

Study on Changes of Rainfall in the Mahaweli Upper Watershed in Sri Lanka, Due to Climatic Changes and Develop a Correction Model for Global Warming

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ABSTRACT

The Climatic changes had been severely effected Sri Lankan economic, social, and agricultural sectors than any other country in this region; the vulnerability is immense owing to high dependency on hydrosphere for power generation, Irrigation for agriculture; domestic and human consumption. Frequent droughts in the country had stand stilled the normal activities nation wide and raised serious questions about the dependency of hydropower to compensate national energy demand. The Kotmale, Victoria, Randenigala and Rantembe reservoirs constructed in the heart of the Upper Watershed area of Mahaweli system; supplies nearly one third of the (29.11 percent) national power generation ⁱ in 2001, effected seriously and showed there vulnerability to the climatic change during past decade.

Significant amount of the rainfall to the upper watershed area of the Mahaweli has been reduced during past hundred years by 39.12 percent ⁱⁱ and the rainfall pattern is in declining trend and it will be 16.6 percent ⁱⁱⁱ reduction severely effect on power generation, agriculture and domestic usages in next twenty years.

Hence the country's energy source combination mix have to be altered and the strategic planning on long term power generation needs to considers the climate changes seriously.

1 INTRODUCTION

1.1 Identification of the topic and statement of the purpose

The Mahaweli Development Programme in Sri Lanka was implemented with the aims of providing water to the dry zone of the country through a massive diversion scheme and also generating hydropower. Under this development Programme, a series of large reservoirs was constructed across the main water course at Kotmale, Polgolla, Victoria, Randenigala, Rantembe and etc. The catchments areas to these reservoirs are categorized as Upper Watershed Management Area of Mahaweli. Located in mostly at the heart of Sri Lanka, The Upper watershed management area of Mahaweli is at the middle of a growing crisis empowered by triggering climatic changes in global, and local climatic changes. Approximately 30 percent of the total hydropower capacity in Sri Lanka, and 23 per cent of lands irrigated under major irrigation schemes in the island, are depend on the water resources of the upper Mahaweli catchments, under a major diversion scheme of the Mahaweli River.

With the changes of the climate in the local level such owing to changes in land-use patterns, industrialization and other natural and artificial alterations to the nature in the hill country of Sri Lanka, and the global level climatic changes are prominent than any other time in the history. While the growing population, industrialization process demands more and more energy. Past several decades the government of Sri Lanka as the main supplier and planner of energy sector based its policies on the hydro power. But frequently occurring droughts and serious power cuts pressured them to setup new installations using alternative energy sources.

ⁱ Central Bank-Economic and social statistics of Sri Lanka, 2003

ⁱⁱ Base year 1902

ⁱⁱⁱ Base year 2002

1.2. Primary Objective

Analyze and calculate long-term rainfall pattern in upper watershed management area of concerning Kothmale, Randenigala, Rantembe and Victoria

1.2.1 Secondary Objectives

Find out the best fit time series model for rain fall pattern in upper watershed management area of concerning Kothmale, Randenigala, Rantembe and Victoria.

Predict the rain fall changes in 2025 to upper watershed management area of concerning Kothmale, Randenigala, Rantembe and Victoria

1.3 Importance of Objectives

The electricity generation during the last fourteen years clearly shows deckling nature of rain fall pattern and cyclic nature of the occurrence of the drought periods during the past few years. The development of the major hydropower resources under the accelerated Mahaweli Project added six hydropower stations to the national grid with a total installed capacity of 600 MW. Unlike the Laxapana cascade, the Mahaweli System is operated as a multi-purpose system. Hence power generation from the associated power stations is governed by the downstream irrigation requirements as well. These requirements being highly seasonable tend to constrain the operation of power stations during certain periods of the year.

2. LITERATURE REVIEW

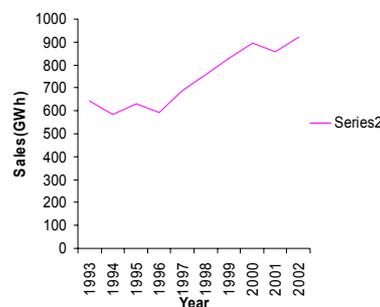
Sri Lanka situated in the Indian Ocean at the southern tip of the Indian sub continent with a land area of 65610 square kilometres. The population is just more than the two hundred millions and the Per capita income is around 835 US\$ per year. As such the GDP growth rate is in average in 5.6 percent in last two decades. During last five years the average economic growth rate is 4.0, -1.5, 6.0 4.3 percent consecutively in 2002(a), 2001, 2000, and 1999 ⁱ.

The driving force of the economy had become the private entrepreneurs. The investors attracted the country owing to its geographical, socio economic characteristics ⁱⁱ. The market demand for electricity for industrial purposes had been increased by 26.65 percent during past five years ⁱⁱⁱ.

ⁱ Annual Report, Central bank of Sri Lanka, 2002

ⁱⁱ Board of Investment, 2002

ⁱⁱⁱ Economic and Social Statistics of Sri Lanka, Central Bank of Sri Lanka, 2003



Source: Central Bank of Sri Lanka, 2003

Figure-1
Power Demand-Sales

2.2 Alternative power sources

Sri Lanka had depend heavily on hydro power, 82 percent of the total system capacity (I.e. 1135 MW) is installed at 15 Hydro power stations. The past accepted norm was using thermal power was only used when hydro energy is not adequate to meet the demand. Unfortunately this norm had been severely threatened by the frequent power cuts occurred soon after few weeks of drought. Therefore thermal and other substitute energy sources are necessary in order to steady fulltime energy supply.

2.3. Impacts on the water resources

The hydrological regime has been adversely affected due to indiscriminate land use changes. It is also pointed out that the river flows have diminished significantly during the last two decades. Productivity of the agricultural land has declined. This has directly affected the income status of the farmers thus creating social problems. Further, reservoir siltation and eutrophication demand considerable maintenance expenditure. Frequent landslides have threatened human life and infrastructure. If these problems are not properly resolved, a future crisis is inevitable and that will jeopardize the expectations of the Mahaweli Development Programme.

With respect to on-site effects of land erosion in Sri Lanka it has been found that alternative uses of land in a given agro-ecological environment, under different technologies and cultural management practices, result in significantly different rates of on-site loss of soil resulting from erosion. Estimates covering a wide range of land uses under different levels of management are shown in Table-01.

The eroded soil washed with the runaway water on the surface and sediment in the bed of the reservoirs. This causes massive reduction of water capacities with the time and spill out of reservoirs for a few inches of rainfall. The soil erosion rate increased with the humane activities in the area especially with agricultural activities in the area and soil erosion intensity changes with respect to the cultivating crops.

Due to the changes of the human and natural interferences the global as well as the local climate has been changing continuously. The prominent monsoons of south-west and north east monsoons rainfall amount has reducing while the contribution of the inter monsoon activities increased. Nevertheless the increment on inter monsoonal activities are not higher than the reduction on southwest and northeast monsoon rainfall

ⁱJayasundara J.M.S.B., Climate Change: 7th Forestry Symposium, Colombo: Department of forestry and Environment, University of Sri Jayewardenepura, 2001

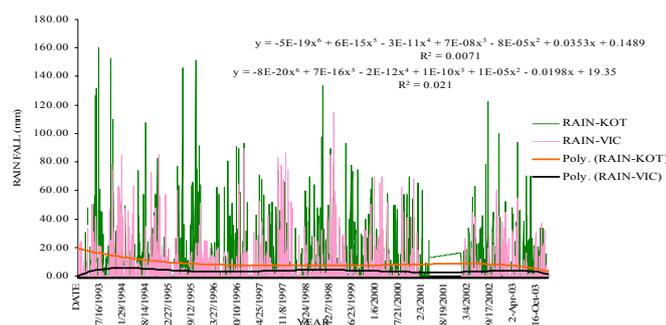


Figure-2
Rainfall data related to the catchments in hydro power stations

3. METHODOLOGY

3.1 Achieving the primary objective

3.1.2 Assumptions

- The water availability in Victoria, Randenigala and Rantembe depend on rainfall to the Mahaweli Upper watershed area.
- The water retaining capacities of the reservoirs changes with the depth of the tank and siltation neglected.
- The global as well as the local climatic pattern has been changes continuously with an equal trend.
- Water loss on seepage, deep percolation is constant.
- Duckwari, Pundaluoya, Nortonbridge, Rajawella, Nawalapitiya, Pussellawa, Pussellawa-sogama, Ohiya, Galaha, Galaha-Kirimetiya, Deltota-Patiyagama, Victoria and Randenigala Meteorological represents the catchments of Kothmale, Victoria, Randenigala and Rantebe reservoirs and the collective change in percentage wise is similar to the total area rain fall change percentage.
- The climate change owing to began during 1974 owing to rapid industrialization of China and India with emission of large quantities of pollutants and 1974 used as a base year for calculations.

3.2 Methodology

Secondary data on the climate was obtained from various Institutions and Organizations such as Meteorological Department and Mahaweli Ministry (Past data nearly a century). Following Meteorological stations at Duckwari, Pundaluoya, Nortonbridge, Rajawella, Nawalapitiya, Pussellawa, Pussellawa-sogama, Ohiya, Galaha, Galaha-Kirimetiya, Deltota-Patiyagama, Victoria, Randenigala and their impact areas were identified using Theseon Polygon method was followed.

3.2.1 Model for predicts the Rainfall in 2005 and calculates the effect on global worming

Past data since 1888 had analysed till 1974 and find out best fit model and obtain the prediction of rainfall values till 2002 since 1974.

Step I

Actual values 1880-1974 \longrightarrow Prediction 1975-2002

Step II

$$Y_1 = f(A, B, C \dots)$$

Step III

Obtaining deference between the actual values and Predict rainfall data since 1974 till 2002. The difference between the predicted value and the actual value Y_2 explains the impact owing to the global worming and the error in prediction followed in the data analysis.

Step IV

$$Y_2 = f(X, Y, Z \dots)$$

Using actual values since 1880 to 2002 predict the Rainfall Y_3 till 2025

$$Y_3 = f(P, Q, R \dots)$$

Step VI

Final predicted Rain fall (Y_x) can be calculated by

$$Y_x = Y_3 - Y_2$$

Using the difference between the actual and prediction values, an equation can be developed as a correction factor forecast till 2025. All the data values are converted to \log_{10} during mathematical calculations.

4. RESULTS

4.1 Prediction of rain fall date 1975-2002

Minitab Software is used to predict the rain fall for the period of 1974 to 2002. Trend analysis is used as the tool for the study.

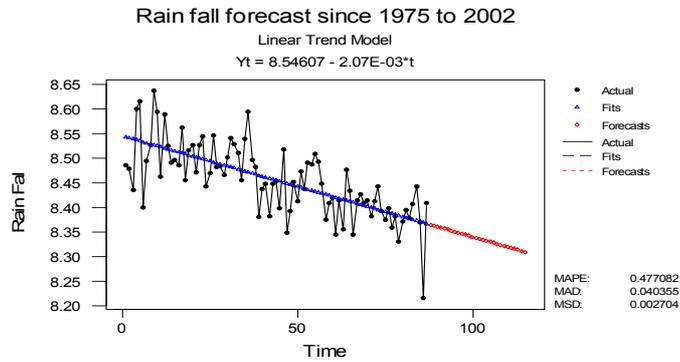


Figure-3
Rainfall Forecast since 1975 to 2002

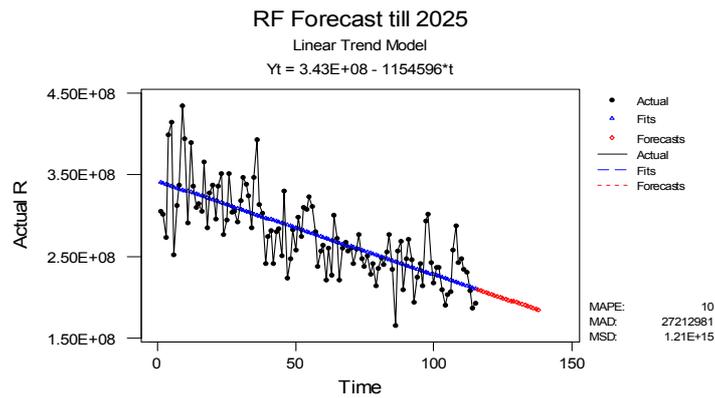


Figure-4
Rainfall forecast till 2025 (trend)
Rain Fall Pattern 1888-2025

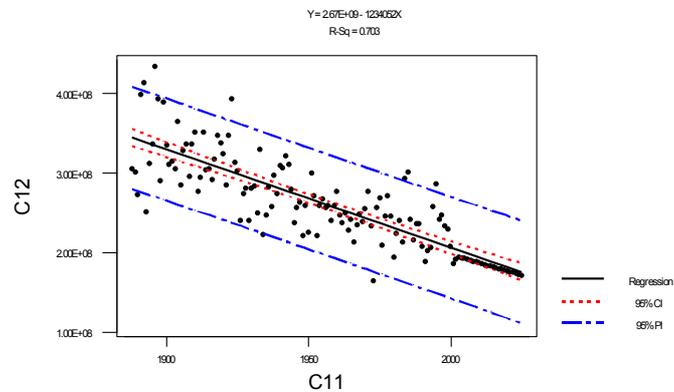


Figure-5
The rain fall prediction 1888 to 2025 with confidence limits

5. RECOMMENDATIONS AND CONCLUSIONS

The annual Rain fall had been severely reducing during past century owing to local and global scale climate changes. Significant amount of the rainfall to the upper watershed area of the Mahaweli has been reduced during past hundred years by 39.12 percent and the rainfall pattern is in declining trend and it will be 16.6 percent reduced during next 21 years. Though Sri Lanka is mainly depend on water resources for energy supply, the Sri Lanka needs to align its national policy concerning on this reality. Hence, it is highly recommended to concern these climatic change findings during strategic planning of power generation sector.

It is highly recommended to concentrate on small scale never ending alternative energy sources as, Solar energy, Wind power, Tidal Power, Ocean waves and etc.,

ⁱ Base year 1902

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