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Original Research Paper

Potential of Rainwater Harvesting in Himachal Pradesh

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ABSTRACT

World-wide pressure on water resources is increasing due to population growth, groundwater mining and climate change. Domestic and agricultural water usage is a significant component of water demand. Himachal Pradesh is experiencing drought like situations since last decade. The intensity of drought is increasing year after year for the past six years. The state is facing serious water shortage problem during the summers. The rainwater harvesting can be implemented as a viable alternative to conventional water supply or on-farm irrigation projects. The water can be stored either in a storage tank or in a soil media as groundwater. The rainwater can be harvested using eco-friendly low cost technologies such as UV-resistant plastic lined ponds, ferro-cement tanks, RCC tanks, etc. and used for multiple purposes. An attempt has been to highlights the various rain water harvesting methods that can be used effectively to augment the water supply position in Himachal Pradesh. There is need to change some existing policies relating to water management to tackle the water shortage during scarcity.

INTRODUCTION

Himalayas, the abode of snow, is a perennial source of water and is responsible for the greenery that is seen in the valleys and spurs. As long as the natural resources of the Himalayan region were sufficient to provide the needs of the people, it was not felt to give a thought on the depleting resources of the region. Gradually it led to over-exploitation of the available resources and has created a series of problems.

Delay in pre-monsoon showers and slow onset of monsoon along with skewed distribution of rainfall in Himachal Pradesh not only leads to serious dislocations, but also causes damage to the crops and also severe water shortage. On the other hand, excessive precipitation causes rapid run-off on steep slopes, resulting in heavy soil loss as well as siltation of river-beds. It may also lead to catastrophic flood hazards in the plains, excessive leaching losses and also dangerous landslide. All this only underscores the need for a scientific and technical approach towards water management, with focus on harvesting and multiple uses of water.

Rainwater harvesting besides helping meet the ever-increasing demand for water, reduce flood hazards, augment the groundwater storage and control the decline in the water level, improve quality of groundwater and reduce soil erosion This is considered to be an ideal solution for water problem, where there is inadequate groundwater supply or where surface resources are either not available or insufficient. Rainwater is bacteriologically pure, free from organic matter and soft in nature. The suggested structures for harvesting rainwater are simple, economical and eco-friendly. Previous studies have shown that substance agriculture in hilly region could be successfully transformed into a profit-earning enterprise by tapping and utilizing rainwater in limited quantities (Saha et al. 2007).

STUDY AREA

Himachal Pradesh is comparatively a small state in north-west Himalayas. The state of Himachal Pradesh is located between 30°22' to 30°12' north latitude and 75°47' to 79°4' east longitude. The mountainous state has altitude ranging from 350 m to 7000 m above mean sea level (SCSTE 2002). Himachal Pradesh is known for its salubrious climate. It also experiences considerable variation in the distribution of rainfall and temperature due to varying aspects and altitudes.

Precipitation declines from west to east and south to north. While the average annual rainfall of Himachal is 1100 mm, it varies from less than 500 mm in Lahaul-Spiti to over 3400 mm in Dharamsala the district headquarters of Kangra which is the second wettest place in India after Mausimram in the Cherapunji district of Meghalaya. Lahaul-Spiti records an average annual rainfall of only 434 mm as a result of the rain shadow effect. Although the state as a whole receives plenty of rainfall, about 70% of it experienced during the months of July to September (SCSTE 2002). No snowfall is seen during winter up to an elevation of about 1500 m, but at an elevation of 3000 m the average snowfall is about 3 m which lasts for four months from December to March. Above 4500 m there is almost perpetual snow. The amount of rainfall and snowfall vary with altitude. The rainiest months are July and August.

MATERIALS AND METHODS

The data were collected from different sources such as Irrigation and Public Health Department, Rural Development Department, Census of India, Department of Science and Technology and Himachal Pradesh University, Shimla.

RESULTS AND DISCUSSION

The study has revealed the following points: The population of Himachal Pradesh has grown from 23.86 lakh in 1951 to 60.78 lakh in 2001. Thus, the population has grown more than 2.5 times in a period of 50 years. Taking the present growth trend into consideration, the population is expected to further rise to 98.61 lakh in 2031 (Sharma 2007). This will be about 1.6 times of the population in the year 2001 (Table 1). The drinking water demand has grown 2.4 times in rural areas and 6.8 times in urban areas in a time period of 50 years (Sharma 2007). The demand will further rise 1.62 times in rural areas as well as urban areas in the next 30 years (Tables 2 & 3). The drinking water sources of 3.2% water supply schemes get affected more than 75%. The drinking water sources of 4.67% schemes get affected between 50 and 75%. The drinking water sources of 6.71% schemes get affected between 25 and 50% and the drinking water sources of 7.33% schemes get affected up to 25%. Thus, the sources of only 22.3% of the piped water supply schemes get affected during summers (Table 4). During drought years there is massive mobilization of water-tankers in summer months when acute shortage of water is felt. On an average 400 water tankers are deployed to cope up the demand of drinking water during summer in the state (Table 5). During year 2009, 704 water tankers were deployed to supply water to the affected population. Most of the tankers were deployed in Bilaspur, Solan, Mandi, Una and Kangra districts.

Most of the water supply schemes, whose discharge gets reduced during summers, fall in Shiwalik hills. The middle and upper Shiwaliks are the recent deposits constituting the main geological formations. The Shiwalik comprises of conglomerate, friable micaceous sandstone, siltstone and claystone. Water holding capacity of the soils is low. Soils are susceptible to excessive soil erosion and land slides due to water. Due to irregular, undulating topography, shallow depth, steep slopes, coarse texture, poor soil structure, scanty vegetative cover and erratic rainfall, during dry periods the soil profile dries up quickly on account of evaporation and transpiration. The crops experience drought like conditions and consequently the crop yields and discharge of water sources are affected adversely.

Baories, dug wells, step wells, khatries and springs are the traditional water harvesting structures that have been used as source of drinking water in this region over the centuries. In many villages these systems have now fallen into disuse with the spread of piped water supply (Sharma 2006). The size of catchments limits the quantity of water collected. The water demand has risen many times. Most of these water sources are highly polluted (Sharma 2004). Every year a huge amount of money is spent by government on installation of new hand pumps in the water scarcity areas. On average 540 hand pumps are drilled every year in the state (Table 4). These hand pumps are mostly installed in areas where there is road connectivity.

Rain water harvesting-A viable alternative: To tide over water scarcity in Himachal Pradesh, rainwater harvesting can be implemented as a viable alternative to conventional water supply or small on farm projects. Rainwater harvesting, irrespective for the technology used, essentially means harvesting and storing rainwater in days of abundance, for use during the lean days. Storing of rainwater can be done in two ways: (i) in an artificial storage and (ii) in the soil media as groundwater.

A demand-supply analysis is required while designing water-collection tanks. Factors such as amount and frequency of rainfall, run off coefficient of the collecting surface, number of users, daily requirement and dearth period are important for calculating the size and capacity of the storage tank.

In domestic rooftop rainwater harvesting systems, rainwater from the roof of house is collected in a storage vessel or tank for use during the periods of scarcity. Usually these systems are designed to support the drinking and cooking needs of the family at the doorstep. Such a system usually comprises a roof, a storage tank and guttering arrangement to transport water from the roof to the storage tank. In addition, a first flush system to divert the dirty water during the first rains and a filter unit to remove debris and contaminants before water enters the storage tank are also provided.

Himachal is an agricultural state and about 80% of its population is dependent on agriculture and horticulture. Rainwater can be collected in large quantities in lined ponds for irrigation. Generally, big ponds are constructed and subsequently lined with non-permeable sheets like agrifilm, silpaulin, HDPE or nylon, or with a semi-permeable coating of clay to reduce the seepage losses.

The roof water, run off water (after filtration, for potable/household purposes) or spring water may be diverted to the pond. A large quantity of water, generally 50,000-20,00,000 litre can be harvested using such ponds, which in turn may be used for irrigation or for other household purposes. Moreover, it is durable and easy to construct with less maintenance cost (Samuel & Satapathy 2008).

To design a water-harvesting tank for irrigation purposes, the irrigation requirements of the cultivated crops have to be calculated first. The knowledge of factors such as effective rainfall, evapotranspiration, application efficiency and leaching requirement, if any, is essential for calculating the irrigation requirements of the crops. Subsequently, the total seasonal water requirement for the entire area to be irrigated can be found. Water needed for other purposes, such as fishery, may also be taken into consideration while designing the tank. Direct evaporation from the water surface in the tank has also to be taken care of and corresponding adjustments can be made in the size of the tank.

Normally three types of ponds viz., embankment type, excavated (dugout) and dugout-cum-embankment type are constructed for collection of excess run-off. Embankment type and dugout-cum-

Table 1: Population growth rate in Himachal Pradesh.

Year	Total population (in Lakh)	Decennial growth rate	Density per square kilometer	Urban population growth rate
1951	23.86	5.42	43	4.1
1961	28.12	17.87	51	6.3
1971	34.60	23.04	62	7.0
1981	42.81	23.71	77	7.6
1991	51.71	20.79	93	8.7
2001	60.78	17.54	109	9.8

Table 2: Total daily drinking water demand in kilolitres.

Year	Total population (in Lakh)	Urban population (in Lakh)	Rural population (in Lakh)	Urban water demand @ 135 litre per head per day	Rural water demand @ 70 litre per head per day	Total water demand
1	2	3	4	5	6	7
1951	23.86	0.98	22.88	13230	160160	173390
1961	28.12	1.77	26.35	23895	189450	208345
1971	34.60	2.42	32.18	32670	225260	257930
1981	42.81	3.25	39.56	43875	276920	320795
1991	51.71	5.00	46.71	67500	326970	394470
2001	60.78	5.96	54.82	80460	383740	464200

Table 3: Projected daily drinking water demand in HP (in kilolitres).

Year	Total population (in Lakh)	Urban population (in Lakh)	Rural population (in Lakh)	Urban water demand @ 135 litre per head per day	Rural water demand @ 70 litre per head per day	Total water demand
1	2	3	4	5	6	7
2001	60.78	5.96	54.82	80460	383740	464200
2011	71.22	7.00	64.42	94500	450940	545440
2021	83.92	8.22	75.70	110970	529900	640870
2031	98.61	9.66	88.95	130410	622650	753060

embankment type of ponds are feasible in hilly and undulating topography. Embankment type of ponds are made by excavating a site surrounded by hillocks from two or three sides and making the embankment from the excavated soil on the remaining sides. In flat areas, where these two types of ponds are not feasible, dugout ponds are constructed.

Three steps are to be followed while designing a water-harvesting pond. These are hydrologic design, hydraulic design and structural design. Hydrologic design involves the estimation of peak rate of run-off volume from the catchments of the pond. The run-off is estimated for a design frequency of 25 years (Schwab et al. 1993).

The hydraulic design includes determination of storage capacity and storage dimensions (length, width and height) of the pond and dimensions of spillway for safe disposal of excess inflow to the pond. Water should flow through the structure safely without overtopping the embankment, and when water leaves the structure its energy should be dissipated. Standard weir formula for determining the crest length is used.

Table 4: Summary of water supply schemes whose discharge got reduced during summers.

S.No	Year	Total no. of water supply schemes	Schemes affected by reduction in quantity of water during summer					Year-wise percentage of the total schemes affected
			0-25%	25-50%	50-75%	> 75%	Total water supply schemes affected	
1	2009	8315	985	746	516	313	2560	30.8%
2	2008	7989	615	612	430	245	1902	23.8%
3	2007	7989	456	453	363	193	1435	18.3%
4	2006	7989	394	42	263	136	1235	15.5%
5	2005	7989	351	461	282	459	1553	19.4%
6	2004	7989	740	550	400	210	2023	25.3%
	Average	8043	590	540	376	259	1790	22.3%
		Percentage of schemes affected	7.33%	6.71%	4.67%	3.2%	22.3%	

Source: Department of Irrigation & Public Health, H.P. Govt., Shimla -1 (2009)

Table 5: Year-wise list of water tankers deployed and new hand pumps installed.

Year	Water tankers deployed	New hand pumps installed
2003	494	467
2004	317	157
2005	286	96
2006	307	517
2007	248	714
2008	391	1257
2009	704	567
Grand Total	2749	3777
Average	392	540

Source: Department of Irrigation and Public Health, H.P. Govt., Shimla-1 (2009).

The seepage losses are generally high in hilly areas and owing to the high rate of seepage loss and evaporation, harvested water will be lost within 1-2 months after recession of rain. Therefore, lining of the pond with non-permeable film is essential for retention of harvested water in the pond for the entire dry season, i.e., from October to December and March to June. LDPE (low density polyethylene) plastic sheets, popularly known as agrifilm, are found to be a low-cost and durable lining material. The following method can be adopted for lining of the pond with agrifilm.

After the pond is excavated according to the design, the pond bed and sides are made weed and stone-free. Steps at 50cm vertical intervals are made on the sides of the pond to hold the agrifilm at place. On top of the sides, a continuous trench of 50 × 50 cm is dug for the purpose of anchoring the agrifilm, to prevent it from sliding down. After the sides and bed are dressed properly, 10cm thick layer of sieved sand is spread uniformly on the bed and sides to provide a cushion to the agrifilm. Then the agrifilm is laid properly on the pond. For joining the film to suit the size and shape of the pond, bitumen of 85/25 and 80/100 grade in the ratio 2:1 is used. Soil cover of 30cm is provided over the agrifilm. Stone pitching is done on the sides only, to safeguard the sides of the pond against erosion and any other external forces. A study of storage behaviour of the pond revealed that seepage loss from agrifilm-lined ponds reduces from 55 to 2.91/m²/day, i.e., by 94.7 % (Samuel & Satapathy 2008).

To prevent seepage and percolation losses, the dug-out tanks can also be lined using UV-resistant polyethylene films such as Silpaulin (200 GSM or more) or nylon (500 GSM). These sheets are made up of waterproof UV-stabilized, heat-seated, multi-layered and cross-laminated plastic materials and hence ensure high tensile strength, long life and high resistance to external pressure. Generally, trapezoidal-shaped storage tanks are constructed by excavating soil and dumping the removed soil along the four sides of the tank. After this, plastic sheets are made into the shape of the pond according to the final dimensions of the constructed pond by a process called thermal welding. Then pond-shaped plastic sheet is inserted into the pond and the sides are stabilized by burying it into the soil or shoulder bunds, or by riveting through the metal rings provided along the side of the pond-shaped plastic sheet. The shoulder bunds can be further stabilized with rubble pitching and vegetative fencing. Soil cover or rubble pitching over the plastic lining is generally not needed in case of tanks lined with UV-stabilize sheets.

It is found that sipaulin or nylon-lined ponds are more stable and have a longer and useful life. It can be made in any size and is also suitable for multiple uses of harvested water. It has been observed that the cost/litre for collecting rainwater/spring water in UV-resistant plastic sheets is significantly less compared to other methods such as concrete, brick masonry, ferro cement, fibre-glass, etc. (Samuel & Satapathy 2008).

The water harvested in lined ponds can be utilized for multiple uses, such as irrigation, drinking water for cattle and other livestock, fishery, duckery, etc., thereby increasing its use efficiency. Various studies carried out in the hilly terrain, based on the estimated annual costs and returns, all the financial viability criteria such as IRR, NPV and BCR were found favourable for investment on plastic-lined water-harvesting tanks (capacity > 40 m^3) integrated with micro-irrigation system and fish farming (Samuel & Satapathy 2008). The analysis indicated that establishment of such an integrated system is not only financially viable, but also a highly attractive proposition for low-cost harvesting and effective use of rainwater/run off. Moreover, the studies suggested that these technologies are sustainable, locally adaptable, cost-effective, applicable and affordable to the farmers.

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