Availability of Surface Water-Use and Irrigation in Zambia

Barnabas Mulenga*, Takao Nakagiri*, Haruhiko Horino*
and Yoshihiko Ogino*

I Introduction

The objective of this paper is to provide an estimate of the potential surface water-use availability for development of irrigated agriculture in Zambia. Development of sustainable irrigation has become an imperative in-order to cushion the impact of droughts that have increasingly become more persistent, acute and disruptive of traditional rain-fed agriculture. Currently, 70% of natural water resources remain untapped and only 28% of the potential available has been harnessed for hydroelectricity power generation.

II Reliability and Limitations of Rain-fed Crop Production

In the recent past, droughts have caused unprecedented decline in rain-fed crop production as the population and food demand increase. The country's population stands at 11 million and increasing at an annual rate of 3.2%. As rain-fed crop production continue to decline, the gap between demand and supply also continue to widen thereby necessitating irrigation intervention in-order to ensure national and household food security. **Figures 1** and **2** show declining staple dietary crop production trend and related national annual consumption requirement and daily per capita calorie intake disparities.

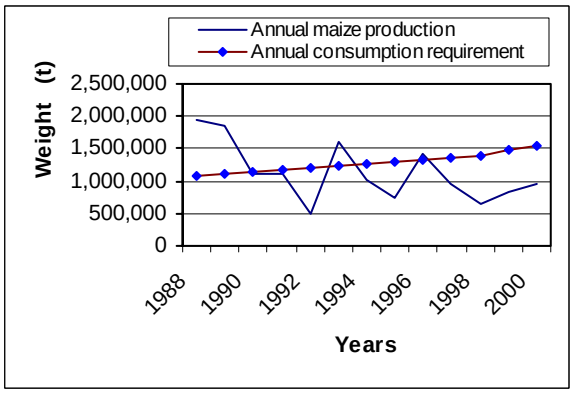

Figure 1 Production trend of staple dietary maize crop

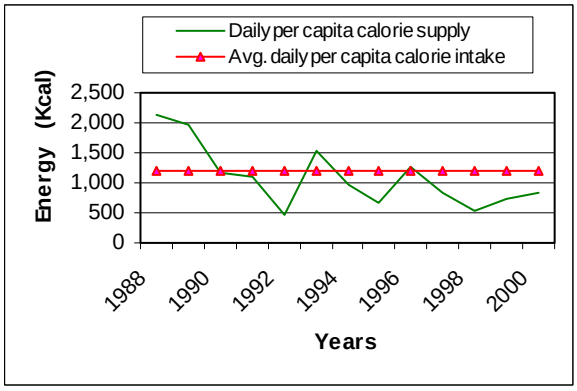

Figure 2 Daily per capita calorie supply

It is evident that as the economy grows and the population increases, a point has already been reached at which rain-fed crop production cannot meet the annual food consumption requirements and is therefore no longer a reliable form of crop production.

III Assessment of Surface Water-Use Availability

Surface Water-Use Availability based on the Intake Rate Potential (IRP)

In this study, IRP was employed in the estimation of water availability for the "worst case scenario" based on direct river flow abstraction and dry season minimum flow conditions. This is at the peak of the dry season, when all seasonal streams, country wide, are dry and the rainfall is nil thereby discounting any flow contribution from these sources. IRP is the discharge that can be abstracted from a river without constructing a water storage facility assuming that the water-use discharge and the discharge necessary to maintain the normal functions of river flow are accounted for. The probable minimum discharge for a 30-year

*Graduate School of Agriculture and Biological Sciences, Osaka Prefecture University
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return period was assumed as the maintenance discharge. This is the amount required to maintain river water depth, ecosystem and ground water conservation as well as recreation. The assumption is reasonable based on the fact that the utilization percentage of rivers in Zambia is still so low that even the minimum flow is considered to be good for environmental management. The water-use discharge is the flow necessary for the exclusive use of river flow at all points downstream. This was estimated based on analysis of domestic demand for both urban and rural areas and calculated from the population projection and assumed per capita consumption rates. Industrial and agricultural water-uses were estimated from the results of questionnaire surveys and analysis of water rights records over 10 years. The following equations were used to estimate IRP based on the maintenance discharge and actual water-use amounts:

$$Q_p = Q_{ds} - Q_c \quad \text{.....(1)}$$

where Q_p is the Intake Rate Potential, Q_{ds} is the dry season minimum discharge and Q_c is the compensation discharge.

The compensation discharge is given by the following equation:

$$Q_c = Q_m + Q_u \quad \text{.....(2)}$$

where Q_m is the maintenance discharge and Q_u is the water-use discharge

Table 1 shows the availability in-terms of IRP and the extent of the imbalance in surface water utilization. Despite being third in size in-terms of volumetric discharge the Kafue River has the highest percentage of water-utilization and the lowest IRP. The river serves the two most populated and urbanized provinces in the country with mining industries and commercial farms.

Table 1 Estimates of IRP for major rivers in Zambia

River Basin	Avg. recorded min. flow (m^3/s)	Maintenance discharge (m^3/s)	Water-use discharge (m^3/s)	Intake Rate Potential (m^3/s)
Zambezi	295	218	6.18	70.82
Kafue	52	20.5	42.51	-11.01
Luangwa	44	16.4	12.07	15.53
Chambeshi	37	28.05	7.0	1.95
Luapula	141	32	8.75	100.25

(-) indicates insufficient river flow to satisfy the given minimum flow condition criteria

IV Discussions and Conclusion

This study confirms that water is evidently available in the main rivers to the extent of even satisfying the "worst-case scenario" with the exception of the Kafue River due to its high water-use percentage. The imbalance is so great that evidently, water stress related problems in the Kafue River basin are in existence particularly during low flow periods. The results further indicates that direct water abstraction from the Kafue River is limited and so construction of water storage facilities is necessary in-order to adequately satisfy both the maintenance and the water use discharges. While the country's surface water potential is high, the potential in the dry season is significantly lower more so if water resources are not developed in the future when demand increases. Based on the results of this study, inter-basin water transfer and/or construction of water storage facilities are proposed to ensure sustainable future development and to avoid potential adverse environmental and social-economic consequences. Inter-basin water transfer is proposed based on the relatively short distance of 75 km between the Luapula River and the upstream part of the Kafue River and the respective highest and lowest IRP of the rivers. Inter basin water transfer can be a viable alternative to augmenting the flow in the Kafue River in-order to maintain the required flow security to sustain all users now and in the future. However, other factors must also be permissible since the Luapula River is an international river. At present the bulk of the country's water flows out towards the sea.

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Abstract Rain-fed crop production in Zambia has been on the decline due to frequent droughts thereby necessitating irrigation intervention. This paper assesses potential surface water-use and provides a case for irrigation development based on quantified estimate of surface water-use availability based on the Intake Rate Potentials (IRP). IRP is estimated for minimum flow conditions based on minimum river flows, drought discharge and maintenance and water-use discharges up to the downstream. The results of this study show the availability and extent of the imbalance in surface water utilization. The need for irrigation intervention is illustratively underscored. Hence, proposals for inter-basin water transfer and/or construction of water storage facilities are made to ensure sustainable future development and to avoid potential future adverse environmental and social-economic consequences as demand gradually increases.