Rain Water Harvesting Potential of Pallavapuram Area of Meerut: A GIS Study

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Abstract:

Meerut is one of the important industrial towns of the western Uttar Pradesh situated about 85 km from Delhi and occupying an area of about 142 km^2. It lies between $28^o57'$ to $29^o02'$ North latitude and $77^o40'$ to $77^o45'$ East longitude. It is a part of Indo-Gangetic plains. Water requirement for the city is mainly met from groundwater. The city well represents the worsening scenario of water scarcity in the country. The increasing population has in fact put enormous pressure on the groundwater resources which is declining at an alarming rate.

Rain water harvesting is the technique of collecting and storing rain water at surface or sub-surface aquifers, before it is actually lost as surface run-off. It is thus a simple and affordable technique for augmenting groundwater table and also supplements day to day water needs of the society. If every city, town and village adopts and implements rainwater-harvesting techniques, the water crisis can be tackled easily. The present paper uses a GIS approach to assess total area of catchments available for rain water harvesting in Pallavapuram area of Meerut and calculate the amount of water which could be really harvested or used for replenishing groundwater reserves. Google satellite images were downloaded for the purpose and georeferenced with the help of Arc GIS 9.2. The different types of catchments included rooftops, roads and open spaces. Arc GIS 9.2. was also used to digitise all the different catchments their respective topology was created. Finally, the area of catchments was calculated to find the total rainwater harvesting potential of the study area.

Keywords: Rainwater harvesting, aquifers, Autocad Map 2000i, Arc GIS 9.2, Pallavapuram

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Introduction

Water is the lifeline of any society. Right from ancient times, civilisations have flourished in the vicinity of water bodies. Availability of drinking water and provision of sanitation facilities are the basic requirements for a healthy society. With the ever increasing population, water has become a scarce resource, especially in urban areas. It has become big challenge for the government and the policy makers to provide safe drinking water for the urban masses. This calls for sustainable and judicious use of water resources. Among the various technologies to augment freshwater resources, rainwater harvesting appears to be a promising, simple, economic and eco-friendly method of water conservation and an ideal solution to recharge groundwater. The rainwater collection system is known to have existed for over 4000 years. [1] The technique is being revived today to give back to nature what we take from it. Rain is the first form of water that we know in the hydrological cycle. Hence it is a primary source of water which is nearly pure. Rain water harvesting is the technique of collection and storage of rain water at surface or in sub-surface aquifers, before it is lost as surface run-off. The augmented resource can be harvested in times of need. Artificial recharge to ground water is a process by which the ground water reservoir is augmented at rate exceeding that under natural conditions of replenishment.

Rainwater Harvesting is of 3 types depending on the types of catchments. Catchments can be in the form of roof tops, roads or open spaces like forests.[2] Rainwater harvesting also depends on the area of catchments which directly accounts for the amount of rain collected. Thus greater the area, greater is the amount of water collected. The quality of water that gets collected from the catchment also depends on the location of the catchment. Roof catchment provides purer water compared to catchments situated in areas where they are open to contamination or are chemically treated. The water collected from such catchments must be treated before being used for any purpose.

There are numerous studies in this regard. Liaw and Tsai (2004)[3] found out the optimum storage volume of rooftop rainwater harvesting systems for domestic use in Taiwan. Jasrotia and Singh (2006)[4] have tried runoff and soil erosion modelling in a catchment area in the Himalayan region, using remote sensing and GIS techniques. Varma and Tiwari (1995)[5] elaborated on the current status and prospects of rain water harvesting. Xu and ZhangQ (2007)[6] did the modeling of surface runoff in Xitiaoxi catchment in China. Bhattacharya & Rane[7] have developed a rainwater harvesting model for South and South-west Delhi. Kumar *et al.*[8] have discussed the potential of Rain Water Harvesting for water scarce regions of India. Centre for Science and Environment (CSE India), Delhi is a pioneer in campaigning about the benefits of rainwater harvesting techniques to the common public. Janhit Foundation is an NGO which works in close cooperation with CSE India and has set up the country's second rain centre in Meerut. It works towards creating awareness among the general public about the decreasing water tables in Meerut and measures to safeguard it through building up rainwater harvesting structures. About 55 rainwater harvesting structures have been set up in Meerut by Janhit foundation. A few prominent sites where the structures have been installed are Mahila Police Thana, Meerut College, A School in Jalalpur Village, Naari Niketan, a building at Civil Lines etc[9].

Methodology

This is a Geographic Information System (GIS) based method further the estimation of overall rainwater capture potential of the Pallavpuram area of Meerut.

The Study Area

The metropolitan city of Meerut is one of the important industrial towns of the western Uttar Pradesh. It is situated about 85 km from Delhi. It occupies an area of about 142 km^2 and lies between 28°57' to 29°02' N latitude and 77°40' to 77°45' E longitude. The metropolitan city of Meerut is a part of Indo-Gangetic plains. The population pressure on the city is ever growing. As per the 2001 census, the population of Meerut (including cantonment area) is 11,67,399. It is the 25th largest town in India (population wise), and the 5th largest town in Uttar Pradesh after Kanpur, Lucknow, Agra and Varanasi. The area is almost devoid of any significant relief features, with the average altitude being only to 220 m from the mean sea level and is composed of unconsolidated alluvial deposits of pleistocene and sub-recent alluvial sediments transported and deposited by river action.

The city of Meerut well represents the worsening water scarcity situation in the country. It once had abundance of irrigation canals. Due to ever increasing population there has been an abnormal growth in the demand for water. This in turn has led to the construction of tube wells and thus groundwater table is decreasing at an accelerated rate. Unlike four decades ago when groundwater was approachable even in a pit just two meters deep, the water table has now fallen down to 20 meters below the surface. Groundwater contamination is another area of concern. The abuse of pesticides and chemicals in agriculture is the primary cause for groundwater pollution in rural areas. People are drinking polluted water containing high percentage of nitrate and fluoride.

Pallavpuram is a planned locality situated in the northern part of the city along the Haridwar-Roorkee Road or NH-58. It appears to be a promising area where rainwater harvesting structures can be installed and all the three types of catchments that is rooftops, the roads as well as open spaces can be utilised for the purpose. An area of about 2 km^2 of Pallavpuram was taken for the study purpose.

Objectives

The main objectives of this paper are as follows:

i. To harness the enormous potential of rainwater harvesting techniques in conserving the ground water reserves of the study area.
ii. To develop a geospatial database of the rainwater harvesting potential for the study area.
iii. To assess the total volume of water collected through rain water harvesting technologies with respect to different types of catchments that is roof tops, roads and open spaces.

Material and Methods

Satellite images were downloaded from Google Earth having the extent as follows:

Left Longitude download=77.7076721191406
Right Longitude download=77.7200317382813
Top Latitude download=29.0729746879443
Bottom Latitude download=29.0477661789349

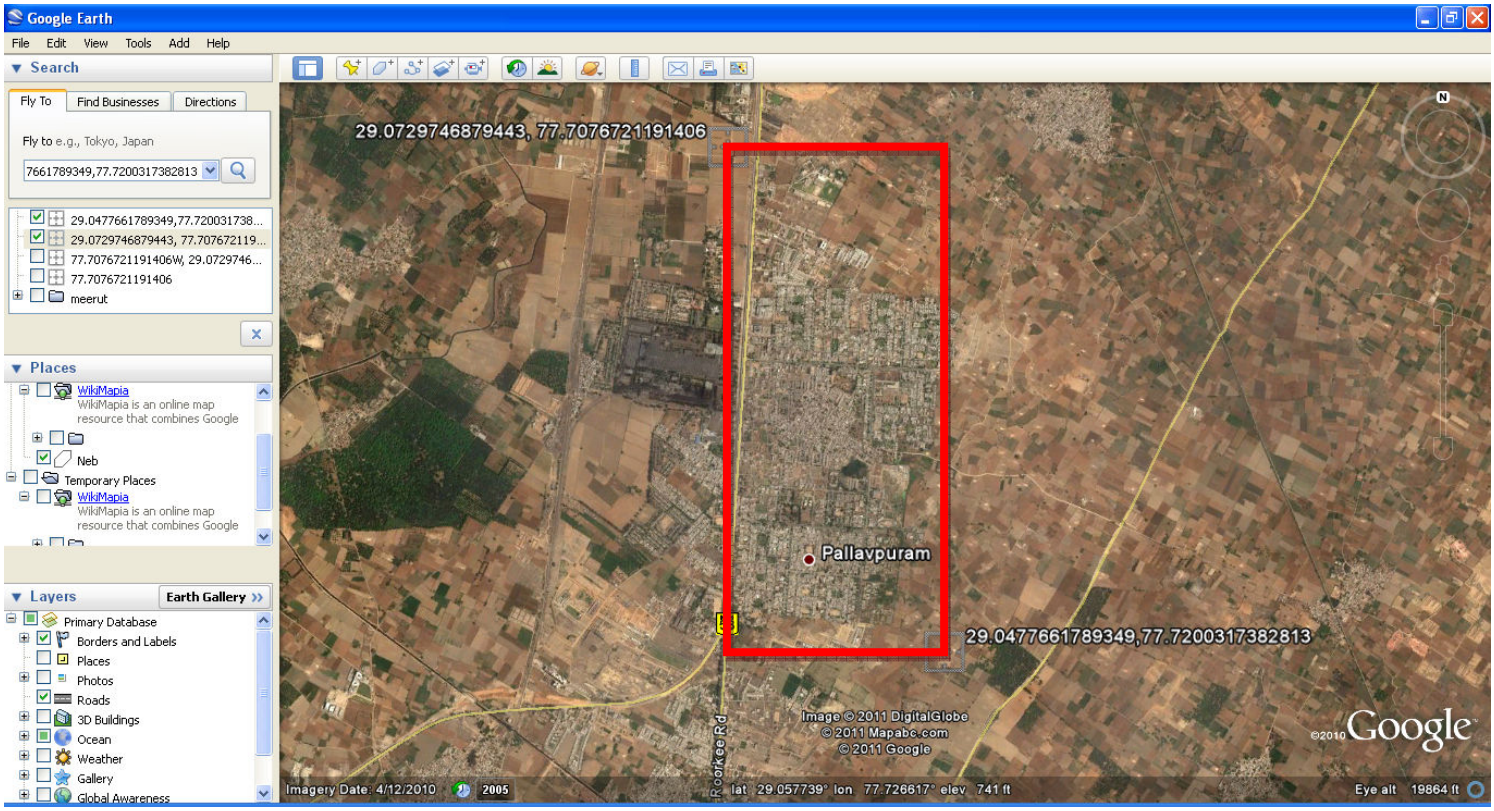

Fig.1: Extent of Downloaded Images from Google Earth

It can be well understood with the help of above figure, where the red rectangle denotes the extent of downloaded images from Google Earth. The images were further combined and georeferenced in Arc GIS 9.2 version. Then the georeferenced images were digitised in Arc GIS 9.2 and different entities were captured like rooftops, roads and streets and open spaces. The rooftops were captured as polygons. Pallavpuram consists of few sub-localities like Pallavpuram Phase 1, Pallavpuram Phase 2 and Palheda Village. The village of Palheda is a bit unplanned and has built up structures and roads which are not very much suitable for rainwater harvesting. So only proper rooftops were digitised and the dilapidated and uneven ones were ignored. In Pallavpuram we have some of the housing plots in continuity without any spaces between them. So, in such cases roof of houses were captured in the form of one big polygon consisting of all the connected houses. The roads were captured as arc while the open spaces or parks were again captured as polygons. After digitisation, the map was further cleaned and the respective topology was created with the help of same software. Then the area of all the catchments were calculated thus giving the total rainwater harvesting area available in the Pallavpuram locality. The information was useful in calculating the total rainwater harvesting potential of the area.

RESULTS AND DISCUSSION

Altogether 1036 polygons were captured as Rooftops in Pallavpuram area. The total area of rooftops was calculated to be 482660.825 m^2 (Figure 2). Apart from this the area of colony roads or streets having a total length of 20413.03989 m and width of about 5 m was found to be 102065.1995 m^2. Area of Main Road having a total length of 3061.85982 m was also calculated taking the width of Road as 15 m. The total area of main roads in the colony excluding NH 58 was found to be 45927.8973 m^2. The total area of open spaces (Figure 4) calculated to be 103938.343 m^2. The formula for calculating the amount of rain water collected in any area is as follows:

Rain Water Collected= Rainfall (mm) x Area of catchment (m^2) x Runoff coefficient

Average rainfall in Meerut is about 1000 mm[10]. The area of the catchments was already calculated with the help of Arc GIS software. Runoff coefficient is the factor which accounts for the fact that all the rainfall falling on a catchment cannot be collected. Rainwater yield varies with the size and texture of the catchment area. A smoother, cleaner, and more impervious roofing material contributes to better water quality and greater quantity. While loss is negligible for pitched metal roofs, concrete or asphalt roofs average less than 10 per cent loss, and built up tar and gravel roofs average a maximum of 15 per cent loss. Table. 1 gives the run-off coefficient of different types of catchments.

Table. 1
Runoff Coefficients of Different Types of Catchments [11]

Tiles	0.8 - 0.9
Corrugated metal sheets	0.7 - 0.9
Concrete	0.6 - 0.8
Brick pavement	0.5 - 0.6
Soil on slopes less than 10 per cent	0.0 - 0.3
Rocky natural catchments	0.2 - 0.5
Green area	0.05 - 0.10

Source: Pacey, Arnold and Cullis, Adrian 1989, Rainwater Harvesting: The collection of rainfall and runoff in rural areas, Intermediate Technology Publications, London

Since most of the rooftops in the study area were made of concrete structures, so average run-off coefficient of the rooftops was taken as 0.7. So the total rainwater that would be collected from rooftops was calculated to be 337862577.5 liters.

Volume of Water Collected from Rooftops= 1000 (mm) x 482660.825 (m^2) x 0.7=337862577.5 litres

The roads in the colony as well as main roads in Pallavpuram area is made up of concrete. So the run-off coefficient of roads were also taken as 0.7. So the total rainwater that could the collected from roads were found to be 103595167.76 litres.

Volume of Water Collected from Road (both Colony Roads and Main Roads) = 1000 (mm) x 147993.0968 (m^2) x 0.7= 103595167.76 litres

The average run-off coefficient of open spaces were taken as .075. So the total rainwater that could be collected from open spaces was found to be 7795375.725 litres.

Volume of Water Collected from Opens Spaces = 1000 (mm) x 103938.343 (m^2) x 0.075= 7795375.725 litres

So the grand total water that could be collected from all the source catchments was found to be 449253121 litres.

Even if we consider 60 percent of collected rainwater to be effectively harvested, then also we get about 269551872.6 litres of water.

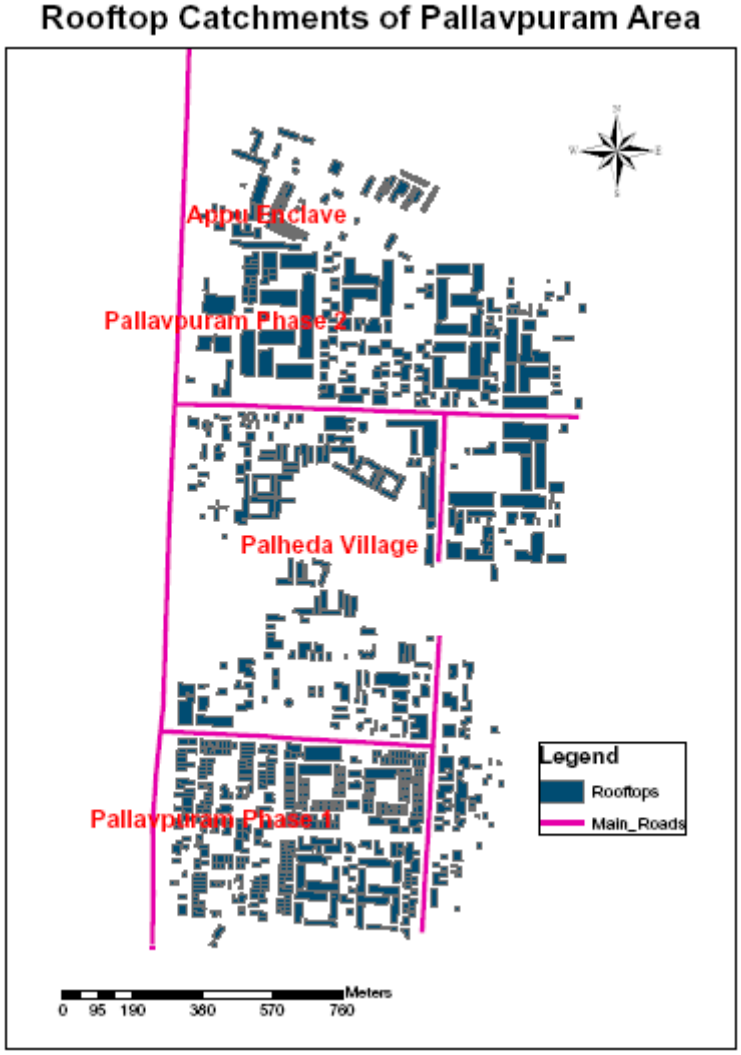

Figure: 2

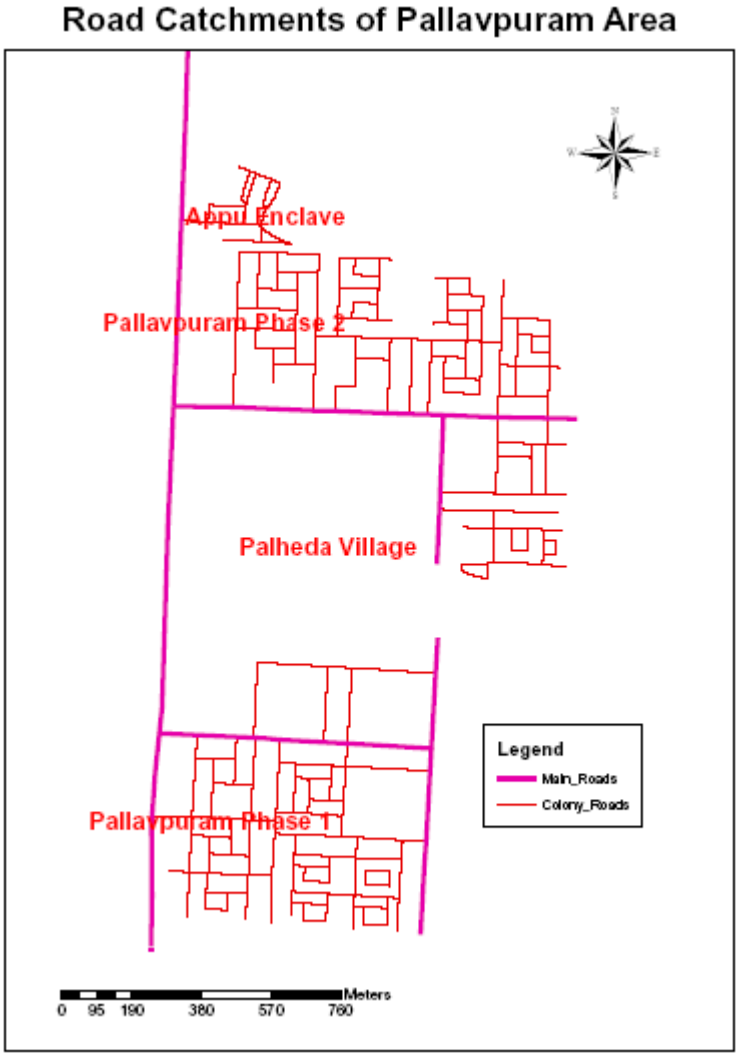
Road Catchments of Pallavpuram Area
Appu Enclave
Pallavpuram Phase 2
Palheda Village
Pallavpuram Phase 1
Legend
Main_Roads
Colony_Roads
0 95 190 380 570 760
Meters

Figure: 3

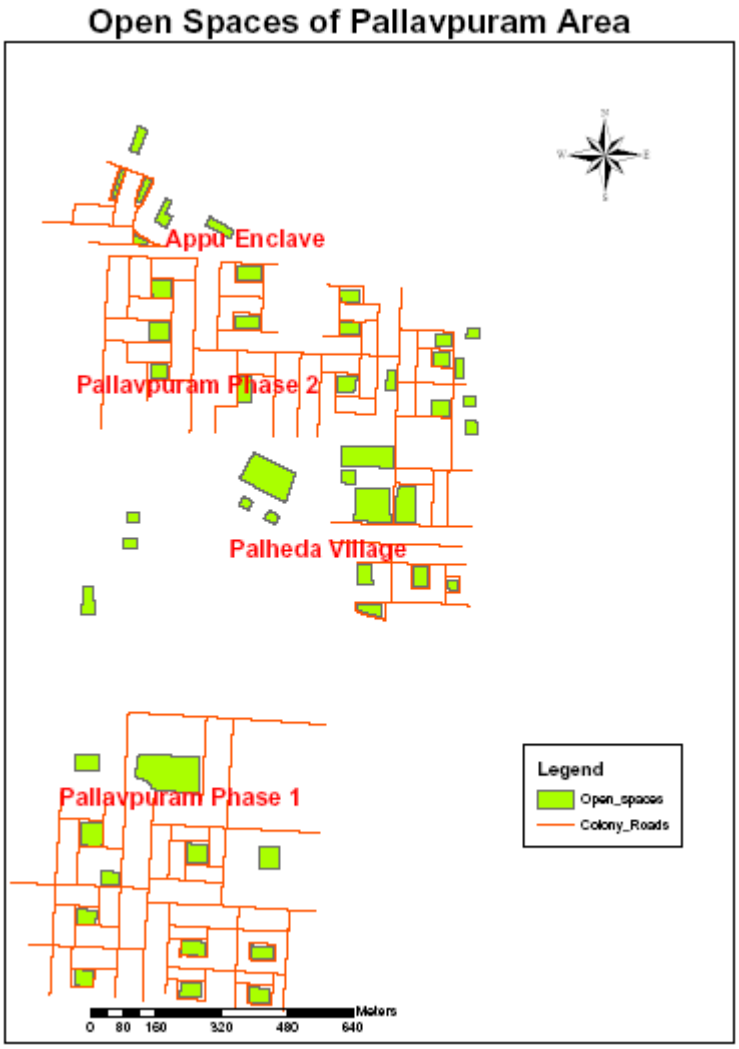

Figure 4

Conclusion

Thus we see that rainwater harvesting is the ideal solution to the water crisis that is going to arise in a few years from now in the study area. The groundwater deterioration has been fast in this region and immediate recharge measures should be taken to address the problem. This can be possible only with the help of rainwater harvesting techniques.

REFERENCES

1. Rain Water Harvesting: An Ideal Solution, http://www.delhi.gov.in/wps/wcm/connect/DOIT_DJB/djb/home/rain+water+harvesting/harvesting2 (accessed September 21, 2011)

2. Rain Water Harvesting: Step by Step Process, http://www.cseindia.org/node/1162 (accessed September 21, 2011)

3. Liaw, Chao-Hsien & Yao-Lung Tsai, (2004). Optimum Storage Volume of Rooftop Rain Water Harvesting Systems for Domestic Use, *Journal of the American Water Resources Association (JAWRA)* 40(4):901-912.

4. Jasrotia A.S., Singh, R. (2006). Modeling runoff and soil erosion in a catchment area, using remote sensing and GIS, in the Himalaya region, India, *International Journal Geoscience Environmental Geology* 51:29–37. doi:10.1007/ s00254-006-0301-6

5. Varma, H.N. Tiwari, K.N. (1995). Current status and prospects of rain water harvesting, *Indian National Committee on Hydrology (INCOH),* National Institute of Hydrology Roorkee, India.

6. Xu L, ZhangQ, LiH, Viney NR, Xu J, Liu J (2007) Modeling of surface runoff in Xitiaoxi catchment, China, *Water Resource Managment* 21:1313–1323. doi:10.1007/s11269-006-9083-6

7. Bhattacharya, A. and Rane, O (2003). Harvesting rainwater: catch water where it falls, Centre for Civil Society, 422-439, at http://www.ccsindia.org/ccsindia/interns2003/chap35.pdf (accessed on 17 May 2011)

8. Kumar ,M. D. Patel, A. & Singh, O.P. Rainwater Harvesting in the Water-scarce Regions of India:Potential and Pitfalls, at http://www.iwmi.cgiar.org/Publications/Other/PDF/NRLP%20Proceeding-2%20Paper%2013.pdf (accessed September 21, 2011)

9. Rainwater Harvesting, at http://www.janhitfoundation.in/rain-water-harvesting.html (accessed November 18, 2011)

10. Environmental Profile of Meerut, at http://cpcb.nic.in/upload/NewItems/NewItem_47_foreword.pdf (accessed November 18, 2011)

11. UN Habitat, Rainwater Harvesting and Utilization, pp 16, at http://www.hpscste.gov.in/rwh/Blue_Drop_Series_02_-_Capacity_Building.pdf (accessed September 21, 2011)