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The Sensible Utilization of Urban Water Resources

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Abstract: Urban water harvesting implies augment of natural water resources to ensure optimum and sustained usage. In this approach the basic unit to initiate is Implementation of roof water harvesting technology at point level i.e. Domestic Rain Water harvesting. Since the Urban area is mostly covered with paved areas, the study deals with the water harvesting in areas such as paved areas, rooftops, open spaces and storm water. In this regard the study of related issues is crucial which was done by utilizing remote sensing and Geographic Information systems.

The study area is known as Visakhapatnam, state of Andhra Pradesh, India. The terrain of the city Visakhapatnam consists of several hills, plain lands, water bodies etc which falls under different categories of Land use. Due to the urbanization and drastic increase in population, the freshwater requirement is increasing day by day and thus the demand to sustainable usage of water and alternative methods to acquire freshwater. Being a natural port city, the Visakhapatnam city is consisting of several industries and in turn it is catering several millions of people which is a key reason for this study.

Keywords: water harvesting, paved areas, storm water, land Use.

1. INTRODUCTION

Water is the most common or major substance on the earth, covering more than 71% of its surface. Out of the total volume of water available on the surface of the earth, only 3% is freshwater. The freshwater is being used for the purpose of human use, industries and agriculture. The freshwater is available on earth in different forms like glaciers, rivers, Ground water, soil moisture, atmospheric water etc...

In India, the water availability per capita is declining. The per capita availability of water at the national level is reduced from about 5,177 m^3 in the year 1951 to the present level of 1,869 m^3. The prominent reasons behind are, the increasing demand for water due to the increasing population and extensive use of water by agricultural sector, the single largest consumer of water. India is blessed with adequate rainfall as a whole, yet there are large regions of dry and drought prone areas. In many places the quality of groundwater is not good. In such places rainwater harvesting may provide lifeline for survival [2, 3].

2. RAINWATER HARVESTING

The Human civilization, entirely depend upon rivers, lakes and ground water to fulfill their water demands. However rain is the ultimate source that feeds all these sources. The Implication of rainwater harvesting is to make sensible use of rainwater at the place where it falls i.e. to conserve it without allowing it to drain away. Rainwater harvesting is an ancient technique enjoying a revival in popularity due to the inherent quality of rainwater. Rainwater is valued for its purity and softness. In non polluted areas it has a nearly neutral pH, and is free from impurities such as salts, minerals, and other natural and man-made contaminants.

3. NEED FOR RAINWATER HARVESTING

Due to over population and higher usage levels of water in urban areas, water supply agencies are unable to cope up demand from available surface sources especially during summer seasons. This has led to digging of individual tube wells by house owners. Even water supply agencies have resorted to ground water sources by digging tube-wells in order to augment the water supply. The replenishment of ground water is drastically reduced due to paving of open areas. Indiscriminate exploitation of ground water results in lowering of ground water table (GWT) rendering many bore-wells dry, which has led to drilling of bore wells of greater depth. This further lowers the water table and such frequent fluctuations in GWT results in presence of higher concentration of salts in ground water. In coastal areas, the over exploitation of ground water results in seawater intrusion thereby rendering fresh ground water bodies' saline [4].

In rural areas also, government policies on subsidized power supply for agricultural pumps and piped water supply through bore and open dug wells are resulting into decline in GWT. The solution to all these problems is to replenish ground water bodies with rainwater by manmade means [3].

4. BENEFITS OF RAINWATER HARVESTING

The Rainwater's environmental advantage and purity over other water alternatives makes it the sustainable option, even though the precipitation cycle may fluctuate from year to

year. The collection of rain water not only leads to conservation of water but also energy since the energy input required to operate a centralized water system designed to treat and pump water over a vast service area is bypassed. Rainwater harvesting also lessens local erosion and flooding caused by runoff from impervious cover such as pavement and roofs, as some rain water is captured and stored. Rain water quality almost exceeds that of ground or surface water as it does not come into contact with soil and rocks where it dissolves salts and minerals. The Rain water is not exposed to many of the pollutants that often are discharged into surface waters such as rivers, and which can further contaminate groundwater. However, rainwater quality can be influenced by characteristics of area where it falls, since localized industrial emissions affect its purity. Thus, rainwater falling in non-industrialized areas can be superior to that in cities which are dominated by heavy industry or in agricultural regions where crop dusting is prevalent [5].

5. ROOFTOP WATER HARVESTING

Rooftop water harvesting is a process of collecting of runoff during rains from impermeable surfaces on houses or close to houses, its storage in water proof vessels and its subsequent use for the inhabitants of the houses. The use may be temporary (within a day or so following a rainstorm), seasonal (throughout the rainy season) or permanent (throughout the year) except in years of exceptionally low rainfall. The rain water from the roof may also be used for recharging the ground water through nearby water sources such as open dug wells or bore wells. It may be achieved in the case of storing the harvested water from roof by diverting the excess water for ground water recharge and in absence of storing vessel by diverting all the water for ground water recharge.

Rooftop rainwater harvesting for household purpose only represent a small part of the total water balances. In areas with significant variations in the annual rainfall pattern, the matching of water supply and water demand may be difficult. However, in terms of economic and human welfare it has a crucial role to play. Rainwater in many cases is the easiest to access, most reliable, and least polluted source. It can be collected and controlled by the individual household or community as it is not open to abuse by other users [1, 6].

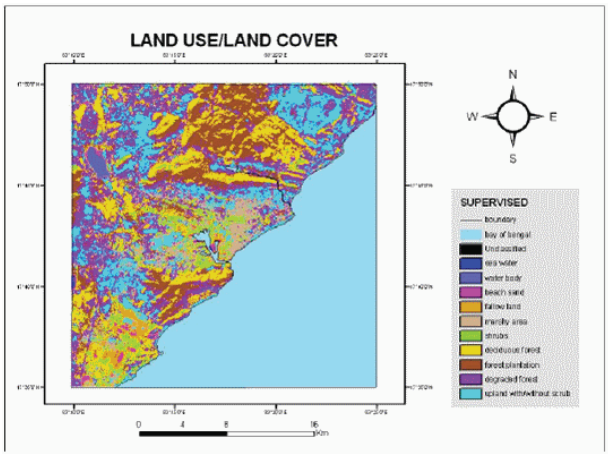
Role of Geo Information System and Remote Sensing in area development plan

Remote sensing is a powerful tool for generating large amount of data related to nature and its resources in a relative short time, and can be prominent source of information for a GIS. Geo Information System (GIS) represents the most effective mechanism for utilizing remote sensed data and also enhances the effectiveness of this data through correlation of remote sensing inputs with data already stored in GIS. The Information derived from satellite data, topographical maps and other socioeconomic data could be stored in GIS as a database. GIS enables effective and efficient manipulation of spatial and nonspatial data for scientific management of watershed and develop alternatives of development model for the benefit of local people.

The Analysis and Proposals for the Study Area – Urban Region – Visakhapatnam, Andhra Pradesh, India.

The study area known as Visakhapatnam, Andhra Pradesh, India. The terrain of the city Visakhapatnam consists of several hills, plain lands, water bodies etc which falls under different categories of Land use. Due to the urbanization and drastic increase in population, the freshwater requirement is increasing day by day and thus the demand to sustainable & sensible usage of water and alternative methods to acquire freshwater. Being a natural port city, the city is consisting of several industries and in turn it is catering several millions of people which is a key reason for this study. The city Visakhapatnam locates between The latitude and longitude of 17° 42' 0" N / 83° 18' 0" E. The Average annual rainfall of the Visakhapatnam region is 980mm.

Greater Visakhapatnam Municipal Corporation (GVMC) was established as a municipal corporation in 1901. It provides water supply and sewerage services to the Greater Visakhapatnam area which has a total population of 1,523,000 people. The present service area of GVMC has a population density of 5,750 persons/ km^2. The GVMC is responsible for water production, distribution and source development. It draws water from the Gostani, Godavari, Sarada and Yeluru Rivers and 5,053 tube wells. There is no private sector involvement in the GVMC's operations. The GVMC follows a 15-year master development plan covering 2006 to 2020 [8].



6. LAND USE RESOURCE PLANNING

Different themes on land and water resources of the study area were integrated and management need for different

landscape units were assessed. Based on careful integration of information on land use, groundwater, soil, and slope the following action plan have been formulated in development of soil and water conservation measures proposed and they are given some mapping unit range from as higher priority to the following unit as one step less priority than the previous. A resource based action plan was evolved for the development, conservation and management on sustainable basis.

7. HYDRO GEOMORPHOLOGY

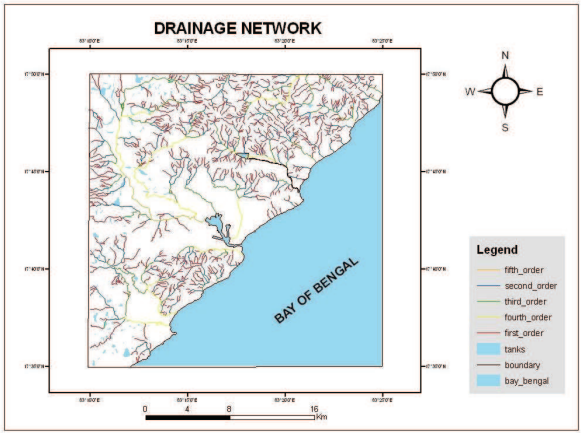
Through visual interpretation techniques to the typical False Colour Composite image the geomorphic and geologic map on 1:50,000 scale is produced. Adequate field checks are carried out before finalization of the thematic map.

8. GROUND WATER POTENTIAL

Ground water potential map plays a vital role in proposing structures. Preparation of ground water potential map requires pre and post monsoon ground water table data. Due to lack of any field data substitute/alternate method has been adopted. For this purpose land use/ land cover map generated based on satellite image interpretation has been utilized. The ground water potential in the watershed area has been categorized in to five classes based on the cropping pattern. They are (i) Good to moderate (ii) Moderate (iii) Moderate to Poor (iv) Poor (v) Poor to Nil.

9. SLOPE AND DRAINAGE

Slope and Drainage maps play a crucial role in addition to flow direction and flow accumulation in hydrological modelling. Slope is one of the important terrain parameters which is explained by horizontal spacing of the contours. In general, in the vector form closely spaced contours represent steeper slopes and sparse contours exhibit gentle slope whereas in the elevation output raster every cell has a slope value. Depending on the slope, rain water harvesting pipe network can be calculated as per the need and the usage.



10. UNDERSTANDING GROUND WATER

Water in the ground is stored in the interstices (Inter – Particulate Spaces) of the soil or rock that forms the earth. It is similar to water being stored in sponge – it is not visible, but can be 'squeezed out'. The soil or rock formations in the earth that contain water are called water Aquifers. Below a certain depth in the ground, the earth is saturated. This level is referred to as the ground water level. This level may be just below the ground level or many hundred meters below the ground level. In the Visakhapatnam area, ground water levels vary between 3 to 60 meters below ground level.

11. PERMEABLE SURFACES

Unpaved surfaces have a greater capacity of retaining rainwater on the surface. A patch of grass would retain a large proportion of the rainwater falling on it, yielding only 10- 15 % as runoff. A considerable amount of water retained on such a surface will naturally percolate in the ground. Such surfaces contribute to the natural recharge of ground water. If paving of ground surfaces is unavoidable, one may use designed pavements in which they retain rainwater and allow it to percolate into the ground [9].

12. DOMESTIC RAIN WATER HARVESTING – A CASE STUDY

Rain water harvesting has been implemented at an apartment in Guntur city, Guntur district, Andhrapradesh, where the residents overcomed the water crisis. While the execution of the apartment itself, the residents by the help of the Promoter designed a water harvesting network by approaching the technical people in the field. The network contains (i) Collection of rain water from terrace, (ii) Pipe network along with the filters, (III) Sump at stilt floor, (IV) Overhead Tank, (V) RO system.

All the rain water will be collected from the terrace of the apartment and connected to the sump at stilt floor level which is of capacity 50,000L, subdivided into three chambers for the maintenance purpose

Photos owned by author with due courtesy by Mr. Swaroop, Architect and Mr. Ram, Promoter.

At the stilt floor before entering into the storage tank i.e. sump several filters were adopted to the pipe network which are easy to main tain so that any kind of debris can be removed. The pictures show the building view, filter, and the sump.

The water is been pumped to the Overhead tank for the usage directly from the sump. A Reverse Osmosis system has been provided for each individual flat from which the residents are using the water in their daily life.

Within the study area depending upon the terrace areas an extensive study has been done targeting how much percent of rain water can be harvested. The table below shows the data depending primarily on the roof top area and annual rainfall.

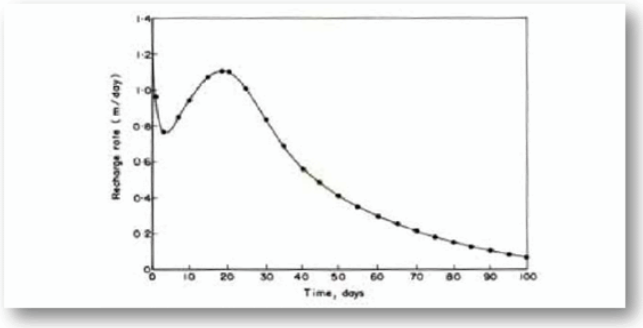
Percent of water demand fulfilled by DRWH from different roof – top area.

Month	Rooftop area in m^2				
	50	**100**	**150**	**200**	**250**
	Percentage of total demand fulfilled from the Domestic Rain Water harvesting				
January	0.44	0.88	1.31	1.75	2.19
February	1.04	2.07	3.11	4.14	5.18
March	0.13	0.25	0.38	0.50	0.63
April	1.31	2.61	3.92	5.22	6.53
May	1.62	3.24	4.86	6.48	8.10
June	43.41	86.82	130.23	173.63	217.03
July	42.54	85.07	127.60	170.14	212.67
August	40.23	80.47	120.69	160.93	201.15
September	41.67	83.33	125.00	166.66	208.33
October	21.83	43.65	65.48	87.31	109.14
November	1.03	2.07	3.09	4.13	5.16
December	1.40	2.81	4.21	5.61	7.02

It is further noticed that the Domestic Rain Water Harvesting can be implemented successfully for the buildings which are having more than 50 sqm as the roof top area. The Limitations are (i) water has to be stored, needs a lot of (ii) storage space, (iii) maintenance, (iv) Implementation of ideal treatment methods for the daily use.

13. ESTIMATION OF GROUND WATER RECHARGE

A typical curve of recharge rate versus time is shown. The initial decrease is attributed to dispersion and swelling of soil particles after wetting, the subsequent increase accompanies elimination of entrapped air by solution in passing water and the final gradual decrease results from microbial growth clogging the soil pores.



The groundwater recharge can be estimated by employing various methods which include empirical methods, analysis of base flow hydrograph, hydrologic budgeting, tracer techniques, and ground water level fluctuation method and mathematical models.

14. METHODS OF HARVESTING THE RAIN WATER FROM THE PAVED AREAS.

Storage of rainwater in Tanks

Similar to Under Ground Drainage network in whole Urban Area, Rainwater/ Storm water collection can be done with the help of Underground Clear Water pipe network.

Method I

The Mouth of this network will be Recharge pits placed at regular intervals, covering all paved areas like roads, pavements, pedestrian spaces etc, The tail end will be the storage tanks provided with in the community level.

Method II

Provision of trench all along the road length at the community level which connects all the roads and collects the cleaned/ treated water through its duct provided at the bottom as shown in the figure I, cross section of the trench which is having

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several layers i.e top to bottom (i) Grating at road level, (ii) Fine aggregate, (iii) 20 mm dia Pebbles, (iv) 40mm dia Pebbles, (v) 6" thick RCC slab with voids at regular intervals through which water goes into the duct. The whole network will be supervised with the help of inspection chambers at regular intervals throughout the network.

In both the above two cases water has to be stored in huge reinforced cement concrete tanks and utilized in the crisis period. This entire Underground Clear water pipe network will be connected to a collection Tank at a feasible Distance within the community region where all the water will be stored in ground by the help of water storage tanks. The storage tanks will be connected to Water treatment plant and further sent to the next storage tank from which the water will be supplied to the people of community.

In the above cross section the pavement/ pedestrian way area should be provided with a RCC slab which is having solids and voids on which human being can walk comfortably so that the rain water is diverted into the trench right below it (the concept in Fig I designed by the author).

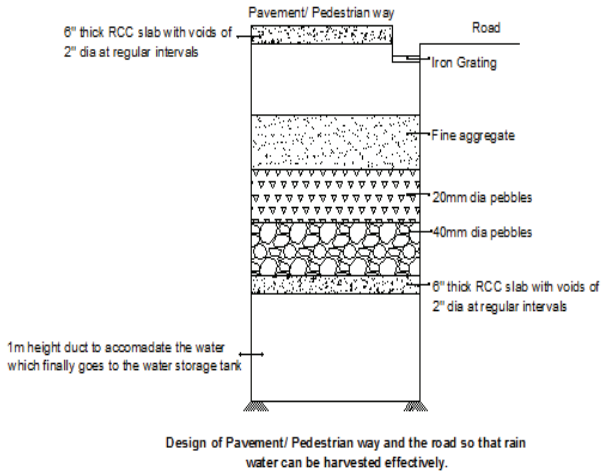

Fig. I

15. RECHARGE OF RAINWATER INTO GROUND

Method I

Incase of the situations where the clear water pipe network cannot be laid where the slope of the ground or the nature of the ground does not permit, water can be recharged directly into the ground. In such cases the paved areas such as Roads, Pavements, Pedestrian ways should be provided/ inter connected with recharge pits at regular distances. The collected Rainwater/ storm water will be recharged into ground directly.

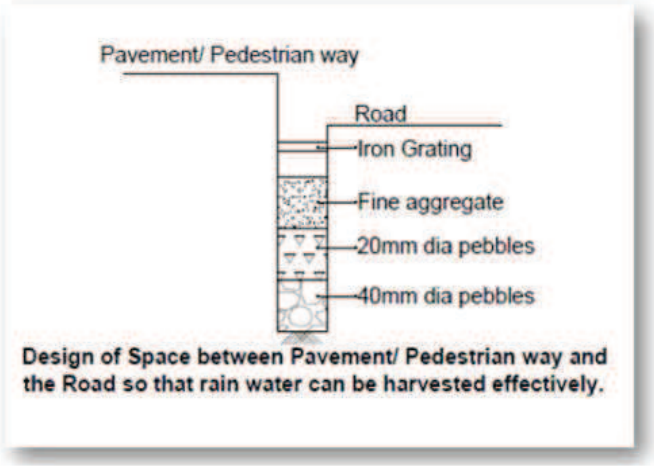

Fig. II

Method II

Provision of trench all along the length of the road as shown in the below picture which will have (i) Iron Grating (ii) Fine aggregate (iii) 20 mm dia pebbles (iv) 40mm dia pebbles, the rainwater collected from the paved areas will be recharged directly at the point level itself through the trench provided into the ground. (the concept in Fig II designed by the author).

Since the study area has the rainfall period for around 3-4 months per year it is recommended for storage of water in ground, the rainwater is most pure form of water that we get, The rain water thus collected can be utilized with the basic treatments.

16. CONCLUSIONS

1. The Water harvesting is necessary in the urban regions where the Ground water table is far below.

2. The Water harvesting is becoming necessity for the urban areas due to the non availability of the ground, all the available ground in urban area is being occupied by the Humans for the needs and development

3. The Rain water harvesting is becoming major water resource for the urban areas as it is being covered with the paved areas, from which the rain water can be collected effectively and can be used for the daily use with minimal treatment.

4. In the planning of the clear water pipe network system at community level, the Geo Information System will have a crucial role. It gives the whole information about the typology of the required area.

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5. The methods in harvesting the rainwater in urban areas as discussed earlier may prove very effective as most of the urban area is occupied by paved areas under the titles roads, terraces, stilts, pavements etc..

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