Rain Water Harvesting through Metalled Roads (A Revolutionary Approach to Water Resource Management in Semi-Arid Region)

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Abstract: The problem of non-availability of fresh water in semi-arid regions is receiving considerable attention all over the world. The most conventional and sustainable method to mitigate this problem is rain water harvesting, having two essential components— a) catchment area and b) water storage tank. Since metalled roads of these areas form many impermeable saucer shaped structure due to undulating topography, the present paper comes with a revolutionary approach to use these roads as the catchment area for the rain water harvesting system. For this purpose, an initial set of studies has been performed to assess the potential of this approach to determine whether the amount of rain water harvested through this technique is feasible or not. Geo-Spatial data set has been acquired from Churu-Ghantel road (a 7.82 km long metalled road stretch) using handheld G.P.S. during the study. Synthesis and Analysis of data through SPSS Inc software reveals that through this method 22.3 million litres fresh rain water can be harnessed annually which is sufficient to fulfil the potable water need of 3060 people for the whole year. Further if we generalize these result for the whole Churu District than this figure rises up tremendously. Therefore, these initial findings provide that ample amount of rain water can be harvested through this technique in semi-arid areas which offers several benefits including provision of supplemental water, increasing soil moisture level, increasing the groundwater table via artificial recharge, mitigating flooding and improving the quality of groundwater. Collected rainwater can be used for irrigation purpose also.

1. Introduction

Water is basic to life. It is a precious resource and has become precious commodity now. Ongoing Industrialization, population growth & urbanization pose pressure on water availability. Utility value of world’s freshwater resources like lakes and rivers are diminishing rapidly due to over exploitation & pollution. Groundwater, an alternative to surface water is also a natural victim. The rate of ground water drawing versus its re-charge has already disturbed the natural aquifer equations. Water scarcity is likely to become more problematic in the near future due to rapid population growth, increasing per capita water consumption and the draught conditions of the world. In semi-arid and arid regions of the world, the situation is even more worsen. Thus, need of the hour is to develop alternative water resources to fulfill the everlasting demand of fresh water. One of the best effective alternative methods for water management and water conservation is rain water harvesting.

Rainwater harvesting can be defined as activity of direct collection of Rain Water and storage of Rain Water as well as other activities aimed at harvesting and conserving rain water, prevention of loss through evaporation and seepage and other hydrological studies and engineering inventions aiming at most efficient utilization of the Rain Water towards best use for the humanity [1] thus Rain Water harvesting is the accumulating and storing, of rainwater for reuse, before it reaches the aquifer. It has been used to provide drinking water, water for livestock, water for irrigation, as well as other typical uses given to water. There are a number of types of systems to harvest rainwater ranging from very simple to the complex industrial systems.

In some cases, rainwater may be the only available, or economical, water source. Rainwater harvesting systems can be simple to construct from inexpensive local materials, and are potentially successful in most habitable locations.

Rainwater harvesting in semi-arid areas offers several benefits including provision of supplemental water, increasing soil moisture level, increasing the groundwater table via artificial recharge, mitigating flooding and improving the quality of groundwater. Collected rainwater can be used for irrigation purpose also.

2. Concept

Undulating topography, harsh climatic conditions and low level of economic development has kept the semi-arid region of Rajasthan, popularly known as “Thar Desert”; more or less aloof from the mainstream of the country for a long time. Low and erratic rainfall, high solar radiation, strong dust-
raising winds, sparseness of vegetation cover and a sand dune dominated landscape present a unique set of challenges while addressing the issues concerning social and economic development of this region. The prime inhibitor of the economic development of the region is non-availability of fresh water even for drinking purpose. The most conventional and sustainable method to mitigate this problem is rainwater harvesting. The villagers of the Thar Desert had evolved an ingenious system of rainwater harvesting known as kunds or kundis. Kund, the local name given to a covered underground tank, was developed primarily for tackling drinking water problems. Usually constructed with local materials, the kund became an ideal device to collect drinking water. The kund consists of a saucer-shaped catchment area with a gentle slope towards the center where a tank is situated. The success of a kund depends particularly on its catchment characteristics. An adequately large catchment area with impermeable in nature can only produce adequate runoff to meet the storage requirements of the kund.

Figure 1. (A) Field Photograph of a typical Kund (B) Schematic representation of structure and working process of a Kund.

Here the Concept is to use metalled roads of semi-arid regions as a catchment area for rain water harvesting system because in semi-arid region a metalled road has the entire three basic features which is necessary for catchment area i.e. 1) saucer-shaped structure 2) Impermeable in nature 3) Adequate size.

Due to undulating topography of desert, the roads of these regions are also undulating in nature. In elevation profile of these roads we can see series of anticlines and synclines.

Figure 2. Undulating roads of Deserts and their typical elevation profile.

As these synclines or depressions are sloped towards the axial plain, rainwater falling on the road is guided to the axial plain.

Figure 3. schematic diagram of the concept of rain water harvesting through metalled roads.

If we build underground water storage tanks along these axial plains through out the road than when it rains, water flows from the sides (limbs) and collects in the sidewalk of the axial plain area and subsequently flows to the water tank.

3. Case Study

To assess the potential of this concept an initial set of studies has been performed in Churu district of Rajasthan which is situated in semi-arid region of Thar Desert. The whole district lies in semi-arid zone of western Rajasthan. In absence of surface water resources the local population depends primarily on ground water to meet out their drinking and irrigation requirements but the ground water itself characterized by medium to high salinity. In general, Churu district has saline (20.9%) to highly saline (17.15%) ground water having electrical conductivity ranging between 5000-8000 and more than 8000 μS/cm [2] showing the unavailability of potable ground water. As unavailability of both potable surface and ground water makes Churu ideal study area for doing research on development of alternative water resources and water management techniques.
In this context, a case study has been performed on Churu-Ghantel road (a 7.82 km long metalled road stretch) to assess the potential of the concept of water harvesting through metalled road.

4. Research Queries

The main objective of this research work is to find out the answers of the following queries:

• Is there any way or method to create/develop in-situ water resource in arid/semi-arid region.
• How much amount of water we can get through that method.
• Is the amount of water what we get is sufficient to fulfill the demand.
• Is it technically and economically feasible.

5. Material and Method

To develop elevation profile primary data were collected with the help of Garmin handheld GPS and secondary data were obtained from Aster-dgem global DEM. Meteorological data were obtained from Meteorological Department of India’s website. Synthesis and Analysis of data were done through SPSS Inc., ArcMap and Google Earth software. Methodological techniques were also obtained from various secondary sources.

6. Results

An elevation profile is generated for the Churu-Ghantel road segment with the help of handheld GPS to find out various possible sites where underground water tanks can be built to harvest rain water.

Computation of data reveals that minimum, average and maximum elevation of the road is 281, 289 and 296 metre. Maximum slope for the segment is 7.8% and the average slope is 1.8%.

The total amount of water that is received in the form of rainfall over an area is called the rainwater endowment of the area. Out of this, the amount that can be effectively harvested is called the water harvesting potential.

The collection efficiency accounts for the fact that all the rainwater falling over an area cannot be effectively harvested, because of evaporation, spillage etc. Factors like runoff coefficient and the first-flush wastage are taken into account when estimated the collection efficiency.

Three different precipitation scenario (maximum, minimum and average annual rainfall during the last five years) were taken into account to calculate the water harvesting potential for the road segment.

Table 1. Maximum annual rainfall scenario

<table>
<thead>
<tr>
<th>Area (m²)</th>
<th>Rainfall (mm/yr)</th>
<th>Collection Efficiency</th>
<th>Water harvesting potential (l/yr)</th>
<th>Water consumption (l/yr/person)</th>
<th>Population benefited</th>
</tr>
</thead>
<tbody>
<tr>
<td>7800 x 7.3 = 56940</td>
<td>670</td>
<td>0.60</td>
<td>2,28,98,880</td>
<td>3,650</td>
<td>6271</td>
</tr>
</tbody>
</table>

Table 2. Minimum annual rainfall scenario

<table>
<thead>
<tr>
<th>Area (m²)</th>
<th>Rainfall (mm/yr)</th>
<th>Collection Efficiency</th>
<th>Water harvesting potential (l/yr)</th>
<th>Water consumption (l/yr/person)</th>
<th>Population benefited</th>
</tr>
</thead>
<tbody>
<tr>
<td>7800 x 7.3 = 56940</td>
<td>213</td>
<td>0.60</td>
<td>72,76,932</td>
<td>3,650</td>
<td>1994</td>
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</table>

Table 3. Average annual rainfall scenario

<table>
<thead>
<tr>
<th>Area (m²)</th>
<th>Rainfall (mm/yr)</th>
<th>Collection Efficiency</th>
<th>Water harvesting potential (l/yr)</th>
<th>Water consumption (l/yr/person)</th>
<th>Population benefited</th>
</tr>
</thead>
<tbody>
<tr>
<td>7800 x 7.3 = 56940</td>
<td>437</td>
<td>0.60</td>
<td>1,49,29,668</td>
<td>3,650</td>
<td>4990</td>
</tr>
</tbody>
</table>

Here collection efficiency of the system is taken as 60% or 0.60 and the average daily drinking water requirement is considered as 10 litres per person.

7. Conclusions

Further if we generalize these results for the whole Churu district than this figure goes to 458 Cr. litres and 6.28 lakh people. Thus this approach has enormous potential to mitigate the potable water crises in arid and semi-arid regions.

Rainwater is a relatively clean and free source of water and this approach of rain water harvesting provides a source of water at the point where it is needed. Further it is socially acceptable and environmentally responsible.
It promotes self-sufficiency and conserves water resources and provides safe water for human consumption after proper treatment.

It is economically feasible approach to harvest rain water as it has low installation/running cost. Installation cost is only restricted to formation of underground water tanks which is far less and over a 5-6 year period, the financial benefits of installing these tanks will prove to outweigh the financial costs as installing of these tanks reduces the chances of road damages caused by stagnation of runoff at depressions and save lot of money which otherwise has to spent on repairing of roads every year.

8. References


