Tropical Agricultural Research Vol. 28 (1): 50 – 63 (2016)

Recent Changes of Rainfall Regime of *Hakwatuna Oya* Watershed of Sri Lanka

A.C.S. Perera*, B.V.R. Punyawardena[1] and E.R.N. Gunawardena[2]

Postgraduate Institute of Agriculture
University of Peradeniya
Sri Lanka

ABSTRACT: *This study was conducted to verify farmers' claim, which was also verified by a field survey, that the availability of water in the Hakwatuna Oya irrigation scheme in Sri Lanka has decreased due to variability of rainfall in the watershed area as a result of climate change. Daily rainfall data of 10 selected stations representing "Hakwatuna Oya" watershed over a 50 year period (1961-2010) were used in this study. The linear regression analysis was used to study the annual trend of rainfall during the study period from 1961-2010. The variability of rainfall during recent decades (1991-2000, 2001- 2010) and the most recent 20-year period (1991-2010) was compared with the base period of 1961-1990, recommended by the World Meteorological Organization (WMO) for climate studies, using Coefficient of Variation (CV %), student t- test and confidence interval at 95 percent. The results showed that there was no significant trend of annual rainfall over the last 50 years. In relation to the four rainfall seasons, there was no significant variability of rainfall during the last two decades compared to the base period, except for few stations. However, the rainfall variability of South West Monsoon (SWM), Yala and Maha seasons displayed significant differences in mean rainfall for Siyabalangamuwa rainfall station, which is the closest to the Hakwatuna Oya scheme in the Intermediate zone. The mean rainfall during post 1990 period was lower than the base period during SWM and Yala season whereas it has increased during Maha season.*

Keywords: *Climate change, rainfall variability, Hakwatuna Oya*

INTRODUCTION

Rainfall in Sri Lanka displays a distinctive characteristic of high temporal as well as spatial variation (Punyawardena, 2007). A major share of rainfall to Sri Lanka is accounted by monsoonal, convectional activities and formation of weather systems in the Bay of Bengal (Punyawardena, 2005). Additionally, it is also governed by the northward and southward migration of the Inter Tropical Convergence Zone (ITCZ) during the year (Jayewardena *et al*., 2005). The two wind regimes, the South West Monsoon (SWM) occur during the period of May to September and the North East Monsoon (NEM) during the period of December to January influence the seasonal rainfall of the island (Kankanam *et al*., 2007). During the period between two monsoons, the ITCZ lies on or near to Sri Lanka and enhances the regional convections forming low level disturbances, depressions and vortices in the Bay of Bengal and the Arabian sea. This process has an influence in the locality providing ample

[1]Natural Resource Management Center, Department of Agriculture, Peradeniya, Sri Lanka
[2]Department of Agricultural Engineering, Faculty of Agriculture University of Peradeniya, Sri Lanka
*Corresponding Author: ernimalg@gmail.com

rainfall to the entire island during the months of October to November, in a season identified as the Second Inter Monsoon (SIM). When the ITCZ is not active, convectional activities due to intensive heating of the land governs the rainfall in this period (Chandrapala, 1995; Punyawardena *et al*., 2004; De Silva *et al*., 2006; Punyawardena, 2007). During the months from March to April, a rainfall season recognized as the First Inter Monsoon (FIM) produces high intensity rains mainly due to thunderstorms resulting from convection activities (Punyawardena *et al*., 2004; Punyawardena, 2007).

Sri Lanka being predominantly agricultural country, has two main cropping seasons associated with rainfall. The SIM and NEM rainfall seasons together forms the major cultivation season known as *Maha* (September – February) and the FIM and SWM collectively forms the minor cultivation season recognized as *Yala* (March – August) (Zubair, 2002; Chithranayana and Punyawardena, 2007). The major rice growing areas of the country are located in the Dry zone (DZ) and the Intermediate zone (IZ). Many Agro-Ecological Regions (AER) in both DZ and IZ do not have a proper *Yala* season and are most vulnerable to droughts thus high variability of rainfall will have negative impacts on the rain fed, as well as irrigated paddy cultivation (Chithranayana and Punyawardena, 2013).

Researchers have observed that there is no significant trend in Sri Lanka's mean annual rainfall (MAR) during the last century except higher variability (Jayawardene *et al*., 2005; Chandrapala, 1995). Few other studies on the prediction of the future climate of Sri Lanka suggests an increase in annual average rainfall across the country while a decrease in rainfall in the Dry areas of the country (Punyawardena *et al*., 2013; De Silva, 2007).

This study was conducted in response to many stakeholders, including farmers, in the *Hakwatuna Oya* irrigation scheme who complains, which was also verified during a field survey, that the "*availability of water for cultivation has decreased during recent years*". The water for cultivation in the above scheme comes from two sources, *i.e.* rainfall and irrigation water issues from the *Hakwatuna Oya* reservoir. It was hypothesized that this could be due to two reasons; firstly due to rainfall variation as a result of climate change and secondly due to anthropogenic activities. This paper attempts to find the validity of the first possibility by investigating the trends and variation in the rainfall received in the *Hakwatuna Oya* watershed and its neighbouring areas in the recent decades compared to the past. The findings would be useful in deriving long term strategies to address this water scarcity issue.

MATERIALS AND METHODS

Daily rainfall values of selected ten rainfall stations representing *Hakwatuna Oya* watershed in the agro ecological regions (AER) of WM_3b, IL_1a, IL_3 and DL_1b over a 50 year period (1961-2010) was used in the study. The *normal ratio method* (Linsley *et al.*, 1982) using three neighbouring stations, was used to estimate the missing rainfall data of each data series. The selected rainfall stations are given in Figure 1 and Table 1. The daily rainfall values were converted to annual rainfall, four seasonal rainfalls (*i.e.* FIM, SWM, SIM, NEM), and two growing seasons (*i.e. Yala* and *Maha*).

Linear regression analysis with the significance test at 5% probability was used to study the annual trend of rainfall during the study period from 1961 to 2010. The variability of rainfall during recent time frames (1991/00, 2001/10, 1991/10) was compared with the base period of 1961/90 using Coefficient of Variance (CV).

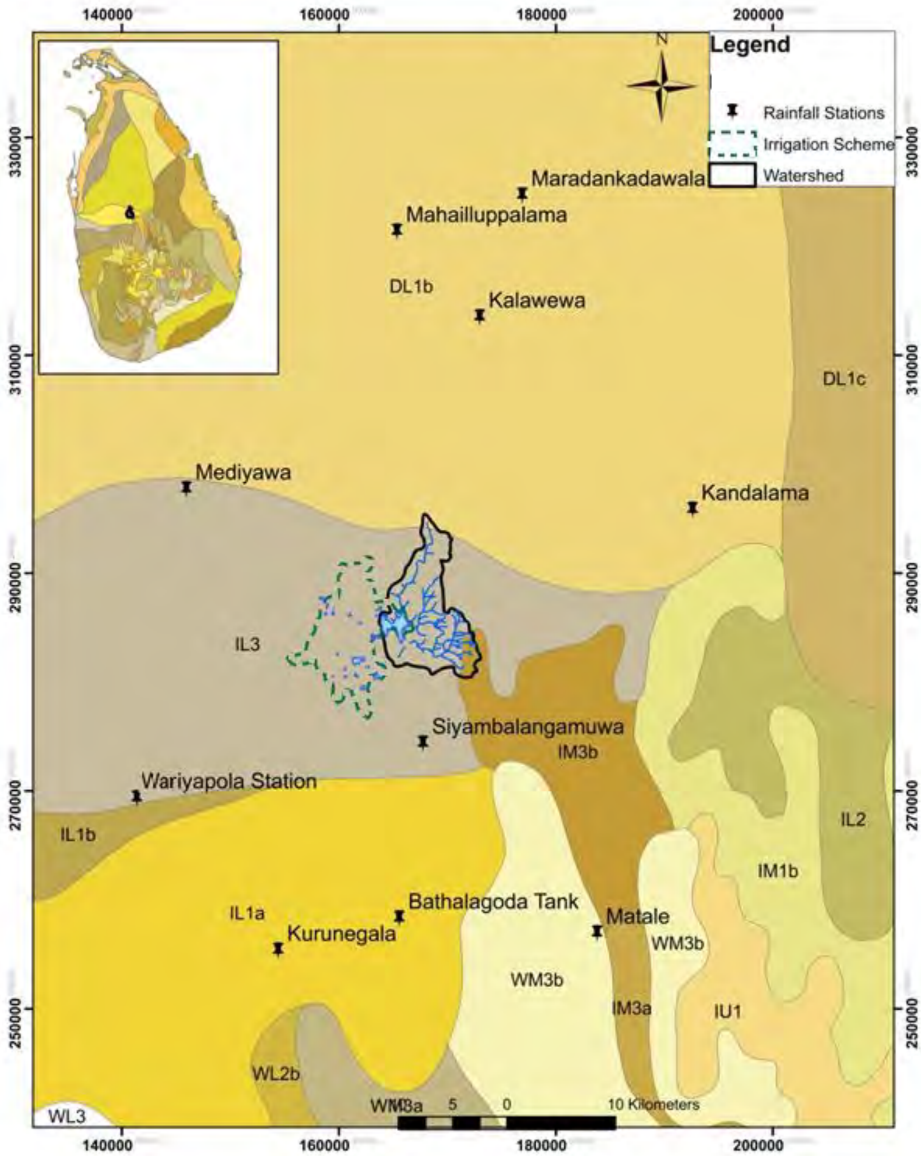

Figure 1. Locations of selected rain gauge stations (Source: Perera, 2015)

This base period has been stipulated by the World Meteorological Organization (WMO) for comparative studies of climate change analysis and, hence was used for this study. A two sample student t-test was conducted to find the significant difference of cumulative rainfall of different time periods against the base period assuming equal variances. The annual rainfall events during last two decades were plotted against the confidence interval (CI) of rainfall received during the base period. The dry years, (*i.e.* rainfall below the lower CI) and wet years (*i.e.* rainfall above the upper CI) were obtained to find whether farmers have experienced more dry years compared to wet years or vice versa during the recent decades.

The same analysis was also conducted for two growing seasons as well as for four rainfall seasons.

Table 1. Selected rain gauge stations of the study

AER	Station	Station No	Latitude	Longitude
WM_3b	Matale	1	7.47 N	80.62 E
IL_1a	Bathalagoda	2	7.52 N	80.45 E
	Kurunegala	3	7.47 N	80.35 E
IL_3	Mediyawa	4	7.88 N	80.28 E
	Siyabalangamuwa	5	7.95 N	80.45 E
	Wariyapola	6	7.63 N	80.25 E
DL_1b	Kalawewa	7	8.00 N	80.53 E
	Kandalama	8	7.87 N	80.68 E
	Mahailluppalama	9	8.60 N	80.27 E
	Maradankadawala	10	8.13 N	80.57 E

RESULTS AND DISCUSSION

Annual Rainfall

The linear trend of annual rainfall over 50 years in the stations surrounding the *Hakwatuna Oya* watershed shows no significant trend for the observed time period (Table 2).

Annual Rainfall Variability

The CV (%) for annual rainfall calculated for the selected stations surrounding *Hakwatuna Oya* watershed for the 1961/90 base period and the next 10 year and 20 year periods are displayed in Table 3 and the annual mean values are given in Table 4.

Table 2. Linear trend of 50 years annual rainfall

AER	Station	1961-2010	
		R^2	p
WM_3b	*Matale*	0.000	0.987
IL_1a	*Bathalagoda*	0.028	0.244
	Kurunegala	0.042	0.153
IL_3	*Mediyawa*	0.003	0.689
	Siyabalangamuwa	0.066	0.071
	Wariyapola	0.032	0.217
DL_1b	*Kalawewa*	0.018	0.348
	Kandalama	0.020	0.328
	MahaIlluppallama	0.025	0.277
	Maradankadawala	0.031	0.223

The annual rainfall shows a decreased variability in comparison with the base period CV% during the most recent decade (1991/00) for all stations. When compared with the base period, 1991/10 period shows a similar pattern with reduced variability in all the climatic zones with the exception of *Bathalagoda*, and *Wariyapola* stations, which shows an increased variability.

Table 3. Coefficient of variability of annual rainfall

AER	Station	CV %			
		1961/90	1991/10	1991/00	2001/10
WM_3b	*Matale*	26	15	15	15
IL_1a	*Bathalagoda*	15	19	14	23
	Kurunegala	17	17	16	20
IL_3	*Mediyawa*	26	20	26	23
	Siyabalangamuwa	24	23	22	23
	Wariyapola	17	20	14	17
DL_1b	*Kalawewa*	24	18	18	18
	Kandalama	25	22	19	21
	MahaIlluppallama	25	20	17	18
	Maradankadawala	26	22	15	19

Confidence Interval of Annual Rainfall

Figure 2 presents the confidence interval (CI) of annual rainfall of the base period in stations surrounding *Hakwatuna Oya* watershed. A total of 7 out of 10 stations had more number of years of extreme events under the lower limit of the confidence interval (LCI) resulting in drought conditions.

Table 4. Mean rainfall and t-stat values of mean annual rainfall

Station	Mean (mm)				t-Stat		
Time period	**1961/90**	**1991/00**	**2001/10**	**1991/10**	**1991/00**	**2001/10**	**1991/10**
Matale	1762	1772	1760	1766	-0.066	0.010	-0.038
Bathalagoda	1699	1583	1620	1602	1.252	1.686	1.211
Kurunegala	2103	1972	1970	1971	1.009	0.981	1.277
Mediyawa	1224	1412	1426	1419	-1.662	-1.773	-1.778
Siyabalangamuwa	1280	1300	1124	1212	-0.173	1.415	0.789
Wariyapola	1690	1634	1713	1673	0.529	-0.230	0.205
Kalawewa	1299	1314	1327	1320	-0.133	-0.249	-0.253
Kandalama	1445	1369	1501	1435	0.601	-0.451	0.101
MahaIlluppallama	1399	1401	1383	1392	-0.020	0.131	0.072
Maradankadawala	1351	1376	1285	1330	-0.192	0.563	0.230
t-critical					2.024	2.024	2.01

Rainfall Variability During Rainfall Seasons

First Inter Monsoon (FIM)

The CV (%) of seasonal rainfall for the FIM season (March- April) for the selected stations for 1961/90 base period and the recent years are given in Table 5. During the periods of 1991/10 and 1991/00, a decreased variability is displayed in all regions except for *Matale, Siyabalangamuwa and Wariyapola*. Comparison of the base period with the most recent 10-year period (2001/10) generally showed a decrease in variability in all regions, except *Bathalagoda*, *Kurunegala, Kalawewa* and *Maradankadawala*, which displayed an increased variability. Table 6 displays the mean rainfall values of FIM season in all 10 stations. Statistical comparisons indicated a significant difference in mean rainfall received by three stations, namely *Matale* and *Mediyawa* for the 2001/10 period and *Kandalama* for the 1991/00 period when compared to the base period.

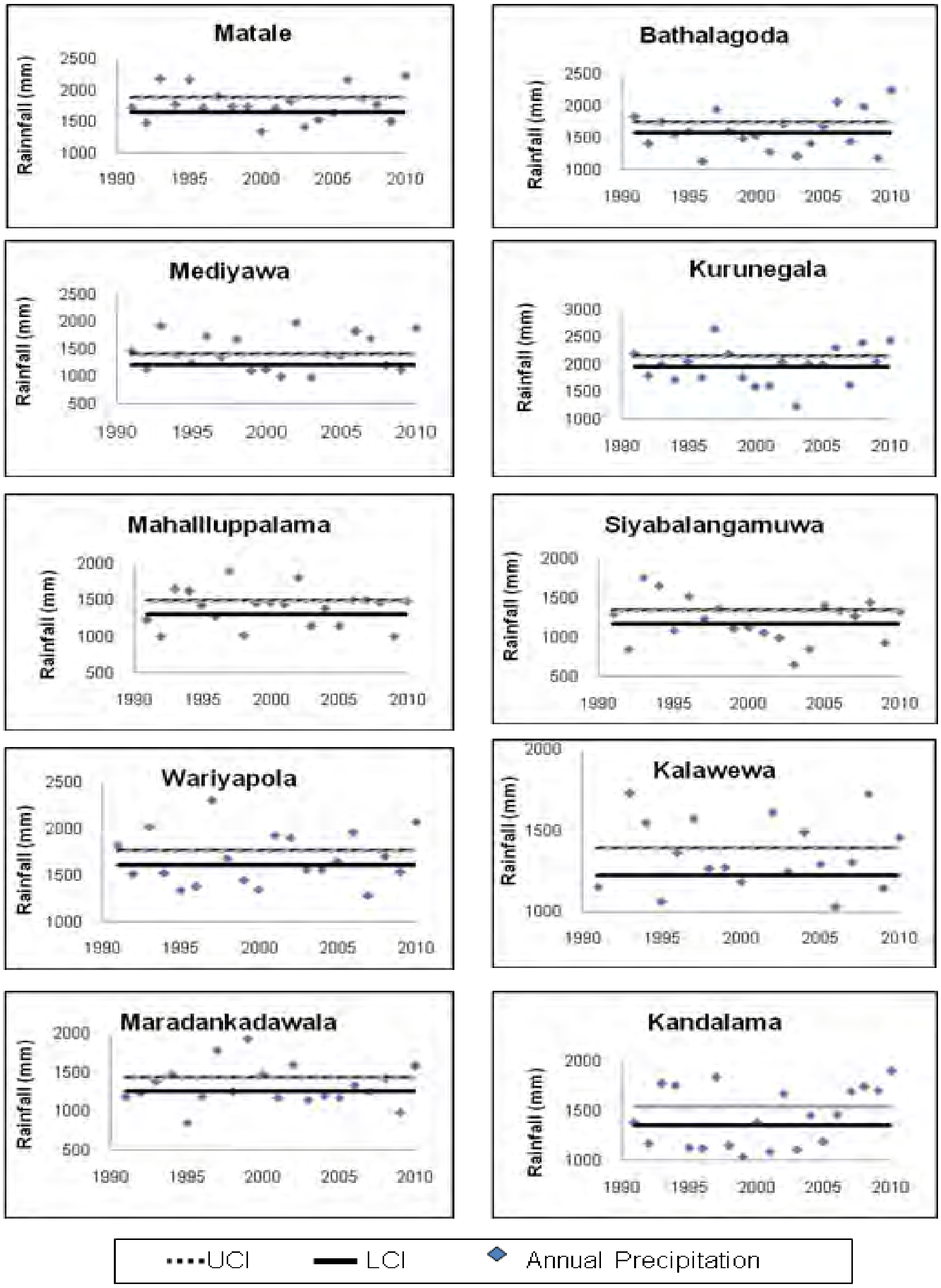

Figure 2. Annual rainfall for years 1991-2010 in relation to the confidence interval of the base period of 1961-1990

Table 5. Coefficient of variability of first inter monsoon

		CV %			
AER	**Station**	**1961/90**	**1991/10**	**1991/00**	**2001/10**
WM_3b	*Matale*	55	40	41	27
IL_1a	*Bathalagoda*	35	41	38	40
	Kurunegala	35	37	28	42
IL*3*	*Mediyawa*	51	38	30	33
	Siyabalangamuwa	53	55	61	43
	Wariyapola	44	39	44	32
DL_1b	*Kalawewa*	49	60	56	54
	Kandalama	44	53	43	39
	MahaIlluppallama	48	46	35	44
	Maradankadawala	42	49	40	52

Table 6. Mean rainfall and t-stat values of First Inter Monsoon

Station	**Mean (mm)**				**t-Stat**		
Time period	**1961/90**	**1991/00**	**2001/10**	**1991/10**	**1991/00**	**2001/10**	**1991/10**
Matale	230	217	**350***	284	0.302	**-2.72***	-1.515
Bathalagoda	312	245	323	284	1.7365	-0.25	0.875
Kurunegala	401	375	446	410	0.527	-0.815	-0.236
Mediyawa	251	256	**384***	320	-0.117	**-2.83***	-1.896
Siyabalangamuwa	240	156	266	211	1.912	-0.576	0.816
Wariyapola	341	295	396	346	0.865	-1.023	-0.099
Kalawewa	228	174	284	229	1.377	-1.261	-0.029
Kandalama	247	**160***	314	237	**2.37***	-1.631	0.311
MahaIlluppallama	257	188	283	235	1.683	-0.577	0.635
Maradankadawala	259	210	268	239	1.294	-0.208	0.618
t-critical					2.024	2.024	2.01

Values and t-stats indicated in bold face and with an asterisk indicate a significant difference compared to the base period

South West Monsoon (SWM)

As shown in Table 7, the rainfall variability of SWM during last 20-year period has increased compared to the base period except in *Matale* and *Wariyapola*. However, according to the mean seasonal rainfall values and the statistical analysis, only three stations located in the IZ *i.e. Siyambalangamuwa*, *Kurunegala* and *Bathalagoda* displayed a significant difference in mean seasonal rainfall (Table 8).

Table 7. Coefficient of variability of South-West monsoon

AER	Station	CV % 1961/90	1991/10	1991/00	2001/10
WM_3b	*Matale*	34	29	28	27
IL_1a	*Bathalagoda*	25	35	29	40
	Kurunegala	26	31	31	27
IL*3*	*Mediyawa*	35	51	44	46
	Siyabalangamuwa	39	62	45	69
	Wariyapola	27	19	23	10
DL_1b	*Kalawewa*	49	58	54	64
	Kandalama	39	55	49	63
	MahaIlluppallama	37	42	34	50
	Maradankadawala	44	62	60	68

Table 8. Mean rainfall and t-stat values of South West monsoon

Mean (mm)	Time period				t-Stat		
Station	**1961/90**	**1991/00**	**2001/10**	**1991/10**	**1991/00**	**2001/10**	**1991/10**
Matale	600	629	507	568	-0.397	1.327	0.582
Bathalagoda	590	506	**401***	**453***	-0.216	**3.39***	**3.09***
Kurunegala	717	693	**552***	623	0.339	**2.53***	1.722
Mediyawa	266	332	199	266	-1.679	1.947	0.001
Siyabalangamuwa	248	270	**138***	204	-0.585	**3.16***	1.407
Wariyapola	508	493	448	470	0.314	1.343	1.083
Kalawewa	238	217	172	194	0.485	1.583	1.311
Kandalama	233	210	175	193	0.673	1.641	1.438
MahaIlluppallama	269	245	226	235	0.287	0.703	0.657
Maradankadawala	245	258	229	244	-0.287	0.356	0.043
t-critical					2.024	2.024	2.01

Values and t-stats indicated in bold face and with an asterisk indicate a significant difference compared to the base period

Second Inter Monsoon (SIM)

As observed in the SWM, the variability during SIM (October-November) has increased in the IZ, while it has decreased in the DZ (Table 9). None of the stations displayed statistical differences in mean values during all time periods considered (Table 10).

Table 9. Coefficient of variability of second inter monsoon

AER	Station	CV %			
		1961/90	1991/10	1991/00	2001/10
WM_3b	*Matale*	36	35	33	39
IL_1a	*Bathalagoda*	30	46	35	52
	Kurunegala	32	39	32	46
IL_3	*Mediyawa*	43	46	38	53
	Siyabalangamuwa	40	37	35	41
	Wariyapola	28	40	40	43
DL_1b	*Kalawewa*	32	36	40	31
	Kandalama	41	31	37	24
	MahaIlluppallama	38	34	37	33
	Maradankadawala	40	30	29	32

Table 10. Mean rainfall and t-stat values of second inter monsoon

Mean (mm)	Time period				t-Stat		
Station	1961/90	1991/00	2001/10	1991/10	1991/00	2001/10	1991/10
Matale	562	539	535	537	0.325	0.375	0.45
Bathalagoda	532	527	644	585	0.089	-1.423	-0.875
Kurunegala	686	649	711	680	0.465	-0.274	0.086
Mediyawa	477	530	582	556	-0.715	-1.23	-1.211
Siyabalangamuwa	484	547	506	527	-0.892	-0.308	-0.757
Wariyapola	590	599	570	585	-0.137	0.286	0.09
Kalawewa	455	535	485	510	-1.325	-0.558	-1.175
Kandalama	510	512	480	496	-0.019	0.432	0.263
MahaIlluppallama	512	561	535	548	-0.673	-0.329	-0.646
Maradankadawala	485	481	440	460	0.065	0.681	0.495
t-critical					2.024	2.024	2.01

North East Monsoon (NEM)

The results for the NEM (December - February) as shown in Table 11, indicate an increased variability in the AERs of WM_3b and IL_1a during the last 20 year period (1991/10), whilst AERs in IL_3 and DL_1b displayed a decreased variability. During the 1991/00 decade, all stations displayed an increased variability compared to the base period except for *Matale*, *Kalawewa* and *Maradankadawala*, which shows a decreased variability. When CV % of the last 10 year time period were compared to the base period, an increased variability could be seen in WM_3b and IL_1a AERs whilst a general decreasing variability could be observed in IL_3 and DL_1b regions. Statistical comparisons indicated no difference in mean rainfall received during the time periods considered.

The variability during the NEM is the highest compared to other three rainfall seasons as the average CV% of all 10-rainfall stations during the base period of NEM is 61%, when compared to FIM (46%), SWM (36%), and SIM (36%). However, in the recent decades the variability of the NEM (55%) and FIM (41%) has decreased whilst SWM and SIM variability displayed an increase with CV values of 46% and 39%, respectively.

Table 11. Coefficient of variability of North East monsoon

		CV %			
AER	**Station**	**1961/90**	**1991/10**	**1991/00**	**2001/10**
WM_3b	*Matale*	58	60	53	70
IL_1a	*Bathalagoda*	47	69	58	72
	Kurunegala	58	64	65	67
IL_3	*Mediyawa*	61	60	74	43
	Siyabalangamuwa	74	71	79	47
	Wariyapola	70	62	76	48
DL_1b	*Kalawewa*	64	49	60	40
	Kandalama	56	57	59	57
	MahaIlluppallama	59	59	62	55
	Maradankadawala	60	56	58	55

Table 12. Mean rainfall and t-stat values of North East monsoon

Mean (mm)	Time period				t-Stat		
Station	**1961/90**	**1991/00**	**2001/10**	**1991/10**	**1991/00**	**2001/10**	**1991/10**
Matale	369	401	395	398	-0.415	-0.309	-0.451
Bathalagoda	272	231	321	276	0.88	-0.833	-0.073
Kurunegala	298	269	266	268	0.456	0.495	0.605
Mediyawa	231	287	278	283	-0.954	-0.941	-1.170
Siyabalangamuwa	247	320	228	274	-0.991	0.307	-0.500
Wariyapola	251	273	283	278	-0.326	-0.528	-0.539
Kalawewa	380	358	478	418	0.259	-1.158	-0.572
Kandalama	451	504	587	545	-0.549	-1.367	-1.185
MahaIlluppallama	355	428	361	394	-0.882	-0.071	-0.616
Maradankadawala	357	434	375	404	-0.946	-0.235	-0.755
t-critical					2.024	2.024	2.01

Rainfall variability during growing seasons

Yala Season

Table 13 and 14 presents the coefficient of Variation (CV %) and the mean values of the rainfall during *Yala* Season (March - August) for the selected stations. A decreased variability could be observed in WM_3b and IL_3 AERs in the decade of 1991/00, whereas IL_1a and DL_1b showed an overall increased variability. For the most recent decade, all stations except *Bathalagoda, Siyambalangamuwa*, *Kalawewa* and *Kandalama* displayed a decreased variability when compared with the base period. The observations for the 20 year time period were similar to that of the 1991/00 decade, where a decreased variability could be observed in WM_3b and IL_3 AERs and IL_1a and DL_1b showed an overall increased variability. Statistical comparisons between the base period and all the other tested periods indicated a difference in mean rainfall in *Siyabalangamuwa* during all time periods considered whereas *Kalawewa*, station showed a difference in mean rainfall between base period and the recent decade.

Table 13. Coefficient of variability of *Yala* season

		CV %			
AER	**Station**	**1961/90**	**1991/10**	**1991/00**	**2001/10**
WM_3b	*Matale*	35	22	25	21
IL_1a	*Bathalagoda*	26	28	30	27
	Kurunegala	26	24	22	23
IL_3	*Mediyawa*	33	27	27	29
	Siyabalangamuwa	42	37	44	32
	Wariyapola	29	23	27	20
DL_1b	*Kalawewa*	31	43	48	35
	Kandalama	32	42	41	38
	MahaIlluppallama	33	28	30	26
	Maradankadawala	34	37	32	41

Maha Season

During *Maha* season (September–February) all stations except *Siyabalangamuwa*, *Kalawewa*, and *Maradankadawala* displayed an increased variability during the 1991/10 time period, and all stations displayed an increased variability during the 1991/00 decade except *Matale*, *Siyabalangamuwa*, and *Maradankadawala*.

Table 14. Mean rainfall and t-stat values of *Yala* season

Mean (mm)	**Time period**				**t-Stat**		
Station	**1961/90**	**1991/00**	**2001/10**	**1991/10**	**1991/00**	**2001/10**	**1991/10**
Matale	684	716	713	715	-0.396	-0.362	-0.508
Bathalagoda	785	787	742	765	-0.027	0.577	0.339
Kurunegala	979	976	811	894	0.033	1.927	1.243
Mediyawa	455	519	517	518	-1.169	-1.118	-1.468
Siyabalangamuwa	645	**350***	**361***	**355***	**3.24***	**3.18***	**4.41***
Wariyapola	721	667	729	698	0.731	-0.118	0.412
Kalawewa	365	341	**498***	420	0.510	**-2.80***	-1.315
Kandalama	404	316	439	377	1.870	-0.676	0.660
MahaIlluppallama	440	384	358	410	1.648	0.592	1.475
Maradankadawala	426	375	408	392	0.979	0.313	0.808
t-critical					2.024	2.024	2.01

Values and t-stats indicated in bold face and with an asterisk indicate a significant difference compared to the base period

In 20 year time period, an increased variability could be observed in all stations except *Bathalagoda, Siyabalangamuwa*, *Kalawewa* and *Maradankadawala*. The statistical comparisons of the distribution of rainfall during *Maha* season between the base period and the next 10-year and 20-year periods as given in Tables 15 and 16.

Table 15. Coefficient of variability (CV %) of *Maha* season

AER	Station	CV % *Maha* 1961/90	1991/10	1991/00	2001/10
WM_3b	*Matale*	29	30	24	36
IL_1a	*Bathalagoda*	26	32	32	25
	Kurunegala	25	34	31	31
IL_3	*Mediyawa*	32	41	40	44
	Siyabalangamuwa	51	38	40	34
	Wariyapola	24	28	31	27
DL_1b	*Kalawewa*	35	30	35	27
	Kandalama	29	37	38	37
	MahaIlluppallama	29	33	34	34
	Maradankadawala	33	28	31	25

Table 16. Mean rainfall and t-stat values of *Maha* season

Mean (mm)	Time period				t-Stat		
Station	**1961/90**	**1991/00**	**2001/10**	**1991/10**	**1991/00**	**2001/10**	**1991/10**
Matale	1078	1069	1074	1072	0.074	0.03	0.065
Bathalagoda	996	957	**1319***	1138	0.398	**-3.22***	-1.629
Kurunegala	1125	971	1303	1137	1.464	-1.529	-0.123
Mediyawa	770	887	927	907	-1.156	-1.456	-1.563
Siyabalangamuwa	679	**945***	777	861	**-2.06***	-0.821	-1.863
Wariyapola	969	993	968	980	-0.25	0.015	-0.150
Kalawewa	912	923	1022	973	-0.096	-0.985	-0.684
Kandalama	1037	1069	1118	1094	-0.266	-0.659	-0.564
MahaIlluppallama	953	1028	1063	994	-1.013	-0.387	-0.864
Maradankadawala	921	1008	904	956	-0.778	0.155	-0.418
t-critical					2.024	2.024	2.01

Values and t-stats indicated in bold face and with an asterisk indicate a significant difference compared to the base period

CONCLUSIONS

There were no conclusive significant trends of rainfall during the last two decades of 1991 to 2010 compared to the base period of 1961-1990, defined by the WMO for climate studies, in 10 selected rainfall stations around the *Hakwatuna Oya* watershed. The number of dry years has slightly increased compared to wet years during last two decades, especially in the IZ, where the command area of irrigation system is located.

In relation to the four rainfall seasons, there was no significant variability of rainfall during last two decades compared to the base period, except for few stations. However, the rainfall variability of SWM, *Yala* and *Maha* seasons displayed a statistical difference in mean rainfall for *Siyabalangamuwa* rainfall station, which is the closest to the *Hakwatuna Oya* scheme in the IZ. The mean rainfall during post 1990 period was lower than the base period during SWM and *Yala* season whereas it has increased during *Maha* season.

Acknowledgement: *This work was carried out with the aid of a grant from the International Development Research Centre (IDRC), Ottawa, Canada. The financial assistance provided by the IDRC to make this study a success is greatly acknowledged.*

REFERENCES

Chandrapala, L. (1995). Comparison of areal rainfall of Sri Lanka on district basis during the periods 1931-1930 and 1961-1990. Proceedings of National symposium on climate change, Colombo.

Chithranayana, R.D. and Punyawardena, B.V.R. (2007). Identification of drought prone agro-ecological regions in Sri Lanka: Journal of the National Science Foundation of Sri Lanka 2008, *36(2),* 117 - 123.

Chithranayana, R.D. and Punyawardena, B.V.R. (2013). Adaptation to the vulnerability of paddy cultivation to climate change based on seasonal rainfall characteristics: Journal of the National Science Foundation of Sri Lanka 2014, *42(2),* 119 - 127.

De Silva, R.P., Punyawardena, B.V.R. and Chandralal, W.D.R. (2006). Characterization of heavy rain and subsequent Dry periods during the North-East monsoon in the Dry zone of Sri Lanka: Journal of the National Science Foundation Sri Lanka, *34(3),* 159 - 161.

De Silva, S.C. (2007). Impacts of climate change on rainfall runoff and water security in Sri Lanka- predictions for 2050S. Proceedings of Water professionals' day symposium on Water resources research in Sri Lanka. University of Peradeniya.

Jayewardena, H.K.W.I., Sonnadara, D.U.J. and Jayewardena, D.R. (2005). Trends of rainfall in Sri Lanka over the last century: Sri Lankan journal of physics. *6,* 7 - 17.

Kankanam, B.N.U.S., Punyawadena, B.V.R. and De Silva, R.P. (2007). Recent variability of southwest monsoon rainfall over Sri Lanka: a statistical approach: Proceedings of Water Professional's day symposium, 133-144.

Linsley, R.K., Kholer, M.A. and Paulhus, J.L.H. (1982) Hydrology for engineers. McGraw-Hill Inc. Japan.

Perera A.C.S. (2015). Impact of climate variability on water availability and paddy productivity in Hakwatuna Oya Irrigation scheme in Sri Lanka. (Unpublished thesis) Postgraduate Institute of Agriculture, University of Peradeniya.

Punyawardena, B.V.R., De Silva, R.P. and Nijananthy, S. (2004). Influence of *El-Niño /La-Nina* episodes on the rainfall regime of the DL_1 region of the north central province of Sri Lanka: Journal of the National Science Foundation Sri Lanka, *32(3&4),* 149 - 156

Punyawardena, B.V.R. (2005). Climate of the Intermediate zone of Sri Lanka. In: Soils of the Intermediate Zone of Sri Lanka.Special Publication No.4, Soil Science Society of Sri Lanka, 6 - 18.

Punyawardena, B. V. R. (2007). Agro-ecology, (Map & accompanying text), National Atlas of Sri Lanka. Second edition. Department of Survey, Colombo, Sri Lanka.

Punyawardena, B.V.R, Mehmood, S, Hettiarachchi, A.K, Iqbal, M, Silva, SHSA and Goheer, A, (2013). Future climate of Sri Lanka: An approach through dynamic downscaling of ECHAM4 General Circulation Model (GCM). Tropical Agriculturist, 161: 35-50.

Zubair, L., Rao, S. A. and Yamagata, T. (2002). Modulation of Sri Lankan *Maha* rainfall by the Indian Ocean Dipole: Geophysical research letters, Vol. *30(2),* 1063.