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Construction of geotagged polytanks in higher hills of Uttarakhand for water resource development and management: Jal Shakti Abhiyan

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ABSTRACT

The main source of water in the Himalayan region is major river system along with a number of streams and springs. A better water management has its multiple linkages in economic development and maintaining ecosystems in the state. Due to limited water resources farmers are restricted to very limited crops, and severely affected there meal i.e. less food for their communities and less earning and low living. Water resource development is the key to higher production by providing irrigation water particularly during critical growth stages. As a result of this farmers can grow larger diversity of crops, including the off-seasons; which helps to feed their communities and encourage their family to stay in hilly area, helps in less migration from hills to urban area in Uttarakhand. Pond line plastic sheet can make major contribution towards achieving this goal. The aim of this research was to assess the impact on water availability through the intervention of low cost geotagged polytank under Jal Shakti Abhiyan programme of ICAR-VPKAS, Almora, specific to the Darima village of Nainital district of Uttarakhand state which falls in higher hills of Himalayas. The ponds were dugout and lined with plastic sheet which is multi-layered cross laminated, ultraviolet stabilized 250 μ thickness. 65 number of polytanks were made under this research, which was geotagged for regular monitoring. The average length, breadth and depth of all polytank is 7.1 m, 4.4 m and 1.6 m respectively. The result showed that it will create an additional water storage capacity of about 3312 cubic meter, which will enhance the farmer`s income and water availability throughout the year. Therefore, this research is focused on better water management for hilly area of Uttarakhand.

1. Introduction

According to the 2018 report of the Intergovernmental panel on climate change (IPCC), if carbon emission continues at the current level warming may exceed 1.5 °C. As a result high intensity rainfall is the key result of climate change in India. It will lead to drastic increase in high rainfall during monsoon as well as cyclones, floods and drought. As a result water resources are most prone to climate change. It is important to undertake efforts for conservation, restoration, recharge and reuse of rain water. Farm pond or on-farm reservoir (OFR) is the most important component of water resource network at the village or farm level. It is used for the storage of rainfall generated surface runoff and is located at the downstream side of the watershed (Sonawane *et al.*, 2014; Kumar *et al.,* 2020; Kumar *et al.,* 2021a). Various studies on India's water budget has been discussed by Gupta and Deshpande (2004), Kumar *et al.,* (2005), and Garg and Hassan (2007). These analyses were based on estimates of water-balance components presented in the various documents of the Government of India (GoI). The National Commission for Integrated Water Resources Development (NCIWRD) prepared a comprehensive report on water resources development in India, which gave data on some components of water balance for the country. However, no studies have been done in context of higher hills for water

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budget estimation in relation to water budget at country level as per available literature. In hilly region due to undulating topography creating water resources is very expensive. With the development of low-cost polytank (LCP) the availability of water resource can be created. The main advantage of low-cost polytank over cement concrete tank is that no cracks are developed over years and less expensive (Kumar *et al.,* 2021b; Kumar *et al.,* 2021c). It has been successfully used to effectively control the seepage loss at much lower cost than the cement tanks. The film used should have minimum thickness of 200 µ, otherwise it becomes prone to physical damage. For enhancement of effective life of plastic film and to avoid the physical damage the protection of the film is necessitated which can be realized through pitching. In addition to surface runoff, natural springs are also source of water in this area and water from these springs can also be taped and stored in LCP which ensures year round availability of water. In the light of above discussion, the objective of this study is to do water budget estimation of constructed low-cost geotagged polytank under Jal Shakti Abhiyan (JSA) of Ministry of Jal Shakti, GoI by ICAR-VPKAS, Almora, specific to the Darima village of Nainital district of Uttarakhand state which falls in higher Himalayas.

2. Study Area

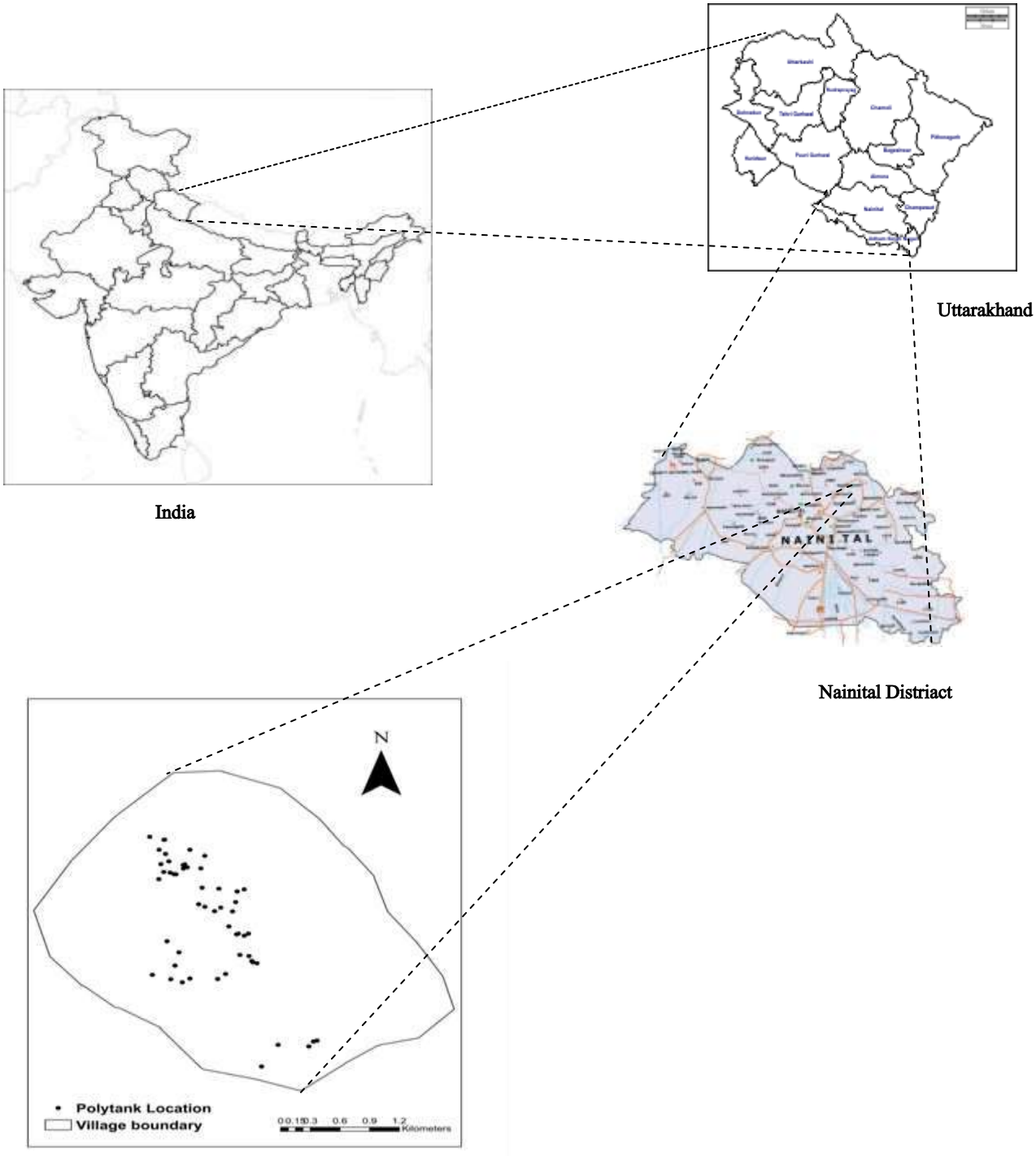
The Darima village of Nainital district is situated in Kumaon division of Uttarakhand, between the latitudes of 29°28'33.20'' N to 29^0 26' 44.16'' N and longitudes of 79^0 37' 9.07'' E to $79^0$39'15.46''E. The total area extent is 806.57 ha out of which 406 ha is under forest as shown in Fig.1. The topography of the area varies between 1793 to 2123 m above mean sea level. The major crops grown in the area include vegetables and fruits viz. potato, vegetable pea, cauliflower, cabbage, pear, peach, apple, apricot, plum, etc. According to census 2011 of India, the total human population of Darima village was 2173, total number of houses were 407 with female population of 49.7% (1079). Total literacy rate of village was 77.2% (1677), in which female literacy rate was 36.2% (787). The Scheduled Caste Population of village was 38.8%. Summer months i.e. May and June are the hottest with the maximum temperature ranging between 23.5 °C to 23.7 °C while temperature falls to its lowest during January with minimum temperature ranging between –3.0 °C to 1.9 °C. The mean annual rainfall based on 118 years record (1901-2018) is 1277 mm as shown in Fig. 2. About 80 percent of the annual rainfall is received during monsoon (June to September) and some rainfall is also received during winter season (December to March). The average relative humidity is 39.7 to 91.9 per cent and average wind speed is 0.45 to 3.96 m/s.

3. Methodology

3.1 Low-cost Polytank (LCP)

To increase the irrigation potential in hills, it is necessary to develop the water resources by means of small tanks (capacity up to 100 m^3). The criteria for the design of tanks should be such that it not only reduces the seepage losses but it is cost effective as well. The cement tank for instance is able to check the seepage losses but the cost becomes the limiting factor in economic exploitation of water resources. On the other hand unlined tanks are proned to heavy seepage losses (300-400 litre per day per $m^{2)}$ and may not be able to supply water for irrigation during stress. Thus, the most important step in construction of polytank is site selection. GIS Based selection of Site of Low cost polytank (LCP) is most important which ensures the maximum surface water that can be intercepted from catchment area. If it is not properly done only few fraction of surface water can be stored and rest of surface runoff goes to natural sources like river which is not fully utilized. Keeping the above points in mind the established GIS based water delineation technique is done before physical site selection. The output of water delineation technique gives the drainage map of the area which all stream order in the study area. The flow chart of this procedure is shown in Fig. 4.

The above two condition in the flowchart should be strictly followed so that water can be used through gravitational force without any extra energy for irrigation purpose. GIS based site selection incorporate all the parameters that affect the surface runoff. After the site selection storage capacity is decided based on amount of the land that is to be irrigated i.e. on the water requirement for crop. The peak water requirement throughout the season is calculated and multiplied with area to get actual water requirement or storage capacity of the tank to be constructed. After estimating the water storage capacity, the dimension of the tank is decided based on the land availability where the LCP is to be made. The side slopes should have a ratio of 1:1 and 1:2 for stable and unstable soils, respectively. In hilly area the depth is decided based on the material below the surface. If subsurface material has not rock then depth could be increased otherwise depth is kept shallow in case of rocky bed. Once the depth of tank is fixed, the length and breadth are fixed according to the physical topography of the selected land. In this way any two parameters can be fixed and third parameter can be varied. For this purpose, required calculation is done in a simple excel sheet. Once the survey is over the excavation process is started for the LCP. The excavation process was finished before the onset of monsoon



Study Area (Darim and Dubkhar Village)

Figure 1. Location of Study area.

Source: (*https://www.google.com/search?q=uttarakhand+state+boundary++image)*

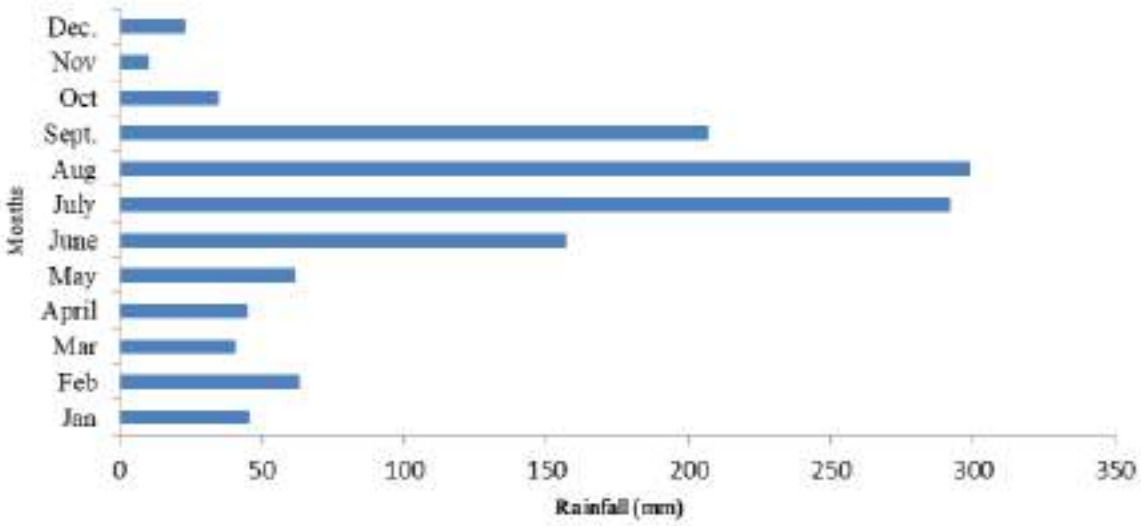


Figure 2. Variation of average annual rainfall on monthly basis
Source: (*Indian Meteorological Department)*

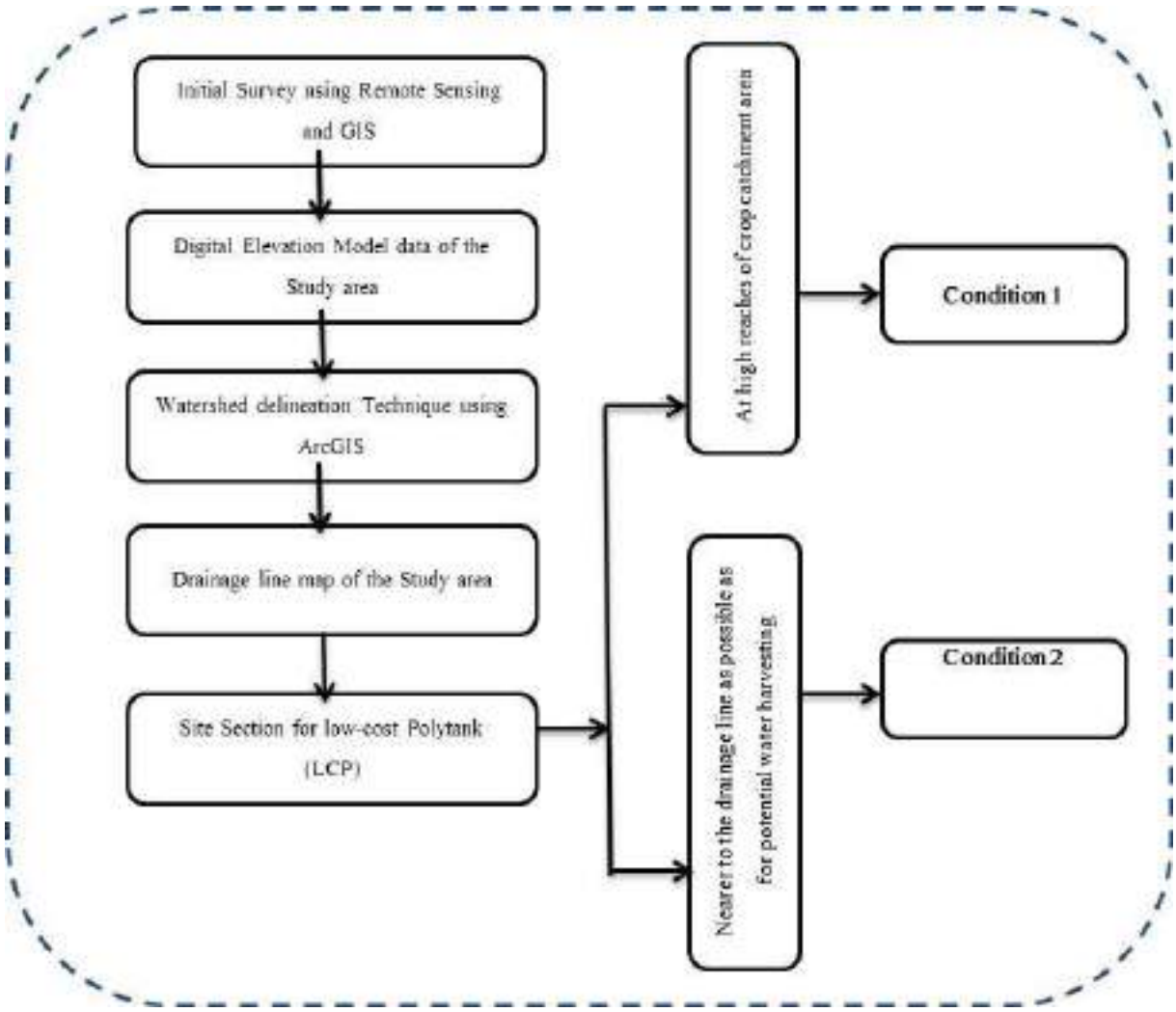


Figure 4. GIS Based selection of Site for Low cost Polytank (LCP)

season. The bed and the sites of tank were levelled by removing the rocks or the stones to avoid the damage to the lining materials. Embankment made by the excavated soil was well compacted for stabilization of side wall. Any type of rocks (sharp piece of rocks) or remaining roots of tree or weeds were fully removed and after that soil is compacted so that no damage is done to polyfilm and thus increases the life span of lining material as shown in Fig. 4. The final step after excavation and proper compaction of bed and side wall was *laying* of lining material. Polyfilm was spread from one end of the LCP so that it was not folded except four corners. Lining sheet is laid down in the excavated tank in such a way that it touches bottom and walls loosely and uniformly and stretches out to the width of about 50 cm all along the tank. About 25 cm outer edge of the polyfilm is buried in the soil so that film is tightly bound. Finally for the safety purpose care was taken to avoid possibility of the children and animals falling and drowning in the LCP. Bamboo fencing of about 1m height is enough to control any such type of mishap. The whole process for construction of LCP step by step is shown in the Fig. 5.

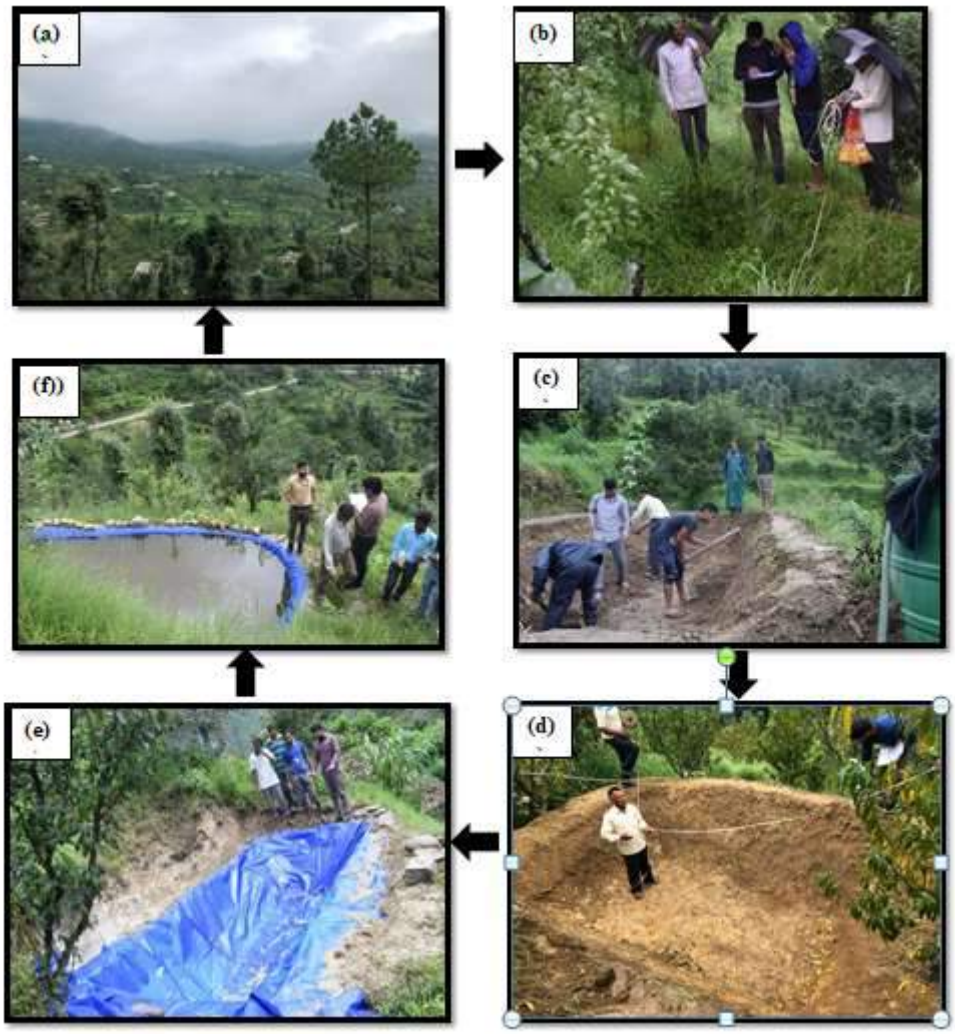


Figure 5. Step by step process for Construction and geotagging of LCP (a) general view of Darima village, (b) site selection and measurement (c) excavation (d) compaction and measurement of polyfilm (e) laying of polyfilm (f) geotagging

4. Result and Discussion

4.1 Geotagging of LCP

After 3 months continuous effort in the study area, 65 tanks were constructed out of which 42 were new and 23 were old. These 23 renovated can tap full potential of surface runoff. The maximum storage capacity of geottaged LPC (V, volume) having 1:1 side slopes can be calculated with following formula:

$$V=H/2[(W-2F)(L-2F)+(L-2H-2F)(W-2H-2F) \quad \ldots. (i)$$

Where, L=Top length (m); W=Top width (m); H=Depth of tank (m); F=Free-board (m)

Note: *L and H can be decided depending upon site conditions. However, H should not be less than 1.5 m and more than 5 m. Normally free board (F) for the small ponds may be kept between 0.1 to 0.3 m.*

Taking account of average monthly rainfall data of nearest India Meteorological Department observatory in the study area. The amount of stored water in tank in calculated using equation (i) for all polytanks in different months is shown in Fig. 6.

4.2 Utilization of harvested water

For effective utilization of harvested water a farmer field day was organized on 9th September 2019 after construction of all the LCP. The motive behind this workshop was to create awareness about how to divert the surface runoff nearer to the tank, how to maintain the LCP efficiently and how to use the harvested water effectively for irrigation purpose, so that more effective runoff harvesting can be tapped and benefits and introduction about gravity based irrigation. This event was attended by scientist of various discipline from ICAR-VPKAS Almora. The stakeholders of this one day workshop were farmers, household women, youth and student.

The total number of poly tank has been repaired and made during visit under *Jal Shakti Abhiyan Programme* is presented in Figure 6.

The average length breadth and depth of all renovated and newly constructed polytank is 7.1 m, 4.4 m and 1.6 m respectively having total water storage capacity of approximately 3312 cubic meter. Renovation of old tank makes enable them to capture its full potential which is not achieved because of leakage and lack of proper maintenance. Around 65 LCPs were made at different location of the Darima village under the JSA having different capacity to conserve the rainfall water during the monsoon and collection of spring and seepage waster during off season. Under this programme old tanks were renovated in addition to construction of new tank. Judicious use of water for obtaining maximum productivity per unit area for stored water should be followed

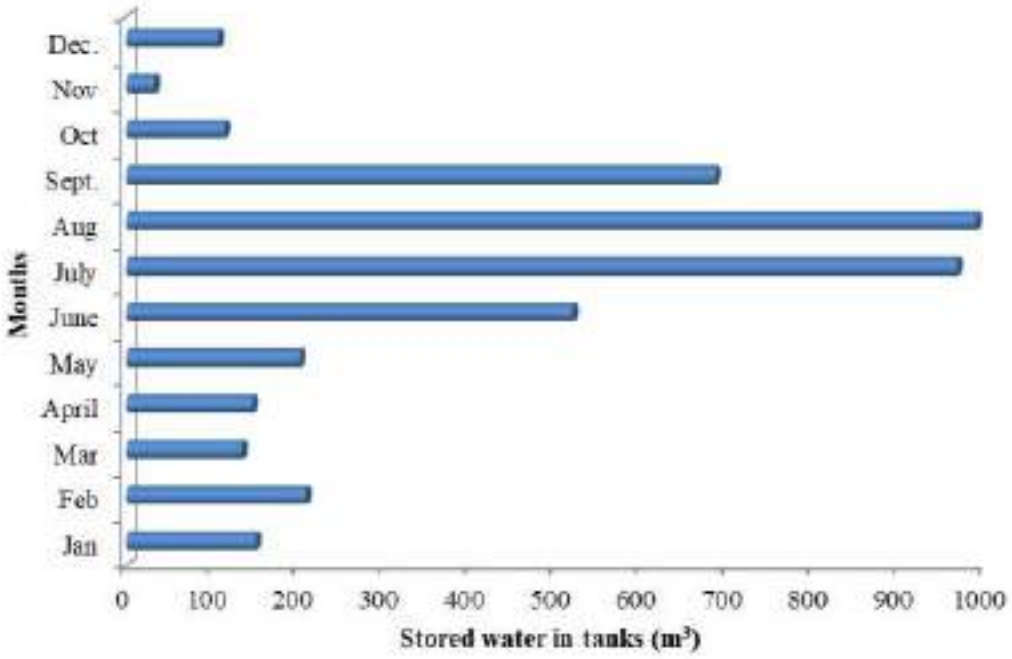


Figure 5. Volume of water stored (m^3) in tank in different months of years

Figure 6. Total number of poly tank has been repaired and made during visit under *Jal Shakti Abhiyan Programme*

5. Conclusion

The Hills and mountain agro-ecosystem of North Western Himalaya is characterized by very low irrigated land and difficult terrain. Water management at difficult terrain along with small and fragmented land is the biggest challenge to improvement in the agricultural productivity and profitability. The prevailing undulated terrain provides ample scope for LCP based water harvesting structure. It is useful for giving irrigation in nearby area of LCP and work as lifesaving irrigation in post monsoon season. Consequently it helps in increasing agricultural productivity and profitability of the farmer. The LCP made in this area were geottaged which will help in continuous monitoring. Hence LCP play important role in water management in higher hills.

6. Acknowledgement

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