PRELIMINARY ASSESSMENT OF SURFACE WATER RESOURCES - A STUDY FROM DEDURU OYA BASIN OF SRI LANKA

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Deduru Oya Basin is one of the major river basins of Sri Lanka, which is located towards the North-Western region of the country covering 2616 km^2 of catchment area. It lies covering the three climatic zones of the country. 94% of the basin's area belongs to Intermediate Zone while 5% and 1% of the area belongs to Wet and Dry Zones respectively.

Deduru Oya starts from the mountainous area of the Matale District in Central Province of Sri Lanka and it falls out to the sea at Chilaw after traversing about 115 kilometers. The rainfall pattern in the basin follows the bimodal pattern where the two peaks are in the months of April/ May and October/November and the minima are in January/ February and August. The hydrometric network in the basin consists of several meteorological stations and two stream gauging stations. Most of the stations are having satisfactory long-term records with least number of missing data. Consistency and validity of meteorological and hydrological data were tested using standard statistical methods. At the Ridi Bendi Ela diversion point of the stream, Deduru Oya basin is divided into an upper and lower basin which are almost equal in size.

The major sources of water available in the basin include direct rainfall, stream flow, surface water storage and groundwater storage. These available water resources vary spatially and temporally across the basin, significantly. Also the rapid population growth, increasing industrial and environmental water demands encourage the assessment of present water availability in the basin which could be used as an index for future potential supply. In this study Geographic Information Systems (GIS) technology is used in assessing the water resources, which facilitates the analysis of water resource and its components with its complex hydrological, ecological and socio-economic inter-relationship. Further, GIS technology is used to store, retrieve and analyse different types of hydrological data and to display them in readily comprehensible manner.

The study shows that there are very low flows in the stream usually during January, February, March, August and September months. More runoffs available at upper basin which is located in the Wet Zone. Middle and tail end parts of the basin locate in the Intermediate and Dry Zones, face water shortage problems in dry periods. These spatial variations of the availability of surface water need to be considered in future river basin planning exercises in order to increase the water use efficiency in the basin.

INTRODUCTION

Deduru Oya basin is the fifth largest river basin in the country covering 2616 km^2. The annual rainfall in the basin averaged to 1628mm. Annual rainfall varies spatially and temporally across the basin significantly. Annual evaporation in the area averaged 1250 mm. The total basin population is approximately one million. Water use for irrigation and agriculture is at very high percentage compared to water usage in other sectors such as domestic, industrial and commercial. There are four major reservoirs to support irrigated agriculture systems in the basin. In addition to the major reservoirs, approximately 3000 small and medium size tanks are found in the basin to provide irrigation and domestic water supplies. In Deduru Oya basin, the surface water availability varies spatially and temporally across the basin, significantly. Hence the water resources assessment is an important exercise to establish accountability of water to meet present and future demands.

MATERIALS AND METHODS

Study Area

97% of the basin's area covered by the North Western Province (Kurunegala and Puttalam Districts) and 3% by the Central Province (Kandy and Matale Districts). The major soil types in the area are Non Calcic Brown Soils, Red Yellow Podzolic Soils and Low Humic Gley Soils. Figure 1 shows the location of Deduru Oya Basin.

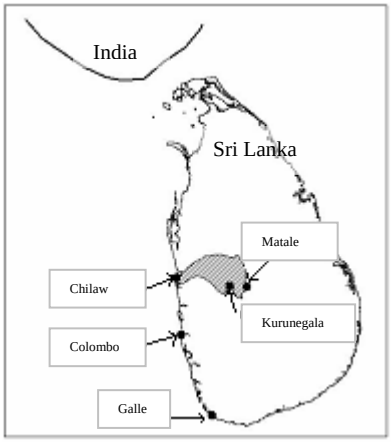


Figure 1. Location of Deduru Oya River Basin

Data Availability

Water Resources data availability for the basin with reference to the Hydrometric Network shown in Figure 2. The following measurements are available.

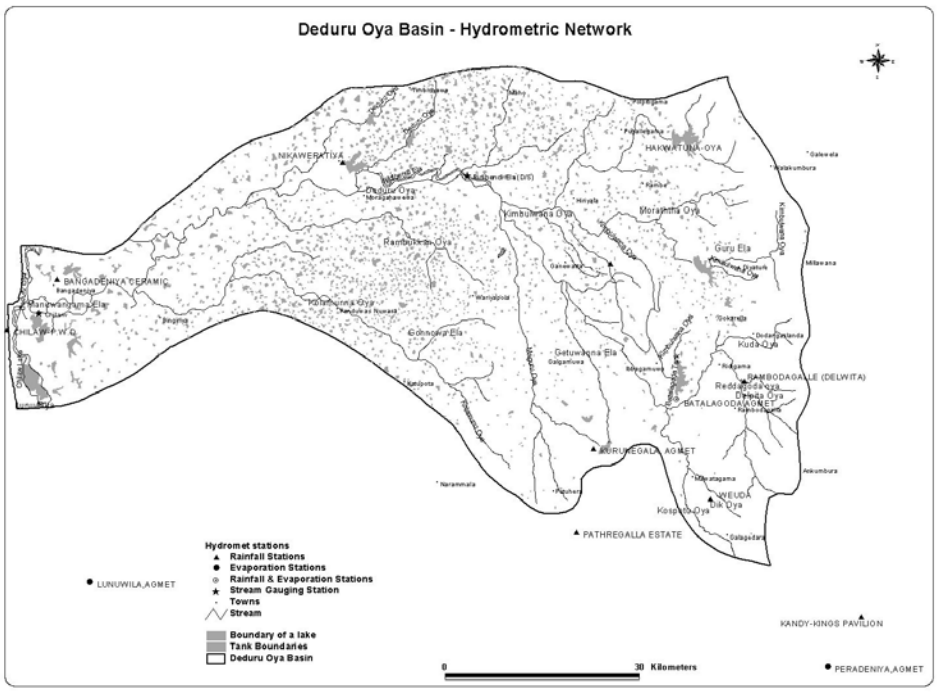


Figure 2. Deduru Oya Basin – Hydrometric Network

Table 1. Rainfall Data

Station	Data Availability at Department of Meoteorology
1.Hakwatuna Oya	1991 – todate
2.Delwita	1898 – todate
3.Kurunegala	1885 – todate
4.Batalagoda	1897 – todate
5.Kandy	1922 – todate
6.Patharagalla	1945 – 2000
7.Weuda	1989 – todate
8.Bangadeniya	1983 – todate
9.Chilaw	1911 – todate
10.Nikawaratiya	1941 – todate

Rainfall: Table 1 shows the rain gauging stations (maintained by the Department of Meteorology) which can be selected with least number of missing data. These stations were selected in order to cover all the different agro-ecological regions within the river basin. Some of these stations have satisfactory long-term records. The mean monthly rainfall considering long term monthly averages for the basin is shown in Figure 3. It can be seen that the driest months are January & February and the wettest months are October & November for this basin. The annual rainfall in the basin averaged to 1628mm. Annual rainfall varies spatially and temporally across the basin significantly.

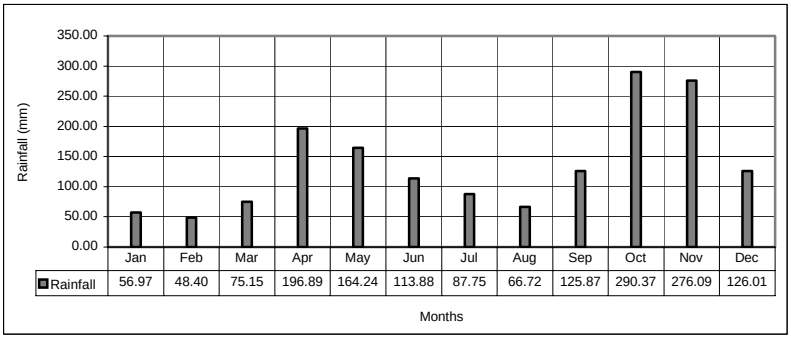


Figure 3. Deduru Oya Basin – Mean Monthly Rainfall

Evaporation:Pan evaporation data for Batalagoda, Lunuwila & Peradeniya stations were taken to represent different agro ecological regions (ECL Report [1]). Data are discontinuous due to missing data for certain months. The long-term mean evaporation (mm/day) estimated for different stations is as follows;

Table 2. Evaporation Data (mm/day)

Month	Batalagoda	Lunuwila	Peradeniya
January	2.93	4.2	4.0
February	3.31	4.7	4.7
March	3.75	4.4	4.4
April	3.61	4.1	3.8
May	3.40	3.3	3.7
June	3.23	3.4	3.0
July	2.94	3.7	3.0
August	3.14	3.7	3.2
September	3.33	3.4	3.2
October	3.08	3.0	2.8
November	2.68	2.7	2.7
December	2.64	3.2	3.3

River Flow: River flow is measured at two gauging stations namely Ridi Bendi Ela diversion point (where the basin is divided equally into upper & lower basins) and Chilaw gauging station (out flow into the sea) by the Department of Irrigation. Monthly stream flow data are obtained for the two stations for the period from October 1971 to September 1979 and October 1990 to September 1998. Data are missing for very few months (Table 3).

Table 3. Stream Flow Data

Station	Period	Average Discharge (MCM)
1.Ridi Bendi Ela	1971-1979,	574.88
	1990-1998	589.29
2.Chilaw	1971-1979,	1182.9
	1990-1998	2703.9

The gross annual mean flow generated in the basin is about 4258 MCM of which about 1966 MCM leaves the basin as uncommitted out flow. (This out flow is estimated considering 28 years flow data at Chilaw gauging station where the tidal effect has an effect on gauge reading and hence the value is not very accurate.)

ANALYSIS AND RESULTS

Data Quality

There are no continuous data available for any of the rainfall, river gauging and evaporation stations. Some of the general checks were performed to find out the correlation of stream flow with near by stations.

Station Densities

Following table compares the station densities with the corresponding World Meteorological Organization (WMO) standards for rainfall, river gauging and evaporation stations. The status of hydrometric network of Deduru Oya has satisfactory proposition, when compared with the WMO standards.

Table 4. Station Densities

Gauging station type	No. of stations	Station Density (km^2/station)	WMO Standard (km^2/station)
Rainfall *	10	262	575
River Gauging	2	1308	1875
Evaporation	4	654	5000

* Considered as non-recording stations

Data Validation

Consistency and validity of meteorological and hydrological data were tested using standard statistical methods.

Validation of River Flow Data: Monthly data for two stations (Ridi Bendi Ela and Chilaw) were subjected to linear regression analysis. The coefficient of determination (R^2) value explains the percentage change in flow of one station as a result of change in the flow of the other station. Monthly flow data of 1971-1979 period showed a R^2 value of 0.5463 whereas R^2 value for 1990-1998 was 0.655 with 95% confidence level (Figure 4).Flow data of Ridi Bendi Ela and Chilaw stations show a better correlation for the period 1990-1998 compared to data available for the 1971-1979.

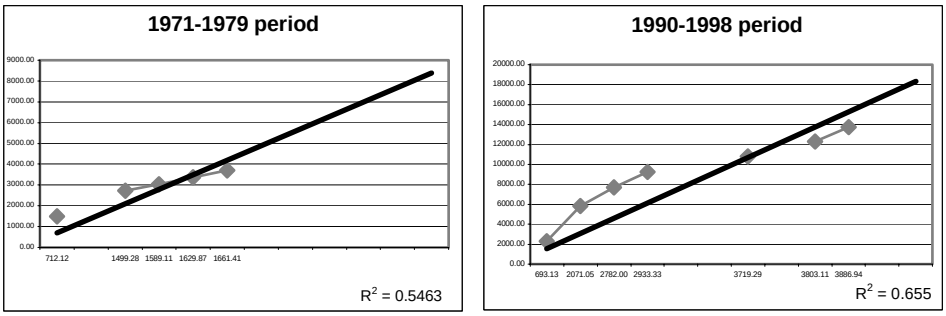


Figure 4. Regression Analysis to find out the correlation of flow data at two stations

GIS applications

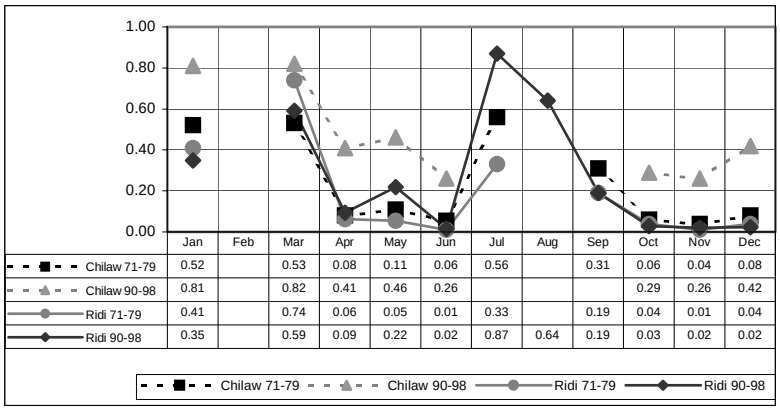
Geographic Information Systems (GIS) was used as a supportive tool in assessing water resources in the basin and preparing maps. Use of ArcView GIS facilitated the determination of basin rainfall by Thession Polygon method. Based on the Agro-ecological Region map of the basin, the rainfall stations were selected with minimum number of missing data. Following table shows the summary of analysis.

Table 5. Summary of GIS Analysis

Major Agro-Ecological Regions in Deduru Oya Basin	% Area	Rainfall (MCM)
IL1, Intermediate Zone Low Country – 75% probable rainfall > 1020 mm	37	1471.79
IL3, Intermediate Zone Low Country – 75% probable rainfall > 900 mm	55	2367.32
IM3, Intermediate Zone Mid Country – 75% probable rainfall > 900 mm	3	94.51
WM3, Wet Zone Mid Country – 75% probable rainfall > 1270 mm	5	463.53

Rainfall-Runoff

Figure 5 and Table 6 give the average rainfall and runoff for the Chilaw & Ridi Bendi Ela gauging stations in the Deduru Oya basin. It is seen that the runoff coefficients for the upper catchment station ie Ridi Bendi Ela is consistent but not so for the lower catchment station which is at Chilaw. The runoff coefficients estimated for the total basin is on the higher side indicating the over estimation of runoff at Chilaw gauging point. There is a high possibility of over-estimating the flow at Chilaw as the gauging station is near the sea and the river has practically a zero gradient in this reach. This error could be avoided by establishing the gauge away from the sea where tides could not reach.



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Chilaw 71-79	0.52		0.53	0.08	0.11	0.06	0.56		0.31	0.06	0.04	0.08
Chilaw 90-98	0.81		0.82	0.41	0.46	0.26				0.29	0.26	0.42
Ridi 71-79	0.41		0.74	0.06	0.05	0.01	0.33		0.19	0.04	0.01	0.04
Ridi 90-98	0.35		0.59	0.09	0.22	0.02	0.87	0.64	0.19	0.03	0.02	0.02

Figure 5. Deduru Oya Basin – Runoff Coefficients (for 71-79 and 90-98 periods)

Table 6. Deduru Oya Basin – Average Rainfall & Runoff

Station		Catchment Area (km2)	Average Rainfall (MCM)	Average Runoff (MCM)	Rainfall Runoff Ratio
Ridi Bendi Ela	71-79	1325	2442.46	574.88	0.23
(upper basin)	90-98			589.29	0.24
Chilaw	71-79	2622	4397.14	1182.9	0.27
(total basin)	90-98			2703.9	0.61

The rainfall pattern in the basin follows the bimodal pattern where the two peaks are in the months of April/ May and October/November and the minima are in January/ February and August.

The rainfall runoff ratio has the higher value in August and the lower value in June. According to table 6, the rainfall runoff ratio for upper and total basin is almost same except for Chilaw gauging station for the period of 1990-1998. The relatively high

rainfall runoff ratio for total basin during the above period may have resulted from over estimation of flow at Chilaw station due to tidal effect.

75% probability of stream flow

The 75% probable stream flow at Chilaw gauging station & Ridi Bendi Ela gauging station considering 16 years continuous data and 9 years continuous data respectively shown in Table 7.

Table 7. 75% probable Stream Flow (MCM)

Gauging Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
Chilaw	40.1	41.5	44.4	89.0	73.2	47.3	40.7	29.4	35.3	113	272	123
Ridi Ben Ela	3.0	1.7	1.9	12.2	17.4	6.50	3.4	1.5	0.8	32.3	88.5	45.3

CONCLUSIONS

- The rainfall pattern in the basin follows the bimodal pattern where the two peaks are in the months of April/ May and October/November and the minima are in January/ February and August.
- There are very low flows in the stream usually during January, February, March, August and September months.
- The rainfall runoff ratio has the higher value in August and the lower value in June
- Water Resources availability in the basin significantly vary spatially and temporally, across the basin.
- Considering the accuracy of river flow data, there is a high possibility of over-estimating the flow at Chilaw as the gauging station is near the sea and the river has practically a zero gradient in this reach. This error could be avoided by establishing the gauge away from the sea where tides could not reach.

REFERENCES

[1] ECL Report, “Preparation of a basin profile of Deduru Oya Basin” , Final Report, Engineering Consultants Limited, (May 1999)