ASSESSMENT OF RAIN WATER HARVESTING POTENTIAL – A CASE STUDY FOR IDAMELANDA

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Abstract

This project assessed the water scarcity and the potential for rain water harvesting of a rural village vulnerable to severe droughts.

Meteorological data was used to calculate the Weighted Average Standardized Precipitation (WASP) Index and Palmer's Drought Severity Index (PDSI. This was then cross referenced with the drought relief data for the region. The lowest and highest correlation values between the two methods were 0.57 and 0.77 respectively.

The feasibility of RWH for both domestic and agricultural activities was then studied and was found to be practical to collect the rainwater using the roof and the land surface as catchments.

Key Words: *Rain Water Harvesting (RWH), WASP, PDSI*

1. Introduction

Drought is the most frequent disaster in Sri Lanka and the expenditure on drought relief has been the dominant except for the recent Tsunami. Rising population and intensification of water use by domestic, industrial and municipal sector along and use changes can lead to higher frequency of drought incidence. Drought leads to agricultural losses, hardships for those in drought affected areas, and also in a loss of hydroelectricity generation leading to planned electricity outages [1] and can be characterized with different measures: there is the meteorological drought – due to deficiency of rainfall; hydrological drought – due to lack of water in the land surface; and agricultural drought when crops and animals lack water. There are several indicators to assess the severity [2] of a meteorological and hydrological drought and out of these; two methods – namely the PDSI and WASP Index – were used in this work.

In accordance to the type of catchment being used, RWH can be categorized into four groups – roof catchment systems, rock catchment systems, ground catchment systems and check and sand dams, hafirs [3]. Depending on the reliability of the system, there are four more categories; (a) Occasional - water is stored for only a few days in a small container. Suitable when there is a uniform rainfall pattern with very few days without rain and there is a reliable alternative water source nearby (b) Intermittent - in situations with one long rainy season when all water demands are met by rainwater; however, during the dry season water is collected from non-rainwater sources (c) Partial - rainwater is used throughout the year but the 'harvest' is not sufficient for all domestic demands. For instance, rainwater is used for drinking and cooking, while for other domestic uses (e.g. bathing and laundry) water from other sources is used and (d) Full - for the whole year, all water for all domestic purposes is rainwater. In such cases, there is usually no alternative water source other than rainwater, and the available water should be well managed, with enough storage to bridge the dry period [4]. The goal of this study is to use the roof area as the main catchment for domestic consumption with a partial reliability. It will also utilize the ground catchment system as much as possible.

Water scarcity is mainly the physical deficit of water in an area. We focused on the Idamelanda Grama Niladari Division located within the Hanguranketa Divisional Secretarial area in Nuwara Eliya District. It is situated at an elevation of 500-600 m above mean sea level with an annual rainfall of 1530 mm with the mean temperature ranging from 20-25^{0}C. Low annual rainfall, occurring from October - December (175 mm) and January and April (100 mm), coupled with high elevation with dry air currents, has resulted in deficits of water. This does not mean that the shortage of water must lead to droughts. This is because if potential capacity to undertake mitigatory measures such as pumping water, transportation to water available areas, introducing drought sustainable crops, rain water harvesting etc. – and in addition the capability of adapt by the people of that area. Both the scarcity of water and vulnerability to this scarcity must combine to lead to a disaster. The vulnerability can be considered for four principal categories – people, economic activity, infrastructure and networks. In the case of droughts, the effect is more on people and economic activities while it has a rare effect on infrastructure or networks in Idamelanda.

At Idamelanda, water is required both for domestic purposes, as well as for agricultural activities. Home gardens are important for the peoples' welfare. In addition, a source of income is from rain fed cultivation in Chena (slash, burn and fallow) land due to non availability of a dependable source of water for agriculture. Slash and burn agriculture is unsustainable as the available forests are being constantly lost. In addition, it affects the water table as water that percolates to the ground during the rainy season prevalent is lost due to flash floods during the wet period. At present, some people use water from deep wells to meet their domestic water needs.

Although drought has a relationship with climate, little use has been made of meteorological information to characterize the characteristics of drought by region and seasons and to make use of this information to inform the design of rain water harvesting units. Here, we investigate the viability of:

(1) Generation of regional, seasonal and long term indicators for drought risk at fine scale
(2) Design Guidelines of a Tank for RWH

2. Methodology

This study utilizes two independent methods, (a) Palmer's Drought Severity Index (PDSI) and (b) Weighted Average Standardized Precipitation (WASP), of assessing the drought.

2.1 Meteorological Data

The meteorological information, rainfall, temperature, solar radiation, wind speed, maximum and minimum relative humidity as well as the soil moisture of the area were needed for the assessment of the severity of the drought and the design for RWH. Since both the rainfall and temperature were not available for Idamelanda itself, there being no established climate station, the data from proximate stations were used for interpolation. The Inverse Distance Method was used for the interpolation [5]. Using this information, all calculations were done. The selected data duration was from 1960-2000.

2.2 Drought Assessment Methodology

Among the indices used to assess drought, we have made use of WASP and PDSI methodologies for our assessment process. The WASP is normalized to a range of values from -4 to +4 while the PDSI ranges from -6 to +6. The negative values indicate less rainfall while positive values indicate excess in rainfall. The PDSI [6] is a measure of drought with due consideration to the soil type, water retaining capacity of the soil and watershed information while WASP concentrates on contextualizing the current rainfall in terms of recent rainfall and what may be expected.

2.3 Comparison of Drought Assessment Methods – WASP and PDSI – with Drought Relief Data

The WASP Index and the Palmer Drought Severity Index (PDSI) were calculated. The severity of the drought was then compared. The WASP index for the Western Region of Sri Lanka was compared with the record of droughts.

3 Results & Analysis

The WASP (Weighted Anomaly Standardized Precipitation) Index and PDSI (Palmer Drought Severity Index) were obtained. The correlation for each month (Table 1) was then calculated to assess the strength of the relationship before graphically comparing the two methods with the recorded drought relief data.

Month	**January**	**February**	**March**	**April**	**May**	**June**	**July**	**August**	**September**	**October**	**November**	**December**
Correlation	0.74	0.59	0.57	0.59	0.61	0.73	0.77	0.74	0.75	0.72	0.67	0.66

Table 1: *Correlation between PDSI and WASP for each month*

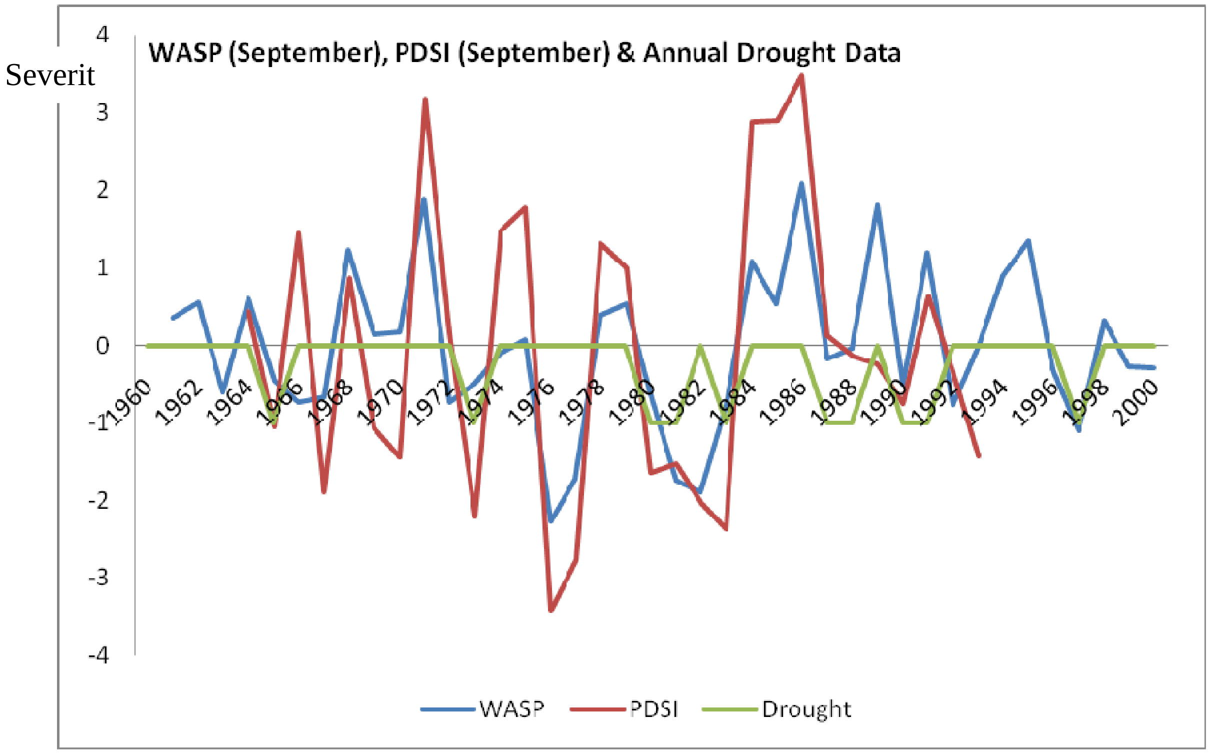

Figure 1: *12 Month WASP and PDSI for the month of September against the Annual Drought Relief Data for the Western Slopes*

By making use of records of relief payments by the government, it is possible to get an idea of how the drought had affected the region of interest. For this, the relief payments in the Western Region (inclusive of Nuwaraeliya) were graphed inversely (so that it is easy to identify the years for which relief had been allocated) with the regional WASP and PDSI values obtained via calculations (Figure 1).

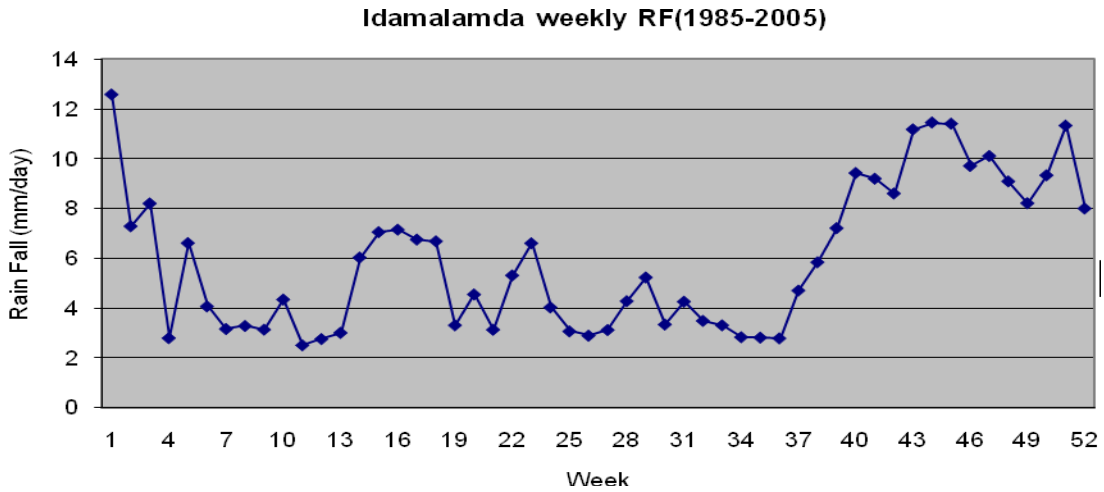

Figure 2: *30 year Averaged Rainfall for Idamelanda area during a year. This data was estimated using 7 neighboring stations – Katugastota, Galpihilla, Dackwari, Woodside, Kurundu Oya, Hope Estate, New Forest – using the Inverse Distance Calculation Method.*

According to Figure 2, Idamelanda gets a rainfall over 8 mm per day for 15 weeks while the rest of the time, it is lesser than that. The period where the rainfall is lower than 8 mm was considered as the dry period [7] for this area and the RWH system design was done to fulfill the water requirements of the people of the Idamelanda area during this 15 dry weeks.

4 Discussion

Design Guidelines of a Tank for RWH

The amount of water that can be collected from a unit area (1 m^2) of roof with Asbestos sheeting (runoff coefficient is taken as 0.84) [8] within the 15 week duration is around 850 liters. As an average, the houses in this area have an approximate roof area of 70 m^2. Using a horizontal area of 50 m^2 from the roof (leaving out 20 m^2 for the chimney, slope of roof etc.) as a catchment during the rainy season, one household can collect about 45 000 liters of water.

Taking the average consumption (drinking purposes only) of a person as 20 liters/day [7, 9], the number of members in a family as five (05), the amount of water needed by this particular family to see the dry period through would be approximately 26 000 liters. Even though they can collect up to 45 000 liters and what they need for their consumption during the dry period is about 25 000 liters, the maximum volume of the tank that is proposed is 8000 l. This is because anything more than this would have an extremely high building cost. At the same time, it is assumed that the water collected in the tank is mainly used for drinking purposes.

It is taken that a home garden has an area of 1 000 m^2 (¼ an acre) and that the area that can be used to collect the runoff is 500 m^2. Taking that 10% of the rainfall goes off as the runoff [10], what is collected is approximately 16 000 liters. The runoff will be stored in a tank below surface level and the volume of this tank was designed as 15 000 liters. It is assumed that most of the runoff is collected and stored so as to be used in irrigation purposes. The irrigation water requirement changes with the crop type and irrigation system to be used, but, in this case, the tank capacity was calculated to store as much water as possible to be collected within the rainy period.

In this context, our work provides a methodology for the design of mitigation for drought through the use of RWH. We proposed an above-the-surface tank (Figure 3a) for collecting rainwater for domestic purposes and a surface level tank (Figure 3b) [11] for collecting the runoff water and showed how climate information should be included in tailoring these units. Through the explicit relationship with climate, we were then able to go on to assess the impact of climate change on both water scarcity and the demands for mitigation.

Figure 3a: *Above-the-surface tank (Idamelanda) under construction (Credit: Janaki Chandimala)*
Figure 3b: *Polythene tank (Moonasinghe, V)*

5 Conclusions

The close correspondence between drought disasters and the hazard index confirms the utility of the WASP methodology to identify drought risk. The PDSI has comparatively lesser correspondence with the relief data and this may be due to the fact that it considers many other factors – temperature, soil moisture, and location – in the calculation in addition to the precipitation. Yet, it is possible to identify a similarity in trends. The correlations among the two methods (Table 1) and the graphic representation (Figure 1) are good proofs for this.

The designs proposed under the study require low installation and maintenance cost, so that the people could achieve the sustainability of their lives and agricultural activities. Investing on RWH tanks is economical in the long run as it could reduce the relief payments.

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