# DEVELOPMENT OF HYDROLOGICAL MODEL TO SIMULATE SURFACE WATER FLOW IN SRI LANKA

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## INTRODUCTION

Water needs to be protected and used in a sustainable way as water demand is an extremely increasing. Domestic, agricultural, hydro power and industrial water requirement in the country is mainly met by surface water body (rivers). It is important to assess the spatial and temporal variation of the river flow for proper water resources management since it is under stress over the erratic monsoon rainfall.

Distributed hydrological models are a competent tool to analyze a hydrological process and response prediction in watershed. Models capability has greatly improved in last decades to analyze the spatial and temporal variation of runoff. Present study simulates the surface runoff of the country using Distributed Hydrological Model and analyzes the spatial and temporal variation over the seasonal rainfall.

## STUDY AREA AND DATA

Sri Lanka, the tear-dropped shaped island off the southeast coast of India in the Indian Ocean, occupies an area of  $65,610 \text{ km}^2$ . 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. Agricultural lands dominate 40 percent of the land cover while more than 30 percent cover by thick forest.

Sri Lanka is rich with 103 small and medium rivers radially flow starting from central highland (**Fig.1b**), collecting about 44 billion cubic meters (bcm) of annual surface runoff with high spatially deviated average annual rainfall (900mm in dry zone and more than 2500mm in wet zone) (**Fig.1a**). However, underneath the aggregate statistics, there lies a stark spatial and temporal variation of surface water flow, which is generally a common feature in countries with arid to semi-arid to humid tropics (Amarasinghe et al. 2005). In fact, Sri Lanka's freshwater availability varies significantly across river basins and rainfall seasons.

Global summary of the daily Rainfall data from NOAA's National Climatic Data Center (NCDC) which collect from Sri Lankan rainfall stations is used as precipitation data. SRTM GRID 90m and Landsat 7 ETM+ remote sensing data were used respectively for elevation and land use derivation.

#### **METHOD**

Distributed runoff model was 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 considered three reservoirs: Subsurface reservoir, a groundwater reservoir, and a third one to account for snowmelt contribution (not consider in this study). The 1000m x 1000m grid size mesh is used for data input and calculation. Flow estimation is calculated by



Fig. 1: (a) Average annual rainfall (b) River Basins

combination of direct flow model 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 kinematic wave method. Flow direction is determined with elevation data and land use data. Concept for calculation (**Fig. 2**) and governing equations for model are as follows;

# Kinematic Wave;

$$\frac{\partial A}{\partial t} + \frac{\partial Q}{\partial x} = (R - R_{in})B$$

$$Q = \frac{1}{n}Bh^{5/3}I^{1/2}$$
(2)

Here, A is the cross section of water  $(m^2)$ , Q is the flow rate  $(m^3 / s)$ , B is a mesh width (m), R is rainfall (m / s), R<sub>in</sub> is the amount of penetration (m / s), t time (s), x is the distance between the flow direction (m), h is water depth (m), I is the gradient flow, n is the Manning roughness coefficient. R<sub>in</sub> was determined by the amount of infiltration and the following equation assumed to be proportional to the depth.

$$R_{in} = k_a \times h \tag{3}$$

In this model the constant  $k_a = (8.0^{-6}1/s)$  is.



Fig 2: Concept of calculation

## Storage function method;

$$\frac{ds}{\partial t} = R_{in} - q \tag{4}$$
$$S = kq^{p} \tag{5}$$

Here, S is the apparent high retention (m), q is a high base flow discharge (m / s), k, p is the model constant (k = 120.0, p = 0.5).

#### **RESULT AND DISCUSSION**

Discharge was simulated for selected river basin in different climatic zones of Sri Lanka. Mahaweli, Walawe, Kalu and Kalani rivers start from central highland (**Fig. 2b**) and Kalu and Kelani river basin totally located in wet zone while Mahaweli and Walawe basins are in both wet and dry zone. Gal oya and Aruvi Aru river basins are completely located in dry zone and they are seasonal. Mahaweli and Walawe rivers discharge(**Fig. 3,4**) bulk amount of water to sea during fourth quarter of year as the result of heavy precipitation from North-East(Dec-Feb) and 2<sup>nd</sup> inter (Oct-Nov) monsoon but Kelani and Kalu river basins showered by South West monsoon(May-Sep) and received their highest discharge(**Fig. 5,6**). Upper part of the Walawe basin receive rainfall from both South West and North East



Fig 3: River discharge and precipitation-Mahaweli river



Fig 4: River discharge and precipitation-Walawe river



Fig 5: River discharge and precipitation-Kalu river



**Fig 7:** River discharge and precipitation-Galoya and Aruvi Aru

monsoon while lower part receive bulk amount from  $2^{nd}$ Inter monsoon since it is located in both zones. Galoya and aruvi aru basins are mainly receive their peak discharge (**Fig.** 7) during  $2^{nd}$  Inter and North East monsoon seasons.

#### CONCLUSION

Monsoon rainfall pattern have a major influence on water availability within the country. Analysis of spatial and temporal distribution of river discharge give better understanding about surface water for water resources management since most of the river basins are seasonal.

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