## Surface Water Resources of Ruhunu Basins

H. M. Jayatillake ${ }^{1}$

## 1. General Context

The Ruhunu River Basins selected for the WWAP Case Study from Sri Lanka include geographically contiguous basins of Walawe Ganga, Kirindi Oya and Menik Ganga, and the smaller rivers and streams bounded by these three large rivers including Malala Basin with a total basin area of 5578 Sq km . The basins are located in the South-East quadrant of the country with the three main rivers originating from the central hills. Walawe Ganga, the largest of the three, originates at a relatively higher elevation of around $1,800 \mathrm{~m}$, above MSL while the origin of Malala and other smaller basins are closer to coast. Major part of the river basins, are located in the 'Dry Zone' of the country with Kirindi Oya, Menik Ganga and Malala Ara discharging to sea through the drier regions of the country.

The aim of this paper is to present an objective analysis of surface water resources in the Ruhunu Basins mainly within the WWAP Case Study Methodology and Indicator frame work using data collected for the study as much as possible and the within the time frame available.

## 2. Rainfall

### 2.1 Rainfall Pattern

Rainfall in the basins is bi-model.(as in the rest of the country) with precipitation from the two seasons each year, the North-East Monsoon from December to February and the South-West Monsoon from May to September, with inter-monsoonal rains proceeding. The annual rainfall pattern defines the two 'Water Seasons' of the country, i.e. the Maha Season lasting from September to March of the following year, and the Yala Season lasting from April to September.

The spatial distribution of the rainfall over a 30 year period from 1961 to 1990, have been estimated using Kringpin Method with data from 266 stations and a pixel resolution of 0.0250 x $0.0250 \mathrm{Lat} / \mathrm{Lon}$. The estimated spatial distribution, were then overlaid to estimate the average rainfalls (Source: Meteorological Department, Sri Lanka). This method of analysis was selected to minimize the errors that can get in due to the uneven distribution of rain gauge stations within the basins.

While the Mean Monthly Rainfalls of Ruhunu Basins are depicted Figure 1, the Mean Seasonal and Annual Rainfall are given in Table 1.

[^0]Figure 1. Mean Monthly Basin Rainfall - Ruhunu Basins.






Table 1. Mean Annual and Seasonal Rainfall - Ruhunu Basins - mm.

| Sub Basin | Maha | Yala | Annual | Seasonal Rainfall <br> Ratio Maha/Yala |
| :--- | ---: | ---: | :---: | :---: |
| Walawe | 1125 | 735 | 1860 | 1.5 |
| Kirindi | 976 | 494 | 1470 | 2.0 |
| Menik | 1051 | 510 | 1561 | 2.1 |
| Malala | 763 | 333 | 1096 | 2.3 |
| Total Ruhunu | 1007 | 567 | 1574 | 1.8 |

Mean annual rainfall ranges from 1096 mm to 1870 mm depending on the basin, with a total basin annual average 1574 mm . The monthly average rainfall ranges from 14 mm to 303 mm in the sub basins with the total basin monthly average ranges from 48 mm 274 mm .

### 2.2 Rainfall - Temporal and Spatial Variation

Evaluation of Seasonal Ratio (Figure 2) which is defined as the ration between mean rainfalls during the season of Maha and Yala, the three basins of Kirindi, Menik and Malala receives only around half the rainfall during the Yala Season compared to that during Maha Season. The highest seasonal variation is observed in the Malala basin.

Figure 2. Seasonal Rainfall Ratio.


Further the rainfall plots of some selected gauging stations (Figures 3a to 3c) show that the upper parts of the Walawe Basin receives rain from both the seasons while the middle and lower watershed of this basin and the rest of the basins receive major part the rain during the Maha Season and the magnitude of rainfall reduces when going from upper water sheds to lower watersheds and from west to east basin wise.

Figure 3a. Monthly Average Rainfalls in Selected Stations in Walawe Basin.



Figure 3b. Monthly Average Rainfalls in Selected Stations in Kirindi Oya Basin.



Figure 3c. Monthly Average Rainfalls in Selected Stations in Menik Ganga Basin.



### 2.3 Rainfall Trends - Long-Term

Figures 4 a to 4 d and Figures 5 a to 5 b depict the Trends of Annual Rainfall over the 100 year period from year 1901 to 2000 in selected stations of the Walawe and Kirindi Oya Basins (Source: Meteorological Department). Rainfall at two stations Holmwood and Campion in Walawe and Dyraba and Hambantota in Kirindi Oya show reducing trends from early 1970s. However, this may require further verification before reaching any final conclusion.

Figure 4a. Annual Rainfall Trends from 1901 to 2000-Walawe in Holmwood.


Figure 4b. Annual Rainfall Trends from 1901 to 2000 - Walawe in Campion.


Figure 4c. Annual Rainfall Trends from 1901 to 2000 - Walawe in Sandrignam.


Figure 4d. Annual Rainfall Trends from 1901 to 2000 - Walawe in Annfield.


Figure 5a. Annual Rainfall Trends from 1901 to 2000-Kirindi Oya in Dyraba.


Figure 5b. Annual Rainfall Trends from 1901 to 2000 - Kirindi Oya in Hambantota.


## 3. Evapo-transpiration

Representative values of potential evapotranspiration worked out based on Penman - Monteith approach for the upper and lower Ruhunu basin is shown in Fig. 6 (Source: Meteorological Department). Mean Monthly Potential Evapo-transpiration (PET) of the upper catchment varies from $2.8 \mathrm{~mm} /$ day to $5.0 \mathrm{~mm} /$ day with lowest during the month of December and the highest during the month of August. The PET for the lower catchment is much higher and varies from 4.6 $\mathrm{mm} /$ day to $6.0 \mathrm{~mm} /$ day with lowest during the month of December and the highest during the month of March. During the months of June to August the order of magnitude of PET is similar in both upper and lower catchments with a value closer to $5 \mathrm{~mm} /$ day.

Figure 6. Mean Monthly Potential Evapotranspiration.


## 4. Water Resources: Availability and Variability

### 4.1 Annual Water Resources

Total annual precipitation in the total Ruhunu Basins is approximately 9.0 BCM while total surface runoff is estimated to be 3.3 BCM per year. With all country estimates these two works out to approximately $7 \%$ and $6 \%$ respectively. Table 2 summarizes the overall annual water resources availability in the Ruhunu Basins, analyzed from the meteorological and hydrological data available.

The annual average surface water resources available in the total Ruhunu basin is around 2900 cu M per capita which is higher than the FAO specified threshold value with Kirindi Oya having the lowest of around 1,950 cum per capita while Malala Ara having the highest value of around 10,950 cum per capita. Care has to be taken therefore in using this indicator to asses the adequacy of water resources in relatively smaller basins.

Table 2. Annual Surface Water Resources - Ruhunu Basins.


### 4.2 Water Resources - Temporal Variation: Maha \& Yala Seasons

There is substantial seasonal variation in water resources availability due to the higher seasonal variability of rainfall and the evpotranspiration. The basin has a higher year-to-year and also a higher regional and seasonal variability of rainfall. Table 3 and 4 summarizes the water resources availability in Ruhunu Basins during the seasons of Maha and Yala respectively.

Table 3. Surface Water Resources - Ruhunu Basins - Maha Season.

| Sub Basin |  | Walawe Ganga | Kirindi Oya | Menik Ganga | Malala Ara | Other | Total Ruhunu Basins |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Catchment Area | Sq km | 2471 | 1165 | 1287 | 402 | 253 | 5578 |
| Population 2001 | 000 | 684 | 261 | 109 | 18 | 54 | 1,125 |
| Average Seasonal Rainfall | mm | 1125 | 976 | 1051 | 763 | 603 | 1007 |
| Average Seasonal Rainfall Volume | MCM | 2780 | 1137 | 1353 | 307 | 153 | 5729 |
| Average Seasonal Surface Runoff | MCM | 1271 | 345 | 273 | 130 |  | 2019 |
|  | \% RF | 46 | 30 | 20 | 42 |  | 35 |
| Average Seasonal Escape to Sea | MCM | 341 | 37 | 261 | n/a |  | 639 |
|  | \% RF | 12 | 3 | 19 | n/a |  | 11 |
|  | $\%$ <br> Runoff | 27 | 11 | 96 | n/a |  | 32 |


| Gross Seasonal Water Resources |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Per Capita | CuM | 4066 | 4364 | 12411 | 17491 | 5094 |
| Gross Seasonal |  |  |  |  |  |  |
| Water Resources per Unit | $\begin{aligned} & \text { MCM } \\ & \text { per } \end{aligned}$ |  |  |  |  |  |
| Catchment | km | 1.1 | 1.0 | 1.1 | 0.8 | 1.0 |

Gross Seasonal
Surface Water
Resources Per

| Capita | Cum | 1,859 | 1,325 | 2,505 | 7,413 | 1,795 |
| :--- | :---: | :---: | :---: | :---: | :---: | :---: |
| Gross Seasonal |  |  |  |  |  |  |
| Surface Water <br> Resources per Unit <br> Catchment |  |  |  |  |  |  |

Table 4. Surface Water Resources - Ruhunu Basins - Yala Season.

| Sub Basin |  | Walawe <br> Ganga | Kirindi Oya | Menik Ganga | Malala Ara | Other | Total Ruhunu Basins |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Catchment Area | Sq km | 2471 | 1165 | 1287 | 402 | 253 | 5578 |
| Population | 0 | 684 | 261 | 109 | 18 | 54 | 1,125 |
| Average Seasonal Rainfall | mm | 735 | 494 | 510 | 333 | 397 | 567 |
| Average Seasonal Rainfall Volume | MCM | 1816 | 576 | 656 | 134 | 100 | 3282 |
| Average Seasonal Surface Runoff | MCM | 893 | 159 | 85 | 60 |  | 1197 |
|  | \% RF | 49 | 28 | 13 | 45 |  | 36 |
| Average Seasonal Escape to Sea | MCM | 184 | 26 | 80 | n/a |  | 290 |
|  | \% RF | 10 | 5 | 12 | n/a |  | 9 |
|  | \% <br> Runoff | 21 | 16 | 94 |  |  | 24 |
| Gross Seasonal Water Resources Per Capita | CuM | 2657 | 2209 | 6023 | 7634 |  | 2918 |
| Gross Seasonal Water Resources per Unit Catchment | $\begin{aligned} & \text { MCM } \\ & \begin{array}{l} \text { per } \\ \mathrm{km} \end{array} \quad \mathrm{Sq} \end{aligned}$ | 0.7 | 0.5 | 0.5 | 0.3 |  | 0.6 |
| Gross Seasonal <br> Surface Water <br> Resources Per <br> Capita | Cum | 1,306 | 609 | 780 | 3,422 |  | 1,064 |
| Gross Seasonal Surface Water Resources per Unit Catchment | MCM | 0.36 | 0.14 | 0.07 | 0.15 |  | 0.21 |

SR-Surface Runoff

## 5. Rainfall Runoff Ratio

There is not much of a difference in the Rainfall Runoff Ratio during the two seasons in basins other than Menik Ganga which has the lowest Rainfall Runoff Ratio. However, the ratio appears to lessen rapidly from west to east with Walawe having the highest (Table 5).

Table 5. Rainfall Runoff Ratio - Ruhunu Basins.

|  | Walawe <br> Ganga | Malala <br> Ara | Kirindi <br> Oya | Menik <br> Ganga | Total <br> Ruhunu <br> Basins |
| :--- | :---: | :---: | :---: | :---: | :---: |
| Annual | 48 | 44 | 30 | 17 | 36 |
| Maha | 46 | 42 | 30 | 19 | 35 |
| Yala | 49 | 45 | 28 | 12 | 36 |

## 5. River Flows

### 5.1 Annual River Runoff

The Figures $7 \mathrm{a}, \mathrm{b}, \mathrm{c}$, and d show average annual flows of the rivers at outfall estimated from the available hydrological data from existing river gauging stations.

Figure 7a. Average Annual Flows at outfall - Walawe.


Figure 7b. Average Annual Flows at Outfall - Malala.


Figure 7c. Average Annual Flows at outfall - Kirindi.


Figure 7d. Average Annual Flows at outfall-Menik Ganga.


Table 6. River Flows - Year on Year Variability.

| Basin | Period <br> Analyzed From <br> to | No of <br> Years of <br> Data | Mean <br> Annual <br> runoff <br> MCM | Coefficient <br> of <br> Regression <br> R Square | R |  |
| :--- | :---: | ---: | :---: | ---: | :---: | ---: |
| Walawe | $42 / 43$ | $68 / 69$ | 23 | 2,221 | 0.090 | 0.300 |
| Malala | $69 / 70$ | $99 / 00$ | 31 | 192 | 0.405 | 0.636 |
| Kirindi | $69 / 70$ | $99 / 00$ | 30 | 511 | 0.250 | 0.500 |
| Menik | $69 / 70$ | $99 / 00$ | 28 | 326 | 0.405 | 0.636 |

Though declining trend in flow is seen in some basins such as Malala Ara the period analyzed is too short to forecast such a trend as these can be short term cycles of changes. There is an appreciable year on year variability in Menik Ganga, Malala Ara and Kirindi Oya basins (Table 6).

### 5.2 Seasonal and Monthly Runoff

Figure 8. Monthly Aerage River Flows - Ruhuna Basins.




Table 7. Seasonal/ Monthly Runoff Variation.

| Sub <br> Basin | Maha <br> Runoff as <br> \% Annual <br> Average | Yala <br> Runoff as <br> \% Annual <br> Average | Runoff Ratio <br> Maha/Yala | R Monthly <br> Variation |
| :--- | ---: | ---: | ---: | ---: |
| Walawe | 57.23 | 40.18 | 1.42 | 0.406 |
| Malala | 67.49 | 31.18 | 2.16 | 0.541 |
| Kirindi | 67.60 | 67.60 | 2.17 | 0.545 |
| Menik | 79.90 | 24.42 | 3.27 | 0.635 |

Figure 9. Seasonal Runoff Ratio.


Highest variability of monthly flow is observed in Menik Ganga Sub-Basin, where the coefficient of variation is 0.635 and with a seasonal Runoff Ratio is close 3.5 and it is lowest in Walawe with a Seasonal Runoff Ratio of less than 1.5 (Table 7 and Figure 9)

## 6. River Water Availability

Table 7 summarizes the water availability in rivers at the different gauging stations in average daily flows against percentage of time.

Table 7. Water availability - Average Daily Flows $\mathrm{m}^{3} / \mathrm{s}$.

| Percentage <br> of Time | Wellawaya | Tanamalwila | Lunugamwehera | Embilipitiya | Kataragama |
| :---: | :---: | :---: | :---: | :---: | :---: |
| $10-20$ | 8.0 | 18.0 | 26.0 | 71.0 | 15.0 |
| $20-30$ | 6.6 | 14.5 | 20.0 | 60.0 | 11.5 |
| $30-40$ | 5.8 | 12.0 | 16.0 | 51.0 | 9.5 |
| $40-50$ | 5.0 | 10.0 | 13.0 | 43.0 | 8.5 |
| $50-60$ | 4.2 | 8.2 | 10.0 | 35.0 | 6.5 |
| $60-70$ | 3.8 | 6.5 | 8.5 | 30.0 | 4.0 |
| $70-80$ | 3.3 | 5.0 | 6.5 | 24.0 | 3.5 |
| $80-90$ | 2.9 | 3.7 | 5.0 | 20.0 | 2.5 |
| $90-100$ | 2.0 | 2.0 | 4.5 | 11.0 | 1.7 |

## 7. Human Impacts on Water Resources

There are 26 major and medium reservoirs in the Basin with total storage capacity of 883 MCM (Table 8) in addition to 11 diversions. Out of the reservoirs Samanalawewa in Walawe is mainly for power generation while providing irrigation water to down stream Kalthota Scheme. The Uda Walawe Reservoir in the same basin is basically for irrigation but has small turbines generating power through irrigation releases. The rest of the reservoirs are purely for irrigation. These interventions in storage and diversions can be summarized as follows:

Table 8. Human Impacts.

|  |  | Walawe | Malala Ara | Kirindi Oya | Menik <br> Ganga | Ruhunu Basin |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Reservoirs |  |  |  |  |  |  |
| Capacity<1 MCM |  | - | 2 | 3 | 1 | 6 |
| $1<$ Capacity $<10 \mathrm{MCM}$ |  | 2 | 5 | 6 | 1 | 14 |
| $10<$ Capacity < 20 MCM |  | - | - | - | - | - |
| $20<$ Capacity < 50 MCM |  | 2 | - | 1 | - | 3 |
| $50<$ Capacity < 100 MCM |  | - | - | - | - | - |
| Capacity $>100 \mathrm{MCM}$ |  | 2 |  | 1 | - | 3 |
| Total no. of Reservoirs | No. | 6 | 7 | 11 | 2 | 26 |
| No. of anicuts | No. | 7 | - | 3 | 1 | 11 |
| Total capacity under reservoirs | MCM | 607.0 | 11.1 | 263.3 | 1.6 | 883.0 |
| Total water spread area | ha. | 5,002 | 443 | 1,856 | 192 | 7,493 |
| Reservoir Density per Unit Area | MCM/Sqkm | 0.25 | 0.03 | 0.23 | 0.00 | 0.16 |
| Reservoir Density per Unit Runoff | MCM/MCM | 0.27 | 0.06 | 0.52 | 0.00 | 0.27 |

The reservoir density per unit catchment is highest in Walawe and Kirindi Oya Basin while that per unit runoff is highest in Kirindi Oya. Menik Ganga has virtually has no storage.

In addition the basin has about 800 minor irrigation schemes out of which about 200 are tanks while about 800 are anicuts.

## 8. Water Use and Demands

The major part of the developed water resources for consumptive use in the basins is used for agriculture, having a share of 94 percent. The average abstractions for domestic water supply excluding individual abstractions are less than $1 \%$ while about $6 \%$ abstractions are for industries. However, agricultural water use include all domestic uses of the communities, requirements for live stock, home gardens, religious and cultural uses and even tourism and part of environmental requirements and hence should not be considered a single sector user. On the hand even if all the
population is provided with pipe borne water total abstractions would not be very high. Walawe has one hydro power station which is a non consumptive use.

With regard to future demands, the expected water demand for Ruhunupura Development Programme is around $520,000 \mathrm{cum} /$ day or 190 MCM per year. This consist of an estimated percentage demand of $50 \%$ for light and heavy industries, $30 \%$ domestic and the balance for commercial and unidentified demands. However, the detail needs will have to be worked out during the pre/feasibility stage of the project.

## 9. Data and information on Water Resources

The major agencies that play major roles in the collection of data and information on water resources in the basins are Meteorological Department, Irrigation Department, Mahaweli authority, Ceylon Electricity Board and the National Water supply Board.

The Meteorological Department collects rainfall from 16 rain gauge stations within the basin and gets agro-meteorological data from eight stations. These stations are not manned by the Met Dept staff but it depends on the other agencies for daily data collection. They can do very little supervision due to lack of resources. The station distribution is not even but concentrated towards upper reaches. Immediate attention must be paid to improve the network and the data collection process if reliable and accurate data are to be obtained in a consistent manner.

The Irrigation Department has six river gauging stations and the distribution is inadequate for current day water management requirements. Similar improvements are required in river gauging as well.

Both ID \& MASL collect data on irrigation water use and management and that too need improvement specially with regard to cropped area monitoring. Technologies such as GPS would help in obtaining reliable data for management.

In all the above case appropriate automation and capacity building in data and information management would be key necessities.

## 10. Critical Problems and Opportunities

Considering the ratio of consumptive use available water resources and withdrawals and AWR ratio, it appears that there is little scope for further development of water resources except in Menik Ganga Sub-Basin and to some extent in Walawe. Any increase of demands would lead to water related problems unless conservation and management is not improved. At present, there are water scarcity and reliability problems during both the seasons for agriculture and other uses.

Soil in most part of the basin is highly permeable and hence agricultural water use is much higher for paddy in some irrigation schemes in the basin compared to rest of the country. Recent attempts to diversify with Banana etc appear to be promising. As water is short both within the sector and competing demands are on the increase efficiency improvement in irrigation should receive priority.

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[^0]:    ${ }^{1}$ Deputy Director (Irrigation Management) \& Project Director (ISRP), Department of Irrigation, Sri Lanka and Sri Lanka Case Study Team Member.

