21. THE IMPACT OF SEASONAL RAINFALL VARIABILITY ON SPATIAL AND TEMPORAL PATTERN OF SURFACE WATER FLOW IN SRI LANKA

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Spatial and temporal pattern of surface water flow over the seasonal rainfall was evaluated in this study. Daily surface runoff for four different years was simulated by a validated hydrological model. Temporal variability of surface runoff was analyzed for six different basins representing different climatic zones. Results show that spatial variability of runoff during southwest monsoon is most significant. Basins located in the dry zone of the country are seasonal and mainly runoff generates during 2nd inter and northeast monsoons. In addition, Surface runoff volume generation during 1st inter monsoon shows a general decrease towards the present while it recover by 2nd inter monsoon in dry zone's basins.

Key Words: *Spatial and temporal, monsoon, hydrological model, climatic zone, surface water flow*

1. INTRODUCTION

Water needs to be protected and used in a sustainable way as the enough fresh water resources available for the humans in a changing climate is one of great challenge faced by global modern society [7,5)]. In per capita terms, Sri Lanka is well above the generally accepted national water scarcity threshold of 1,700m^3 /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 103 distinct river basins and four rainfall seasons. The seasonal rainfall variation over Sri Lanka is basically determined by the Monsoon regime and coincides with a major change in the wind field together with the southward and northward shift of the Intertropical Convergence Zone[3)]. The seasonal rainfall variation is conventionally expressed by two main climatic seasons, namely Southwest monsoon (mid–May to September) and Northeast monsoon (December to February) while two inter-monsoons, namely 1st Inter-monsoon (March to mid-May) and 2nd Inter-monsoon (October to December) appear in between two main monsoons [2)]. Combination effects of wind and topography have marked influence on large spatial and temporal variability of rainfall over the country. Further, 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 [1)].

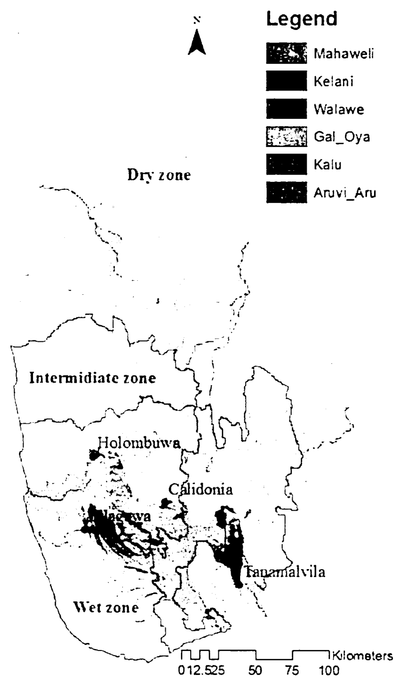

Fig. 1: Calibrated and validated catchment and selected river basins

2. 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 cover 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.

3. 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.[6)] under the structure proposed by Kazama et al.[4)] 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).

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, and 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**.

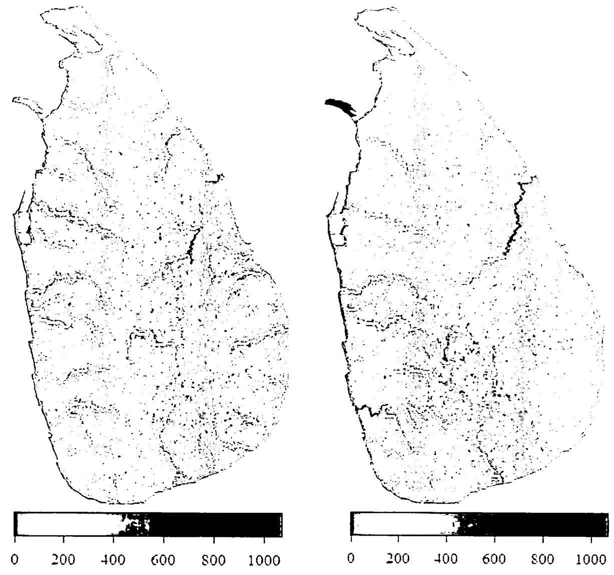

Fig. 2: Spatial variability of average (1974, 1984, 1994, and 2011) seasonal surface runoff (m^3/s), minimum - 2nd Inter monsoon (left), maxiumu - Southwest monsoon (right)

4. 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 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 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.

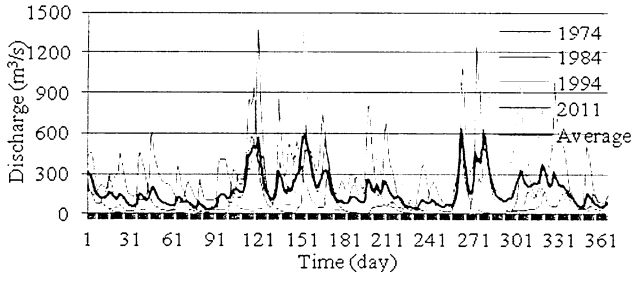

Fig 3: Temporal variability of discharge -Kalu River

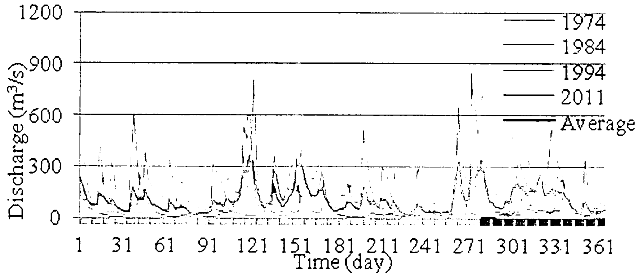

Fig 4: Temporal variability of discharge -Kelani River

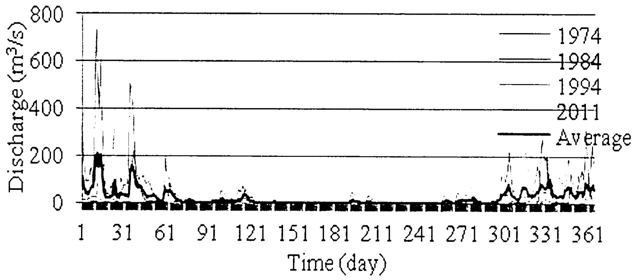

Fig 5 : Temporal variability of discharge – Gal Oya

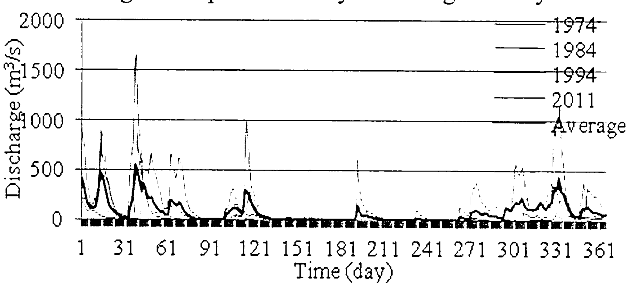

Fig 6: Temporal variability of discharge – Aruvi Aru

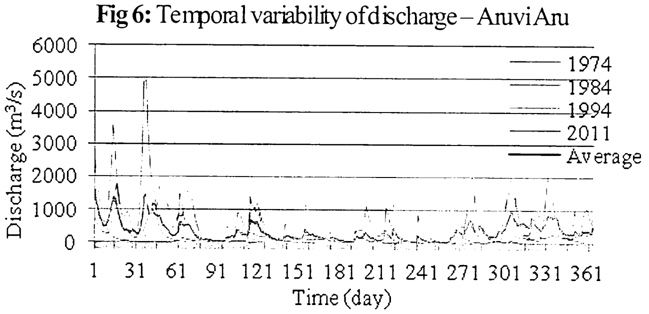

Fig 7: Temporal variability of discharge - Mahaweli River

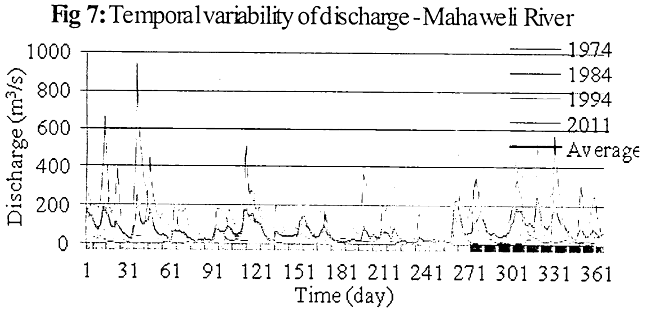

Fig 8: Temporal variability of discharge - Walawe River

5. 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 south western 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.

6. ACKNOWLEDGMENT

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