Assessing Meteorological Data for Reference Evapotranspiration in Kyela and Mbarali District

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Abstract

A study to assess meteorological data for reference evapotranspiration in Kyela and Mbarali District was necessary to equip farmers in ungauged improved traditional irrigation systems with information for improved planning, design and management of hydraulic structures. These systems are managed by farmers through irrigator's organizations thus water depth is an important input in derivation and monitoring flow discharge. The current study estimated Evapotranspiration rate using Penman Monteith method whereby climatic data was obtained from Karonga and Igawa meteorological stations. FAO Climwat – Cropwat 7.0 was used to analyse climatic data, determine Crop Evapotranspiration (ETrice) and estimate irrigation water requirements. The study recommends irrigators in Kyela and Mbarali Districts to utilize results from this study to gauge their irrigation infrastructures and regulate irrigation flows, as depth of water conveyed in the structures

Keywords: Evapotranspiration, hydraulic structures, Irrigation water requirements

1. Introduction

Over the past decades, cross-sectoral water utilization in Tanzania has grown considerably due to rising human populations, increasing food demands and economic activities that require water in their production. At the same time, agriculture has remained the engine of development in the country, employing more than 80% of the total population. Recognizing this, the Government of Tanzania has attached great importance to the development of the Agriculture sector. In order to hasten transformation of Agriculture in the country the Government has adopted a delivery methodology (Big Results Now-BRN) to help achieve Tanzania Development Vision 2025 aspirations, in which irrigated agriculture has an important role to play.

In irrigation BRN intends to develop 78 improved traditional irrigation schemes in the country of which 36 are located in Mbeya region; Mbarali district (34) and Kyela district (2). Recent studies in the Region (Kashaigili et al., 2003; Kayombo, 2016; Lankford and Franks, 2000; Rajabu et al., 2005; SMUWC, 2001 and Sokile et al., 2003) have been concerned with increased benefits for poor people, the environment and other river basin stakeholders by application of new knowledge to enhancement of productivity of irrigation and transference of water to meet other needs. Despite these efforts and investments done by the Government and donor partners, to improve infrastructure in traditional irrigation schemes, less work has been done to capacitate irrigation farmers with information and skills required to ease monitoring water flow rate in ungauged improved traditional irrigation infrastructures. In situations of growing water stress there is a need for improved water resources management to secure and maximize the benefits from water.

The study of evapotranspiration and estimation of irrigation water requirements was necessary to establish a mechanism blue print that can aid irrigators to gauge improved traditional irrigation infrastructures and regulate water flows efficiently. The study has wide applications not only to farmers but scholars as well.

2. Literature

According to FAO (1998) crop evapotranspiration is the consumptive use, commonly known as the sum of Evaporation; Water evaporating from adjacent soil, water surfaces, and surfaces of leaves of the plant or intercepted precipitation and Transpiration: Water entering plant roots and used to build plant tissue or being passed through leaves of the plant into the atmosphere. The subject of evapotranspiration and irrigation water requirements is widely reported in literature (Allen et al., 1998; Doorenbos and Kassam, 1979; FAO, 1977; Hargreaves,1975 and Howell, 1990). Husam Al-Najar (2011) Igbadan et al., (2005) and Smith et al., (2002) used FAO CROPWAT model in estimating crop water requirements for irrigation.

3. Methodology

3.1 Description of the study area

Mbarali and Kyela Districts are located in Mbeya Region, which is situated in the Southern Highlands of Tanzania between Latitude 7^0 and 9^0 31' and between Longitude 32^0 and 35^0 East of Greenwich. The Region borders the Republics of Malawi and Zambia to the South, Rukwa Region to the West, Singida and Tabora Regions to the North and Iringa and Njombe Regions to the East. Climate data was collected from two meteorological stations namely Igawa and Karonga, of Mbarali and Kyela Districts respectively.

3.1.1 Location

Igawa Station is located at latitude 8.760 South, Longitude 34.380 East and Altitude 1070 m.a.m.s.l. Karonga Meteorological Station is located at an altitude 529 m.a.m.s.l., latitude 9.950S and longitude 33.880E.

Kyela District Council is located in the Southern end of Mbeya region and it is one among seven Districts in the region. The district lies between 35^o 41' and 30^o Longitudes East of Greenwich meridian and 9^o25 and 9^o40 Latitudes South of Equator. In the East Kyela District borders with Makete and Ludewa Districts in Iringa region, in the West with Ileje District in the North with Rungwe District in Mbeya Region and to the South Kyela borders with the Republic of Malawi. Mbarali and Kyela District were selected purposefully because they are implementing 36 out of 78 selected irrigation schemes to deliver BRN methodologies.

Mean annual rainfall in Mbarali District is about 800mm in wet years and 450mm in dry years. The rains fall between November and April. The area has a unimodal type of rainfall. The mean daily, maximum and minimum, temperatures range from 280C to 320 C and 9.5 to 19.50C respectively. The highest values are recorded in October and November while the lowest values are experienced in June and July. The mean daily net solar radiation varies from 7.5 MJ/m2/day to 12.3 MJ/m2/day. The average annual evaporation is 1701mm. The total evaporation from July to October when dry season farming takes place is 640mm. The climate of the area, which is typical of Usangu Plain, favors the cultivation of cereals, legumes and vegetables under irrigation during the dry season.

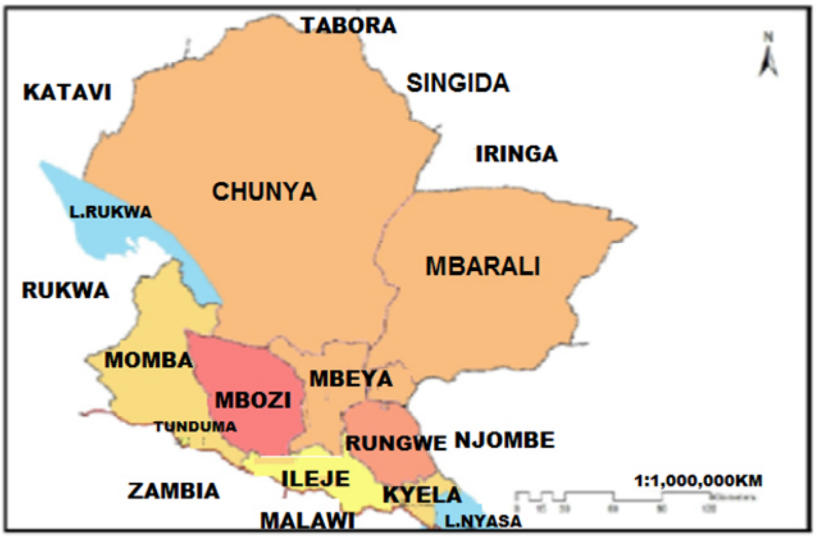

Figure 1: Map of Mbeya showing the study area (Mbarali and Kyela District)

The main rain season in Kyela District is between November and June with a mean annual rainfall between 2000mm and 3000mm. Normally in April and May the District experiences heavy rainfall accompanied with the floods of river Songwe, Kiwira, Mbaka and Lufilyo. The District has a warm and humid climate with a mean daily temperature of 23^{o} C.

3.1.2 Water resources

Mbarali District is located in the Rufiji river basin and has several rivers that originate from the northern slopes of the Poroto Mountains and Chunya Mountains. From the mountains the rivers flow to the Usangu Plains, before joining the Great Ruaha River. Some main rivers include river Mkoji, Meta, Lunwa, Lwanyo, Mambi, Mswiswi, Ipatagwa, Mlowo, Mwambalizi and Gwiri. All the rivers drain the Mkoji Sub-catchment, including the Mkoji River itself. These rivers are perennial upstream of the Tanzania-Zambia Highway, but seasonal downstream of irrigated areas. This is mainly due to dry season irrigated agriculture, which uses all the water that would have kept it flowing during the dry season. Figure 2 shows rivers that drain into the Mkoji sub catchment.

Kyela District is in the Lake Nyasa River basin. Main rivers draining in the basin include Malola River, Mwalisi and Lukuju Rivers (Ilolo plains), Ngugwisi and Ikulu River (Mbeje plain & Ikumbiro plains), Kasyabone river (Mabunga plains), and Ikulu river.Most of these rivers generate from Kaburu Mountains in Kyela and Rungwe mountains.

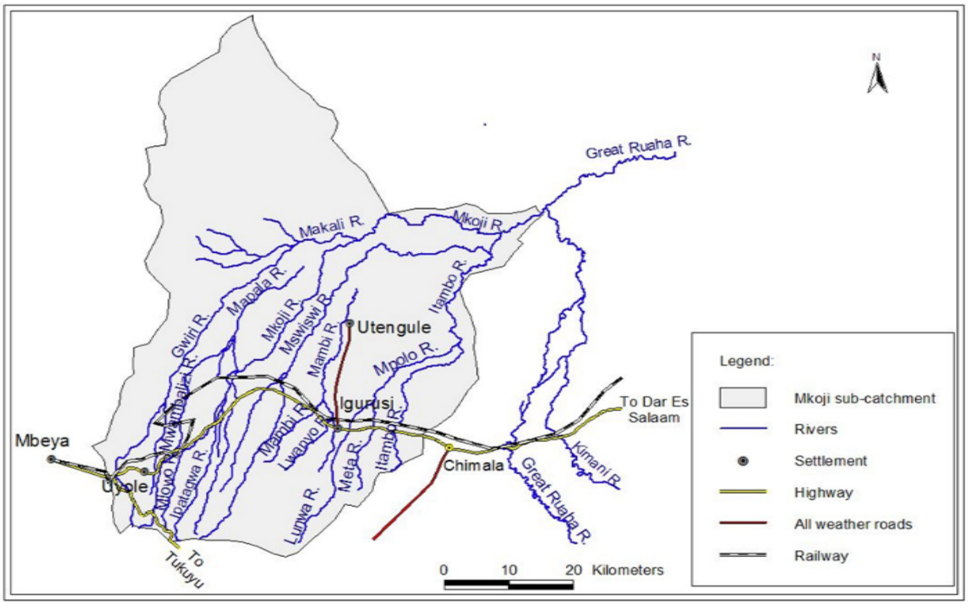

Figure 2: Rivers in Mkoji sub catchment (Mbarali District)

3.1.3 Soil

The soils of the study area are typical of Usangu plain as described in SWMRG (2004). The soil textural class is predominantly sandy clay loam. The mean water holding capacity of the soil is about 100 mm/m.

3.2 Simulation of crop water requirements and water use

The weather data (rainfall, maximum and minimum temperatures, relative humidity, wind speed and sunshine hour data) obtained from the weather stations was input into the FAO CROPWAT model version 4.2 to generate the crop water requirements and crop water use (actual evapotranspiration) for each crop and for each cropping seasons. The FAO CROPWAT model was adopted for this study because it is simple to use and the default crop input parameters are widely applicable.

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For the crop under study (Rice), the crop parameters required as input data in the model, which include crop coefficient (Kc), rooting depth and depth of moisture extraction, were taken as the default data for the respective crops in the CROPWAT model. The other crop parameters, which include planting dates and length of crop growing period for each crop, were adjusted to the cropping calendar in the study area. The cropping calendar for the crops, especially planting dates was dictated by the period of the onset of rains, which varies from third decade of November to second decade of January. For the purpose of simulation, the planting dates for the crops were assumed to be from the period when the rainfall is established. In general, most of the rain-fed crops are planted between the first decade of December and the first decade of January in the district, depending on when rainfall is established and the soils soft enough for tillage. Assumption on date of planting had to be made because there were no records on exact dates the crops were planted.

4. Results

Improved tradition irrigation systems in Mbarali and Kyela were equipped with improved infrastructures including intake weir and main conveyance and regulatory infrastructures which are prerequisites to facilitate effective water control. The intent is to share water among users and uses whereby the current study envisages establishment of optimum amount of water required at the head of the canal, in the main conveyance system and applied in the fields to be vital. In order to establish values for net irrigation requirement the current study made use of climate data from reliable meteorological stations, crop grown (rice) and soil type (sandy clay loam).

4.1 Effective Rainfall

Results in Figure 1 show that in Kyela and Mbarali District rainfall starts in November and continues upto May. The rainy season is longer than the dry season; it covers 58% of the year. Heaviest rainfall generally occurred between the months of December and March, whereby peak monthly record was 206mm which was observed in Kyela District in March. The mean annual rainfall for Kyela District was 66.6mm and that for Mbarali district was 56mm out of which 76.9% of the rainfall was effective. This implies 23.1% of rainfall was lost through surface runoff and deep percolation. Furthermore results show that driest months are June to October. The rainfall amounts as well as the onset of the rainy season can vary considerably from year to year. The mean coefficient of variation is about 23 % for the both Mbeya District and Kyela District. This variation often has detrimental effect on crop production and other activities that depend on the reliable availability of water, especially in the drier areas.

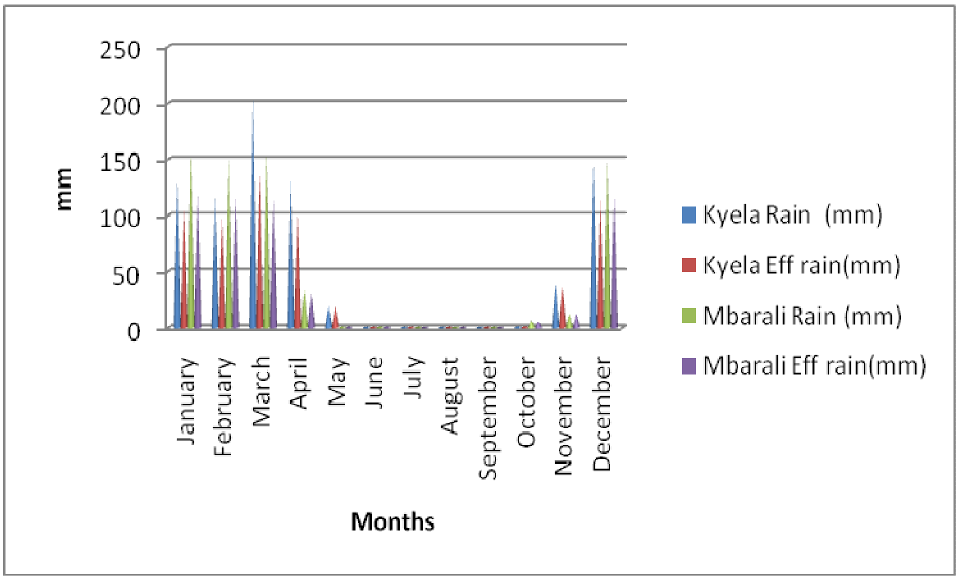

Figure 3: Rainfall in Kyela District and Mbarali District

4.2 Cropping Pattern

Paddy is the main crop during the rainy season. It is usually planted in December after onset of the rains, by broadcasting. Only few farmers transplant paddy in this area. Varieties commonly grown are Kilombero, Rangi Mbili, Morogoro and Zambia. Some farmers use fertilizers while others do not. The fertilizers used are Minjingu Rock Phosphate (MRP) and Di-ammonium Phosphate (DAP) for basal application and urea for topdressing. Paddy is normally harvested in May with an average yield of paddy of about 2.3t/ha. During the study it was observed that the cultivated area ranged between 63% and 100%.

4.3 Reference crop evapotranspiration (ETo)

Figure 2 shows the combination of two separate processes occurring in the two Districts, whereby water is lost on the one hand from the soil surface by evaporation and on the other hand from the crop by transpiration; evapotranspiration (ET). According to FAO (1998) Evaporation is the process whereby liquid water is converted to water vapour (vaporization) and removed from the evaporating surface (vapour removal). Transpiration consists of the vaporization of liquid water contained in plant tissues and the vapour removal to the atmosphere. Crops predominately lose their water through stomata. These are small openings on the plant leaf through which gases and water vapour pass.

The results show that mean Evapotranspiration (ETo) for rice cropping season (December – March) was 4.65mm/day for Kyela District and 4.54mm/day for Mbarali District. This explains that the ETo for Kyela District was higher than that for Mbarali District by 20.4%. The only factors affecting ETo are climatic parameters; these include water availability in the topsoil; the evaporation from a cropped soil is mainly determined by the fraction of the solar radiation reaching the soil surface. This fraction decreases over the growing period as the crop develops and the crop canopy shades more and more of the ground area. When the crop is small, water is predominately lost by soil evaporation, but once the crop is well developed and completely covers the soil, transpiration becomes the main process.

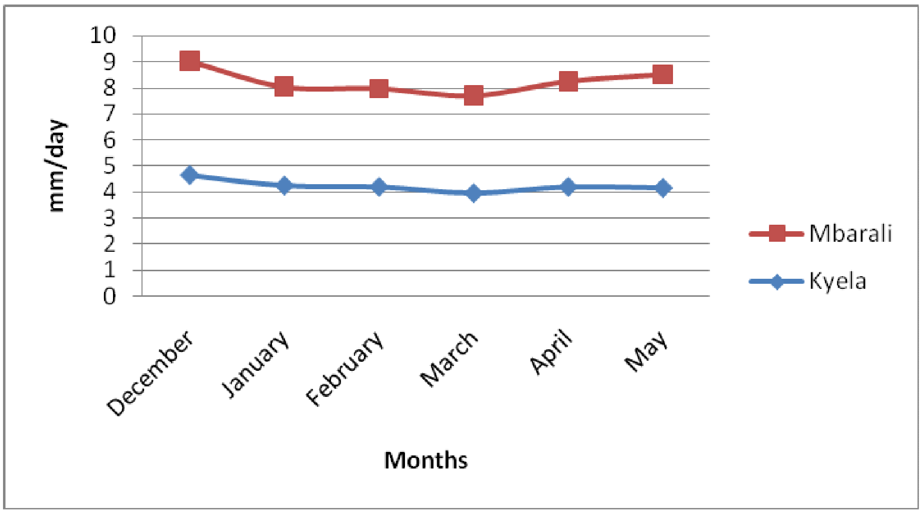

Figure 5: Mean ETo for Kyela and Mbarali district

4.4 Rice Evapotranspiration

The crop evapotranspiration (ET_{crop}), under standard conditions, is the evapotranspiration from disease-free, well fertilized crop, grown in large fields, under optimum soil water conditions, and achieving full production under the given climatic conditions (FAO, 1977 & FAO, 1998). Results in Figure 3 show ET_{rice} for Kyela District ranged from 4.02mm/day to 4.73mm/day with a mean of 4.38mm/day, while ET_{rice} for Mbarali District ranged between 4.12mm to 4.42mm with a mean value of 4.24mm/day. Observed mean ET_{rice} values were higher in Kyela District than Mbarali District. The highest ET_{rice} values in the two districts were observed in

December, when the crop was in initial to development stage. These stages take a total of 60 days; 30 days for initial stage and 30 days for development stage (FAO, 1998).

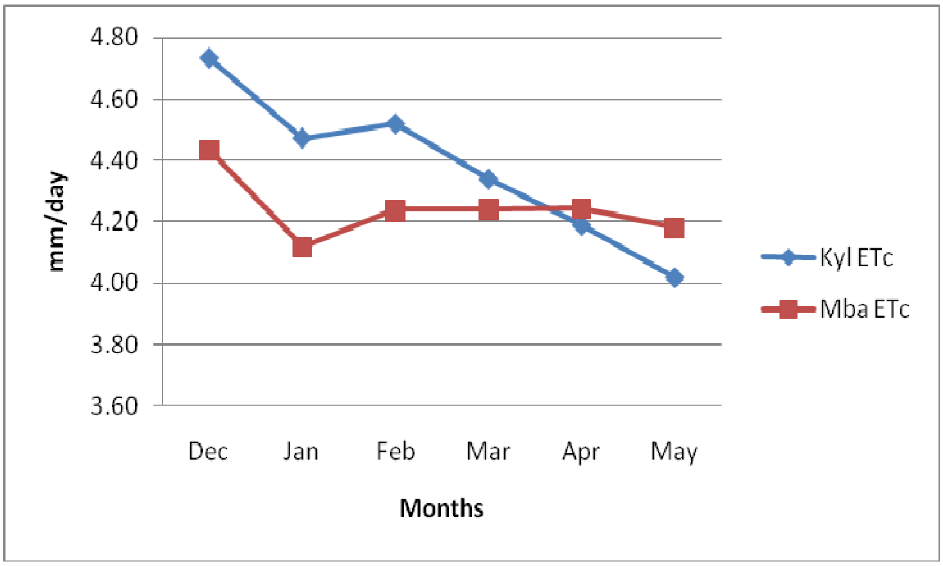

Figure 6: ET_{rice} for Kyela District and Mbarali District

4.5 Irrigation Water Requirements

Water requirement of a crop refers to the total quantity and the way in which a crop requires water from the time it is sown to the time it is harvested. FAO (1998) defined this as the difference between the crop water requirement and effective precipitation. The irrigation water requirement also includes additional water for leaching of salts and to compensate for non-uniformity of water application. Results in Figure 3 show the net and gross irrigation water requirement for development of paddy in Kyela District and Mbarali District. The mean net irrigation water requirements are 407mm and 425mm and gross irrigation water requirements are 41.5mm and 40.5mm for Kyela District and Mbeya District respectively.

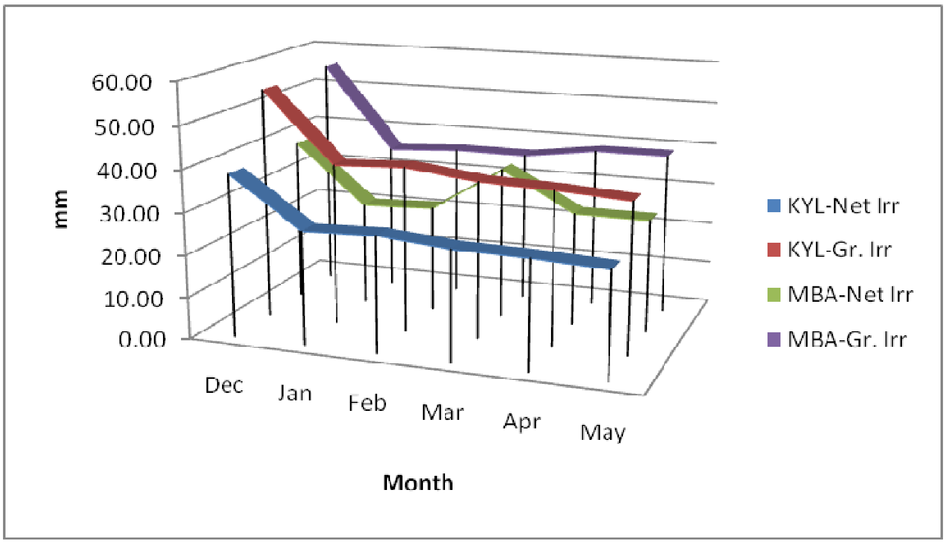

Figure7: Net and Gross Irrigation Water Requirements

5. Conclusion

The current research has proposed irrigation water requirements for Improved Traditional Irrigation Schemes in Mbarali and Kyela Districts with the aim of contributing to the National efforts to hasten transformation of Agriculture in the country through adoption of Big Results Now delivery methodology to help achieve Tanzania Development Vision 2025 aspirations. The aim was to provide context based knowledge familiarized result to irrigators. The future irrigation generation will be knowledge oriented, and to meet development strategies knowledge on Irrigation Water Requirements is a promising solution. The results presented wind up that gross irrigation water requirement for optimum production of Paddy in Kyela District is 192.02mm and that for Mbarali District is 240.42mm. The results may be used as a guide to farmers to help them regulate water flows for improved performance and sustainable productivity.

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