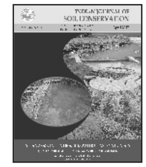
Vol. 45, No. 3, pp 270-278, 2017
Indian Journal of Soil Conservation
Online URL : http://indianjournals.com/ijor.aspx?target=ijor:ijsc&type=home



Impact of water harvesting structures on runoff and soil loss in Ayalur watershed, Erode district, Tamil Nadu, India

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ARTICLE INFO

***Article history*:**
Received : July, 2017
Revised : November, 2017
Accepted : November, 2017

Key words:
Ayalur watershed,
Runoff,
Soil loss,
Water harvesting

ABSTRACT

The present investigation was carried out during the years 2014 and 2015 in Ayalur watershed located in Erode district of Tamil Nadu, India on the impact that the water harvesting structures constructed in a watershed have on impounding runoff and trapping sediment load from the watershed. This watershed which is located in semi arid tropics had a series of 20 water harvesting structures in the form of percolation ponds, dug out ponds and check dams with a total water storage capacity of 21868.8 m^3. During the year 2014, when annual rainfall of 494.4 mm had been received, the 20 water harvesting structures had impounded 8281.0 m^3 of runoff and trapped 611.9 tonnes (t) of sediments in them. Similarly in the year 2015 which had received 610 mm annual rainfall, 26561.9 m^3 of runoff had been impounded and 1643.5 t of sediment load had been trapped by the structures. When weighted with the annual rainfall, it was observed that the average runoff for Ayalur watershed in the study period was 18378.1 m^3 and the average sediment load trapped by the structures was 1181.7 t. Taking into account 512.2 ha which is the catchment area of the last structure in the series, the soil loss was worked out as 2.3 t ha^{-1}.

1. INTRODUCTION

Agricultural systems, and in particular rainfed agriculture in the semi-arid tropics (SAT), are highly vulnerable to various types of climatic and socio-economic shocks (Garg *et al.*, 2011). In the SAT region, the average annual rainfall ranges between 300 and 800 mm and the rainfall variability is significant in terms of both seasonal and annual distribution leading to frequent drought and dry spells. India occupies the largest SAT area of any country in the world. With respect to water resources of India, the total rainfall amounts to about 4000 km^3 which includes about 1869 km^3 as river runoff and 430 km^3 as replenishable groundwater. The country gets the major share of its surface runoff from the monsoon precipitation with about 85% of the annual rainfall occurring over four to five months with actual number of rainy days varying from 4 to 56 days. Failure of monsoon exposes the agriculture to drought and famine and other damaging effects, while above-average monsoon results in flooding, inundation and resulting devastation (Chandra, 2000). In semi-arid and dry sub-humid agro-ecosystems rainfall variability generates dry spells (short periods of water stress during critical growth stages) almost every rainy season (Barron *et al.*, 2003; Rao *et al.*, 2006 and Singh and Ranade, 2009).

The rainfed agriculture contributes 58% to world's food basket from 80% agriculture lands (Raju *et al.*, 2008). In recent years, it has been realized that rainfed agriculture in India, which was almost entirely neglected during the green revolution in the 1970s, also has remarkable scope for agricultural development (Garg *et al.*, 2011). Watershed management is increasingly being recognized as the ideal approach for integrated natural resources management in rainfed areas. About 51% of India's geographical area (329 m ha) is categorized as degraded, most of which occurs in rainfed agro-eco systems. Degradation of agro-ecosystems and declining sustainability are major concerns for agricultural development in many poor regions of India where rural livelihoods depend directly on management of land and water resources (Reddy *et al.*, 2007). About 58% of the population is dependent on agriculture, and two thirds of the cropped area is dependent on rainfall without any protective irrigation. Watershed development program is, therefore, considered as an effective tool for addressing many of these problems and recognized as potential engine for agriculture growth and development in fragile and marginal rainfed areas (Joshi *et al.*, 2005 and Wani *et al.*, 2006). In order to conserve rainwater, minimize land degradation, improve groundwater recharge and increase cropping intensity and crop productivity a watershed management approach is adopted (Samra, 1997; Kerr *et al.*, 2000 and Wani *et al.*, 2002).

Watershed development programmes in India in 1980 started primarily with aim to reduce soil erosion in agricultural land and to control gully formation (Joshi *et al.*, 2005, 2009). Soil erosion is one of the most serious problems in India (Sharda *et al.*, 2010). Soil erosion causes land degradation upstream and increases sediment loads in downstream water bodies (Yang *et al.*, 2003). It is estimated that the annual loss rate of reservoir storage capacity due to sedimentation is about 0.5-1.0% in most of the river basins in India and elsewhere (Walling, 2007). The Indian collaborative initiative of watershed management programmes has been ongoing in various forms for the last 30 years (Wani *et al.*, 2008). The main aim is to enhance rural livelihoods and wellbeing, recognising the value of well-managed water and land resources. This concept ties together the biophysical notion of a watershed as a hydrological unit with the social aspect of community and its institutions for building resilience in agriculture by sustainable management of land, water, and other resources (Reddy *et al.*, 2007). To date, in India, an estimated 88.5 m ha of land is assumed to have been included in this initiative (Wani *et al.*, 2008). The watershed management initiative has not only transformed livelihoods and enhanced resource management, but has also changed micro to small-scale (0.1-10 km^2) watershed hydrological characteristics. As yet, there is little systematic quantification of how much impact these field-to-community-scale soil and water conservation measures may have had on watershed water balance, water quantity and quality (Garg *et al.*, 2011).

Soil and water conservation practices are the primary step of watershed management programme. Land and water conservation practices, those made within agricultural fields like construction of contour bunds, graded bunds, field bunds, bench terraces, broad bed and furrow practice and other soil-moisture conservation practices, are known as *in-situ* management. Likewise, construction of check dams, farm ponds, percolation ponds, gully control structures, is known as *ex-situ* management. *Ex-situ* management practices reduce gully formation and harvest substantial amount of runoff, which increases groundwater recharge and irrigation potential in watersheds. Hence evaluation of the impact that both *in-situ* and *ex-situ* conservation practices in a treated watershed have on its hydrology *viz.* runoff and soil loss will help to determine the effectiveness of these various conservation measures for natural resource management.

In water-stressed areas, concern has been raised about potential downstream implications from large-scale adoption of upstream water management techniques (Calder, 1999). However, the downstream impacts on stream flow from small-scale water storage systems have been shown to be very limited, even with large-scale implementation (Evenari *et al.*, 1971; Schreider *et al.*, 2002 and Sreedevi *et al.*, 2006). On the other hand, in closed and closing basins, more water is used than is renewably available, at least during parts of the year, which constrains opportunities for agricultural water management (Molden *et al.*, 2001 and Molle, 2003). India will continue to rely on careful water and land management to further enhance agricultural production and rural livelihoods.

With this in view, a study was taken up in Ayalur watershed located in Erode district, Tamil Nadu during the years 2014 and 2015, to quantify the impact that water harvesting structures constructed in this watershed had on the runoff impounded and the sediment load trapped in them.

2. MATERIALS AND METHODS

ICAR-Indian Institute of Soil and Water Conservation, Research Centre, Udhagamandalam, had taken up Ayalur Watershed in Gobichettipalayam *taluk*, Erode district, Tamil Nadu to develop it as a model watershed during the XIth Five Year Plan under the Centrally Sponsored Scheme of Macro Management of Agriculture-National Watershed Development Project for Rainfed Areas (NWDPRA), Ministry of Agriculture, GoI, New Delhi. This watershed project had been implemented during the period 2008-2013. Ayalur watershed lies in the semiarid tropical zone characterized with scanty rainfall and dry climate. The average annual rainfall is about 600 mm, with a little more than half of the annual rainfall (about 51%) received during the North-East monsoon, around 30% during the South-West monsoon and close to 20% during summer showers in the months of April and May.

The mean monthly maximum and minimum temperatures are 37.9°C and 20°C, respectively. The base map of Ayalur watershed prepared in GIS (Geomedia Professional software) using inputs from field survey, GPS readings, Survey of India toposheets (1:25000 scale) and Google Earth images is presented in Fig. 1 and the chief watershed characteristics generated from this map is presented in Table 1.

In Ayalur watershed, out of the total area (782.0 ha) about 90% (708.38 ha) is under cultivation, of which 60.1% (430.47 ha) is under rainfed agriculture. Area under this land use is restricted to the upper and middle parts of the watershed which is occupied by gravelly red sandy soil. Partially irrigated agriculture is practiced under 17.27% (122.35 ha) of the cultivated area, which is mostly present in the middle reaches of the watershed and characterized by red sandy to red sandy loam soil. Irrigated agriculture using bore wells and open wells is practiced in 144.53 ha present in the lower reaches of the watershed, constituting 20.40% of the cultivated area. Soils in this area is red loam and the slope ranges between 0-1% (Khola *et al.*, 2008).

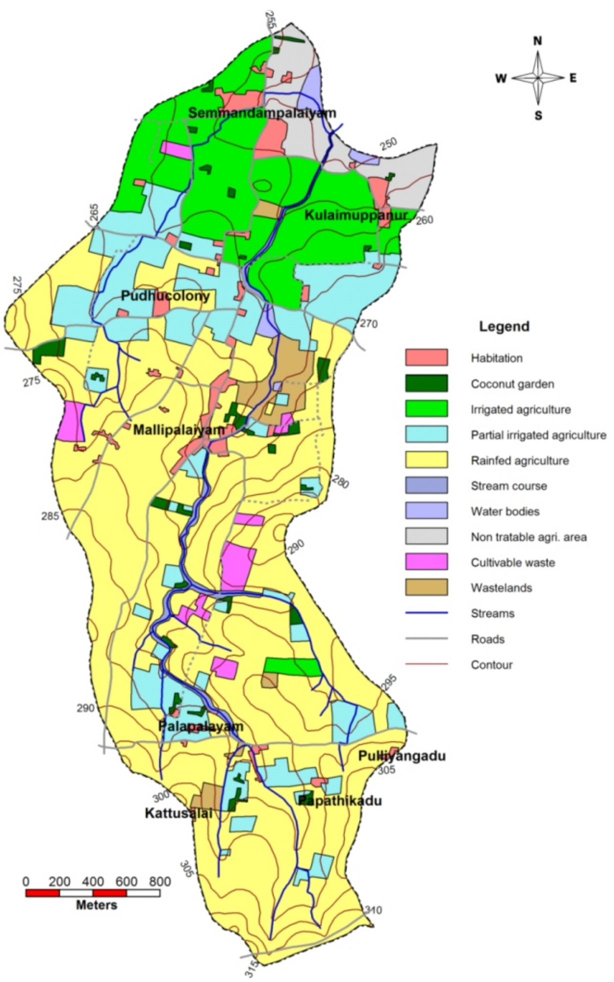

Fig. 1. Characteristic features of Ayalur watershed

Table: 1
Salient watershed characteristics of Ayalur watershed

S.No.	Parameters	Particulars for Ayalur watershed
1.	Geographical coordinates	
	Latitude	11°22'16" to 11°25'19"N
	Longitude	77°22'43" to 77°24'10"E
2.	Area	782 ha
3.	Shape	Fern
4.	Relief	65 m
5.	Slope range	< 1 - 7%
6.	Order of watershed	Third
7.	Drainage density	1.87 km km^{-2}

A field survey was conducted in Ayalur watershed to make an inventory of the watershed interventions that had been carried out to check erosion and improve water harvesting and groundwater recharge (Table 2) and a map depicting the water harvesting interventions was prepared in GIS environment (GeoMedia Professional) which is presented in Fig. 2.

For assessing the status of hydrological interventions and their impact on runoff and soil loss, survey was conducted, at the beginning of the investigation period, in the ponding area of selected hydrological interventions like Random Rubble Masonry check dams (2) and percolation ponds (6) that had been created in Ayalur watershed. Depth *vs.* capacity curves were developed for each of these eight water harvesting structures and staff gauges were erected in their areas of impounding. Three runoff gauging stations had been installed in the watershed by ICAR-IISWC, Research Centre, Udhagamandalam, for generation of hydrographs in the events where overflow occurred. However, during the period of this investigation no over flow event was observed. In case of runoff events where overflow had not occurred, the amount of runoff stored behind the percolation ponds and check dams was computed after each runoff event from the depth *vs.* capacity curves developed and added up to find the cumulative total of runoff harvested in an year because of the hydrological interventions carried out. A function was fitted between capacity of the eight structures which were

Table: 2
Water harvesting interventions in Ayalur watershed

S.No.	Intervention	Unit
1.	New Percolation pond	8
2.	Rejuvenated percolation pond	4
3.	Dugout pond	2
4.	RR masonry check dam	6

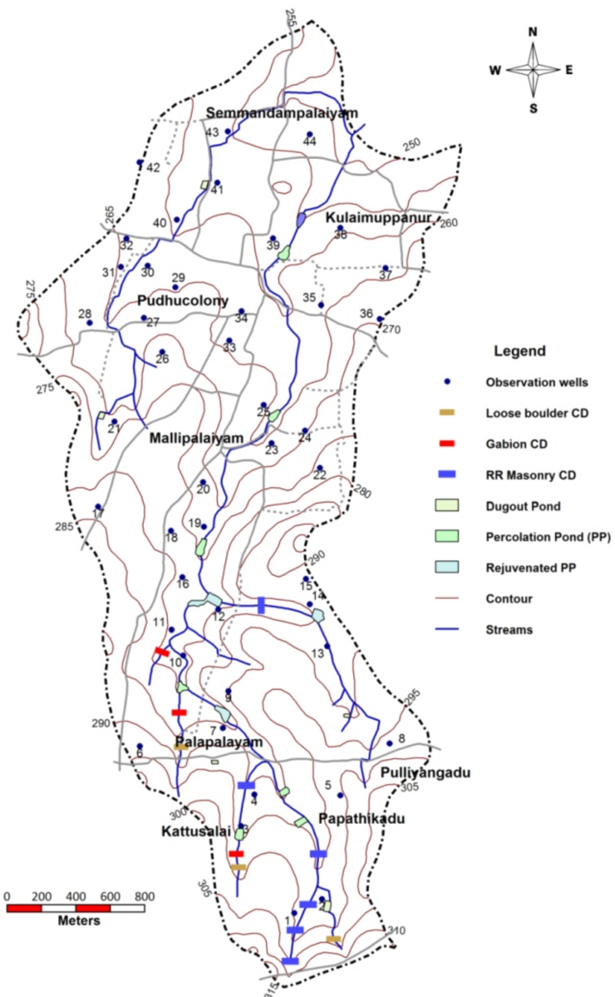

Fig. 2. Water harvesting interventions in Ayalur watershed

monitored and the runoff harvested in them. This function was used to find the runoff stored behind rest of the structures that had been constructed for water harvesting in Ayalur watershed (4 check dams, 2 dugout ponds and 6 percolation ponds) for which the capacity was a known feature.

The depth of sediment trapped behind the structures was measured from the soil deposited against the gauges, after every filling. For unit depth of impounding, the sediment trapped was calculated and multiplied with the weighted area average depth of impounding to compute the total for a particular filling and the cumulative total of sediment trapped was calculated for individual years. Like for runoff, extrapolation for the other water harvesting structures was carried out by fitting a function between the runoff harvested and the sediment trapped behind them.

3. RESULTS AND DISCUSSION

Rainfall

Daily rainfall which was recorded in Ayalur watershed during the years of study, 2014 and 2015 have been compiled and season wise data is presented in Table 3.

A cumulative total of 494.4 mm and 610 mm rainfall had been recorded in Ayalur watershed during the years 2014 and 2015, respectively. A comparison of the rainfall received in these two years with the long term average rainfall (normal) received in Gobi *taluk* where the watershed is situated clearly shows that both 2014 and 2015 had received 28.7% and 12% lesser annual rainfall than the normal annual rainfall of the study area. Though scanty and sporadic rains are expected in the dry period from January to March, it is observed that Ayalur watershed had recorded no rainfall during dry periods of both years of study. Summer showers received during the months of April and May in the year 2014 was 62.4% lesser than the average rainfall while no rainfall had been received during the same period in 2015. It is noteworthy that the south west monsoon period which lasts from June to September had received higher rainfall than the average during both 2014 and 2015 *viz.*, 73.5% and 54.9%, respectively. However the trend had reversed during the year 2014 for the north east monsoon period (October-December) in Ayalur watershed, when 66% lesser rainfall than the normal had been received. For the year 2015, though reduced rainfall had been recorded, the reduction was only 4.6% than the normal rainfall of this period. This is a point to note as runoff causing events with high intensity showers are normally a feature of the north east monsoon and the summer showers and are rarely encountered during the south west monsoon.

Table: 3
Monthly Rainfall recorded in Ayalur watershed (2014 and 2015)

Months / Season	Rainfall (mm)			Deviation (%) from Normal	
	2014	2015	Normal	2014	2015
January	0.0	0.0	14.0	-100.0	-100.0
February	0.0	0.0	12.0	-100.0	-100.0
March	0.0	0.0	19.0	-100.0	-100.0
Dry period (A)	0.0	0.0	45.0	-100.0	-100.0
April	0.0	0.0	53.0	-100.0	-100.0
May	48.5	0.0	76.0	-36.2	-100.0
Summer showers (B)	48.5	0.0	129.0	-62.4	-100.0
June	59.3	157.0	38.0	56.1	313.2
July	64.2	12.0	57.0	12.6	-78.9
August	86.2	57.5	42.0	105.2	36.9
September	125.2	72.5	56.0	123.6	29.5
SW monsoon (C)	334.9	299.0	193.0	73.5	54.9
October	80.0	59.0	153.0	-47.7	-61.4
November	21.0	241.0	123.0	-82.9	95.9
December	10.0	11.0	50.0	-80.0	-78.0
NE monsoon (D)	111.0	311.0	326.0	-66.0	-4.6
Total (A+B+C+D)	494.4	610.0	693.0	-28.7	-12.0

A compilation of the individual rainfall events in Ayalur watershed into various rainfall depth classes had been made for the years 2014 and 2015 and presented in Table 4. For the year 2014, maximum number of 12 events had occurred in the depth class of 10-25 mm where a total of 191.5 mm which is 38.7% of the annual rainfall had been recorded. This is followed by a total of 186 mm rainfall which is 37.6% of the annual rainfall, received in the depth class of 50-100 mm and recorded in three events. In the year 2015, 163.5 mm rainfall (26.8% of annual rainfall) received in ten events was recorded in the depth class of 10-25 mm while a single event of 148 mm (24.3% of annual rainfall) had occurred in the depth class of 100-150 mm.

Table: 4
Distribution of rainfall in Ayalur watershed (2014 and 2015)

Rainfall depth classes (mm)	2014			2015		
	Amount (mm)	% of total	No. of events	Amount (mm)	% of total	No. of events
<2.5	9.6	1.9	6	3	0.5	2
>2.5-5	5.2	1.1	1	44	7.2	10
>5-10	31.1	6.3	4	69.5	11.4	7
>10-25	191.5	38.7	12	163.5	26.8	10
>25-50	71	14.4	3	120	19.7	3
>50-100	186	37.6	3	62	10.2	1
>100-150	0	0.0	0	148	24.3	1
Total	494.4	100.0	29	610		34

Status of Water Harvesting Structures

A total of twenty water harvesting structures had been created in Ayalur watershed during project implementation phase, details of which are presented in Table 5. The structures are well distributed in the watershed with the last structure being an existing percolation pond with a catchment area of 512.2 ha which includes the catchment area of the other nineteen structures situated upstream to it. The structures for water harvesting are basically of three types in this watershed *viz.,* Random Rubble Masonry check dams (RRCD), percolation ponds and dugout ponds. The impounding capacity of these water harvesting structures covers a wide range from 25 to of 9472 m^3 with the total summing up to 21868.8 m^3.

Storage Depth *vs.* Capacity and Planar area Relationship for Monitored Structures

For the eight water harvesting structures selected for monitoring in Ayalur watershed, regression equations were fitted for stage *vs.* capacity relationship in these structures by varying the order of equation so that R^2 values were close to one and were able to predict the capacity of the structures

Table: 5
Details of water harvesting structures in Ayalur watershed

S.No.	Names of WHS	Type of structure	Catchment area (ha)		No. of upstream structures	Capacity (m^3)	Structures selected for monitoring
			Excluding upstream structures	Including upstream structures			
1	CD-1	RRCD	2.20	2.20	0	25.0	
2	CD-2	RRCD	6.10	8.30	1	30.0	
3	New CD	RRCD	4.29	12.59	2	76.0	
4	Samiyappan	Percolation pond	7.68	7.68	0	100.6	√
5	CD-3	RRCD	20.13	40.40	4	31.5	√
6	Kannan	Percolation pond	18.16	58.56	5	1136.0	
7	Ramasamy	Percolation pond	8.99	67.55	6	1294.2	√
8	Subramani	Percolation pond	16.89	16.89	0	756.3	√
9	Rajamani	RRCD	10.09	26.97	1	184.9	√
10	DP Rajamani	Dugout pond	2.82	2.82	0	427.0	
11	Palani	Rejuvenated PP	33.29	130.63	10	1875.0	
12	Chettiyar Thottam	Percolation pond	23.20	153.83	11	214.6	√
13	DP Senthil	Dugout pond	5.87	5.87	0	365.0	
14	Thattan Murugesan	Percolation pond	48.90	54.77	1	1016.0	
15	CD Natraj	RRCD	15.45	70.21	2	257.0	
16	Natraj	Rejuvenated PP	54.34	278.38	15	9472.9	√
17	Venkidasamy	Percolation pond	21.49	299.87	16	978.9	√
18	Mallipalayam	Percolation pond	91.82	391.69	17	658.0	
19	Parmasivam	Rejuvenated PP	105.07	496.76	18	1620.0	
20	Existing PP at Outlet	Percolation pond	15.43	512.20	19	1350.0	

accurately (Table 6). The maximum depth of impounding varied from 0.9 to 4.0 m and the total capacity ranged from 31.5 to 9472.9 m^3 for the selected structures. Surfer software was used to plot contours of storage depth in each of the selected structures to compute storage capacity at varying depths of impounding. For the pond which had the largest capacity, single equation was not found sufficient to accurately predict the capacity for different stages of impounding. Therefore, an attempt was made to develop three equations for the three depth classes (<1.5 m, depths ranging from 1.5-3.0 m and >3.0 m) to compute capacity accurately from the depth of water impounded in that particular structure. In a similar fashion, regression equations were fitted for predicting stage *vs.* planar area of the structures which are presented in Table 7. The planar area of the selected structures varied from a low of 82 to 7065 m^2 for the largest structure among the selected eight of them. Like the equations fitted for predicting storage capacity from depth, three equations were fitted for the largest structure to predict the planar area from the depth of water impounded in it *viz.* for stages <1.5 m, stages ranging from 1.5-3.0 m and stages >3.0 m.

Runoff and Soil Loss

During the years 2014 and 2015, data was monitored on the runoff harvested and sediments trapped in the eight selected water harvesting structures which is presented in Table 8 along with the runoff causing rainfall for the different structures and the number of events which had contributed to the runoff harvested in each of the eight structures. Total annual runoff harvested in the eight selected structures was 2788.2 and 16514.3 m^3 during 2014 and 2015, respectively. It can be deciphered from Table 8 that for the year 2014, total runoff harvested in each of these eight structures varied between 28.7 and 712 m^3 while in the year 2015, it varied from 54.6 to 12145.5 m^3. The number of runoff events ranged from 3 to 6 for the different structures during 2014 while it ranged from 5 to 8 during 2015. The soil deposited with the runoff during the year 2014 varied between 4.0 t and 73.2 t and in the year 2015 varied between 10.3 t and 325.8 t with

Table: 6
Depth *vs.* capacity relationship for selected water harvesting structures in Ayalur watershed

S.No.	Pond	Max. depth of storage (m)	Max. capacity (m^3)	Stage *vs.* Storage capacity relationship	
				Equation	R^2
1	Samiyappan	1.2	100.6	$y = -56.858x^4 + 173.41x^3 - 64.141x^2 + 9.8451x$	0.99
2	CD-3	0.9	31.5	$y = -14.17x^4 + 39.618x^3 + 14.881x^2 - 0.2106x$	1.00
3	Subramani	1.3	756.3	$y = 414.4x^2 + 44.679x$	0.99
4	Ramasamy	1.6	1294.2	y = 466.48x2 + 58.116x	0.99
5	Rajamani	1.2	184.9	$y = -41.123x^3 + 188.45x^2 - 11.769x$	0.99
6	Chettiyar Thottam	1.3	214.6	$y = 113.77x^4 - 139.07x^3 + 116.99x^2 + 3.2518x$	0.99
7	Natraj	4.0	9472.9	<1.5 m, y = 168.89x3 - 101.11x2 + 24.637x	1.00
				1.5 - 3.0 m, y = 1117.4x2 - 2580.6x + 1739.3	1.00
				>3.0 m, y = 178.45x3 - 230.3x2 + 441.96x	1.00
8	Venkidasamy	1.4	978.9	$y = 1011.7x^5 - 4688.9x^4 + 7033.3x^3 - 3037x^2 + 798.97x$	0.99

Table: 7
Depth *vs.* planar area relationship for selected water harvesting structures in Ayalur watershed

S.No.	Pond	Max. depth of storage (m)	Planar area at full level (m^2)	Stage *vs.* Storage area relationship	
				Equation	R^2
1	Samiyappan	1.2	207.5	$y = -508.02x^6 + 2231.7x^5 - 3599x^4 + 2429.9x^3 - 427.39x^2 + 42.43x$	0.99
2	CD-3	0.9	82.0	$y = -57.39x^3 + 119.87x^2 + 28.943x$	0.99
3	Subramani	1.3	1064.2	$y = 777.62x^4 - 2159.2x^3 + 1609.5x^2 + 654.18x$	0.99
4	Ramasamy	1.6	1344.2	$y = -339.34x^2 + 1399.3x$	0.96
5	Rajamani	1.2	264.3	$y = -617.98x^5 + 2344.6x^4 - 3100x^3 + 1552.9x^2 + 52.217x$	0.99
6	Chettiyar Thottam	1.3	626.1	$y = 247.68x^3 - 134.85x^2 + 157.05x$	0.99
7	Natraj	4.0	7065.2	$y = 499.54x^3 - 526.36x^2 + 296.26x$	1.00
				$y = -869.91x^3 + 6072.7x^2 - 11504x + 7474.1$	1.00
				$y = 163.19x^3 - 753.8x^2 + 2167.5x$	1.00
8	Venkidasamy	1.4	1878.2	$y = -179.78x^4 + 809.21x^3 - 345.51x^2 + 86.34x$	0.99

the total soil trapped amounting to 236.6 and 810.6 t in the years 2014 and 2015, respectively. It is pertinent to note that during the year 2015, one rainfall event had occurred on I[st] June where 148 mm of rainfall had been received in a single day which is not a common occurrence in this area. The runoff harvested in the monitored structures due to this rainfall event and sediment load trapped is presented in Table 9. It can be observed that a total runoff of 14780.9 m^3 had been harvested from the eight structures under monitoring which is a whopping 73.5% of the total annual runoff of 16514.3 m^3. This rainfall event had also caused a high soil loss of 668.7 t which works out to be 82.5% of the total annual sediment load trapped by the selected eight structures.

As it was not possible to monitor all the twenty water harvesting structures that had been created or rejuvenated during the watershed implementation phase, extrapolation of the data monitored in eight selected structures was done by developing regression equations between capacity and runoff harvested in the selected structures during the respective years (Fig. 3 and Fig. 4). These equations were then used to find out the runoff harvested in 12 of the water harvesting structures which were not under monitoring (Table 10). Regression equations were also fitted to establish the relationship between runoff harvested and sediments trapped in the structures under monitoring (Fig. 5 and Fig. 6). These equations developed

Table: 10
Computation of runoff harvested and sediments trapped by the non-monitored structures in Ayalur watershed (2014 and 2015)

S.No.	Names of WHS	Runoff harvested (m^3)		Sediments trapped (tonnes)	
		2014	2015	2014	2015
1	CD-1	25.4	27.8	3.8	8.1
2	CD-2	30.4	33.4	4.4	9.2
3	New CD	76.0	84.6	9.0	17.0
4	Kannan	750.3	1289.2	49.5	102.7
5	DP Rajamani	378.9	478.5	31.4	53.3
6	Palani	795.0	2155.5	41.1	144.2
7	DP Senthil	331.1	408.6	28.3	48.0
8	Thattan Murugesan	710.1	1150.5	48.3	95.2
9	CD Natraj	242.0	287.1	22.3	38.1
10	Mallipalayam	535.2	740.4	40.4	71.2
11	Parmasivam	819.1	1854.1	47.1	130.5
12	Existing PP at Outlet	799.2	1537.8	49.9	115.4
	Total	5492.8	10047.5	375.3	832.9

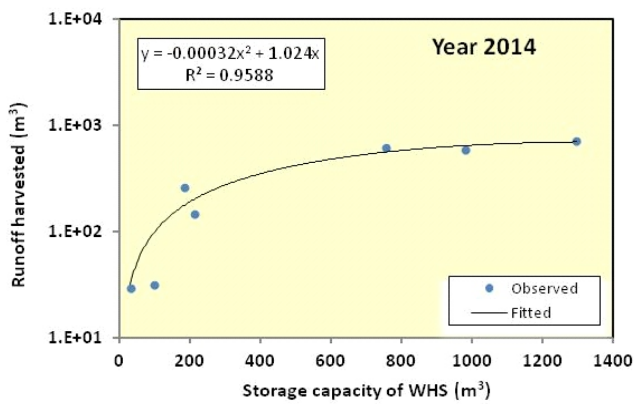

Fig. 3. Relationship between storage and runoff harvested during 2014

Table: 8
Runoff harvested and sediments trapped by the monitored water harvesting structures in Ayalur watershed (2014 and 2015)

S.No.	Water harvesting structure	2014				2015			
		Runoff causing rainfall (mm)	No. of runoff events	Runoff harvested (m^3)	Sediments trapped (t)	Runoff causing rainfall (mm)	No. of runoff events	Runoff harvested (m^3)	Sediments trapped (t)
1	Samiyappan	220	4	31.3	4.6	355	6	84.5	17.1
2	CD-3	227	5	28.7	4.0	320	5	54.6	10.3
3	Subramani	186	3	618.3	31.3	355	6	1265.2	87.5
4	Ramasamy	220	4	712.0	73.2	370	7	1390.1	178.3
5	Rajamani	236	5	254.9	25.8	355	6	391.1	48.3
6	Chettiyar Thottam	220	4	145.0	13.9	370	7	372.5	36.8
7	Natraj	220	4	413.8	34.9	384	8	12145.5	325.8
8	Venkidasamy	245	5	584.1	48.9	355	6	810.8	106.4
	Total			2788.2	236.6			16514.3	810.6

Table: 9
Runoff harvested and sediments trapped by the monitored water harvesting structures in Ayalur watershed on 01-06-2015

S.No.	Parameter	Samiyappan	CD-3	Subramani	Ramasamy	Rajamani	Chettiyar Thottam	Natraj	Venkidasamy	Total
1	Runoff (m^3)	44.1	41.4	719.7	806.8	246.2	267.5	12072.1	583.1	14780.9
2	Soil loss (tonnes)	12.6	8.0	63.0	124.0	28.2	26.5	318.6	87.8	668.7

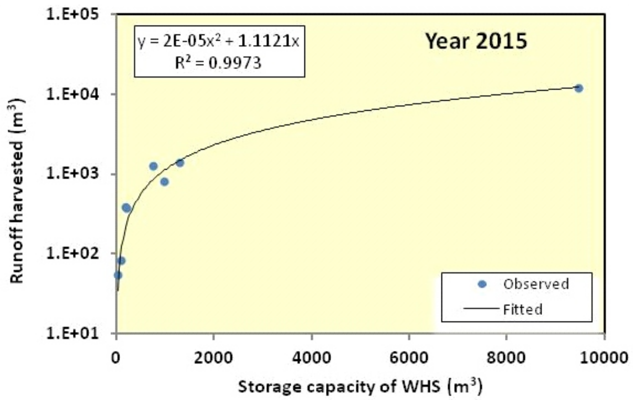

Fig. 4. Relationship between storage and runoff harvested during 2015

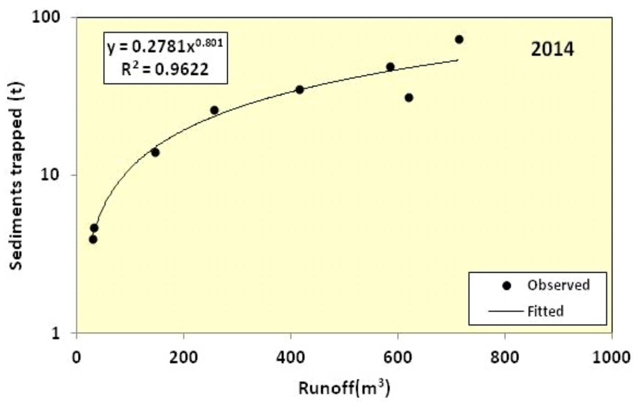

Fig. 5. Relationship between runoff and sediments trapped during 2014

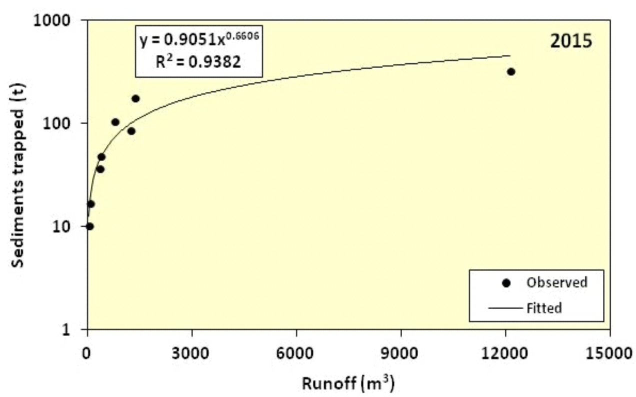

Fig. 6. Relationship between runoff and sediments trapped during 2015

for the individual years 2014 and 2015 were then used to the find the sediment deposited in the other 12 structures which were not under monitoring.

The total runoff in each of the 12 non-monitored structures varied between 25.4 and 819.1 m^3 during 2014 and between 27.8 and 2155.5 m^3 in the year 2015. Similarly sediments trapped varied between 3.8 and 49.9 t during 2014 and between 8.1 and 144.2 t during 2015. The total annual runoff harvested from the 12 structures was calculated as 5492.8 and 10047.5 m^3 and the sediment load trapped as 375.3 and 832.9 t for the years 2014 and 2015, respectively.

In total, runoff harvested in all 20 of the water harvesting structures (monitored and non monitored) in Ayalur watershed summed up to 8281.0 m^3 and 26561.9 m^3 during 2014 and 2015, respectively. When weighted with the annual rainfall, the average value of runoff was computed as 18378.1 m^3 (Table 11). The sediment load trapped in the 20 structures was calculated as 611.9 t and 1643.5 t during 2014 and 2015, respectively which amounts to 1.2 t ha^{-1} and 3.2 t ha^{-1} yr^{-1} considering a catchment of 512.2 ha at the outlet. When weighted with the annual rainfall, the average value of sediment trapped was computed as 1181.7 t which works out to 2.3 t ha^{-1} (Table 11). Similar results have been reported by Sikka *et al.* (2004) in Salaiyur watershed of Coimbatore district of Tamil Nadu wherein water harvested in the 20 structures with a total capacity of 26600 m^3 within a catchment area of 513 ha ranged from 2800 to 38592 m^3 and soil loss from 0.5 to 1.6 t ha^{-1} yr^{-1} with annual rainfall ranging from 344 to 771.2 mm.

4. CONCLUSIONS

In watersheds like Ayalur which are located in semi arid regions it is vital to conserve every drop of rainfall that has been received. It has been established from the study that water harvesting structures that have been created in a terrain like that of Ayalur watershed, can harvest runoff ranging between 16.2 to 51.9 m^3 ha^{-1} of catchment area from annual rainfall ranging between 494.4 mm (deficit rainfall) and 610 mm (close to normal). The above study reiterates the fact that water harvesting structures created in a watershed not only impound water which can supplement the groundwater recharge, but also aid in trapping sediment load. This sediment load carried along with the runoff has high enrichment ratio and is the reason for farmers adopting the practice of lifting the silt load trapped in water bodies and applying it to their fields for enhancing the fertility status. This is substantiated by the fact that the government of Tamil Nadu

Table: 11
Total runoff harvested and sediments trapped by the WHS in Ayalur watershed (2014 and 2015)

Particulars	Runoff harvested (m^3)			Sediments trapped (t)		
	2014	2015	Average**	2014	2015	Average**
Monitored	2788.2	16514.3	10369.6	236.6	810.6	553.6
Estimated	5492.8	10047.5	8008.5	375.3	832.9	628.0
Total	8281.0	26561.9	18378.1	611.9	1643.5	1181.7
Per unit area*	16.2	51.9	35.9	1.2	3.2	2.3
Rainfall (mm)	494.4	610	552.2	494.4	610	552.2

*With catchment area of 512.2 ha, **Weighted with rainfall had recently passed an order allowing farmers to take the silt load deposited in water bodies, free of cost. This would be effective when structures are well distributed throughout the watershed like that in Ayalur watershed so that majority of farmers will have opportunity to adopt this practice.

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