LOWLAND TECHNOLOGY INTERNATIONAL Vol. 3, No. 1, 69-75, June 2001
International Association of Lowland Technology (IALT), ISSN 1344-9656

Technical Note

ESTIMATED CONSUMPTIVE USE AND FIELD IRRIGATION REQUIREMENT FOR RICE DURING THE DRY PERIOD: A CASE STUDY IN THE GANGES LOWLAND REGION OF SOUTHWEST BANGLADESH

Muhammad Qumrul Hassan[1]

ABSTRACT: This paper deals with the Consumptive Use (U) and the Field Irrigation Requirement (FIR) for rice crop during the dry period of the Jessore district in the Ganges lowland of southwest Bangladesh by using the Blaney-Criddle Method. The estimated U ranges from 3.11 mm/d in December to 7.65 mm/d in April. The minimum and maximum estimated FIR for rice crop in the months of December and April is about 3.54 mm/d and 6.61 mm/d, respectively. The total seasonal FIR is about 807 mm for rice crop during the present dry period. The above results may prove useful for the future planning of a rice crop-design calendar of the Jessore district during the dry period.

INTRODUCTION

The term "water loss" is well known in the hydrologic equation. It can be expressed in a simple way: precipitation - water loss = Runoff. In Bangladesh, precipitation mainly comes from rainfall. Rainfall is the main input component to the system of the hydrodynamic ondition of Bangladesh in one hand. And loss of water from the system (earth surface) by evapotranspiration and run-off (output) processes on the other. These input and output processes of the system are ultimately controlled to the regional hydrologic cycle. These various water loss processes are stated as follows to give the reader a better understanding of the local environment: interception loss due to vegetation; evaporation from surface water bodies and soils; transpiration from plant leaves; evapotranspiration or consumptive use from irrigated or cropped land; infiltration into the groundwater reservoir from the landsurface, and also different surface and subsurface leakage phenomenon. Interception loss is high at the beginning of rainfall and gradually decreases, the loss is, from 0.5 mm to 2.0 mm per shower. It is greater in the case of light showers than when rain is continuous. Effective rain is equal to rainfall minus interception loss. Evaporation losses are high in arid regions where water is impounded while transpiration is the major cause of water loss in humid regions. The values of transpiration ratio for different crops vary from 300 to 800 and for rice it varies from 600 to 800 (Raghunath 1991).

Consumptive use is the quantity of water per annum used by either cropped or natural vegetation in transpiration or in the building of plant tissue, together with water evaporated from the adjacent soil, snow, or from intercepted precipitation. It is sometime termed "evapotranspiration" (Lee 1934). Irrigation requirement is the quantity of water, exclusive of precipitation, that is requried for crop production. It includes surface evaporation and other economically unavoidable wastes (Blaney 1952 and Criddle 1952). Evapotranspiration or consumptive use is of great importance in the local Agro-climatic studies on the earth surface. There are several methods of estmating evapotranspiration which are employed in different

1 Professor, Department of Geology, University of Dhaka, Dhaka-1000, BANGLADESH.
Note: Discussion on this paper is open until December 25, 2001.

climatic conditions as well as potential use, for example, tanks and lysimeter experiments in the field condition, by installation of sunken (Colarado, USA) tanks, by equations as developed by Lowry-Johnson (1942), Thornthwaite (1948), Penman (1948), Blaney-Criddle Method (1950), etc. In this paper, the Blaney-Criddle Method has been used for the first time in the Jessore district of southwest Bangladesh to estimate the Consumptive Use and the Field Irrigation Requirement for rice crop.

METHOD AND MATERIALS

The Study Area

Jessore is located in the lowland areas of southwest of Bangladesh and is situated on the western bank of the lower Bhairab river, which is a distributary of the Ganges river (Fig. 1). The area receives 1556 mm of annual rainfall (average of 1968-88). The summer mean maximum temperature is 40°C and the winter mean minimum temperature is about 9.6°C. The mean maximum evaporation is 513 mm/d (April). The maximum climatic stress in the dry period is about - 4.51 mm/d (March) and the mean annual climatic stress is - 2.98 mm/d (Table 1) . The mean annual surplus is 5.91 mm/d (Hassan 1993).

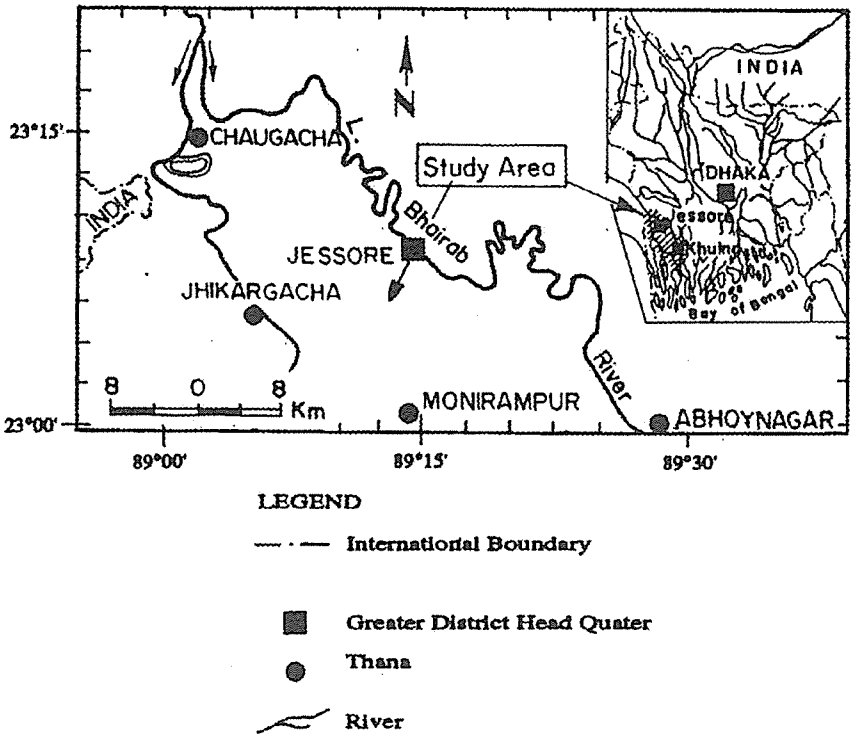

Fig. 1 Location map of the study area of southwest Bangladesh

Methods

The Blaney-Criddle Method has been widely used (especially in the USA) for consumptive use determinations as follows:

$$U = \sum \frac{kp(4.6t + 81.3)}{100} \quad (1)$$

$$U = \sum kf = K \sum f = KF \quad (2)$$

Where,

U = Seasonal consumptive use (mm).
t = Mean monthly temperature (°C).
p = Monthly percentage of hours of bright sunshine for the year.
k = Monthly consumptive use coefficient determined from experimental data.
f = Monthly consumptive use factor, $f = \frac{p(4.6t + 81.3)}{100}$.
K, F= Seasonal values of consumptive use coefficient and factor, respectively.
Σ = Summation for all the months of the growing season.

Field Irrigation Requirement (FIR):

$$FIR = \frac{U - \sum Pe}{nj} \quad (3)$$

where,

nj = irrigation application efficiency.
Pe = Effective rainfall (mm)/Climatic stress (mm). In this calculation, climatic stress has been used instead of effective rainfall, because the effective rainfall could not be estimated due to small amount of input (rainfall) to the system during the dry period.

Data Accumulation and Processing

In the present study, long-term (1968-88) climatic data have been used. The data were rainfall, evaporation, temperature and sunshine. The primary data were collected from the Bangladesh Water Development Board (BWDB) and the Bangladesh Meteorological Department, respectively. The primary data were processed by the Lotus 123 computer program. Afterwards the long-term mean values were used in the equation (1) and (3), and obtained the present results of the study. In this study the used water application efficiency (nj) and the consumptive use coefficient (k) for the rice growing season on an average basis are 90% and 1.0, respectively.

RESULTS AND DISCUSSION

Hydrological Calendar

In Bangladesh, the hydrological calendar starts in April and ends in March of the following year. Dry period generally lasts from November to April (6 months). The remaining six months (May to October) are considered to be the wet period (Fig. 2). The rainfall received in the dry period is about 11% of the annual total in Jessore. This period in Jessore is characterized by high tempratures as well as high relative humidity. Also the sunshine hours are increased during this period. It may be said that the climatic stress condition prevails in the dry period, while, in the wet period, the climatic surplus condition prevails with 89% of annual total rainfall. Figure 2 shows the climatic stress and surplus condition of the Jessore district. It can be seen that the climatic stress condition prevailed for eight months, from October to May (Hassan 1993). Previously, the climatic stress condition lasted six months in

the area, from November to April (Manalo 1977). It can be observed that previously the duration of the dry period in Jessore was equal to the duration of the dry period in Bangladesh. The present study indicates that the dry period has been extended by up to 2 months. On the other hand, the same duration is subtracted from the wet period of the local hydrological cycle of the area. This is also an indication of changes of some climatic variables in the present time (Hassan 1995).

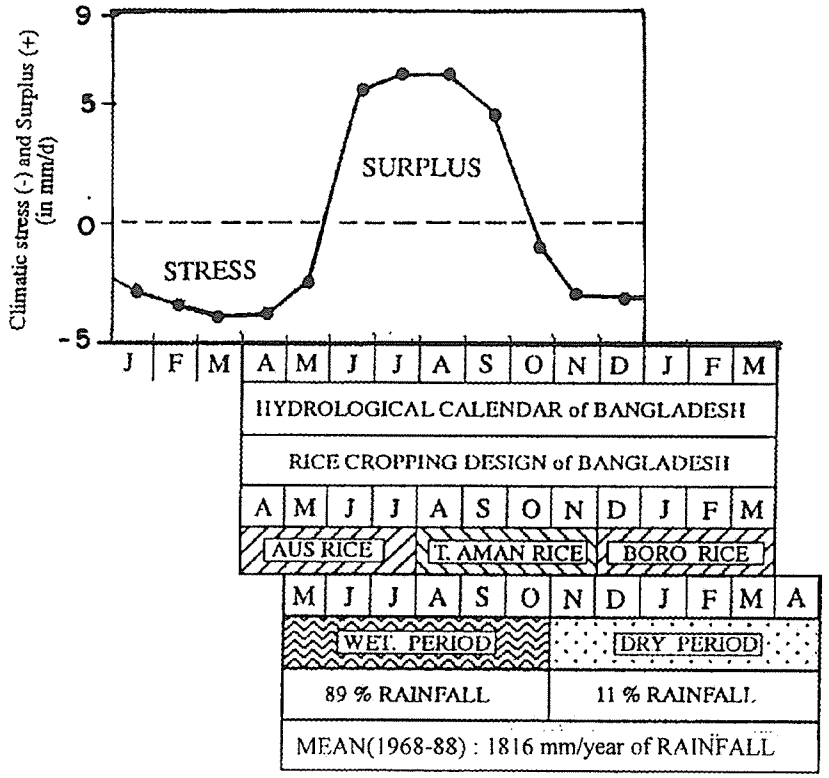

Fig. 2 Climatic stress and surplus balance along with the local hydrological calendar showing the rice cropping design of the study area (Jessore) of southwest Bangladesh

Rice

The main food of Bangladesh is rice and different types of rice are cultivated in the country throughout the year. There are three types of rice: (i) Aus rice cultivates from April to July (4 months), (ii) Transplant Aman rice cultivates from August to November (4 months), and (iii) Boro rice cultivates from December to March (4 months). Aus paddies require irrigation only for one or two months in the initial growth stage. For the last two months of the growth stage, aus rice only requires water from direct surplus rain. Transplant Aman paddies normally require no irrigation system. Water is received directly from monsoon rain. Boro paddies are completely dependent on irrigation systems, because at the time boro rice is grown in the area which is under climatic stress condition. Surface water and ground water can help overcome this situation, so calculations on net irrigation requirement are essential for rice in the dry period. In this paper calculations are only made in the dry period (from November to April). Actually in the wet period irrigation systems are not required.

Climatic Data

The climatic data of long-term monthly mean (1968-88) of the dry period namely, temperature, sunshine, rainfall, evapotranspiration and climatic stress of the area have been presented in Table 1, where it can be seen that the mean temperature ranges from 18.6°C in January to 29.2°C April and the sunshine hours range from 7.69 hours/d in December to 8.11 hours/d in April. Rainfall ranges from 0.34 mm/d in the month of December to 3.19 mm/d in the month of April. Evapotranspiration, also shown in table 1, was estimated by Penman Method, and ranges between 3.11 mm/d in December and 7.65 mm/d in April.

Table 1 Mean monthly climatic data during the dry period of Jessore district

Months	Temperature (°C)	Sunshine (hours/d)	Rainfall (mm/d)	Evapotranspiration (mm/d)	Climatic Stress (mm/d)
November	22.9	7.78	1.08	3.83	-2.75
December	18.8	7.69	0.34	3.11	-2.77
January	18.6	7.81	0.39	3.37	-2.98
February	21.0	8.14	0.71	4.41	-3.70
March	25.7	8.08	1.09	5.60	-4.51
April	29.1	8.11	3.19	7.65	-4.46

Climatic Stress and Consumptive Use Factor

Table 2 shows the estimated monthly climatic stress and consumtive use factor of Jessore. The maximum climatic stress occurs in the month of April (-134.10 mm/month) and the minmum climatic stress occurs in the month of November (-82.50 mm/month). The total seasonal climatic stress in the dry period is about -637.67 mm.

Table 2 Estimated mean monthly climatic stress and consumptive use factor of Jessore district

Months	Climatic stress (mm/month)	Consumptive use factor
November	-82.5	14.53
December	-85.8	12.93
January	-92.0	13.03
February	-103.3	14.49
March	-139.8	16.14
April	-134.1	17.46
Seasonal total	-637.6	F=88.58

In this study the data for effective rainfall has not been used, because at the time, the area had received negligible amount of rainfall and at the same time experineced high evapotranspiration. Therefore, the water balance of the area is negative, i.e. climatic stress condition. Because of this, the calculation has been made on the basis of climatic stress instead of effective rainfall.

Consumptive Use and Field Irrigation Requirement

Table 3 presents the estimated monthly Consumptive Use (U) and the Field Irrigation Requirement (FIR) during the dry period of Jessore district. The estimated consumptive use ranges from 12.92 mm/month in December to 17.46 mm/month in April. The estimated FIR ranges from 107.81 mm/month to 168.40 mm/month and the total seasonal FIR is about 806.92 mm.

Table 3 Estimated mean monthly consumptive use (U) and the FIR during the dry period of Jessore district

Months	U=KF (mm/month)	FIR (mm/month)
November	1.0x14.53	107.81
December	1.0x12.92	109.77
January	1.0x13.03	116.77
February	1.0x14.49	130.90
March	1.0x16.14	173.27
April	1.0x17.46	168.40
Seasonal total	88.58	806.92

Table 4 gives us a correlation between the estimated FIR for rice of Jessore district and the standard record ranges (Shaw 1988). The total seasonal standard FIR for rice (which ranges from 500 mm to 950 mm) depends on the respective climatic conditions of the region. The estimated total seasonal FIR for rice in Jessore district is 807 mm.

Table 4 Ranges of seasonal FIR (mm) for rice crop from November to April

Crop	Shaw (1988)	Jessore
Rice	500 – 950	807

CONCLUSIONS

The estimated total seasonal FIR for rice crop of Jessore district is about 807 mm for six months from November to April. Boro rice, which cultivates for four months from December to March, has an estimated total seasonal FIR of about 520.61 mm. It may be mentioned here, that Karim and Akhand (1982) estimated FIR for Boro rice at about 503.60 mm (Table 5).

Table 5 Ranges of seasonal FIR (mm) for Boro rice (4 months duration)

Crop	Karim and Akhand(1982)	This study
Boro rice	503.60	520.61

This study of FIR for Boro rice of the area is a little higher than that of Karim and Akhand's (1982) estimation. This may be due to the changes of some climatic variables of the area which has been reported by Hassan (1995). The estimated results can be useful for the future planning of rice crop in the present dry period of the lowlands of southwest

Bangladesh.

ACKNOWLEGEMENT

Thanks are due to the organizations (BWDB and BMET) of Bangladesh for suppling the essential climatic data. I would like to thank DAAD for fellowship in 1996 and also Prof. Dr. A. Pekdeger, Director, Institute of Applied and Environmental Geology, Free University of Berlin, Germany for scientific discussion on the paper.

REFERENCES

Blaney, H.F. (1952). Definations methods and research data, consumptive use of water: A Symposium. Trans. Am. Soc. Civil Engrs, 117: 949-967.

Blaney, H.F and Criddle W.D. (1950). Determining water requirements irrigated areas from climatological and irrigation data. US. Dept. Agr. Div. Irrigation and Water Conserv. SCS TP 96.

Criddle, W.D. (1952). Irrigated crops consumptive use of water: A Symposium. Trans. Am. Soc. Civil. Engrs. 117: 991-1000.

Hassan, M.Q. (1993). Estimated climatic stress and surplus balance of Southwest Bangladesh. Bangladesh J.Sci.Res. 11(2): 211-215.

Hassan, M.Q. (1995). Changes of some climatic variables: A preliminary study from southwest Bangladesh. Dhaka Uni. J. Sci. 43(1): 35-43.

Karim, Z and Akhand, N.A. (1982). Net irrigation requirement of rice and evapotranspiration of wheat and potato for different locations of Bangladesh., Soil and Irrigation Publ. BARC. 11: 40.

Lee, C.H. (1934). Report of the committee on absorption and transpiration. Trans. Am. Geophys. Union, 15(2): 295-296.

Lowery, R.L. Jr. and Johnson A.F. (1942). Consumptive use of water for agriculture. Trans. Am. Soc, Civil, Engrs. 107: 1243-1256.

Manalo, E.B. (1977). Agro-climatic Survey of Bangladesh. Publ. BRRI and IRRI, Bangladesh/Philippines: 36.

Penman, H.L. (1948). Natural evaporation from open water, bare soil, and grass. Proc. Roy. Soc., London, Ser. A, 139: 120-145.

Raghunath, H.M. (1991). Hydrology. Wiley Eastern Ltd. (4th. ed.) New Delhi: 475.

Shaw, E.M. (1988). Hydrology in Practice. (2nd ed.). Chapman and Hall, London: 539.

Thornthwaite, C.W. (1948). An approach towards a rational classification of climate. Geog. Rev., 38: 55-94.