Impact of water deficiency on agro economy: a case study of Northwest Bangladesh

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Abstract

This study examines the effects of water shortage on agricultural wages in Northwest Bangladesh. For this study, meteorological data including information on the monthly temperature, precipitation, wind speed, hour of sunshine and humidity of six weather stations have been utilized during the monitoring period from 1985 to 2005. With the objective to analyze water surplus and water deficiency, a simple soil-water balance model and the modified Penman formula were applied to the Northwest Bangladesh. The seasonality of Mann-Kendell trend statistics has been used to identify the spatial variation of water surplus and deficiency throughout the region. For micro level verification of the result, a detailed field survey has been conducted within the study area. The results showed that the values of the potential evapotranspiration estimated by the modified Penmen equation were negative for certain periods. In this instance, the water deficiency of the district of Rajshahi was observed significantly in the period of pre-monsoon and post-monsoon. The field study also verified that because of such deficiency in water, the agricultural scenario of the area was widely influenced which lead to less agricultural production and less economic benefits.

Keywords: Evapotranspiration, Water balance, Water surplus & deficit, Mann Kendell, Agro economy, Northwest Bangladesh.

1. INTRODUCTION

Against the backdrop of severe water crisis hitting almost two thirds of the global population, Bangladesh, once considered a country of abundant water resources or otherwise known as a country of rivers, *haors* and *baors* - is now facing an acute water crisis and seasonal flooding (Khan, 2003). Analysis of the relative effects of water deficiency shows that the droughts of 1994-95 in the northwestern districts of Bangladesh led to a shortfall of rice production of 3.5 million tons (Paul, 1995). In Rabi season's water shortage would severely affect wheat and Boro crops at vegetative growth stages. (World Bank, 2000c). Bangladesh is losing 220 ha of arable land everyday, while the population increase is continuing at an alarming rate. The population of Bangladesh in 2020 is predicted to be 161.25 million, for which total food deficit would be about

49.13 million tons (Paul,1995).To meet up with food demand of the increased population and to save bio-diversity of the country, the best use of cultivable land as well as modernization of agriculture is very important. In this context, it is necessary to maximize utilization of the limited water resources. The Northwest Bangladesh suffers immensely from lack of water availability, which negatively effects the agricultural production of this area. In summery, the objectives of the study are: (i) Identify the water surplus and water deficit periods; and (ii) Suggest how the local people may effectively manage the water shortage during deficit period.

2. MATERIALS AND METHODS

For this study, meteorological data including information on monthly temperature, precipitation, wind speed, hour of sunshine and humidity of six weather stations were utilized during the monitoring period from 1985 to 2005 and collected from Bangladesh Meteorological Department (BMD). These data were used to calculate potential evapotranspiration using the specific Penmen method modified by Doorenbos and Pruit (1977). In the modified Penman method, the ETp can be estimated with the equation 1:

$$ETp = C\,[W \cdot Rn + (1\text{-}W) \cdot f\,(u) \cdot (ea - ed)] \qquad (1)$$

where ETp is the potential evapotranspiration (mm/day); C is the correction factor to compensate the day and night effect under climatic conditions, and relates the solar radiation, the maximum relative humidity and the day and night wind speed (dimensionless); W is the weighing factor related to the temperature and the altitude (dimensionless); Rn is the liquid radiation (mm/day); $f(u)$ is the function related with the wind (dimensionless); ea is the water vapor saturation pressure (mbar); and ed is the real saturation pressure of the vapor in the air (mbar). The estimation of the water balance for an average year is based on three digital geo-referenced data sets for precipitation (Leemans and Cramer, 1991), reference evapotranspiration (Fischer *et al*., 2000) and soil moisture storage properties (FAO, 1995b).The water surplus and deficit can be explained with the soil water balance equation (FAO, 1978),

$$S = P - E - \triangle W \qquad (2)$$

Here, S = Surplus; P = Precipitation received; E = Potential evapotranspiration. $\triangle$W = The change in soil water storage.

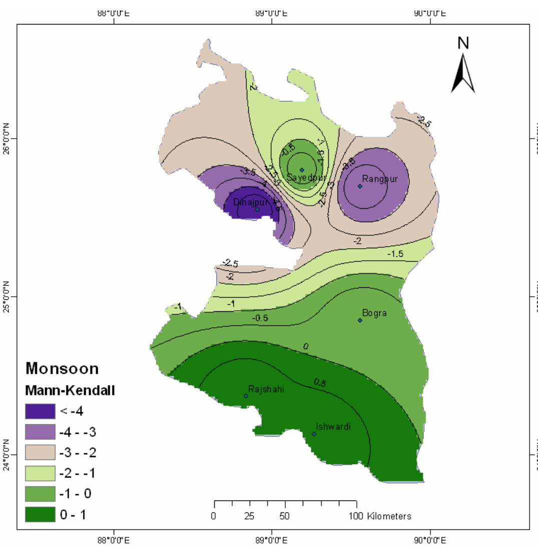
Among some non-parametric trend tests, the sequential version of the Mann-Kandell rank test has the ability to detect the beginning and/or end of the trend(Kaioglu and Freiwan, 2008). Therefore, this test was used to identify trends and spatial variation of water deficit for three seasons such as monsoon, pre monsoon, and post monsoon.

For micro levels, verification of the result obtained from the detailed field survey has been conducted on the study area, Alokchtra Mouza of Godagari Upazilla, the sub-district of Rajshahi district. Each plot of the village was thoroughly investigated and its physical and agricultural characteristics were recorded using fractional code method. For the research area, a questionnaire was prepared to conduct socio-economic survey. The questionnaire for the socio-economic survey was prepared through primary field visits and tests. Small group discussions were held with the inhabitants of the village to find out the existing crop production scenario and their perception about availability of crop water requirement.

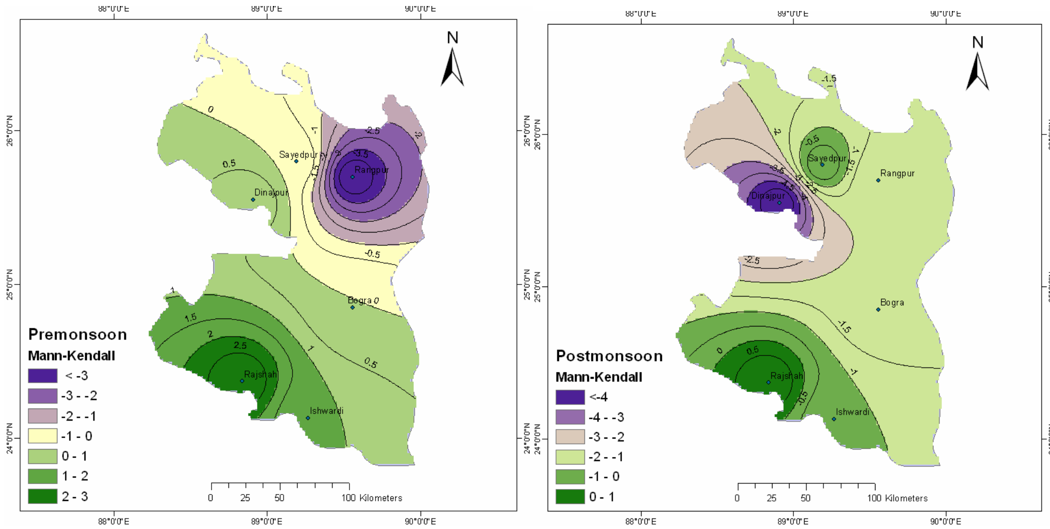
3. RESULTS AND DISCUSSION

3.1. Identification of Water Surplus and Water Deficit Periods

The seasonal Mann-Kendell trend statistics shows that water deficiency was observed significantly in the pre-monsoon and post-monsoon period in Rajshahi(Fig 1).



(a)



(b) (c)

Figure 1: Seasonal Mann-Kandell statistics of (a) pre monsoon (b) monsoon and (c) post monsoon water deficit with increasing and decreasing trends at 99% confidence level.

3.2. Water deficiency and agricultural practice

For a better understanding of this water deficiency, an attempt has been made to study sites, which are close to the station's covered circumference and where the influence of agriculture on the land use is predominant. In this pretext, the Alokchatra mouza (divided into eastern and western part) of Godagari Thana of the Rajshahi district has been selected for verifying the result obtained. The low-lying eastern part of the study area produces single crop(T. Aman) in a year without supplementary irrigation by the deep tube well facility whereas the western elevated surface of the study area produces a double or triple crop in a year. Because of water deficiency during the water deficit period, no crops are produced in the eastern part of the study area. Therefore, the economic loss of the eastern area will be the amount of production that could be obtained from the production of double or triple crops using the irrigation capability of a deep tube well.

Table 1: Economic Return of Crops Produced with Deep Tube Well intervention (field survey, 2007)

Crops	Cultivated area(Acre)	Per Acre Production()mand)	Total Production (Taka)	Gross return (Taka/acre)	Total cost (Taka/acre)	Net return (Taka/acre)
Boro	130.5	65.0	2119577.8	16242	1980	14262
Aus	66.1	37.9	626263.5	9474.5	1520.4	7954.1
Potato	4.4	151.6	274332	62348.2	4625.9	57722.3
Wheat	2.1	17.3	18659	8885.2	14563	5677.7
Mustard	8.3	7.6	119235	14365.6	1245	13120.6
Winter Vegetables	19.4	85.4	1429206.8	7367.05	19230	54440.5
Total	230.8		4565238.3			

From the analysis of Table 1, it is observed that in the deep tube- well command area farmers receive a net return of 14,262 Taka from per acre production of only *boro* rice. As the eastern part of the study area is low-lying and more fertile, farmers would be much more interested in the production of *boro* rice because of high productivity per acre given the facility of deep tube well irrigation. Therefore, increasing the cropping intensity can change the economic status of the farmers of the eastern part considerably.

4. CONCLUSION

Rajshahi is dry in winter and moderately dry in pre monsoon, which means water deficiency is observed in the period between mid-October to mid-May and water remains in surplus from mid-May to mid-October. The rate when potential evapotranspiration occurs is the highest during April and the lowest in December in Northwest Bangladesh. A rate of annual potential evapotranspiration is the highest in Rajshahi and the lowest in Bogra. A micro- level study verified that because of such deficiency in water the agricultural scenario of the area was widely influenced. On the local level, therefore, the Barind Authority was impelled to establish a deep tube well to meet the crop water requirement through irrigation. However, the benefits of this intervention was not equally available throughout the entire region. The region that was deprived of such modern intervention showed less agricultural production and deprivation in terms of economic benefits. To bring about profit making changes in the crop production scenario, the local people are using modern interventions like deep tube wells unaware of the negative effect of over usage that may occur. Moreover, such ignorance leads to excessive extraction and impairing its influence upon water balance condition of the particular site. However, there can be solutions to this problem which neither the agricultural experts nor local people are aware of. There is currently no effort being undertaking to establish a surface water treatment in this region. They probably spend huge sums of money for the purposes of repairing these deep or shallow tube wells, but the local level government and community should take an attempt to re-excavate and dredge the low-lying ditches or ponds. Therefore, such unwise usage of underground water may lead to a disastrous consequence for the agriculture and the agro ecosystem of this area.

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REFERENCE

Doorenbos, J. and Pruitt, W. O., 1977. Crop Water Requirements. *Irrigation and Drainage Paper* No. 24, (rev.) FAO, Rome, pp. 15-29.

FAO (1995b), The Digitized Soil Map of the World Including Derived Soil Properties. (Version 3.5), *FAO Land and Water Digital Media.* Series 1, Rome, Italy.

FAO (1978), Effective rainfall in irrigated agriculture**.** FAO Irrigation and Drainage Papers - 25, Rome, Italy.

Kadioglu M, Freiwan M. 2008. Climate variability in Jordan. *International Journal of Climatology* 28: 69-89.

Khan, A. H. (1995). Water Resources Development and Management in Bangladesh. Symposium Organized by Bangladesh Association for the Advancement of Science (BAAS), June 8, 1995, Dhaka, Bangladesh.

Leemans, R. and W. Cramer, (1991) *The IIASA database for mean monthly values of temperature, precipitation and cloudiness on a global terrestrial grid.* Research Report RR-91-18, International Institute of Applied Systems Analyses, Laxenburg, Austria.

Paul BK. 1995. Coping mechanisms practiced by drought victims (1994/5) in North Bengal, Bangladesh. *Applied Geography* 18:355–373.

.World Bank, Bangladesh Climate Change and Sustainable Development, Report No.: 21104-BD, December, 2000c.