

SPATIAL AND TEMPORAL VARIABILITY OF SURFACE WATER FLOW IN SRI LANKA

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INTRODUCTION

Sri Lanka is blessed with 103 small and medium rivers, collecting about 52 billion cubic meters (bcm) of annual surface runoff in a geographic area of 65,000 km². In per capita terms, Sri Lanka is well above the generally accepted national water scarcity threshold of 1,700m³/person suggested by Falkenmark et al (1989) since the current average annual runoff is about 2,800 m³/person. However at the local scale already three districts (Colombo, Puttalam and Jaffna) are within the national water scarcity threshold as Sri Lanka's freshwater availability varies significantly across river basins and rainfall seasons. Many drivers including demographic pattern, economic growth and consumption pattern contribute to an increase and vary spatial and temporal water demand, have changed significantly since the early 1990s. Further, recently inconsistency of seasonal monsoon weather patterns has a major influence on surface water availability and management system in the country. Hence it is timely requirement to analyze the inter-annual and intra-annual spatial and temporal variability of surface water flow under seasonal monsoon patterns in the Sri Lanka.

STUDY AREA

Sri Lanka is the tear-dropped shaped island (Fig. 1) off the southwest coast of India in the Indian Ocean. The topography of the land surface varies from very shallow along most of the coastline, flat and rolling hills in most central parts, to the highlands in the south-central part. Reddish Brown Earth (Dry zone) and Red Yellow Podzolic (Wet zone) are the two major soil types which covers more than 80 percent of the land. Agricultural lands dominate 40 percent of the land cover while more than 30 percent covered by thick forest.

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 Shuttle 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. In this model, flow estimation is calculated by a combination of direct flow and base flow model. Direct flow is calculated with the kinematic wave method and base flow is calculated with the storage function method. River flow is also calculated by the kinematic wave method. Governing equations for the model and model structure were further detailed by Kashiwa et al. (2010).

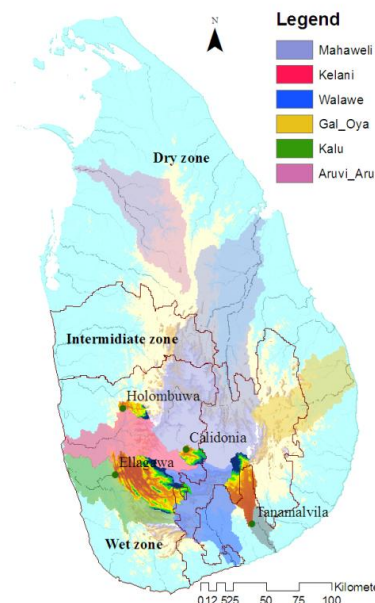


Fig. 1: Calibrated and validated catchment and selected river basins

Daily potential evapotranspiration was calculated by Hargreaves equation. Daily rainfall and potential evapotranspiration spatial data were developed by inverse distance weighted interpolation method. The model was calibrated (2006-2007) and validated (2010-2011) to four different catchments (Calidonia, Ellagawa, Holombuwa, Tanamalvila) as shown in Fig. 1 representing different climatic zones and soil types. Surface runoff was simulated for four different years (1974,1984,1994,2011) using spatially dispersed validated model's parameters based on soil and land use data. Seasonal surface runoff volume was calculated for six different basins (Mahaweli, Walawe, Kalu, Kelani, Gal Oya and Aruvi Aru) as shown in Fig. 1.

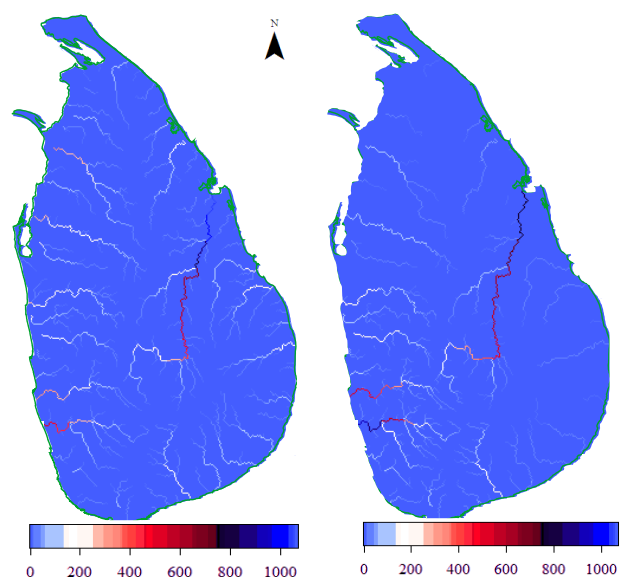


Fig. 2: Spatial variability of average (1974,1984,1994,2011) seasonal surface runoff (m³/s), minimum - 2nd Inter monsoon (left), maximum - Southwest monsoon (right)

RESULTS AND DISCUSSION

As shown in Fig. 2 minimum and maximum spatial variability of seasonal surface water flow can be seen respectively during 2nd inter monsoon (October – November) and southwestern monsoon (May – September). River discharge in basins, completely located in the wet zone of the country (Fig. 3, Fig. 4) show low temporal changes whilst basins in the dry zone (Fig. 5, Fig. 6) show a greater temporal variation. Further Mahaweli and Walawe rivers' hydrographs (Fig. 7, Fig. 8) show also a shortage of runoff during southwestern monsoon for all the years. Most of the river basin in the dry zone is seasonal and their surface water flow is mostly limited to 2nd inter and northeastern (Dec – Feb) monsoons. In addition, Surface runoff volume generation during 1st inter monsoon (March – April) shows a general decrease towards the present while it recover by 2nd inter monsoon in dry zone's basins. But the river basin in Wet zone does not show significant inter-annual changes. Aruvi Aru and Gal Oya basins are well above the annual national water scarcity threshold due to less population but temporal variability is the main constraint. Mahaweli and walawe are the main river basins to facilitate dry zone's agricultural water demand and water

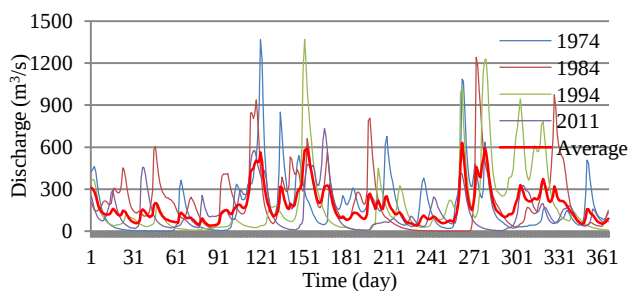


Fig 3: Temporal variability of discharge -Kalu river

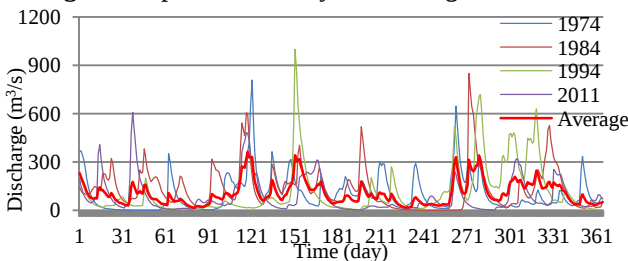


Fig 4: Temporal variability of discharge -Kelani river

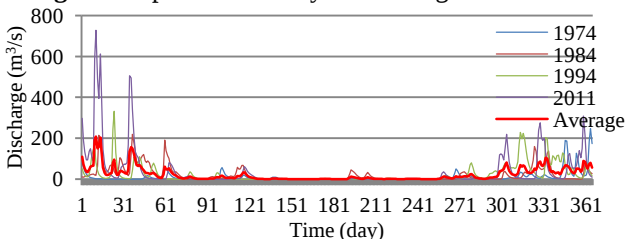


Fig 5 : Temporal variability of discharge –Gal Oya

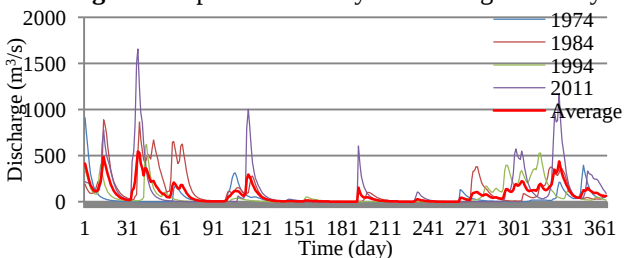


Fig 6 : Temporal variability of discharge – Aruvi Aru

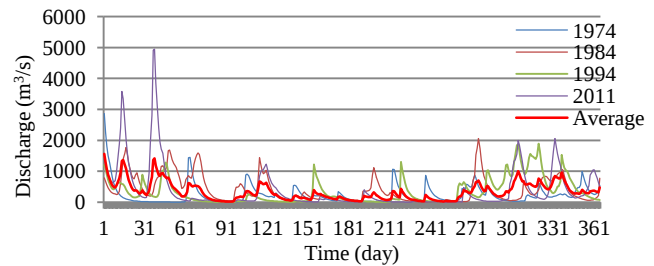


Fig 7: Temporal variability of discharge - Mahaweli river

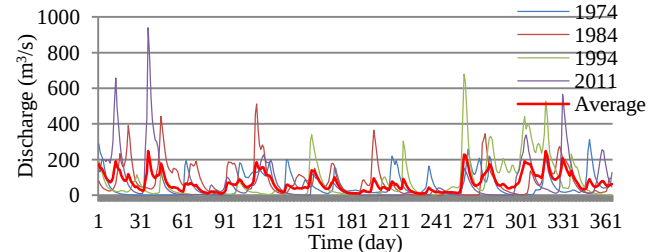


Fig 8: Temporal variability of discharge - Walawe river

shortage during the southwest monsoon affect continuous water supply. Per capita term, Kelani basin (totally located in the wet zone) is under the accepted national water scarcity threshold by 2011 due to higher population density.

CONCLUSIONS

The monsoon rainfall pattern has a major influence on water availability within the country and highest spatial variability can be seen during the southwestern monsoon. Highest temporal variability of surface water flow can be seen in river basin located in dry zone but Mahaweli and Walawe river basins are located in wet and dry zone both and facilitate water demand in the dry zone during southwestern monsoon. Per capita term, Kelani river basin under the national water scarcity threshold. Hence a proper understanding of quantitative inter-annual and intra- annual spatial and temporal variability of surface runoff will help to get advanced measures to overtake water shortage by storing water during rainy seasons in the dry zone and divert excess water from water rich basins to dry zone's basins.

ACKNOWLEDGMENT

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