Variation of Annual and Seasonal Rainfall Patterns in Kandy District of Sri Lanka

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Abstract- Rainfall variability over space and time must be regarded as the most significant aspect of the monsoon climate over Sri Lanka. The main objective of this study was to identify the spatial distribution of annual and seasonal rainfall in Kandy District (2005-2014) and long term annual and seasonal rainfall trends in Kandy (1875-2014). The monthly rainfall data have been collected from 19 rainfall stations in Kandy District. The data was obtained from the Department of Meteorology and other relevant institutions. Spatial interpolation was applied to prepare the isohyet maps for Kandy District using Radial Basis Functions Method in ArcGIS 10.4. The rainfall trends over the 140-years period were estimated using the Linear Regression model. The Mann-Kendall statistical method was used to identify the significant or non-significant monotonic tendencies. According to the analysis the highest annual average rainfall (5,660 mm) has been recorded at Galamuduna Estate in Dolosbage, and the lowest is recorded at Kundasale (1,594 mm) during the study period from 2005 to 2014. According to the seasonal rainfall, during the FIM period (March-April) the rainfall varies from 700 mm (Craighead Estate) to 241 mm (Minipe). Rainfall during SWM period (May to September) varied from 3,436 mm at Galamuduna to 174 mm at Minipe. The Southwestern windward side received the highest rainfall while the Eastern leeward side received the lowest rainfall during SWM season. The Galamuduna Estate (1053 m) is situated in highest rainfall region of Wet Zone Up-Country of Sri Lanka. The SIM period (October to November) showed most evenly distributed rainfall over the Kandy District. During the NEM period (December-February), the highest rainfall was recorded in the Eastern side of the Kandy District. The highest rainfall (700 mm–1,000 mm) is recorded in and around Minipe station during this season. Kandy Plateau area received a lower rainfall in the NEM season. The study revealed that the annual and seasonal distribution of rainfall over Kandy District has considerable variations. Based on the annual average rainfall, the wettest place of the Kandy District was the Galamuduna Estate and the driest places were the Kundasale and Minipe. The month of June was recorded as the wettest month (777 mm) in Galamuduna and the same month, Minipe (5 mm) was observed as the driest month during the study period. The complex topographical features and orographic barriers highly affected for the seasonal rainfall variations in the Kandy District. According to long term rainfall data series (1875-2014), the results clearly show that there is a statistically significant decrease in annual rainfall (2.6 mm/year) in Kandy station. The FIM, SIM and NEM seasons do not show a significant rainfall trend, but the SWM season rainfall shows a statistically significant decreasing trend. The drop in the SWM season rainfall is 2.4 mm per year.

Index Terms - Leeward side, Rainfall, Trend, Variation, Windward side.

I. Introduction

The Kandy District is situated in the Central Highland of Sri Lanka. It extends in latitude from 6^0 26’ to 7^0 29’ North and from 80^0 26’ to 80^0 59’ East longitudes. The District is bounded North by Ukuwela, Rattota, Laggala, Pallegama and Wilgamuwa Divisional Secretary Divisions (DSD) of Matale District, East by Mahiyangana DSD of Badulla District and Walapane, Hanguranketha, Kothmale, Nuwaraeliya and Ambagamuwa Korale DSDs of Nuwaraeliya District and West by Aranayake, Bulathkohupitiya, Mawanella and Rambukkana DSDs of Kegalle District and Mawathagama and Rideegama DSDs of Kurunegala District. Kandy District has an area of 1,940 square kilometers.

The Kandy District has extended from 100 m to 1600 m in height from the sea level. Its Eastern side is bounded to Mahaweli River. The annual average rainfall is 1840 mm for the Kandy District. The Minipe DSD in the Eastern region of the District is consisting with mountains features and Low-Country Dry Zone landscapes. The average temperature of the areas of; Delthota, Pasbage Korale, Ganga Ihala Korale, Udadumbara and Panwila shows a low temperature than other areas of the District but the Minipe shows a higher temperature.

The Mahaweli River is the main river which flows across the Kandy District and it covers 110 km (total of 335 km) within Kandy District. In addition to that, the stream of water of Deduru-Oya begins in the Poojapitiya DSD and Ma-Oya begins in the Ganga Ihala Korale DSD. The Southern part of Knuckles mountain range situated in Kandy District is a unique ecological zone. This zone is the main catchment area of Mahaweli and Aban Ganga. Hantana, Ambuluwawa, Balana range, Alagalla, Hunnasgiriya and Dolosbage mountains are located in Kandy District. The waterfalls like; Asupini Ella, Galaboda Ella, and Kadiyanhela are also situated in the Kandy district.

Out of total land of the Kandy District, 41,521 hectare (21%) is covered with forest. A large number of the animal community live in the forest belongs to the District. Among them Elephant, Leopard Monkey, Wild Boar, Kola Diviya, Deer, Barking Deer are prominent. Wild elephants can be seen in the areas such as Udadumbara, Minipe, Randenigala sanctuary and Meemure.

Rainfall of Sri Lanka is of multiple origins, including monsoonal, convectional and depression activities. In the rainfall calendar of Sri Lanka, there are four distinctive periods have been recognized. They are,

i. First Inter Monsoon (FIM): March to April
ii. South West Monsoon (SWM): May to September
iii. Second Inter Monsoon (SIM): October to November
iv. North East Monsoon (NEM): December to February

Variability of rainfall over space and time must be regarded as the most significant aspect of the monsoon climate over Sri Lanka. The Central Highland contains many complex topographical features such as valleys, plains, ridges, peaks, plateaus, basin and escarpments. These topographical features strongly affect the spatial patterns of winds, seasonal rainfall, temperature, relative humidity and other climatic elements, particularly during the monsoon seasons.

The Central Highlands is an important catchment area for the river systems of Sri Lanka. Hence, the rainfall changes of the Central Hills of Sri Lanka have been studied widely. Madduma Bandara and Kuruppuarachchi (1988) found that the annual precipitation at Nuwaraeliya in the Central Highlands has decreased during the last century where land use has undergone significant changes. For example, between 1956 and 1981, area under tea and forests decreased from 61% to 39% and from 17% to 15%, respectively. On the other hand, the homestead and croplands increased from 7% to 17% and from 7% to 15%, respectively. Kayane et al. (1995) have shown that rainfall during the SWM Season has decreased in the Central Highland since the 1870's. They also suggested that a significant decline in rainfall in the plateau could be related to global warming and the rise of the Sea Surface Temperatures (SST) in the surrounding Indian Ocean. Further, they have pointed out that the increased SST over the Indian Ocean will intensify the Indian Monsoon circulations, which in turn may increase the coastal windward rainfall with a comparative decrease of rainfall in the leeward areas of Sri Lanka.

Rekha and Punyawardena (2003) have found that negative anomalies of rainfall are evident in the western slopes of the Central Highland where SWM is the dominant rainfall governing mechanism. The analyses clearly show that increased variability is the most dominant feature of the rainfall regime in the Central Highlands during recent time than that of any other trend. Madduma Bandara and Wickramagamage (2004) have found a significant decrease in annual rainfall in the upper watershed areas, over the last 100 years, reflecting at least a 20% decline at Nuwaraeliya and west facing slopes. They have pointed out that the primary reason for the decline in annual rainfall appears to be the failure of the SWM that brings the largest share of total rainfall to the westerns parts of the Central Hills.

Malmgren et al. (2003) used monthly average rainfall data of 130 years, between 1870 and 2000 to examine the rainfall patterns. They concluded that some stations in Central Highlands demonstrate a decrease in the SWM, but no statistically significant upward or downward trend exists for the NEM. During the FIM and SIM the only statistically significant trend in the Central Highlands was the decreasing trend observed in Nuwaraeliya.

Wickramagamage (2015) examined the daily rainfall variations for the period from 1981 to 2010. Out of 48 stations, 39 displayed negative trends during SWM period. The strongest negative trends are found in the Central Highlands and surrounding areas. SWM is the dominant rainfall season in the Southwestern lowlands as well as the Highland Wet Zone of Sri Lanka. It is clearly shown that almost the entire island experiences a reduction of rainfall during SWM. This decrease is negatively influenced to the irrigation and agriculture, domestic water supply, industrial water supply and power generation in the country.

II. METERIALS AND METHODS

The main objectives of this study are to examine; (i) the spatial and temporal variations of annual and seasonal rainfall patterns in Kandy District, (ii) the long term annual and seasonal rainfall trends of Kandy station. The monthly rainfall data have been collected from 19 rainfall stations (Figure 1 and Table 1) in Kandy District for the period from 2005 to 2014. The data was obtained from the relevant institutions like:

i. Department of Meteorology, Colombo.
ii. Natural Resource Management Centre (NRMC).
iii. Mid Country Tea Research Institute, Hantana.
iv. Peradeniya Botanical Garden.
v. Tea Estate Offices in the Kandy District.

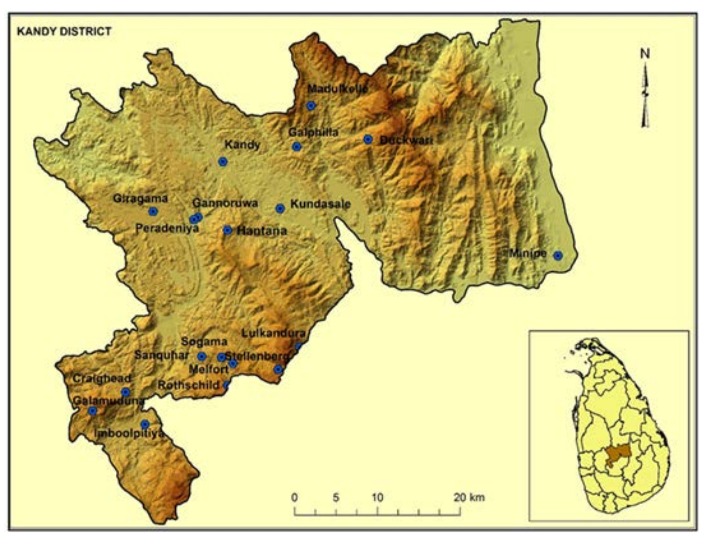

Figure 1: Geographical Distribution of the Rain Gauge Stations in the Kandy District.

Spatial interpolation technique was applied to prepare the isohyet maps of rainfall for Kandy District using Radial Basis Functions Method in ArcGIS 10.4. To identify long-term trends in the rainfall of Kandy, the monthly rainfall has been obtained from the Katugastota (Kandy) Meteorological station from 1875 to 2014. The rainfall trends over the 140-years period were estimated using the Linear Regression model. The Mann-Kendall statistical test was used to distinguish significant and non-significant monotonic trends.

Table 1: Geographical Distribution of the Rain Gauge Stations in the Kandy District.

Rainfall Station	Latitude (North)	Longitudes (East)	Elevation (m)
1. Kandy	7^0 20'	80^0 38'	477
2. Gannoruwa	7^0 16'	80^0 36'	479
3. Kundasale	7^0 16'	80^0 41'	492
4. Hantana	7^0 16'	80^0 38'	762
5. Peradeniya	7^0 16'	80^0 35'	472
6. Giragama	7^0 16'	80^0 32'	523
7. Galphilla	7^0 21'	80^0 42'	710
8. Madolkele	7^0 23'	80^0 43'	1095
9. Stellenberg	7^0 06'	80^0 41'	1260
10. Sanquhar	7^0 07'	80^0 36'	853
11. Sogama	7^0 07'	80^0 37'	1067
12. Melfort	7^0 06'	80^0 38'	975
13. Rothschild	7^0 05'	80^0 38'	972
14. Imboolpitiya	7^0 02'	80^0 32'	600
15. Galamuduna	7^0 03'	80^0 29'	1053
16. Craighead	7^0 04'	80^0 31'	900
17. Lulkandura	7^0 07'	80^0 42'	1082
18. Duckwari	7^0 21'	80^0 47'	1105
19. Minipe	7^0 12'	80^0 58'	113

III. RESULTS AND DISCUSSION

A. Variation of Annual Rainfall

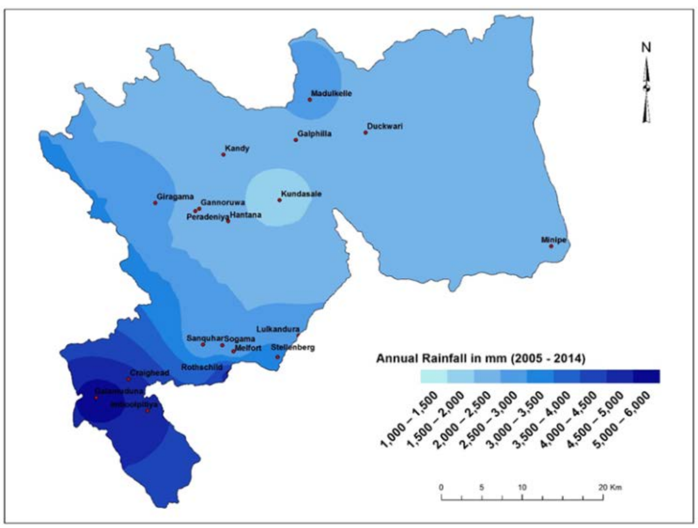

Figure 2: Variations of Mean Annual Rainfall in Kandy District

The mean annual rainfall varies from 2000 mm in the driest parts (Eastern part of the District) to over 5000 mm in the wettest parts (Southwestern slope of the District) (Figure 2). The highest annual average rainfall (5,660 mm) has recorded at Galamuduna Estate (Dolosbage), and the lowest is recorded at Kundasale (1,594 mm) during the study period. From 2001 to 2014 the Galamuduna annual average rainfall was 5,176 mm.

B. Variations of Seasonal Rainfall

March to April belongs to the FIM period and during this time convectional rains are occurred overland especially in the afternoon and convergence activity in the ITCZ (Inter Tropical Convergence Zone) plays a major role. During this time, evening occur thundershowers too. ITCZ is migrating over Sri Lanka this time. The FIM rainfall variation in Kandy District is shown in figure 3. The distribution of rainfall during this period, the rainfall varies from 700 mm (Craighead Estate) to 241 mm (Minipe).

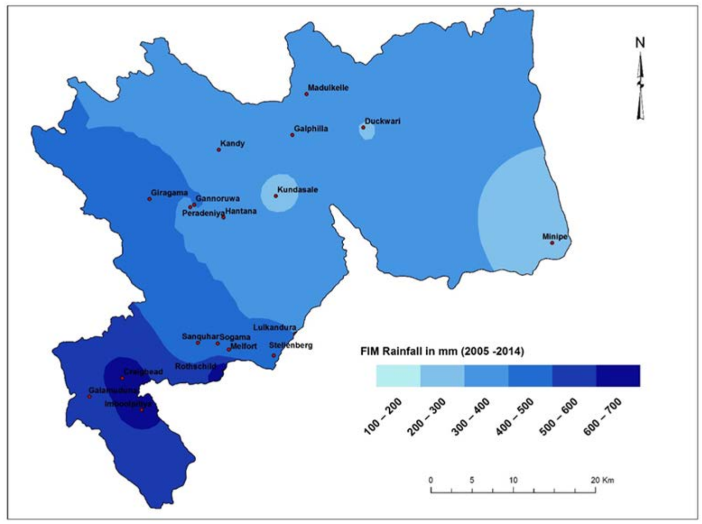

Figure 3: Variations of Rainfall during FIM Season in the Kandy District

SWM period occurs during May to September when depressions, and cyclonic wind circulations activate in the low and mid troposphere of the atmosphere. Orography also controls the rainfall distribution in Sri Lanka during this period. When winds originate in the South-west side of Sri Lanka, it brings a large amount of moisture from the Indian Ocean. Equatorial westerlies are also activated during this time. When these winds encounter slopes of the Central Highlands, they transport heavy rains on to the mountain slopes and the Southwestern sector of the island. But the leeward slope in the East and North East receive little rain during this period. During this season the ITCZ move gradually northward. The Kandy District rainfall during SWM period varied from 3,436 mm at Galamuduna to 174 mm at Minipe (Figure 4). The Southwestern windward side of the Central Highland received the highest rainfall while the Eastern leeward side received the lowest rain during SWM season. The Galamuduna Estate is situated in highest rainfall region of Wet Zone Up-Country of Sri Lanka. Out of 4 rainfall seasons, the spatial variation is high in Kandy District mostly during SWM period.

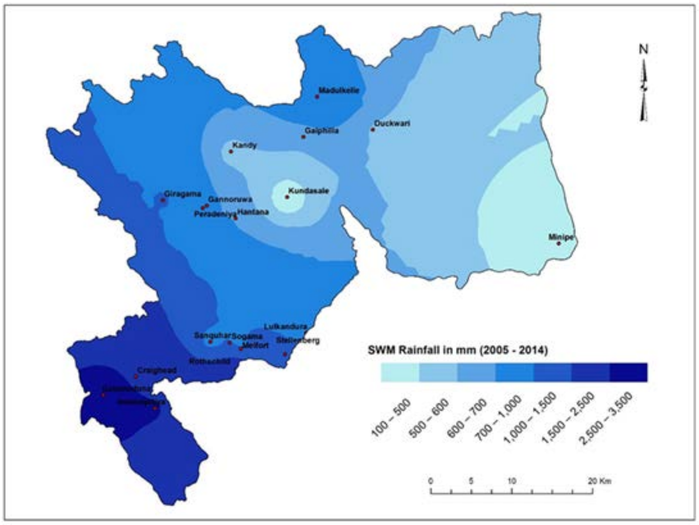

Figure 4: Variations of Rainfall during SWM Season in the Kandy District

SIM period occurs during October to November: convection, cyclonic wind circulation, and convergence activity make the rainfall widespread due to ITCZ migrating over Sri Lanka during this period. The tropical depression has the highest frequency during this time. The SIM period is the period with the most evenly distribution of rainfall over Sri Lanka and this characteristic clearly shows in the Kandy District (Figure 5). Almost the entire District receives in excess of 500 mm of rain during this season, with the Southwestern slops receiving higher rainfall in the range of 1000 mm to 1500 mm.

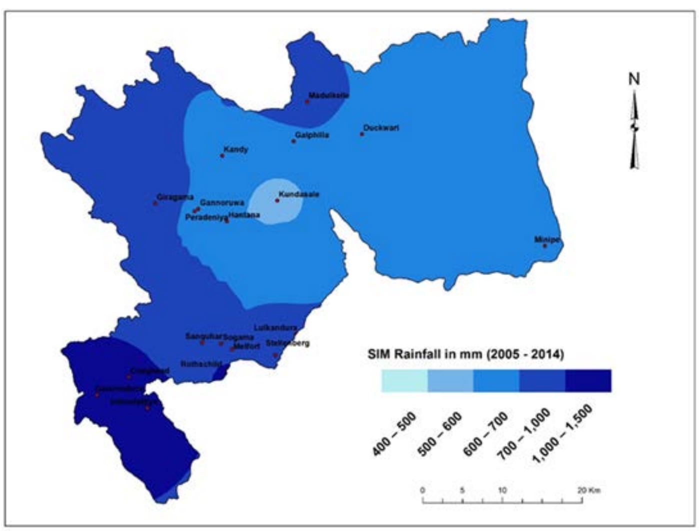

Figure 5: Variations of Rainfall during SIM Season in the Kandy District

NEM occurs in December to February. Monsoon winds come from the North Eastern side, bringing moisture from the Bay of Bengal. During the NEM period, the highest rainfall amounts are recorded in the Northeastern slopes of the Central Hills. This season is characterized by the ITCZ positioning itself South of Sri Lanka. The highest rainfall was recorded in the Eastern side of the Kandy District during NEM period (Figure 6). The highest rainfall (700 mm–1,000 mm) is recorded in and around Minipe station during this season. Kandy Plateau area received a lower rainfall in the NEM season.

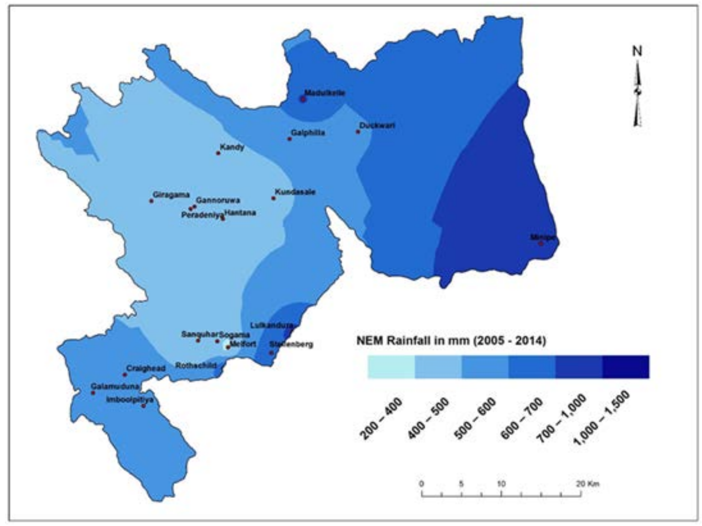

Figure 6: Variations Rainfall during NEM Season in the Kandy District

Based on the annual average rainfall, the wettest place of the Kandy District was the Galamuduna Estate and the driest places were the Kundasale and Minipe. The month of June was recorded as the wettest month (777 mm) in Galamuduna and the same month, Minipe (5 mm) was recorded as the driest during the study period. Total monthly average rainfall in Galamuduna and Minipe shows in figure 7.

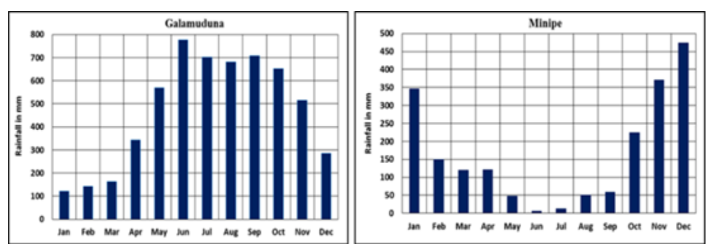

Figure 7: Monthly Average Rainfall at Galamuduna and Minipe

C. Orographic Effect and Variation of Monsoons Rainfall in Kandy District

Yoshino et al (1983) pointed out that the location of the Central Highland is one of the main physical structures which control the climate of Sri Lanka. Horizontal and vertical structures of the physical setting of the Sri Lanka topography create large diversity to change the rainfall distribution. The Western side of the Central Highland receives more rainfall than Eastern side and especially when SWM rainfall activates. Similarly, when NEM activate the rainfall is higher on the Eastern side but compare to SWM, NEM give less rainfall. Orographic effect of the Central Highlands of Sri Lanka has similar patterns with the global figures of the orographic rainfall in the tropical mountains and highlands (Rekha, 2005).

It is well known that the high amount of rainfall receive on the Western side of Sri Lanka and is induced by the topographic barriers known as the Western slopes of the Central Highland. The relief of Sri Lanka characterized by the Central Highland is one of the major factors governing the climate of Sri Lanka. Considerable spatial differentiation of the climate is to be expected in the SWM as well as in the NEM season, as results of the effects of the Central Highlands, which form an orographic barrier across the path of the monsoonal air masses and winds. Thus, not only the highlands take on the role of a climatic shed, but at the same time, there is also established the regional differentiation of the highlands into a windward side and a leeward side, including the flanking lowlands. Due to opposing wind direction of the SWM and NEM, the windward and leeward sides of the highlands keep changing their role according to the rhythm of the monsoon change: those parts of the highlands on the windward side during the other monsoon seasons and vice versa. The windward and leeward side effect of the Central Highlands on the monsoonal air masses may exercise the greatest effects on rainfall and wind, as also on the other climatic elements though to a lesser degree.

The topographical barriers highly affected in the rainfall distribution patterns of Kandy District specially SWM and NEM seasons (Figure 8 and 9). Figure 8 shows geographical location and monthly average rainfall in Stellenberg and Lulkandura stations. According to direct distance, these two stations are situated by close distances. But barriers of North part of Piduruthalagala mountain range situated between this two stations. Therefore Stellenberg was located in the Western slope of the Central Highland (windward side of SWM season and leeward side of NEM season) and Lulkandura was located in the Eastern slope of the Central Highland (windward side of NEM season and leeward side of SWM season). The Stellenberg station has received in excess of 175 mm of rain during every month of SWM season (May to September). Month of July has received in excess of 250 mm of rainfall. But Lulkandura station has received fewer of 160 mm of rain during every month of SWM season. The month of August was recorded as the driest (123 mm) month in Lulkandura. In this situation, the opposite case is true during NEM period. The Lulkandura station has received in excess of rainfall during NEM season (December to February) and month of December was recorded as the wettest (356 mm) month in this station. But the month of February was recorded as the driest month in Stellenberg.

Figure 9 shows geographical location and monthly average rainfall in Galamuduna and Craighead stations. These two stations are situated in the Western slope of Central Highland and windward side of SWM season and leeward side of NEM season. Monthly rainfall distribution shows high rainfall during SWM period from May to September in Galamuduna and Craighead. NEM period Galamuduna and Craighead stations have received low rainfall because these two stations situated in the leeward side of Central Highland and located by close distance. But every month belongs to the SWM season have received high rainfall amount to Galamuduna than Craighead, i.e. from 2005 to 2014 the Galamuduna month of June rainfall was 700 mm and the same month Craighead rainfall was 531 mm. The main reason for this micro-scale rainfall variation is the barriers of Kabaragala mountain range situated between Galamuduna and Craighead stations. According to this rainfall pattern, the complex topographical features and orographic barriers are highly affected for the seasonal rainfall variations of Kandy District.

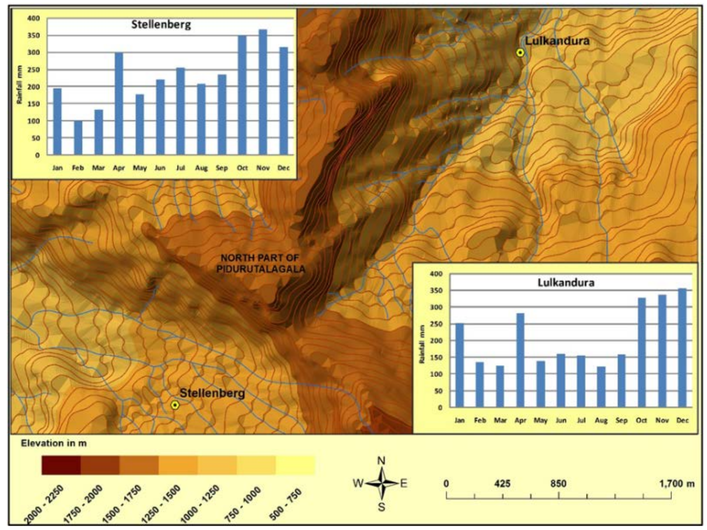

Figure 8: Geographical Location and Monthly Average Rainfall in Stellenberg and Lulkandura

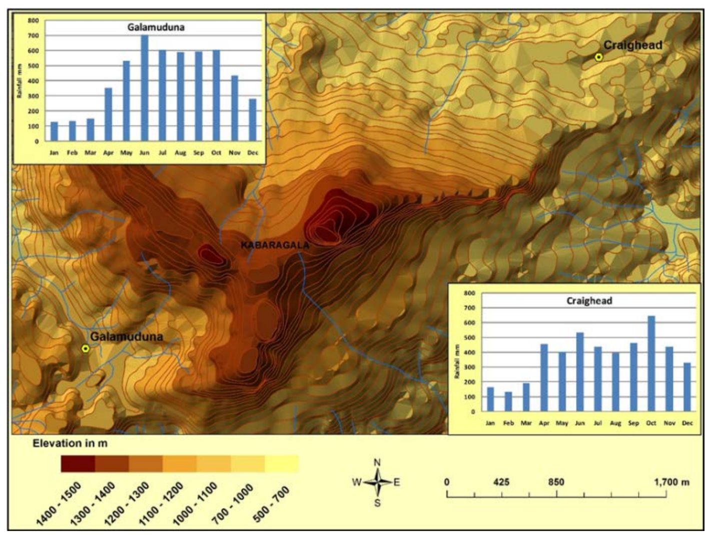

Figure 9: Geographical Location and Monthly Average Rainfall in Galamuduna and Craighead

D. Long term rainfall trends in Kandy station

The annual average rainfall (1875-2014) is 2026 mm in Kandy station. Figure 10 shows that the monthly distribution pattern of rainfall in Kandy station. The highest rainfall amount has received in the month of October and lowest rainfall amount has received in the month of February. Out of total amount of annual rainfall (2026 mm), 288 mm (14%) has received in FIM season, 771 mm (38%) has received in SWM season, 562 mm (28%) has received in SIM season and 401 mm (20%) has received in NEM season during 1875 to 2014.

The annual average rainfall has decreased by an amount of 243 mm (about 11%) during 1945 to 2014 period compared to 1875 to 1944 period. FIM rainfall has been decreased by an amount of 8 mm (about 3%), SWM rainfall has been decreased by an amount of 218 mm (about 25%) and NEM rainfall has been decreased by an amount of 28 mm (about 7%) during 1945 to 2014 period compared to 1875 to 1944 period. Only SIM rainfall has been increased by an amount of 9 mm (about 2%) during 1945-2014 period compared to 1875-1944 period (Figure 11).

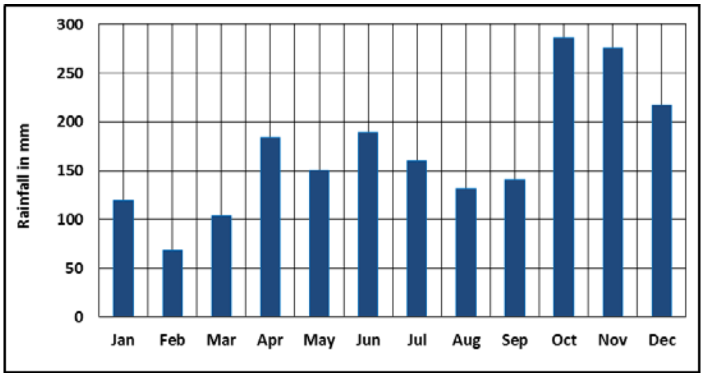

Figure 10: Annual Average Rainfall in Kandy Station (1875-2014)

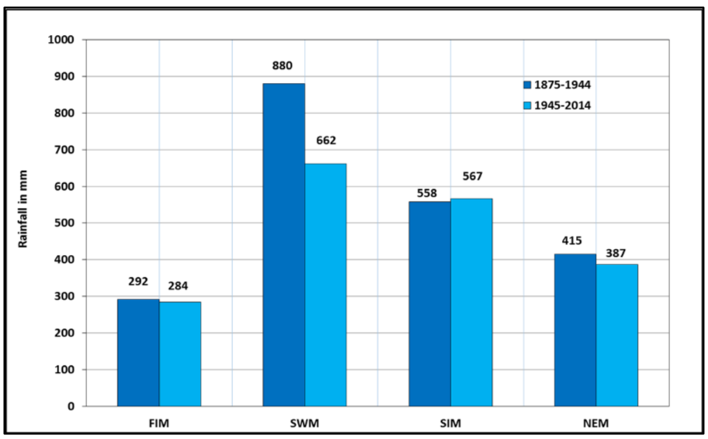

Figure 11: Seasonal Average Rainfall in Kandy station (1875-1944 and 1945-2014)

An annual total rainfall time series analysis from 1875 to 2014 was done for the Kandy station and it shows a significant ($P<0.05$) decreasing trend. The rate of decrease of annual rainfall was 2.6 mm per year for the period 1875-2014 in Kandy station (Figure 12).

Figure 13 shows the FIM, SWM, SIM and NEM seasonal rainfall totals. All the seasons demonstrate significant year-to-year variations. However, trend analyses of the rainfall amounts in the FIM, SIM and NEM seasons do not show a monotonic decreasing or increasing trend at the 95% confidence level according to the Mann-Kendall statistical test. In contrast, the SWM rainfall amount demonstrates a decreasing trend at the same level of confidence. The negative slope of the equation of the linear regression line shows a 2.6 mm drop in the SWM. Even the application of robust regression to minimize the influence of outliers produced a 2.4 mm decrease in SWM rainfall per year.

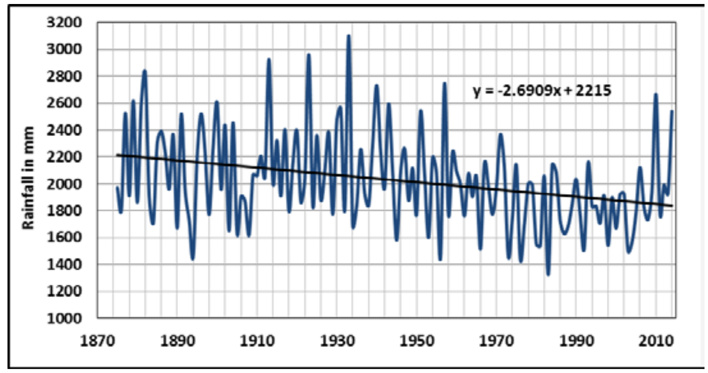

Figure 12: Annual Rainfall Trends in Kandy station (1875-2014)

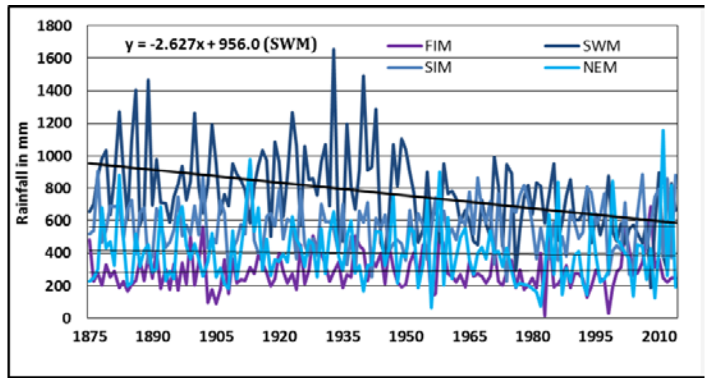

Figure 13. Trends of Seasonal Rainfall in Kandy station (1875-2014)

IV. CONCLUTIONS

The mean annual rainfall varies from the driest parts (Eastern part) of the Kandy District to over the wettest parts (Southwestern slope). During FIM period the rainfall varies from western side i.e. Craighead Estate to eastern side i.e. Minipe. The rainfall during SWM period, the Southwestern windward side of the Kandy District received the highest rainfall while the eastern leeward side received the lowest rainfall which varied from i.e. Galamuduna to Minipe. The SIM period most evenly distribution of rainfall over Sri Lanka has been noticed and its characteristic are clearly shows in the Kandy District. During the NEM period, the highest rainfall figures are recorded in the Eastern slopes of the Kandy District. This season is characterized by the ITCZ positioning itself South of Sri Lanka. The highest rainfall is recorded in and around Minipe station and Kandy Plateau area received a lower rainfall in the NEM season. Due to opposing wind direction of the SWM and NEM, the windward and leeward sides of the highlands (including Kandy) keep changing their role according to the rhythm of the monsoon change. The annual average rainfall has been decreased by an amount of 243 mm (about 11%) during 1945 to 2014 period compared to 1875 to 1944 period. SWM rainfall has been decreased by an amount of 218 mm (about 25%) during 1945 to 2014 period compared to 1875 to 1944 period. Only SIM rainfall has been increased by an amount of 9 mm (about 2%) during 1945-2014 period compared to 1875-1944 period. SWM season rainfall shows a statistically significant decreasing trend. The drop in the SWM season rainfall is 2.4 mm per year. The reason for the decrease in rainfall in Kandy station during SWM season cannot be properly understood without a good knowledge about clouds that produce rainfall over the Central Highlands. A ground-based cloud observation system is not available in Sri Lanka. Such a system must be established in order to study clouds over Sri Lanka.

REFERENCES

[1] B. Malogren, A. Hulugalla Ranatunge, Y. Hayashi and T. Mikami, "Precipitation Trends in Sri Lanka since the 1870's and Relationship to El Nino-Southern Oscillation", *International Journal of Climatology*, 23, 2003, PP. 1235–1252.

[2] C.M. Madduma Bandara and P. Wickramagamage, "Climate change and its impact on upper watersheds of the Hill country of Sri Lanka", 2004, In: Srikantha Herath, Assela Pathirana and S.B. Weerakoon , *Proceedings of the International conference on sustainable water resources management: In the changing environment of the monsoon region*: Volume 1, National Water Resources Secretariat, Colombo.

[3] C.M. Madduma Bandara and T.A. Kuruppuarachahi, "Land use change and hydrological trends in the upper Mahaweli basin", Paper Presented at the Workshop on Hydrology of Natural and Man-made Forest in the Hill Country of Sri Lanka, 1998, In: N. Hennayake, R. Nianthi, N. Samad, R. Alagan & K. Kumarihamy (ed), *Traversing No Man's Land*, Interdisciplinary essays in honour of professor C.M. Madduma Bandara, godage international publishers (pvt) Ltd, Colombo, Sri Lanka, 2009, p. 87.

[4] I. Kayane, K. Nakagawa, H. Edagawa and C.M. Madduma Bandara, "Hydrological consequences of global warming revealed by the century long Climatological data in Sri Lanka and South West India", *in An Interim Report of IGBP Activities in Japan*, 1990-1994, Science Council of Japan, Tokyo, 1995, pp. 65-81.

[5] K.W.G. Rekha Nianthi and B.V.R. Punyawardena, "Seasonal variability of rainfall in the Central Highlands of Sri Lanka", Paper presented at the International Conference on Mountain Environment and Natural Hazards Management, North Eastern Hill University, Shillong, India, 2003, In: K.W.G. Rekha Nianthi, *Climatological Research: Sri Lanka*, S. Godage & Brothers (Pvt). Ltd, Colombo, Sri Lanka, 2012, PP. 50-56.

[6] K.W.G. Rekha Nianthi, "Orographic effect of the central highlands on the monsoon rainfall in Sri Lanka", *Proceedings of the Peradeniya University Research Sessions*, Sri Lanka, Vol. l, November, 2005, P.29.

[7] M.M. Yoshino, J. Kayane and C.M. Madduma Bandara, *"Climate Water and Agriculture in Sri Lanka"(ed)*, Institute of geosciences, University of Tsukuba, Japan, 1983.

[8] P. Wickramagamage, "Spatial and temporal variation of rainfall trends of Sri Lanka", *Theoretical and Applied Climatology*, DOI 10.1007/s00704-015-1492-0, Springer-Verlag, Wien, 2015.

[9] www.kandy.dist.gov.lk

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