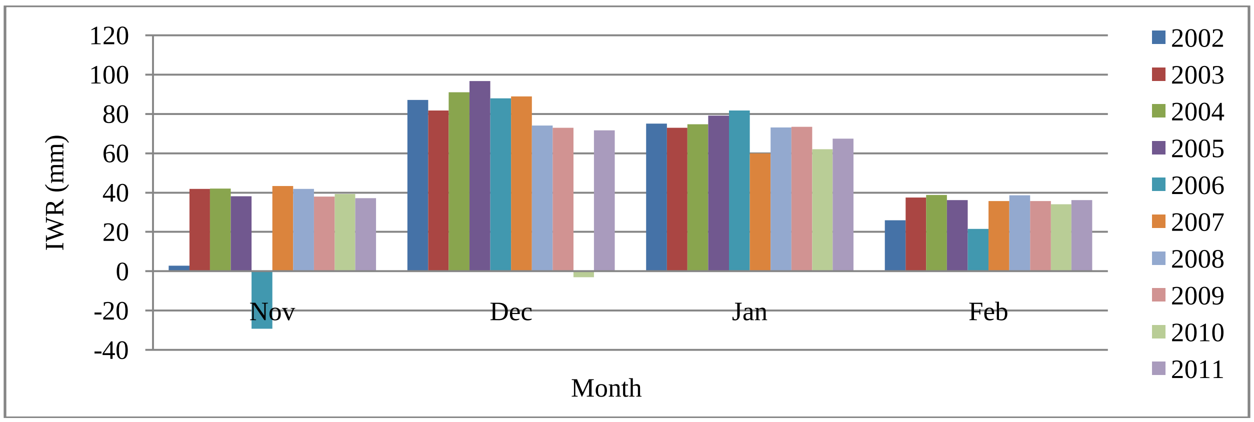


**Figure 9: Monthly variation of IWR at Charghat**

The irrigation water requirement graph shows that wheat water requirement is increasing with the passage of time and require maximum amount of water at the crop development and mid season stage. The crop water requirement varied from -121.9 mm/month to 96.7 mm/month. The maximum IWR was observed in the month of December while the minimum was observed in the month of February. IWR decreases in the month of March as wheat was in maturity stage. It was also found that irrigation water requirement was less in the maturity stage as compared to the initial stage. Negative value of irrigation water requirement indicates that there no need of any irrigation water and rainfall is sufficient to meet the need of irrigation.

## Conclusion

The present study shows that in the study area the irrigation water requirement for wheat was higher in the vegetative and mid-season stage from December to January and comparatively less irrigation water was required in initial and maturity stage. In the study area it was also found that irrigation water requirement highly correlated with crop water requirement due to absence of monsoon in rabi season (November to February).

## References

Alam B. M., Uddin A.B.M., Bablu H. M.A.Z. and Kamaly K. M. H. 2012. Rajshahi Water Supply and Sewerage Authority: Achievements and Challenges.

FAO (1992). Guide lines for predicting crop water requirement. Irrigation and Drainage paper 24, Food and Agricultural Organisation of United Nations, Rome.

Islam M. M. and Rahman S. M. 2012. B.Sc. thesis on, Study on Water Requirement for different crops in Barind Area, Rajshahi, RUET, Rajshahi

Zotarelli L., Dukes M. D., Romero C. C., Migliaccio K. W. and Kelly M. T. 2009. Step by Step Calculation of the Penman-Monteith Evapotranspiration (FAO-56) Method. University of Florida AE459.

Garg S.K. 1976. Irrigation Engineering and Hydraulic Structure, Khanna Publishers, 2-8, Nathmarket, NaiSarak, Delhi-110006.