Rainwater harvesting for agro-ecological risk elimination in Matara District

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Abstract

Daily rainfall data over 35 years for several stations in Matara District viz.: Kekunadura, Thihagoda, Mapalana, Ellewela, Denagama and Mawarala were used to assess the rainwater availability for roof water harvest.

Weekly evapo-transpiration was deducted from the weekly roof runoff to estimate the runoff excess of the week. Computer program "First" (Weerasinghe, Lue, Sabatier) was used to assess the onset time of each location based on the 0.75 of the forward accumulation probability of weekly rain commencing from 1st March.

Accumulated weekly runoff excess from the week of onset was used to calculate the maximum tank size.

It was emerged that forward accumulation of 100 mm rainfall at 75% probability commencing from 1st March occurs during 12th and 18th standard weeks in different locations of the Matara District and the maximum tank capacity to catch the entire roof runoff from an average roof of $40m^2$ for Mawarala, Mapalana, Ellewela, Thihagoda, Denagama and Kekunadura should be 49, 26, 24, 24, 14 and 12 m^3 respectively. It is also established the commanding area of the roof when crop commencement is conducted at the onset time is thrice that of the roof area for all the locations.

INTRODUCTION

The quantity of rainfall received over an area provides a general picture on its sufficiency to meet crop yields without introducing irrigation practices. However the recent trend in agroclimatology indicates that often dry spells encountered during cropping season creates many problems for Agricultural production in different areas. A detailed analysis of the agroclimatology in different locations of Sri Lanka was conducted by Weerasinghe (1989 1991 and 1993). It was pointed out that occurrence of dry spells is often even within the rainy season, and measures to improve micro, meso and macro scale water conservation are necessary for optimization of the agricultural production.

In Sri Lankan agricultural understanding, home garden constitutes a unique production unit, which provides ample amount of vegetables and fruits. As such water conservation in home gardens for subsequent use is important to improve the agricultural production from home gardens. The water conservation in home garden could be easily done by collecting roof runoff for irrigation. If this could be practiced, it would save the water and eliminate the risk of water scarcity for crop production in the home garden sector while reducing the erosion problems. It will help to smoothen out variation in water availability, while providing good quality water where ground water or surface water is saline.

The harvesting of water from the surface of roofs for domestic and agricultural uses is not a new concept and it has been a common practice in dry areas as well as wet areas in developing countries. Different aspects of rainwater harvesting are well demonstrated by Pacey, et.al 1986. Baoxiv (1997) pointed out the fact that utilizing rainwater is the best way of development for the rainfed agricultural areas in china. According to C.S. de Silva (1998), rainwater harvesting for ground water recharge has a far greater importance in dry zone of Sri Lanka. Heijnen et al (1998) pointed out that the regular bimodel rainfall pattern favours the application of rainwater harvesting in Badulla and Matara districts.

As such roof water harvesting will be a meaningful effort to conserve the water in home garden which can be designated as a micro scale water conservation practice. Such practice will minimize the soil erosion problems due to release of large flux of rainwater collected from roofs to roadways and culverts. It also helps to recharge the ground water wells, which are major supplier of domestic water especially in pre-urban and remote areas.

The objectives of the present research are to calculate the climatic risk and water balance in different locations of Matara district and to work out a methodology to calculate the optimum tank size for rain water conservation based on the rainfall probabilities.

RESEARCH DESIGN / MATERIALS AND METHODS

In order to achieve the set objectives, a water balance analysis was conducted using the daily rainfall data over 35 years for six stations in Matara District viz.: Kekanadura, Thihagoda, Mapalana, Kamburupitiya, Ellewela, Denagama and Mawarala. Pan evaporation of the Mapalana meteorological station was used to calculate potential evapo-transpiration.

Average roof area of a farmer was assessed by a survey and it was found as $40m^2$. Runoff form a corrugated sheet was measured to estimate the runoff coefficient and it was found as 0.85.

Weekly evapo-transpiration was deducted from the weekly roof runoff to estimate the runoff excess of the week.

Computer program "First" (Weerasinghe, Lue, Sabatier- 1990) was used to assess the onset time of each location based on the 75% of the forward accumulation probability of weekly rains commencing from 1st March which is the beginning of 'Yala' season after the January and February dry period and, 1st September which is the beginning of 'Maha' season.

Dryness of the week is decided by the availability of <10-mm rain at 75% probability calculated by the Markcov chain procedure, using the computer program 'First'.

Accumulated weekly runoff excess from the week of onset was used to calculate the maximum tank size.

Optimum tank size was decided by estimating the accumulated weekly rainfall at 75% probability of the 52 weeks of the year.

RESULTS AND DISCUSSION

Matara district is located in the Southern province of Sri Lanka with an area of 1282.5 km^2. It lies within latitude 6^0 - $6^020'$ North and longitude $80^023'$ - $80^043'$ East. The climate of the district is characterized by nearly constant temperature and largely variation in rainfall. There are seven agro-ecological regions in Matara district named WU1, WM2, WM1, WL4, WL2, WL1 and IL2.

Mean annual rainfall and Agro-ecological regions of selected stations are given in table1. Locations of the stations are given in Fig.1. It is evident that the highest annual rainfall occurred in Mawarala station in mid country wet zone (WM2) agro-ecological region whereas the lowest occurred in Kekanadura which is in low country wet zone (WL4) agro-climatological region.

Table 1: Mean Annual Rainfall and Agro-climatological Regions of selected Meteorological Stations in Matara District

Station	Mean Annual Rainfall (mm)	Region
Kekanadura	1720	WL4
Denagama	1824	IL2
Thihagoda	1985	WL2
Ellewela	2146	WL2
Mapalana	2182	WL2
Mawarala	3066	WM2

It appears that annual rainfall of different locations in Matara district increases with the elevation. Even though the location Kekanadura is in the region of low country wet zone according to agro-ecological map, its annual rainfall is less than in Denagama which is in low country intermediate zone. Therefore Kekanadura may locate in the intermediate zone along with Denagama.

Table2: Number of dry weeks in different stations in Matara district.

Station	Dry weeks		
	Year	'Yala'	'Maha'
Mawarala	10	8	2
Mapalana	20	16	4
Ellewela	25	17	8
Tihagoda	38	27	11
Denagama	34	26	8
Kekanadura	35	24	11

Number of dry weeks in each station commencing from 1st March, for the entire year, and for the 'Yala' and 'Maha' seasons separately were assessed to decide on the irrigation demand of the locations (Table 2). Highest number of dry weeks occurrs in Tihagoda, whereas the lowest numbers are in Mawarala and Mapalana. It shows that in the locations where mean annual rainfall is < 2000mm, there have about 80% dry weeks in the annual cycle, whereas in the stations, receiving the mean annual rainfal > 2000mm number of dry weeks in the annual cycle is less. In Mawarala which is wettest among selected locations has about 23% dry weeks in the annual cycle. Therefore it is evident that water for supplimentory irrigation is very essential for these locations for optimization of the agricultural production. This is very much valid for Tihagoda, Denagama and Kekanadura areas.

The 100mm forward accumulation probability of weekly rains commencing from 1st March for 'Yala', and 1st September for 'Maha' seasons in different locations are given in Fig.2 and Fig.3 respectively. The week, on which the accumulation of 100mm rains at 75% forward accumulation probability is considered as the onset time of the respective station. Onset time of the each station for the individual seasons of 'Yala' and 'Maha' are given in table 3.

Table 3: Onset time of different Stations for 'Yala' and 'Maha' seasons based on 100 mm rainfall accumulation at 75% probability.

Station	Onset time (weeks)	
	'Yala'	'Maha'
Mawarala	12	39
Mapalana	14	39
Ellewela	15	40
Tihagoda	16	39
Denagama	16	39
Kekanadura	18	41

The 14th week of the year in the 'Yala' season appeared to be the onset time for Mapalana and, the 12th, 15th, 16th ,16th and 18th week for Mawarala Ellewela, Thihagoda, Denagama, and Kekunadura respectively. The onset time for 'Maha' season for all stations lies in between 39th and 41st standard weeks. It shows that onset time is advanced with the increase of annual rainfall in selected locations. It is also clear that high rainfall occurs in the beginning of the year in the locations, where annual rainfall is high.

Excess of the roof runoff based on the average weekly rainfall

The maximum cumulative runoff excess is observed in 48th to 52nd week of the year in all regions.
The tank capacity of each station to collect entire roof runoff of the year from the onset time of 'Yala' on wards is given in fig.4. Fig.5 and 6 indicate the tank size to collect 'Yala' and 'Maha' rains separately.

Table 4 : Maximum possible tank capacity for roof runoff collection in different stations (roof area = 40m^3)

Station	Maximum possible tank capacity (m^3)		
	Year	'Yala'	'Maha'
Mawarala	49	24.5	25
Mapalana	25.5	13	15
Ellewela	24	13	12
Tihagoda	24	12	14.3
Denagama	13.7	7	13
Kekanadura	12.4	6	9.2

The maximum possible tank capacity to collect annual runoff excess when average rainfall of the week is cumulated, is found to be 12 – 49 m^3 in different locations. Analogically the tank size should be 6 – 25 m^3 to collect 'Yala' rains and 9 – 25 m^3 to collect 'Maha' rains for Kekanadura, Denagama, Ellewela, Thihagoda, Mapalana and Mawarala stations (Table 4). The tank capacity to collect average weekly rainfall for 'Yala' and 'Maha' seasons is more or less same for the wetter regions (WM2 and WL2 regions) whereas the tank capacity for the collection of 'Maha' season is approximately doubled that of the 'Yala' season in the drier areas (IL2 and WL4 regions).
However the tank capacity to collect entire annual runoff coincides with the total tank capacities of 'Yala' and 'Maha' seasons in wetter regions.

Roof runoff based on dependable weekly rainfall

The tank capacity to catch the entire annual roof runoff, based on the 75% probable weekly rains is found to be 9 – 25 m^3 in different locations. However the tank size should be 3 – 12 m^3 to collect 'Yala' rains and 'Maha' rains separately (Table 5).

Table 5 : Optimum tank capacity of dofferent stations.

Station	Optimum tank capacity (m^3)		
	Year	'Yala'	'Maha'
Mawarala	25.0	12.4	12.1
Mapalana	14.0	5.8	8.1
Ellewela	15.0	7.6	6.3
Tihagoda	8.8	3.3	5.5
Denagama	10.3	7.0	3.2
Kekanadura	10.0	4.8	5.1

It is worth noting that the tank capacity in 'Yala' season is higher than it is in 'Maha' season in Denagama and Ellewela stations and the tank capacity in 'Yala' and 'Maha' seasons are nearly equal in Mawarala and Kekanadura. However tank capacity to collect 'Maha' rains in Mapalana and Tihagoda should be high compare to 'Yala' rains. Therefore it could be suggested to account the tank capacity as 12, 8, 8, 7, 5 and 5 for Mawarala, Mapalana, Ellewela, Denagama, Tihagoda and Kekanadura respectively. From the above, it is evident that construction cost of the roof runoff tanks could be reduced when dependable rainfall of the week is considered.

CONCLUSION

1. Forward accumulation of 100 mm rainfall at 75% probability commencing from 1st March and from 1st September, occurs during 12th and 18th standard weeks and during 39th and 41st standard weeks in different locations of the Matara District.
2. When the average rainfall of the week is cumulated to collect the roof runoff excess of the year from an average roof of $40m^2$ for Mawarala, Mapalana, Ellewela, Thihagoda, Denagama and Kekunadura , the tank capacity would be 49, 26, 24, 24, 14 and 12 m^3 respectively. If, to collect the rainfall of the respective 'Yala' and 'Maha' seasons, the tank size should be 26, 13, 13, 12, 7 and 6 m^3 , and 25, 15, 12, 14, 13 and 9 m^3 for the respective stations.
3. When dependable rainfall of the week is considered for roof water collection, the tank size to collect annual roof runoff would be 9, 10, 10, 14, 15 and 25 m^3 for Tihagoda, Denagama, Kekanadura, Mapalana, Ellewela and Mawarala respectively. However if the roof runoff of the 'Yala' and 'Maha' seasons to be collected individually the tank size may reduced to 3 – 12 m^3 in different locations of the Matara district.

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Fig. 1: LOCATION OF THE SELECTED RAIN GUAGE STATIONS IN MATARA DISTRICT

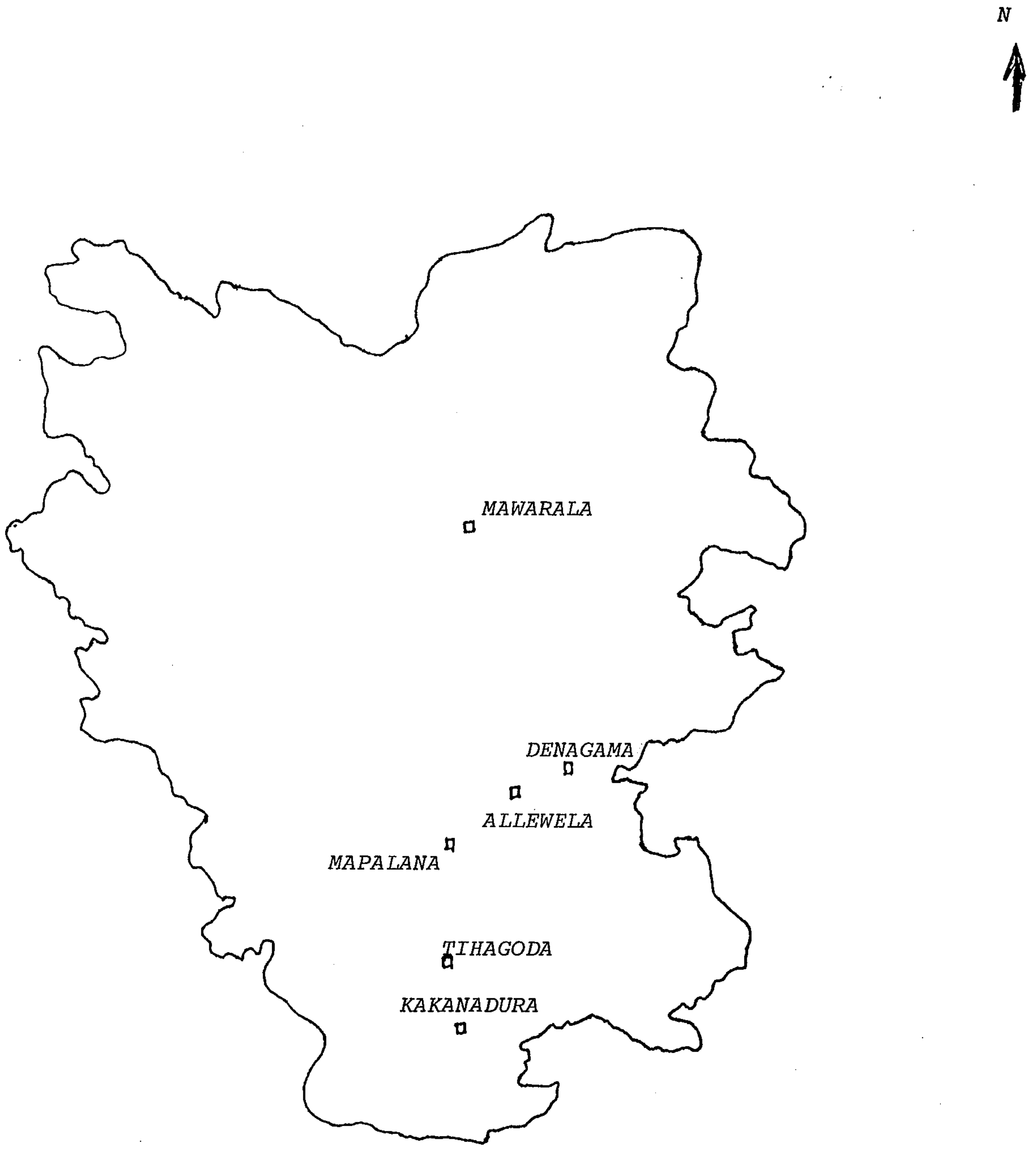

Fig1 . **Forward accumilation probability of 100mm rainfall from 1st March**

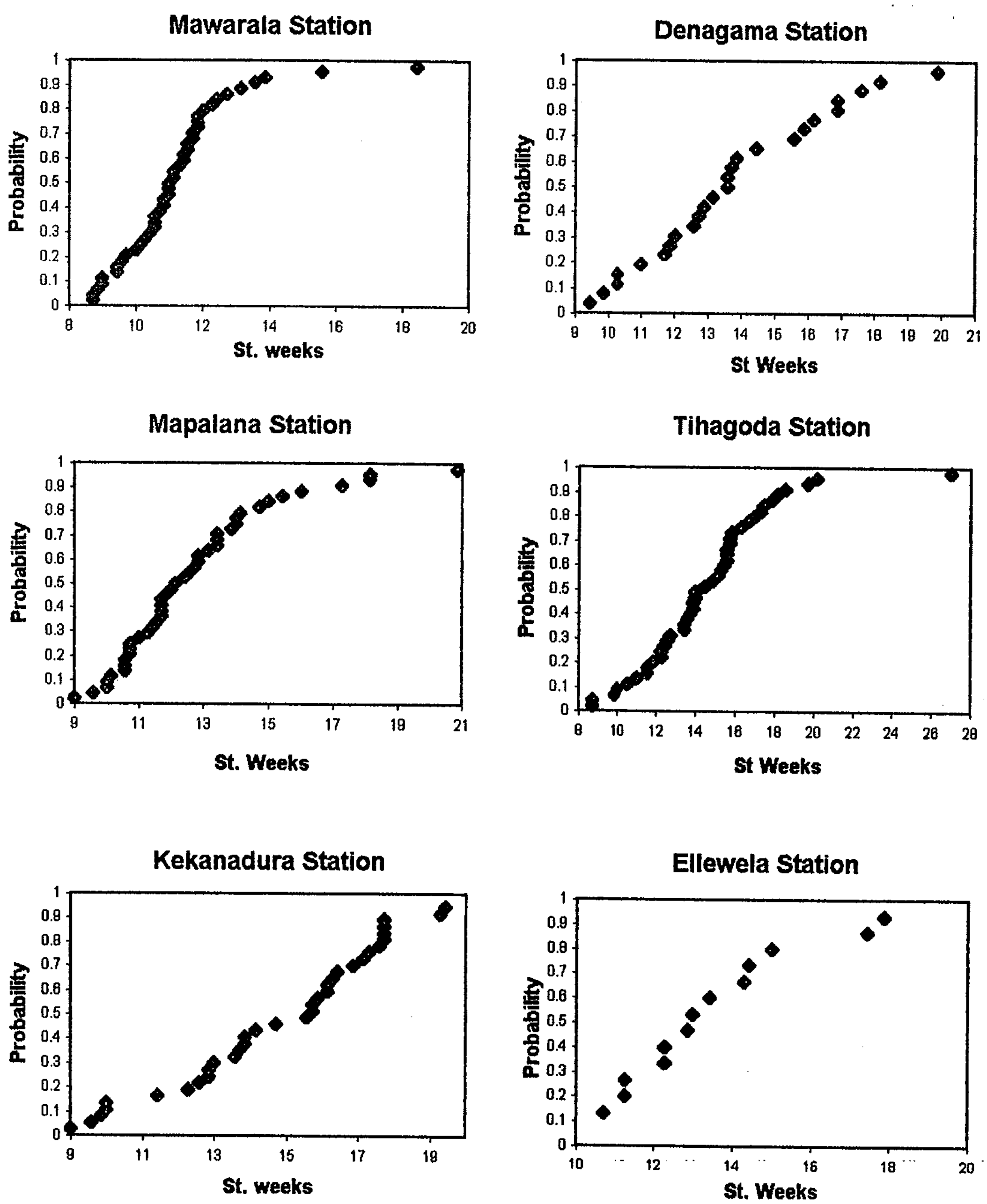

Fig.3: Forward Accumilation probability of 100mm rainfall from 1st September

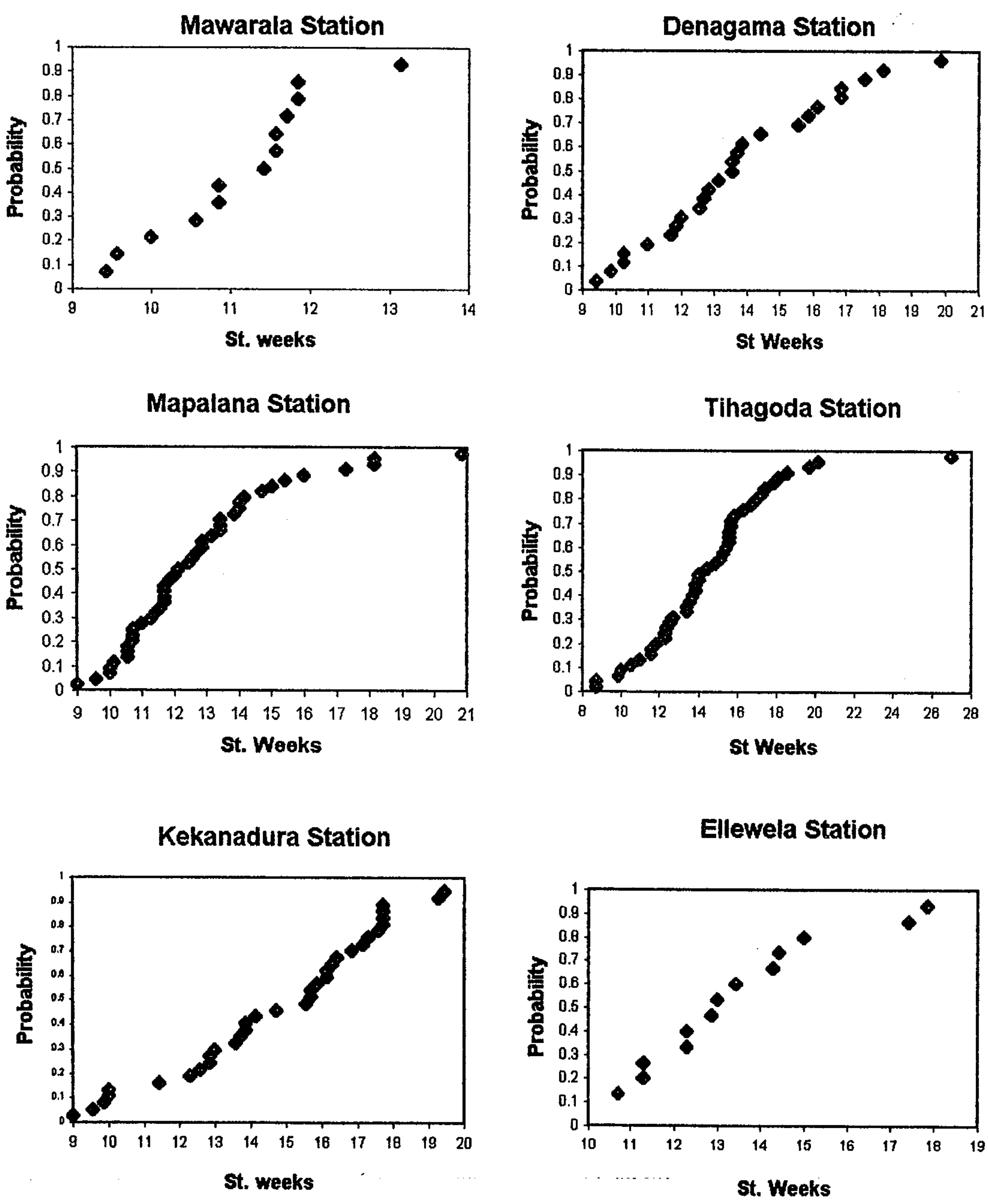

Fig.4: Tank capacity in different stations for the year

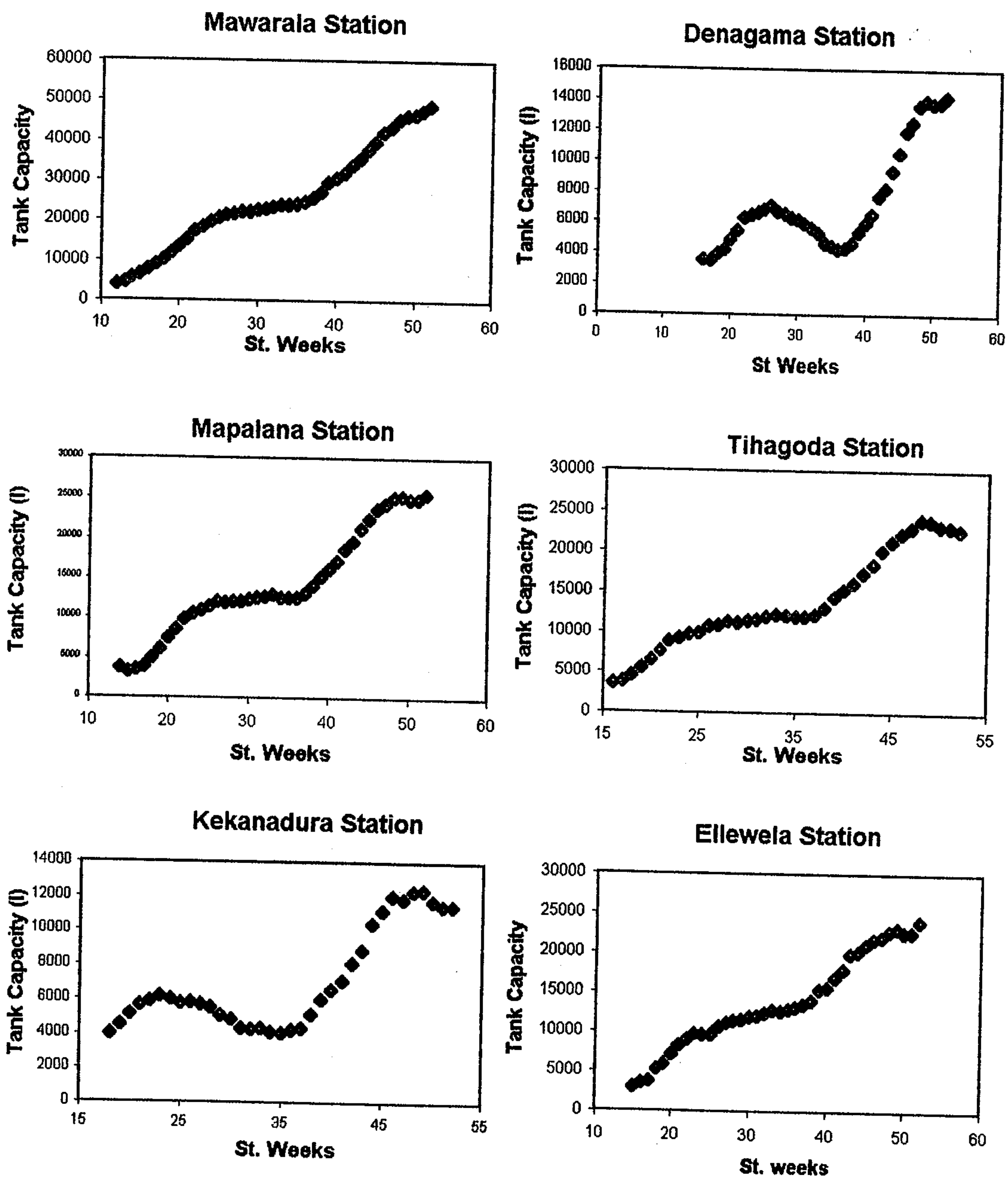

Fig.5: Tank capacity in different stations for 'Yala' season

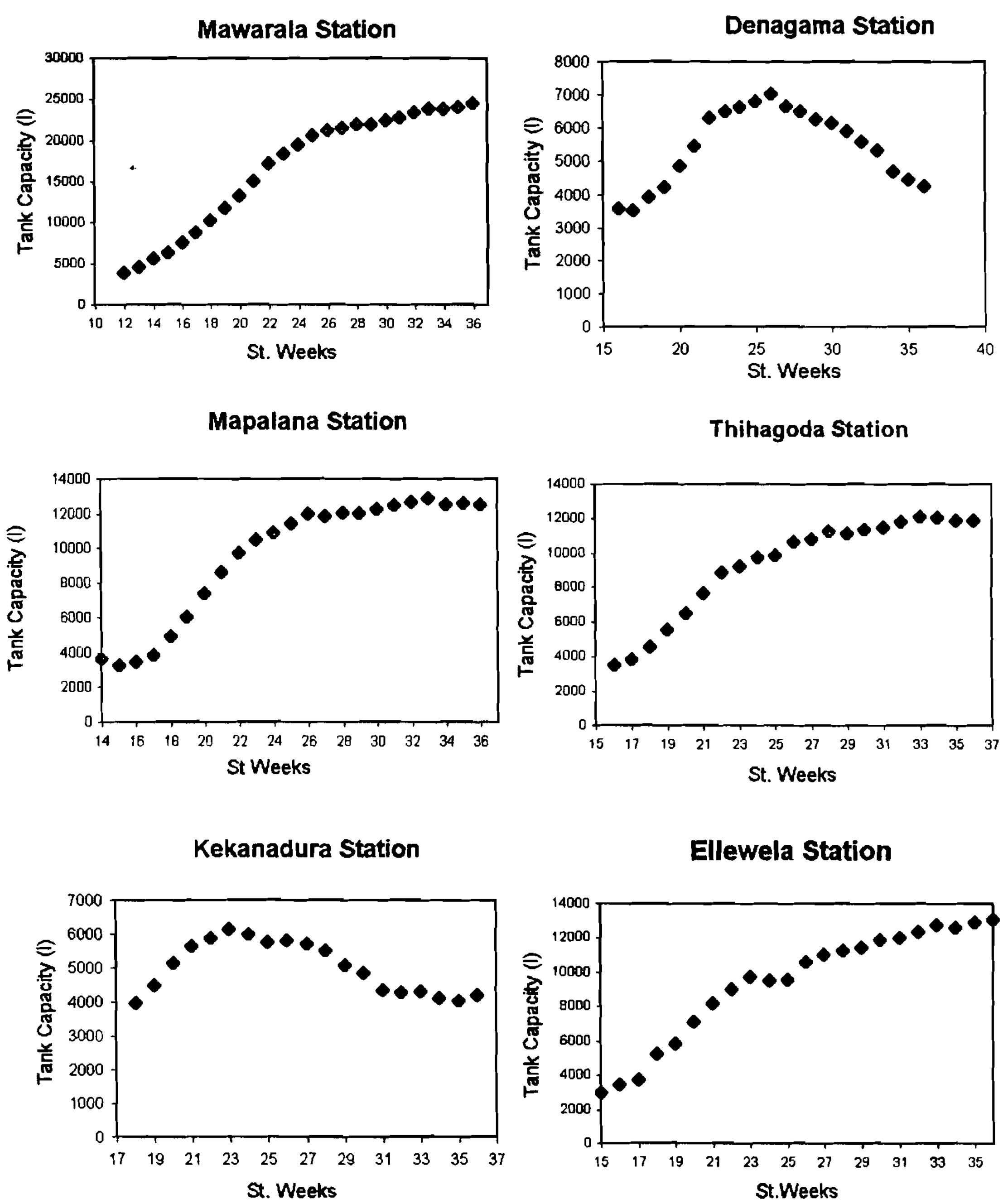

Fig.6: Tank capacity in different stations for 'Maha' season