Assessing Drought and Enabling Adaptation through Rain Water Harvesting

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Abstract (200 words)

Rain water harvesting is a tested environmentally friendly mitigation option that has been used traditionally in Sri Lanka to mitigate drought risk. Its enhanced use can serve as an adaptation strategy for rising water stress due to climate and land use change. This 12-month project assessed the water scarcity and the potential for Rain Water Harvesting (RWH) of a village in Eastern Sri Lanka, Idamelanda, which is vulnerable to severe droughts as established through interviews with the villagers and local government officials. Meteorological data for the area was used to assess the severity, making use of two independent assessment methodologies for meteorological drought. These meteorological drought indices were found to coincide with a measure of drought disaster for Eastern Sri Lanka – that is the relief payments for drought. In the next stage, the meteorological data and drought indices were used to design the collector and storage tanks of a prototypical RWH unit, which is inexpensive and feasible with local technical resources. A concept note on developing the RWH unit in the community was drawn up so that RWH may be implemented in Idamelanda as a prototype

Cover Photograph: The construction of a low-cost storage tank in Idamelanda for Rain Water Harvesting. In the background is one of our team members (Badra Nawarathna). Photo Credit: Janaki Chandimala, 2007.

Background and Purpose

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 with land 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 (Zubair et al., 2006).

Drought is 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 of a meteorological and hydrological drought and out of these; two methods – namely the PDSI and WASP Index – were used in this work.

Water scarcity is mainly the physical deficit of water in an area. This may be due to several factors. 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 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 leads 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 negligible effect on infrastructure in Idamelanda.

In Idamelanda, water is required both for domestic purposes, as well as for agricultural activities. Home gardens are important for the people’s welfare. In addition, one major 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.

Rain water harvesting is a tested environmentally friendly option that has been used traditionally in many parts of Sri Lanka and in other ancient cultures to mitigate drought risk, and its enhanced use can serve as an adaptation strategy for rising water stresses. RWH may be broadly defined as the capturing, diversion and storage of rain water for different purposes such as drinking, domestic use, irrigation, aquifer recharge and storm water abatement. It is of course an ancient technique which exists already in various forms in many settings. These techniques are being revived due to the increasing drought in recent decades (Ariyananda, 1998).

The parameters that go into identifying the viability of RWH systems are rainfall, evaporation, catchment, conveyance and storage characteristics. In a community setting, the catchments are usually roof based or ground based systems. The storage systems can include tanks, cistern or pond systems. Different techniques based on factors such as number of rain days, exceedance of rainfall over certain thresholds, probability distribution of storms, dry spells can be used in design of RWH systems (Nawaratne and Weerasinghe, 1998). It has been assessed that agro-climatic potential and risk for crop can be mitigated by rainwater harvesting which also eliminates drought risk for crop production. Rain Water Harvesting (RWH) techniques are being revived due to the increasing drought in recent decades.

The objective of this research was to investigate the severity of the drought in Idamelanda and the feasibility of RWH in the above mentioned area. It was found that RWH is possible for both domestic purposes (using the roof as the catchment) and for limited irrigation purposes (using the runoff). The methods that were used for this were comparison of the severity of the drought using two independent measures, WASP and PDSI, and comparing with the relief data of the area. As a mitigatory measure, key elements of a prototypical RWH unit dependent on climatic factors, the collector and storage was designed with a minimal cost tapping into local resources.

Methods and Partners

In this section, we describe (a) the processing of meteorological data (b) the Drought Assessment Methodology (c) Comparison of Drought Assessment methods – WASP and PDSI (d) aspects of the vulnerability to drought (e) list some relevant capacities of the communities and the (f) design of the RWH.

(a) 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. Using this information, all necessary calculations were done. The selected data duration was from 1985-2005.

(b) Drought Assessment Methodology

Among the indices used to assess drought, Palmer Drought Severity Index (PDSI), the Standardized Precipitation Index (SPI), Weighted Anomaly Standardized Precipitation Index (WASP) etc. are commonly used indicators. Out of these, we have made use of WASP and PDSI methodologies for our assessment process. Both the WASP and PDSI were normalized to a range of values from -4 to +4. The negative values indicate less rainfall while positive values indicate excess in rainfall. The PDSI 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.

(c) Comparison of Drought Assessment Methods – WASP and PDSI

Using close proximity meteorological stations, the rainfall and temperature data for Idamelanda was estimated. This data was then used to calculate the WASP Index and the Palmer Drought Severity Index (PDSI). The severity of the drought was then compared. The WASP index for the Eastern Region of Sri Lanka was compared with the record of droughts (Figure 3). The close correspondence between drought disasters and the hazard index confirms the utility of the WASP methodology to identify drought risk.

(d) Vulnerability Assessment

We interviewed villagers in Idamelanda. We also interviewed government officials including the Mahaweli Headworks, Administration ,Operation and Maintenance (HAOM), Agricultural officer, Hanguranketha Division Unit Manager of Hadabima Authority and the Head of the Hanguranketa Divisional Secretariat. All parties confirmed the exposure to drought and vulnerability to drought in the hill top village of Idamelanda to drought.

(e) Capacities of the community

There is support from AGA office and *Samurdhi* organization (government sponsored poverty alleviation program), technical resources from HAOM to support community activities. In addition, village organizations like Funeral Assistance Committees etc. when it comes to looking after matters of community welfare. Yet given the depressed economic condition, there is a difficulty in mobilizing adequate funds. Yet the villagers have expressed an interest in RWH due to the present difficulties in hauling water.

(f) Design

Based on interviews, we determined that the primary use of RWH shall be for domestic needs and home gardens. The primary elements of a RWH unit that need to be designed are the Collector and the Storage. We adapted methodologies provided by past literature to generate sizing of these based on meteorological, hydrological and demographic data.

Summary of Results

Here, we discuss a) Generation of regional, seasonal and long term indicators for drought risk at fine scale, Objective b) Interpretation of the risk of water scarcity in south-eastern Sri Lanka, c) Design Guidelines of a Tank for RWH and d) Proposal for a RWH Unit.

a) Generation of regional, seasonal and long term indicators for drought risk

The WASP (Weighted Anomaly Standardized Precipitation) Index (Figure 1) and PDSI (Palmer Drought Severity Index) (Figure 2) were calculated. All this information was compared with each other to assess the severity of the drought. The hydrological data was not used in this case for the simple reason that there was only a very small stream which flowed only during the rainy season. The drought period that is predicted via different models have to be appraised before any step is taken to mitigate it. This is because negative values indicate less rainfall and higher the value, severity increases.

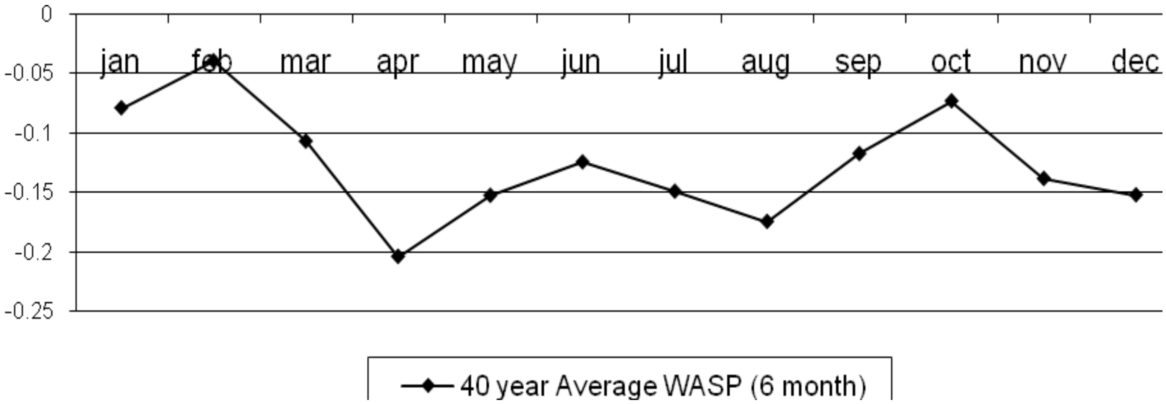

Figure 1: Weighted Anomaly Standardized Precipitation Index for Idamelanda region. High sustained negative values indicate greater propensity to drought. The most likely months for drought are April and August.

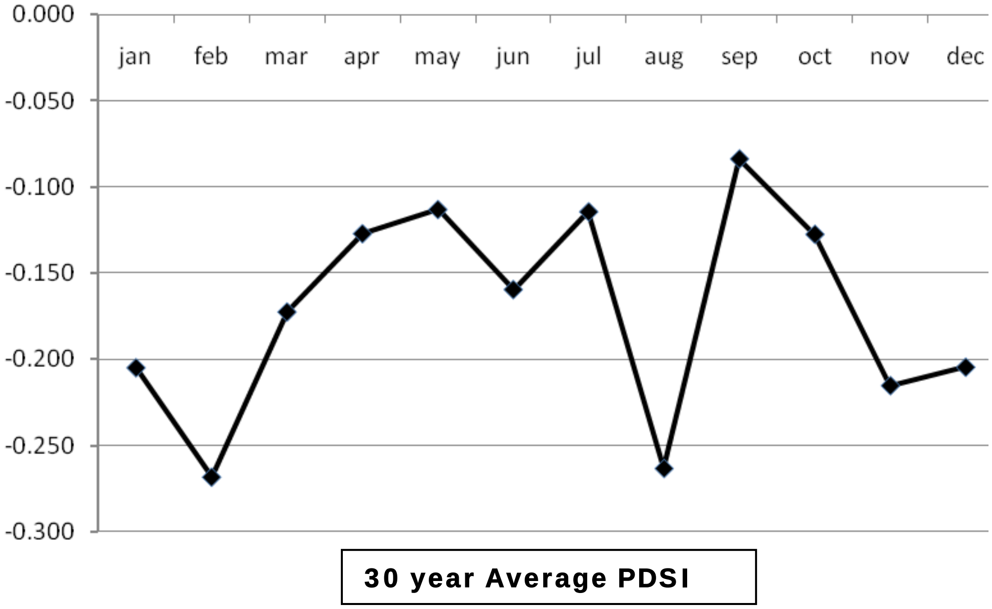

Figure 2: Palmer's Drought Severity Index for Idamelanda region. High sustained negative values indicate greater propensity to drought. The most likely months for drought are February and August.

b) Interpretation of the risk of water scarcity in south-eastern Sri Lanka.

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 Eastern Region (inclusive of Idamelanda) were compared with the regional WASP indices (Figure 3). They proved that this area is, without doubt, prone to severe drought.

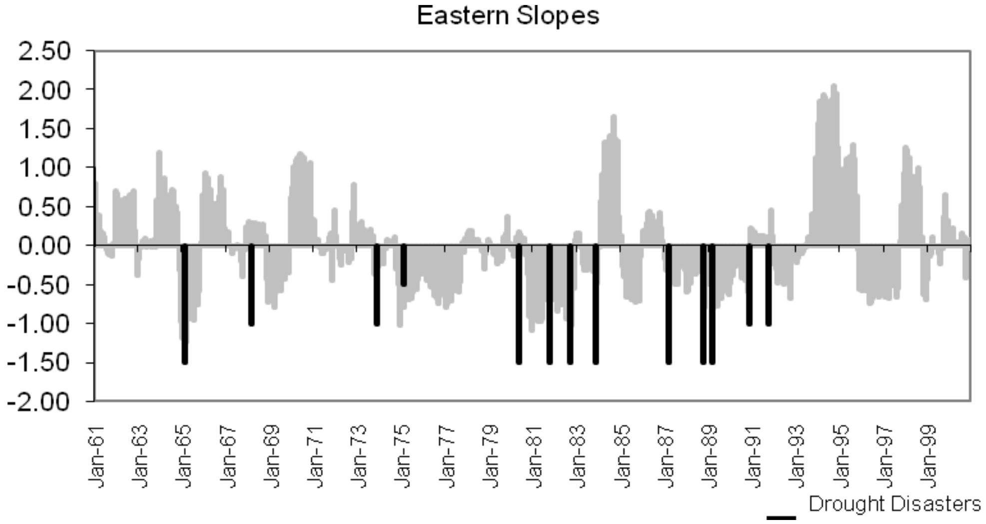

Figure 3: The WASP drought index for the Eastern Slopes region of Sri Lanka is shown in grey shading from 1960-2000. Along with that the history of relief payments is marked as black bars. The relative heights of these bars in proportion to the classification of drought as minor, medium and major and allocated weights of 0.5, 1.0 and 1.5. These bars coincide with periods of drought as identified by the WASP index with just some minor exceptions. Thus there is correspondance between meteorological drought index and actual drought disasters and WASP is thus useful for disaster risk estimation.

c) Design Guidelines of a Tank for RWH

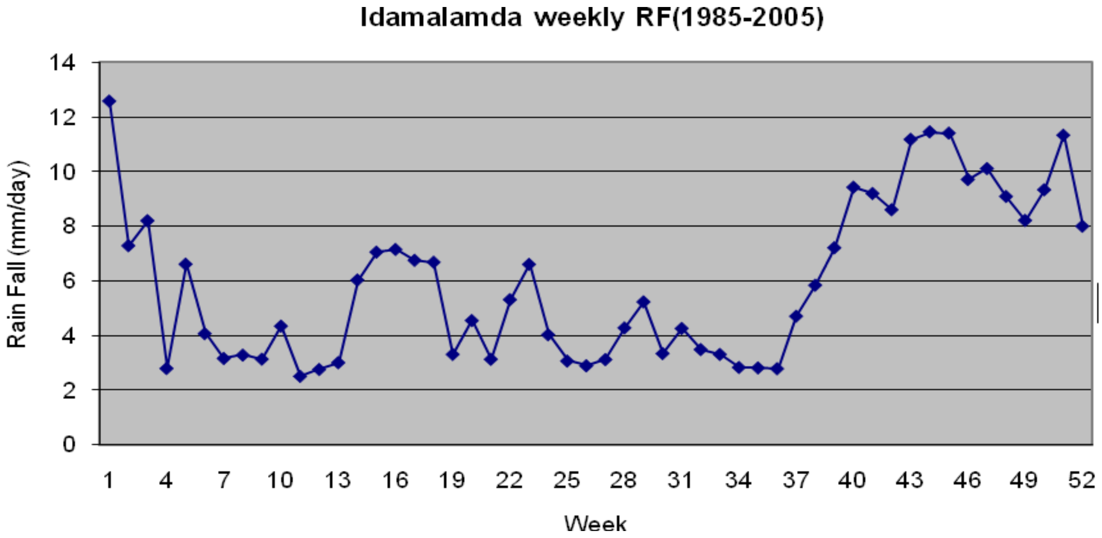

Figure 4: 21 year Averaged Rainfall for Idamelanda area during a year. The x-axis indicates week number from January to December. The rainfall for Idamelanda was estimated using 7 neighboring stations – Katugastota, Galpihilla, Duckwari, Woodside, Kurundu Oya, Hope Estate and New Forest

According to Figure 4, 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 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.

The amount of water that can be collected from a unit area (1 m^2) of roof with Asbestos sheeting taking runoff coefficient as 0.84, (Navaratne C.M., 2003) 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 of a person as 20 liters/day (Rajkumar S.G.G,1999), 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 be expensive. 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. If it is assumed that 10% of the rainfall goes off as the runoff (Rockstrom J, 2000), 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.

d) Proposal for a RWH Unit

It is proposed to build a tank (Figure 5a) above the ground surface to collect the run off from the roof and a polythene tank (Figure 5b) to collect the run off from the ground.

Figure 5a: Above the surface tank under construction (Credit: Janaki Chandimala) 5b: Polythene tank (Source: Moonasinghe V, 2004)

Based on the previous assumption that the roof area is 70 m^2 with an inclination of 20^0 with the horizontal, made of Asbestos sheets with a runoff coefficient of 0.84, there are only five (05) members in the family who has a minimal consumption of 20 liters per day and that the home garden is 1 000 m^2, the following designs are given for low cost installation and maintenance. It is proposed to make use of local materials and technical capacities for construction and installation.

Above the ground tank:

Collector:
The collector is 50 m^2 of roof area and is proposed to have Asbestos sheets as the roofing type as it has a higher runoff coefficient when compared with tiles. Runoff coefficients for Asbestos and tiles are 0.84 and 0.75 respectively (Navaratne C.M., 2003).

Storage:
The tank is to be made using cement and bricks in a cylindrical shape. The diameter should be 2.5 m with a height of 2 m to store 8 000 liters. The inlet pipe (4 inches) should be situated at the top and using a simple mechanism, the pipe will be moved away from the inlet during the first rains so that collection commences only after the roof is flushed.

Ground level Polythene tank:

Collector:
The total exposed land area is taken as the collector surface.

Storage:

It is made from a thick tube of 3 ft (0.9 m) wide polythene (used for packaging and concrete work), slit along one edge and sunk into a 23 ft (7 m) deep; 2ft (0.6 m) wide trench (Moonasinghe V, 2004).

Discussion

Many expressions of national policy have recognized the central role of drought and water resources management. For example, Sri Lanka's Initial National Communication under the United Nations Framework Convention on Climate Change (Oct. 2000) proposed that Sri Lanka can achieve not only sustainable life through better way of irrigation but also solve the hydro power energy demand by drought management. It argues that the water resource management is one of the areas that should be prioritized in order to enhance the social, environmental and economic growths in the country. This communication goes on to suggest that vulnerability be properly assessed and that minor storage reservoirs should be encouraged along with participatory micro watershed management. Our work is also consistent with the envisaged programs under the National Environmental Action Plan as revised recently identified proper watershed management as a key concern. Drought is identified as a key concern by the recent inter-agency report from Sri Lanka on Disaster risk management.

In this context, our work provides a methodology for the design of mitigation for drought through the use of RWH. We have provided a design methodology and show how climate information should be included in tailoring these units. Through the explicit relationship with climate, we are then able to go on to assess the impact of climate change on both water scarcity and the demands for mitigation.

The designs which we have proposed under our study have a low installation cost and a maintenance cost. It will also help a great deal towards the sustainability of their lives and other agricultural activities. In addition to this, investing on RWH tanks is economical in the long run as it ensures that the relief payments that should otherwise have been given are reduced.

Next Steps

The initial as well as the most important step of this research is to make the technical support personnel, government officials and community leaders aware of these results. Along with this a proposal for obtaining external funding to support the implementation of an RWH unit is needed.

We can have an awareness programs for the responsible personnel in the Idamelanda area (Local NGOs, Grama Niladari, Monks andAdditional Government Agents etc.) By now they know about the drought period from experience. Information on implementing RWH methods can be provided. Different methods that can be used – open or covered tanks, pits, barrels etc. – can be displayed for their inspection and knowledge. Also support can be extended to construct their own RWH units.

The results of this research can be disseminated by our partners so as to incorporate them in design and policy and implement the work with time.

The next major step of this project would be to implement the proposed RWH units with community involvement in the Idamelanda area. The villagers can also play a major role in applying for funding to implement RWH as a policy by dissemination of these results. They can go further by quoting these results to the MASL, AGA Offices etc. in addition to outside sources of funding. The villagers can change from Chena cultivation to other sustainable methods once RWH methods are implemented as they will be able to make use of the collected water to see their agricultural activities through. This is good for both the people and the environment. We shall also circulate proposals to different organizations so as to obtain funding for the implementation of the tank as a community project.

In addition to this, we will be writing some research papers on this topic as well so that other people can make use of our findings to go another step in RWH, which a requirement in today's context for sustainability.

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