CONSIDERING SEASONAL ENVIRONMENTAL WATER REQUIREMENTS IN WATER RESOURCES ASSESSMENTS IN SRI LANKA

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INTRODUCTION

Emerging freshwater scarcity has been recognized as a global issue of the utmost importance. There is a growing awareness that increased water use by humans does not only reduced the amount of water available for future industrial and agricultural development, but also has a profound effect on aquatic ecosystems and their dependent species (Vorosmarty et al. 2000). The utilizable amount of the water resources in the river is represented by the difference between the total water availability and the Environmental Water Requirement (EWR). By comparing estimates of the total resource capacity with estimates of the EWR and actual total water withdrawals, the regions in which human water use conflicts with the maintenance of functional ecosystems could be identified (Smakhtin et al., 2004). Previous studies have estimated the mean total annual volume of water that should be allocated for environmental purposes. However, the seasonal variability of Environmental Water Requirement (EWR) for aquatic ecosystems have not been considered explicitly in the past water resources assessments. It is, however, critically important in water resources assessment because certain volume of water is needed for the maintenance of freshwater ecosystem, mainly depend on the seasonal flow characteristics and other water use. This study aims to summarize the seasonal and spatial variability of the total water volumes required for such purpose in Sri Lankan river basins.

METHOD

The spatial characteristic of the basins is described by three base maps, i.e. land use, elevation and soil, which were derived respectively from the Landsat Enhanced Thematic Mapper (ETM+) images, the Suttle Radar Topography Mission (SRTM) digital elevation model and generalized soil map of Sri Lanka. Daily meteorological stations' data from Meteorological Department, Sri Lanka was used as precipitation and temperature and daily river discharge data from Irrigation Department, Sri Lanka was used to calibrate and validate the distributed hydrological model.

A distributed hydrological runoff model developed by Kashiwa et al. (2010) under the structure proposed by Kazama et al. (2004) was modified to estimate the surface runoff in Sri Lanka. The validated distributed hydrological model was employed to simulate natural runoff for the period 1975 -2004 at a spatial resolution of 1 km x 1 km.

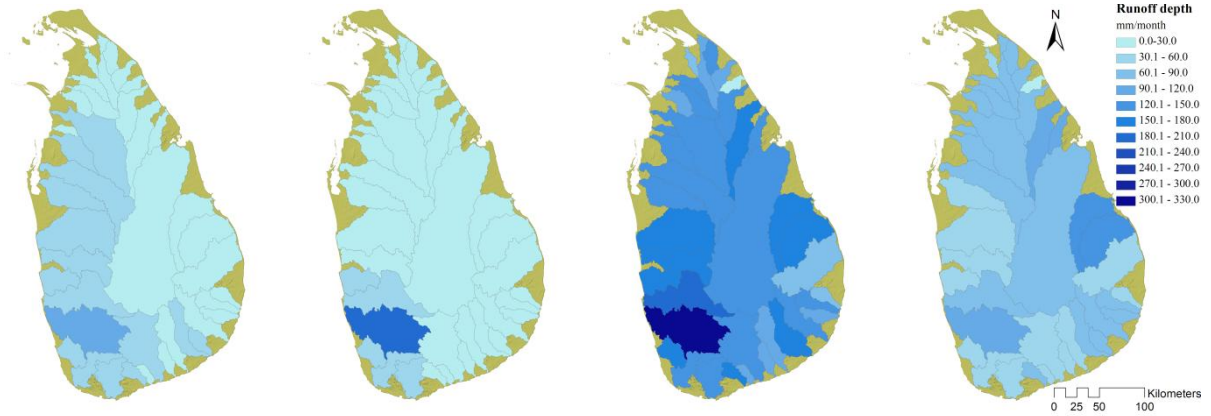
CALCULATION OF ENVIRONMENTAL WATER REQUIREMENT

According Smakhtin et al. (2004), basins with highly variable flow regimes have a larger proportion of the total annual flow during the wet season, which typically lasts for one to three months. During the dry period, variable-flow rivers may have very low discharges or go completely dry. Estimations of the total EWR for these basins or regions will most likely be dominated by estimates of the environmental High Flow Requirement (HFR). The annual total flow in basins with stable flow regimes is determined by the Low Flow Requirement (LFR), which continues through most of the year with a relatively small flow increase during the wet seasons. The method developed by Smakhtin et al. (2004) was modified and used to compute EWR for four different monsoon seasons, 1st Inter (March – April), Southwest (May – September), 2nd Inter (October – November), Northeast

Table 1 A conceptual rule for estimating the environmental high flow requirement

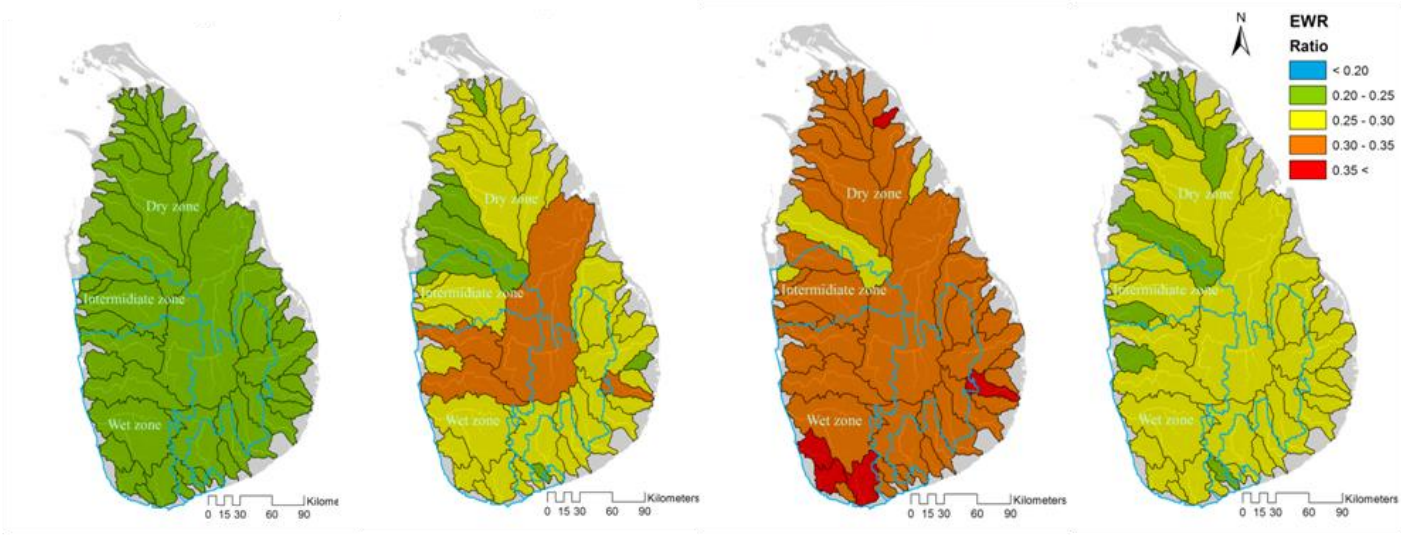
Low Flow requirement (Q90)	High Flow Requirement (HFR)
If Q90 < 10% MSR	Then HFR = 20% MSR
If 10% MSR ≤ Q90 < 20% MSR	Then HFR = 15% MSR
If 20% MSR ≤ Q90 < 30% MSR	Then HFR = 7% MSR
If Q90 ≥ 30% MSR	Then HFR = 0

Note: MSR – Mean Seasonal Runoff



(a) 1st Inter monsoon (b) Southwest monsoon (c) 2nd inter monsoon (d) Northeast monsoon

Figure 1 Spatial variation of area-average mean monthly river runoff depth at each monsoon season



(a) 1st Inter monsoon (b) Southwest monsoon (c) 2nd Inter monsoon (d) Northeast monsoon

Figure 2 Spatial variation of seasonal Environmental Water Requirement (EWR)

(December- February) using simulated daily natural runoffs. The total EWR is assumed to consist of ecologically relevant low and high-flow components. Both components are related to river flow variability. The LFR was assumed to be equal to the daily flow, which has exceeded 90% of the time on average throughout a season (Q90). The HFR was approximated by a set of thresholds linked to the different LFR levels (Table 1) proposed by Smakhtin et al. (2004). EWR by 39 selected river basins in Sri Lanka was calculated for each precipitation season and presented as a percentage of seasonal mean monthly runoff volume.

RESULTS AND DISCUSSION

The computed area-average seasonal runoff depth using 30 years simulated natural runoff shows higher runoff volume during 2nd inter and northeast monsoons by all selected basins, whereas dry zone's basins are running dry at the southwest monsoon (Figure 1). As shown in Figure 2 the computed seasonal Environmental Water Requirement by each river basin show a higher percentage of seasonal runoff volume available for aquatic ecosystem during 2nd inter monsoon as a result of the high percentage of LFR due to stable stream flow characteristics. The all selected river basins show the less percentage of seasonal runoff for EWR during the first inter monsoon because of none stable flow characteristics, HFR contributes a high percentage to the total EWR during dry seasons of the year. It is obvious that spatial and seasonal variation of EWR is existed and its varied between 20% to 35% of the seasonal runoff volume of respective basin. This percentage agrees with the country annual EWR values published by Smakhtin et al. (2004). In this study, the EWR calculation only accounted for the natural hydrological conditions. However, the calculation could expand to include additional factors, such as cultural and economic perspectives. Because of the unavailability of detailed information about these potential variables, the EWR calculations were limited to natural hydrological conditions. The past water resources assessment index has been used annual EWR for the aquatic ecosystem in their calculation. However the water resources assessment on sub annual scale have to consider the seasonal variation of EWR allocation by each river basin.

CONCLUSIONS

Our study explicitly considers the difference in the availability of water between the different precipitation seasons of the year. Available water for aquatic ecosystem during the dry season of the year is limited. It is clear that the allocation of seasonal EWR by each river basin for aquatic ecosystem is varied based on available water volume and flow characteristics. Hence it should be considered the spatial and seasonal variability of EWR in the water resources assessment for sustainable water management. Further studies are needed to assess the allocation of EWR under extreme condition such as prolonged multi-annual droughts.

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REFERENCES

Kazama, So., Hyejin, Ku., Sawamoto, M. (2004). Uncertainty of morphological data for rainfall-runoff simulation. Proceedings of the International Conference on sustainable Water Resources Management in the Changing Environment of the Monsoon Region, 1, pp. 400-406

Kashiwa S., Asaoka Y., Kazama A: Flood analysis Modeling of snow melting and Estimation, proceedings of the rivers Technology, Volume 16, pp.289-294, 2010.

Smakhtin, V., Revenga, C., Döll, P., 2004. Taking into account environmental water requirements in global-scale water resources assessments, Colombo, Sri Lanka : International Water Management Institute, Comprehensive Assessment Research Report 2.

Vörösmarty, C.J., Green, P., Salisbury, J., Lammers, R.B., 2000. Global water resources: vulnerability from climate change and population growth. Science 289 (5477), 284–288.