International Research Symposium
Rajarata University of Sri Lanka

IRSyRUSl 2015

Drought Hazard and Managing Its Impacts through the Disaster Management Approach: A Study in the North Central Province of Sri Lanka

Gunawardhana L.M.A.P[1]. and Lal Mervin Dharmasiri [2]
Department of Environmental Management, Rajarata University of Sri Lanka, Mihintale[1].
Department of Geography, University of Kelaniya, Kelaniya[2]

ABSTRACT

Drought is a weather relatedhazard occurred due to both natural and manmade phenomenon. It is considered as a creeping or slowly onset hazard. Drought creates numerous socio-economic and environmental problems.North Central Province (NCP) is a one of the provinces of Sri Lanka frequently undergone to droughts.73% of the people in the NCP practice agriculture as the major livelihood and they are frequently affected to drought. But there is no institution which responsible for drought directly and there is no drought management policy or early warning system for the country. In this context, general objective of this research was to introduce a model for managing impacts of drought for the NCP. The specific objectives were to identify nature of drought in the NCP, to examine perception of the people about drought, to identify adaptation strategies used by the people, and to develop a model to manage impacts of drought. Both primary and secondary data were collected using questionnaire, interview, group discussion, and field observation. Data were analysed both quantitatively and qualitatively. Results highlighted that there are meteorological, hydrological, agricultural and socioeconomic drought in the NCP and 44% of people in NCP identify drought due to lack of rainfall within expected time. 50% of people in NCP believe that drought is occurred due to destruction of forest. There are so many traditional drought forecasting strategies within the farmers of NCP. Various adaptation strategies are being used by the farmers to cope with drought impacts where both on farm and off farm strategies are used. Model created by the researcher using disaster management cycle i.e. mitigation, preparedness, response and recovery can be used for managing impacts of drought.

KEYWORDS: *Disaster, Drought, Drought Impacts, Drought Management, Hazard.*

[1] Corresponding author: Gunawardhana L.M.A.P: Pradeeplmap85@gmail.com-

1. Introduction

Drought is one of the environmental hazards but it is unable to find universally accepted definition because of its complex characteristics when compared with other environmental hazards such as Floods, Tsunami, Landslides, Earthquake, Cyclones, and Tornadoes etc. However, Definition of drought is essential in order to get in depth understanding about drought hazard and manage its impacts.

Drought means various things to various people, depending on their specific interest. To the farmers, drought means a shortage of moisture in the root zone of his crops. To the hydrologist it suggests below average water levels in streams, lakes, reservoirs. To the economist, it means a water shortage which adversely affects the established economy. Each has concern which depends on the effects of a fairly prolonged weather anomaly (Palmer, 1965). Drought dentition is the main complex task when doing research on drought hazard. Other natural hazards except drought have clear time its existing area and spreading time. Its happening may be onset and its start, existing and the end can be identified clearly like an accident happened in the road. But drought hazard can be compared with only disease of the cancer. Because it takes time to understand to begin of drought and its impacts like a cancer. It is difficult to decide the end of life of the patient who is suffering from cancer. Therefore, it is hard to decide to commence of the drought hazard, its spreading, time existing and the end like disease of the cancer. The people who are suffering from drought bear different views (Saarinen, 1966).The recurrent shortages of water for agriculture, animal husbandry and for domestic use, caused by droughts and dry spells had always been a serious natural and economic set back to the peasant communities (Madduma Bandara, 1983).Droughts are recognized as an environmental disaster and have attracted the attention of environmentalists, ecologists, hydrologists, meteorologists, geologists and agricultural scientists. Droughts occur in virtually all climatic zones, such as high as well as low rainfall areas and are mostly related to the reduction in the amount of precipitation received over an extended period of time, such as a season or a year. Temperatures; high winds; low relative humidity; timing and characteristics of rains, including distribution of rainy days during crop growing seasons, intensity and duration of rain, and onset and termination, play a significant role in the occurrence of droughts. (Wilhite, 1992).Definition of drought is very difficult but if it is necessary to develop the research field on drought hazard, stable effort should be tolerated as well as definitions should be always modified (Thennakoon, 1993).

According to Keith Smith (1996),drought is different from other environmental hazards and he has further explained that there are three inheritance features to the drought hazard in comparison with the other environmental hazards. First, drought is a 'creeping' hazard because droughts develop slowly and have a prolonged existence sometimes over a period of many years. Second, droughts are not constrained to a particular tectonic or topographic setting and their impact can extend over very large regions. Consequently, drought has similarities with long term environmental degradation and it is often difficult to tell where drought ends and human induced desertification begins. Third, impacts of droughts vary greatly between the developed and lesser developed countries. In the most developed countries no one dies because of drought today but in many lesser developed countries the effect of unusually low rainfall on already precarious food supplies creates a strong link between drought and famine related death. Out of the weather-related disasters, drought is certainly the most complex one and its causes multifaceted are not well understood. Persisting over months or years, drought affects extended areas and large populations. Its environmental and socio economic impacts, however ,stems not only from the duration ,severity and spatial extent of the precipitation deficit ,but also to a large extent from the environmental, social and economic vulnerability of affected regions (Hamdy, 2004).Drought is the consequence of a natural reduction in the amount of precipitation over extended period of time, usually a season or more in length, often associated with other climatic factors (such as high temperatures, high winds and low relative humidity) that can aggravate these verity of the event (Sivakumar, 2005).One might define drought in Libya as occurring when annual rainfall is less than 180 mm, if less than 2.5 mm of rainfall in 48 hours in USA, actual seasonal rainfall deficient by more than twice the mean deviation in India, but in Indonesia, Bali drought might be considered to occur after a period of only 6 days without rain, (Ragab, 2005).Drought is the state of insufficiently of water in the environment for cropping, domestic, commercial and industrial uses. Drought cannot be fully controlled, but its damages can be minimized through strict conservation practices and application of local recycling methods supported by strict regulations (Seneviratne, 2006).It is a normal event that takes place in almost every climate on Earth, even the rainy ones. Drought manifestation varies from region to region and therefore,makinga global definition is a difficult task. Drought occurs over most parts of the world, even in wet and humid regions. This is because

drought is defined as a dry spell relative to its local normal condition. On the other hand, arid areas are prone to drought because their rainfall amount critically depends on a few rainfall events, (Sun, 2006).

Drought is a deficiency in precipitation over an extended period, usually a season or more, resulting in a water shortage causing adverse impacts on vegetation, animals, and/or people. It is a normal, recurrent feature of climate that occurs in virtually all climate zones, from very wet to very dry. Drought is a temporary aberration from normal climatic conditions, thus it can vary significantly from one region to another. Drought is different than aridity, which is a permanent feature of climate in regions where low precipitation is the norm, as in a desert (National Drought Mitigation Center U.S., 2008).Differences in hydro meteorological variables and socioeconomic factors as well as the statistic nature of water demands in different regions around the world have become an obstacle to having a precise definition of drought (Ashok & Vijay, 2010).Droughts have been a part of our environment since the beginning of recorded history, and humanity's survival may be testimony only to its capacity to endure this climatic phenomenon. Drought is considered by many to be the most complex but least understood of all natural hazards, affecting more people than any other hazard (Wadid, 2011).Drought is one of the severe meteorological disasters (Xing-peng & Ji-quan, 2013).The shortage of the rainfall, the erratic distribution of the rainfall, highs evapotranspiration, water erosion, low water holding capacity of soil that all of them are the major causes of drought. (Zareiree, 2014).

Therefore, considering all above definitions given by various researchers, drought can be understood as slowly onset, weather related hazard of the environment and it can be caused due to both socio natural factors in all the regions of the world. The meaning of drought can be changed from person to person, country to country or region to region. Mainly four types of drought can be identified as meteorological, hydrological, agricultural and famine or socio economic droughts. Deficiency of rainfall within the expected time period called as meteorological droughts while if there no sufficient surface and underground water in the tanks, ponds, and rivers identified as hydrological drought. Lack of soil moisture level for crops is called agricultural droughts and deficiency of food can be understood as socioeconomic or famine droughts. Finally, drought can create adverse impacts to the community causing socio economic and environmental impacts.

Sri Lanka is one of the Asian counties which is frequently undergone to drought hazards, when drought is occurred it is always transformed into disaster creating numerous adverse impacts to the community. Every year, somewhere in the country, people are affected by seasonal droughts of short-duration. Droughts of regional significance occur once in every 3 to 4 years (Disaster Management Centre(DMC), 2012). Severe droughts of national significance occur after a considerable period of time, within 10 years or so. After the severe drought of 1935-1937, the other severe droughts of national significance occurred during the periods 1947-1949, 1953- 1956, 1965, 1974-1977, 1981-1983, 1985 and in 1995-1996. Of all these major droughts, those during the periods 1953-1956, 1974-1977, 1981-1983 and 1995-1996 caused major set-backs to the economy. The worst drought in the history of Sri Lanka took place in 2001 with another severe drought experienced in 2004. In other years during the period between 1974 and 2007 droughts demonstrated a cyclic trend creating peaks at three to four year intervals in 1976, 1979, 1983, 1986, 1989, 1991, 1997, 2001, 2004,2007, 2012, and 2013 The largest number of people affected by drought, and the greatest damage to paddy, occurred in 2001 and 2004. 5,071,625 people were affected by drought in 2001 and 2,198,521 in 2004. 104,399 hectares of paddy were lost in 2001 and 47,105 hectares in 2004.The Districts most prone to droughts include: Kurunegala, Hambantota, Moneragala, Puttalam, Anuradhapura, Badulla, Ratnapura, Ampara, Matara and Nuwara Eliya (Future in our hands development fund , 2011).According to Sri Lanka's Department of Agriculture, 43,000 hectares of rice paddies have so far been destroyed by the drought. Rice is an important component in Sri Lankan diets and also for income generation in total, Sri Lanka cultivates around 390,000 hectares of rice 11.1% contributes to the GDP (Central Bank Report 2013). According to statistics, the Government allocated Rs. 16,693,828 in 2006, Rs.19, 921,772 in 2007, Rs. 15,286,758 in 2008 and Rs.27, 655,774 in 2009 for the supply of drinking water for drought- affected people. Therefore, it is obvious that there are more impacts of drought to the nation by influencing economy, society and the environment but drought condition is not considered and taken into account seriously because it is not damage to the human lives but indirectly it influence very highly than other natural disasters by losing agricultural crops and yields and lacking safety water for domestic purposes and causing heavy burden to the economy of the country (Central Bank of Sri Lanka , 2014).

North Central Province (NCP) of Sri Lanka has a high risk of drought because NCP is wholly within the Dry Zone and main livelihood of area is agriculture (Ministry of Environemnt and Natural Resources, 2007). Though there are ancient cascade system in the Dry Zone, people in the area are suffering from lack

of water for agriculture and safe water for drinking and other domestic purposes. For example, 880,529 persons and 108,451 families affected from the drought in 2004(Disaster Information Management System in Sri Lanka, 2004). According to department of census and statistics, total population in NCP is 1,264,000 and 90% practice the agriculture as their main livelihood (Homes, 2001). Therefore, inhabitants in the NCP can be heavily affected from the drought hazard than the other natural hazards losing their family income and drinking and other domestic water and there is high risk to create other health, social and environmental issues for example, high prevalence of kidney failure patients in the area may be a lack of good quality water for drinking and cooking. Further, when analyzing economic condition of the NCP, Poverty is increasing for example poverty headcount ratio for the two period from 2009/10 and 2012/2013 by districts, poverty headcount ratio has been reduced in all districts except Anuradhapura, Polonnaruwa and Monaragala. Anuradhapura and Polonnaruwa belongs to the NCP where poverty headcount ratio from 5.7 to 7.6 and from 5.8 to 6.7 has been increased during the period of 2009/10 to 2012/13 respectively. This may be the continuous occurrence of drought in this area.

2. Statement of the Problem

After Indian Ocean Tsunami on 26th of December 2004, Sri Lanka government has taken steps to identify major hazards occurred in Sri Lanka and laid a foundation to create effective disaster management to reduce impacts of hazards and achieve safer and resilience of lives and property where regulatory and institutional framework such as Disaster Management Act, National Council for Disaster Management, Ministry of Disaster Management, National Disaster Management Policy, Disaster Management Centre for National Co-ordination and Subnational Coordination Committees (Provincial level, District level ,Local level and Village Levels) were introduced. According to Disaster Management Act no 13th of 2005, 21 hazards have been identified where drought has been identified as a major hazard in Sri Lanka. But, though there is legal and institutional framework, there is no reduction of impacts of drought hazards especially in the NCP of Sri Lanka but people in the NCP living with drought having following both on farm and off farm adaptation strategies. On the other hand, though there is a common disaster management cycle i.e. mitigation, preparedness, response and recovery, it is not clear what are the activities that can be taken to manage impacts of drought in each phase of the Disaster Management Cycle. That is why the researcher carried out this research to achieve following objectives.

3. Objectives of the Study

- To identify nature of drought in the NCP
- To review the present disaster management mechanism
- To develop a model to manage impacts of drought using Disaster Management Cycle

4. Review of Literature

Researcher used Keith Smith's theory on Environmental Hazards and drought theory in 1996. Researcher mainly used the book published by M.U.A.Thennakoon in 1986 named 'Drought Hazard and Rural Development' and Research article written by C.M. Madduma Bandara in 1983 on 'effect of drought on the livelihood of peasant families in the Dry Zone of Sri Lanka: A study on the Mahapothana Korale in the North Central Province.' In addition to that various types of Annual reports, Journals, Magazine, and internet websites were used to find the background data on drought hazard.

5. Methodology

Both primary and secondary data were used by the researcher. Primary data were collected using questionnaire, group discussion, key person interviews and field observation. Secondary data were collected from various institutions, books, journals articles, research articles, websites etc. Rainfall data from nine meteorological stations covering NCP and from 1955 to 2014 over 60 year period were collected from the Department of meteorology. Data were analysed using both quantitative and qualitative methods. Specially, one of the drought index called Standardized Precipitation Index (SPI) was calculated to understand the frequency of drought in the NCP and its spatial distribution during the past 60 year's period. 150 samples were used to check the perception of the people on drought hazard of the NCP where Rambewa, Thirappane and Medirigiriya Divisional Secretariat Divisions were selected to fill the questionnaires. Data were presented as text, graphs, and tables.

6. Results and Discussions

Under the result of the study, first nature of drought hazard has been presented having analysed rainfall data of two meteorological stations named Anuradhapura and Polonnaruwa covering North Central Province (NCP) and calculating drought index named Standardized Precipitation Index (SPI). Then, the mechanism of disaster management of Sri Lanka has been reviewed briefly and finally created a model for manage impacts of drought using Disaster Management Cycle. Results of the study can be shown as follows.

6.1 Nature of drought hazard in the NCP

When analysing rainfall data covering 60 year period from 1955 to 2014, it is easy to analyse drought events. Table 01 clearly shows that in Anuradhapura, mean value of monthly rainfall is reducing within the months of May to September. But rainfall has been increased during the month of October to May but it is gradually decreasing.

Descriptive statistics	Jan	Feb	Mar	Apr	May	Jun	July	Aug	Sep	Oct	Nov	Dec
Mean	92	56	69	166	81	14	28	36	68	251	252	207
Median	58	32	51	153	69	5	13	11	57	239	233	169
Mode	150	0	0	134	75	0	0	0	0	211	168	89
Standard Devi.	88	88	63	79	69	27	37	49	59	128	101	138
Range	349	528	297	341	268	173	165	218	266	638	455	647
Minimum	0	0	0	30	0	0	0	0	0	46	74	19
Maximum	349	528	297	371	268	173	165	218	266	684	529	666
Sum	5492	3344	4111	9971	4879	866	1692	2182	4055	15046	15133	12435
Count	60	60	60	60	60	60	60	60	60	60	60	60

Table 01: Descriptive values of rainfall data of Anuradhapura meteorological Station from 1955-2014

Source: Analysed by the researcher using rainfall data, 2015

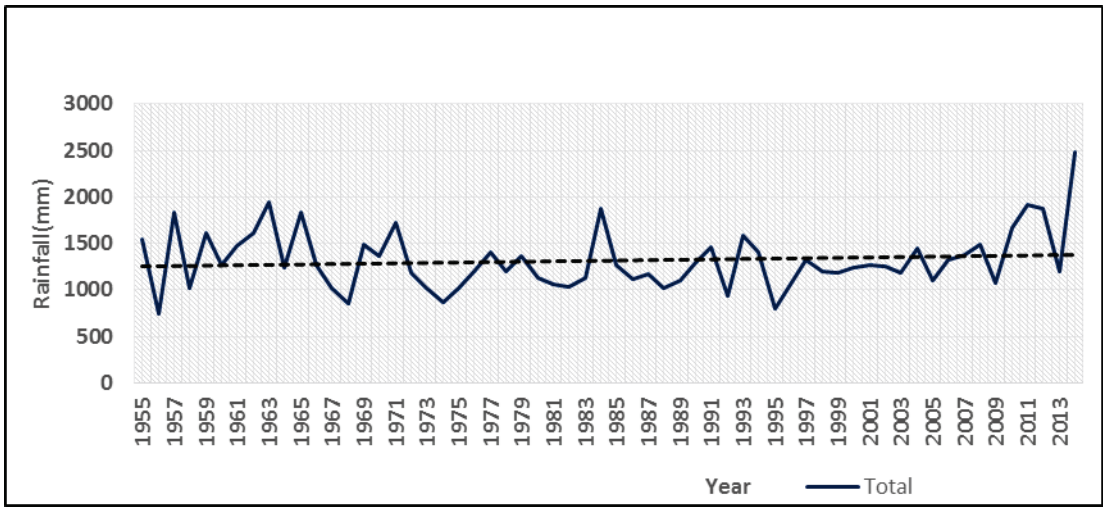


Figure 01: Total Annual rainfall over 60 years from 1955 to 2014 in Anuradhapura (mm)
Source:Analysed by the researcher using rainfall data, 2015

Figure 01 clearly shows that rainfall in Anuradhapura is highly fluctuated and there is a cyclic trends. Some years have been undergone severe drought because total annual rainfall has been reduced more than 750 mm.

Descriptive statistics	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Mean	204	137	74	52	48	16	39	41	66	181	352	408
Median	153	68	54	37	33	3	26	35	67	142	294	385
Mode	47	0	0	18	0	0	0	0	68	347	157	495
Standard Devi.	179	166	68	54	45	24	42	45	50	123	180	214
Range	597	703	249	270	172	101	162	159	191	494	646	1054
Minimum	0	0	0	0	0	0	0	0	0	10	131	90
Maximum	597	703	249	270	172	101	162	159	191	504	777	1144
Sum	8164	5491	2946	2078	1908	637	1556	1658	2654	7240	14094	16333
Count	40	40	40	40	40	40	40	40	40	40	40	40

Table 02: Descriptive values of rainfall data in valachchena meteorological station in Polonnaruwa

Source**:**Analysed by the researcher using rainfall data, 2015.

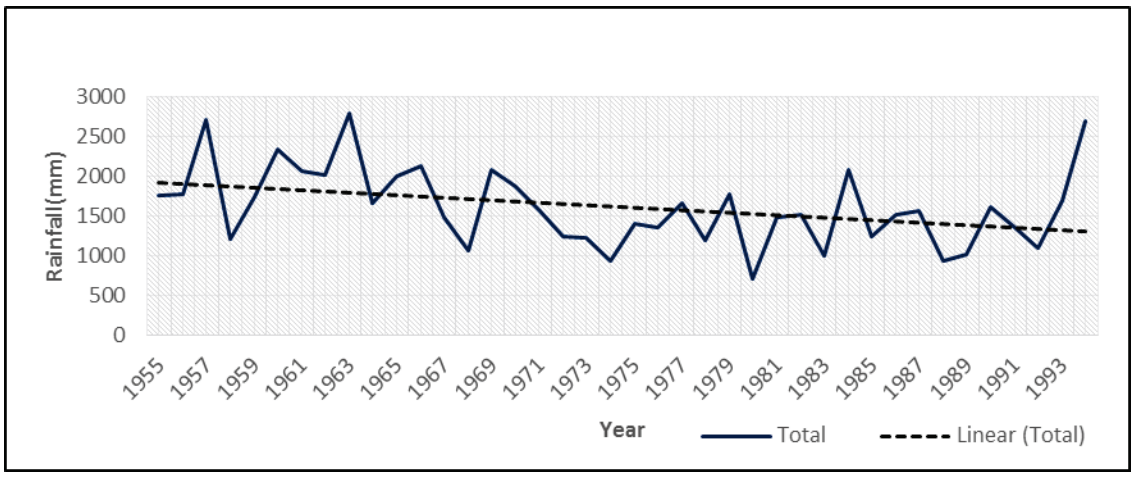


Figure 02: Total annual rainfall over 40 year period from 1955 to 1993 of Valachchena in PolonnaruwaSource: Analysed by the researcher using rainfall data, 2015

Table 02 and figure 02 show condition of drought in the polonnaruwa district where it is clear that rainfall is highly fluctuated over 40 year period. When exploding above figures and tables it is easy to understand the behaviour of rainfall pattern in the NCP. It was found that when compared with Anuradhapura and Polonnaruwa, rainfall amount is high in Polonnaruwa but there is a long term increasing rainfall in Anuradhapura but there is a decreasing trend of rainfall in Polonnaruwa. Further, when analysing Standardized Precipitation Index (SPI) introduced by American scientist McKee et al in 1993, it is easy to understand the frequency of drought occurring in the NCP and its severity. Table 03 shows SPI values and its interpretation and figure 03 and 04 shows the frequency of drought and severity where all positive values shows flood events and all negative values show drought events. But here, only considered drought events.

Table 03: SPI values and severity of drought

SPI Value	Interpretation
2.0 over	Wet
1.5 to 1.99	Moderately wet
1.0 to 1.49	Slightly wet
-.99 to .99	Near normal
-1.0 to -1.49	Moderately dry
-1.5 to -1.99	Severely dry
-2 and below	Extremely dry

Source: Modified by the researcher 2015.

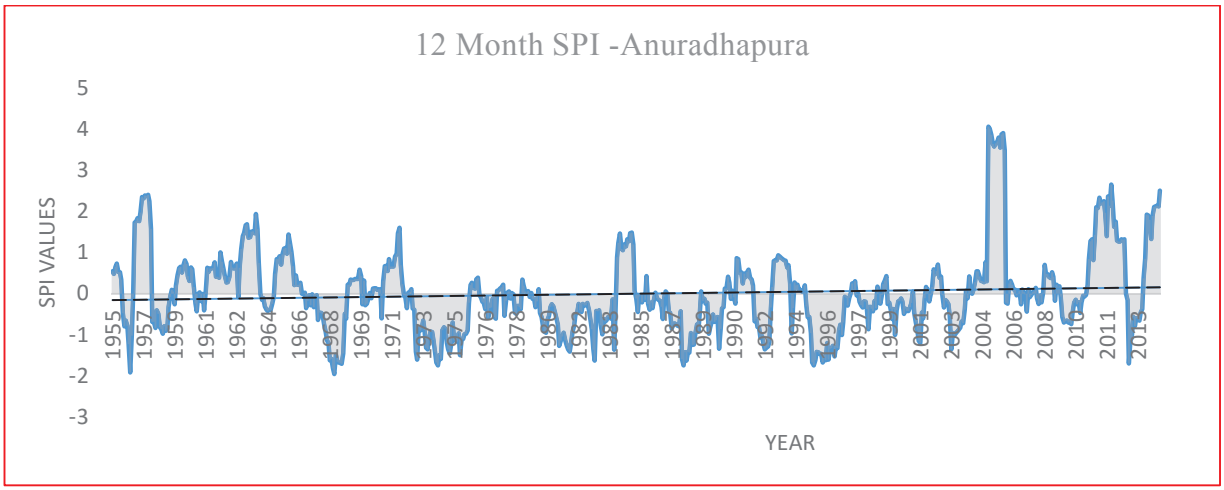


Figure 03: 12 Months SPI values in Anuradhapura meteorological station
Source: Calculated by the researcher 2015.

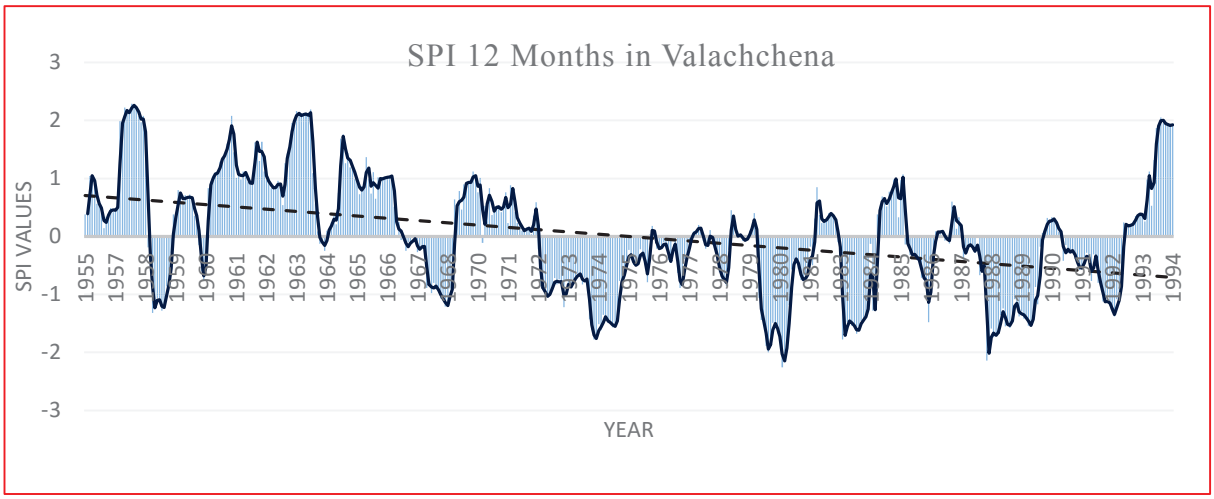


Figure 04: 12 Months SPI values in Valachchana Meteorological Station in Polonnaruwa

Source: Calculated by the researcher 2015.

When exploring figure 3 and 4 it is easy to understand the frequency of drought events during the past 60 years from 1955 to 2014 and its severity. So, near or more than -1.5 SPI values show severe drought and SPI value -2 or higher values extreme drought in the NCP. Hence, both figure 3 and 4 clearly shows that frequency of severe and extreme event of drought have been increased over time in the NCP. Years 1956, 1968, 1974,1981,1988,1992,1996,2003,2009 and 2013 have been undergone to severe drought during the past 60 years in the NCP.

6.2 Disaster Management Mechanism in Sri Lanka

After Indian Ocean Tsunami on 26th of December 2004, Government of Sri Lanka laid the foundation to minimize the impacts of disasters occurred in Sri Lanka. After, the Tsunami event, it pointed out that the weakness of the Government to response to disasters .Hence, according to recommendation of the Parliament Select Committee, Disaster Management Act no 13 of 2005 was introduced which provides the legal and institutional framework to manage disasters in Sri Lanka. Disaster Management Act provides National Council for Disaster Management, Disaster Management Centre, Disaster Management Policy, Ministry of Disaster Management, National and Subnational level coordination plans, etc. National Council for Disaster Management (NCDM) is the high level body which is chaired by H.E. President. NCDM is composed with President, Prime Minister, Leader of the Opposition, 20 ministers relevant subjects i.e. Social Services, Rehabilitation and Reconstructions, Home Affairs, Health, Science &Technology, Housing, Cost Conservation, Irrigation, Power, Defence, Police, Finance, Land, Fisheries Aquatic Resources, Foreign Affairs, Water supply, Highways, Urban Development, Education and Environment. Five members of the opposition party, Chief Ministers of nine provinces, Major function of the NCDM the provides the leadership and the resources for the process of Disaster Management in Sri Lanka. All functions and composition of the NCDM is explained in the Disaster Management Act no 13 of 2005 in details. Figure 05 shows structure of the NCDM of Sri Lanka as bellow.

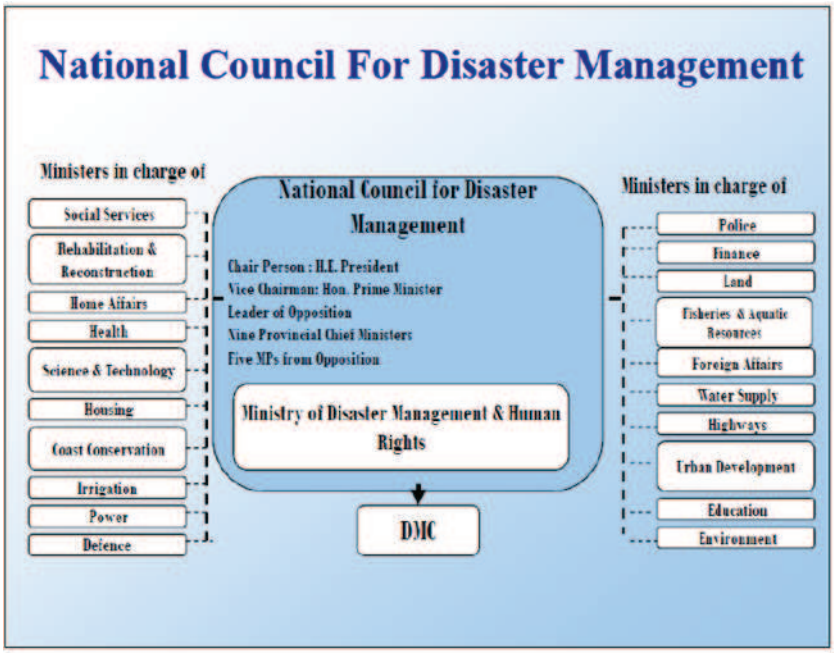
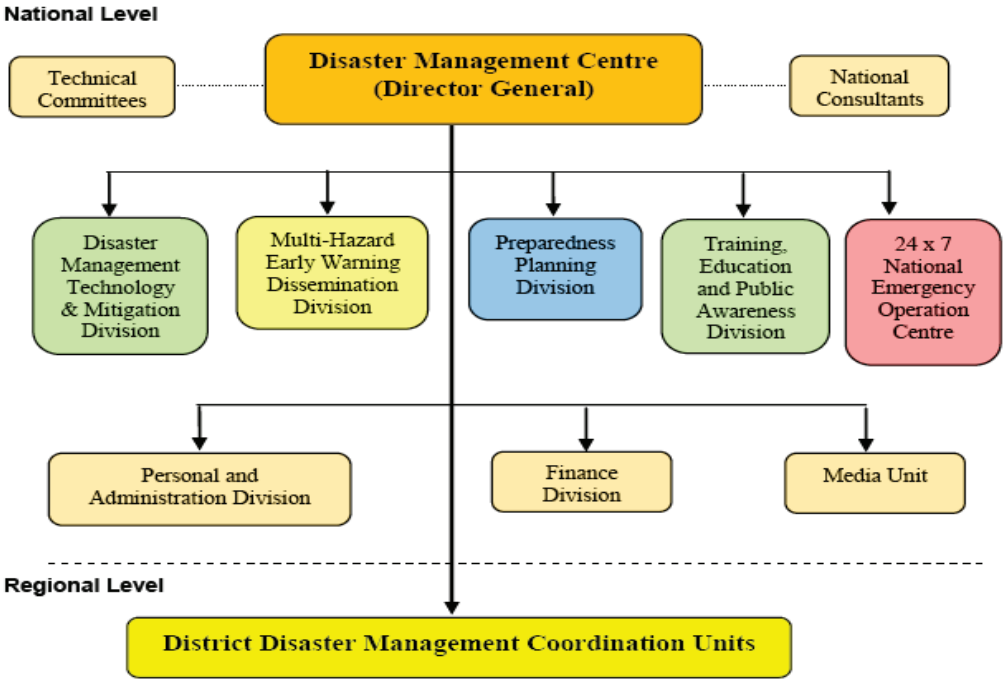


Figure 05: Structure of the NCDM of Sri Lanka

Source:(Disaster Management Centre , 2011)

Disaster Management Centre (DMC) is the main body of Coordination of Disaster Management activities which is under the Ministry of Disaster Management. All functions and duties of the DMC have also been explained within the Disaster Management Act in details. Figure 06 shows the organisational structure of the DMC and it is composed with several divisions and headed by the Director General.

Figure 06: Organisational Structure of Disaster Management Centre



Source:(Disaster Management Centre , 2011)

In addition to above mechanism, Parliament Select committee has recommended to establish district and local level disaster management plans, and effective communication systems, and National Emergency Operation plan, Multi hazard Early Warning System etc. By now special attention has been given for the Tsunami hazard, but there is no adequate attention has not been given for the drought hazard. Because, there is no direct responsible institution for drought, there is no drought early warning system, and thereis no separate drought policy for the country.

6.3 Managing impacts of drought

When exploring impacts of drought, particularly in the NCP there are so many socio economic and environmental impacts on community created by the seasonal drought. Because majority of the people in the NCP are practicing agriculture as the major livelihoods. All types of drought i.e. meteorological, hydrological, agricultural and socioeconomic or famine drought can be found in the NCP. Because 76% of people in the NCP identify drought when there is no rainfall within the expected time period. 16% of people identify drought as when there is no water in the surface and underground bodies. 5% of people identify drought when there is no adequate water for agriculture. People in the NCP believe that drought is occurred in once in every 2-3 years. Therefore, people in the NCP suffering from drought impacts but there is no comprehensive drought management plan. Sri Lanka is also used common disaster management cycle where threre are four major parts of the cycle as mitigation, preparedness, response and recovery. Figure 07 shows the common disaster management cycle but it is not clear what are the activities to be carried out when managing impacts of drought. On the other hand, drought is different from other environmental hazards. Therefore, figure 08 shows suggested drought management cycle created by the researcher.

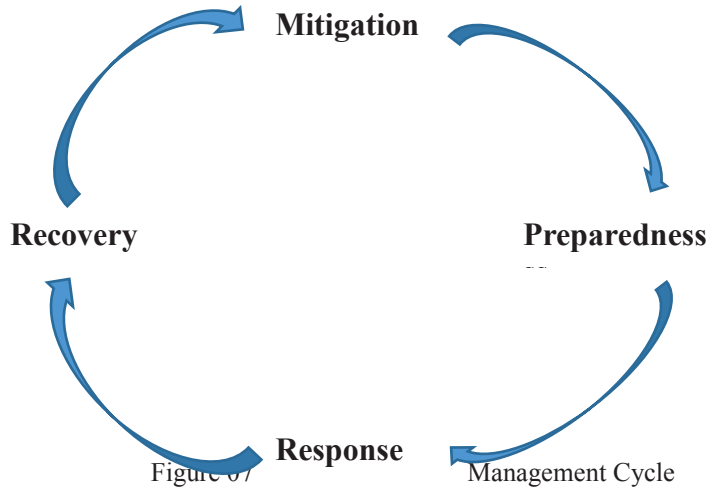


Figure 07 Management Cycle

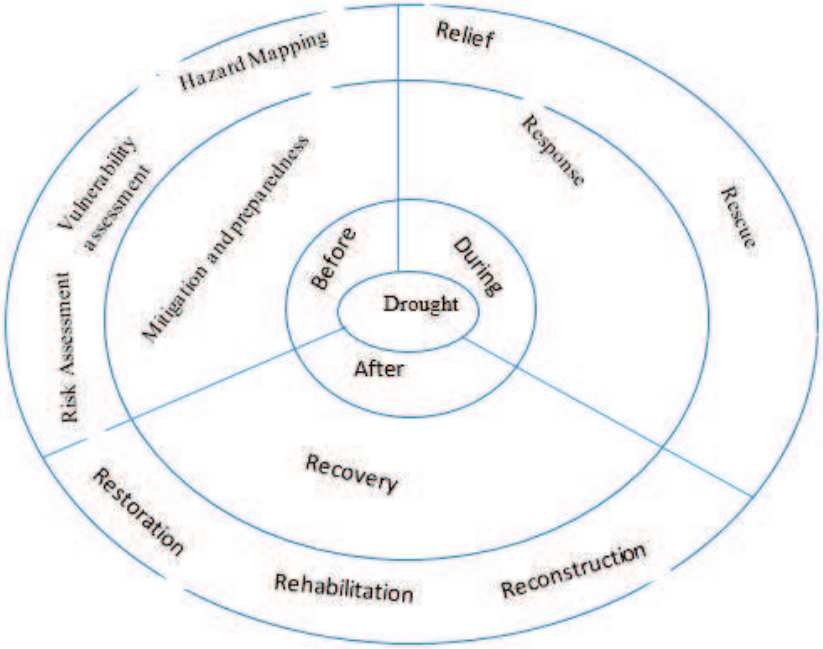


Figure 08 : Proposed Drought Management Cycle

Source: Created by the researcher, 2015.

7. Conclusion and recommendations

Drought is the one of socio natural hazard of the environment. Drought is different from other hazards because it is not a rapid onset hazard and there is no direct loss of lives due to drought but it may cause vast impacts to the society creating socio economic and environmental problems. Therefore, it is time to conduct more and more research on drought hazard to understand the nature of drought and its spatial and temporal distribution of the NCP. Drought severity can be changed from place to place. Therefore, it is needed to identify the activities that can be done under each phase of drought i.e. before, during and after to reduce and manage the impacts of drought in the NCP. Drought policy is an essential component to the country and drought early warning system should be prepared to minimize the impacts of drought in the NCP.

References

Ashok, K., & Vijay, P. (2010). A review of drought concepts. *Journal of Hydrology*, 202-216.

Central Bank of Sri Lanka . (2014). *Sri Lanka Socio-Economic Data.* Colombo: Statistics Department,Central Bank of Sri Lanka .

Disaster Management Centre . (2008). *Disaster Event & Impact Profile.* Colombo: Disaster Management Centre.

Disaster Management Centre . (2011). *Annual Report* . Colombo: Disaster Mnagment Centre .

Disaster Management Centre(DMC). (2012). *Hazard profile of Sri Lanka* . Colombo: Ministry of Disaster Management ,Vidya Mawatha,Colombo 07.

Disaster Managment Centre . (2005). *Towards a Safer Sri Lanka : A road map for Disaster Risk Management* . Colombo : Ministry of Disaster Managment .

Future in our hands development fund . (2011). *The impact of drought and adaptation practices of rice growing communities in Uva Province in Sri Lanka* . Pesticide Action Network, Asia and the Pacific.

Hamdy, A. (2004). Drought planning and mitigation measures in the mediterranean region. *Options Meditarerraneans, seris A, No 80*, 235-239.

Homes, E. (2001). Rain, drought and dreams of the prosperity. Enschede, the Netherlands: University of twente.

Madduma Bandara, C. (1983). Effect of drought on the livelihood of peasnt families in the Dry Zone of Sri Lanka: A study on the Mahapothana Korale in the North Central Province. Climatological Notes ,Tsukuba,Japan, 61-76.

Ministry of Environemnt and Natural Resources. (2007). Sri Lanka Strategy for Sustainable Development. Colonbo: Ministry of Environment and Natural Resources.

National Drought Mitigation Center U.S. (2008). Drought. the National Oceanic and Atmospheric Administration (NOAA).

Palmer, W. (1965). *Meteorological Drought.* Washington: Office of Climatology,U.S.Weather Bureau,Washington ,D.C.

Ragab, R. (2005). Water Management Strategies to Combat Drought in the Semi-Arid Regions. *Expert Meeting on Drought in the Arab Region UNESCO*, 28-30.

Saarinen, T. (1966). *Perception of the drought hazard on the Great piains, Research paper No 106* . Chicago: Department of Geography, University of Chicago.

Seneviratne, H. (2006). *Environmental Hazards.* 12,A, Millawana,Pahalagama,Matale.: Author.

Sepulcre-Canto, G., & al, e. (2012). Development of a Combined Drought Indicator to detect agricultural drought in Europe. *Natural Hazards and Earth System Sciences*, 3519–3531.

Sivakumar, M. (2005). *Natural Disasters and Extreme Events in Agriculture,.* New Yourk: Springer Berlin Heidelberg , New Yourk .

Sun, Y. a. (2006). How often does it rain . *J.Clim*, 916-934.

Thennakoon, M. (1993). *Drought and Farmer* . Colombo: Central Bank of Sri Lanka.

Wadid, A. (2011). *Drought vulnerability in the Arab region:A case study -Drought in syria(2000-2010).* P.O.Box:2440 Damascus, Syria: Arab Center for the Studies of Arid Zones and Dry Lands.

Wilhite, D. (1992). *Preparing for Drought: A guidebook for Developing Countries,.* Nairobi,Kenya: Climate Unit, United Environment Program.

Xing-peng, L., & Ji-quan, Z. (2013). Assessing Maize Drought Hazard for Agricultural Areas Based on the Fuzzy. *Journal of Integrative Agricultur*, 532-540.

Zareiree, A. (2014). Evaluation of Drought Hazard Area of GharehAghaj Basin in Iran, Using GIS. *Atmospheric and Climate Sciences*, 147-154.