

# Water conservation potential and opportunities in mountainous region in climate change scenario

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*Water is the most precious gift of nature, essential for human and animal life, and plays an important role for plant growth. Unlike most resources, there is no substitute for water. Water resources play an important role as a catalyst for the economic development of a nation. Therefore, it is necessary to develop, conserve, utilize and economically manage this critically important resource on an integrated basis so as to meet the ever-growing demand for agriculture, industry, domestic use and power generation.*

**Key words:** Climate change, Mountainous Region, Water conservation

JAMMU and Kashmir is a hilly area having varied topography and great diversity in cultural, social and economic practices of its different regions. As per the official data, Jammu and Kashmir had 8.47 lakh hectare agriculture land in 2005-06 which has shrunk to 7.94 lakh hectare till 2015-16. Non-availability of assured irrigation is one of the important limiting factors which are hindering growth of agriculture and horticulture sector in Jammu and Kashmir. The region though bestowed with vast perennial water resources, suffers from scarcity amidst plenty. There is sufficient average annual rainfall in state but its erratic and uneven distribution both spatially and temporarily results in frequent water shortages. This adversely affects the crop production due to moisture stress during critical growth stages of crop. It has been observed that in Kashmir Valley the discharge of natural water streams/springs varies from 2 to 20 litres/minute. With the rise in temperature and global warming, an abundant amount of water is being lost to the river in the form of flash floods, occurring due to rapid melting of glaciers.

The soil prevailing in the region, silty clay loam is fairly permeable but because of steep slopes water does not get enough time to percolate down. The irrigated area in Jammu and Kashmir has increased from 261 thousand hectares in 1950-51 to 320.81 thousand hectares in 2010-11. Rainfed agriculture is usual practice and about 70% farming is solely dependent on rainfall. The shortage of irrigation water in non-spell period is still continuing. Therefore, lack of assured water, the most persistent constraint to increasing productivity has been identified as the single most important factor hindering adoption of modern technologies and an alternate approach is urgently needed to provide adequate water for improving productivity of Kashmir valley region.

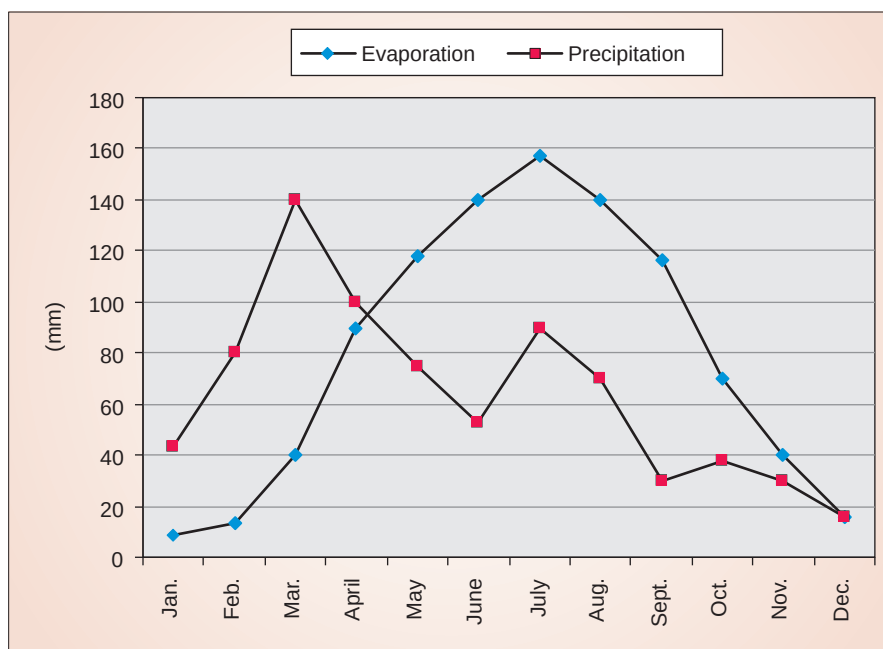
## Effect of climate change

Jammu and Kashmir has been facing severe floods and droughts problems very frequently and there is no long-term forecasting for these events. The extreme rainfall event observed in Jammu and Kashmir valley during the first week of September 2014 turned into the

worst disaster in the flood history of Jhelum river in Kashmir. The long-term average of precipitation shows monthly precipitation of less than 50 mm for the past thirty years in September before the extreme flood event took place.

The temperate region of Kashmir valley has average annual precipitation in the form of rainfall/snowfall (650 to 1,150 mm). The majority of precipitation is during December to May. The percentage of precipitation in the form of rain and snowfall during these months is 62% of the total precipitation. The remaining precipitation in the form of rainfall can be harvested at the selected sites and provide life saving irrigation to crops during moisture stress periods. The growth of irrigation potential is 19% which is lowest than rest of the country. Even though water use efficiency is lowest in rice crop, still out of 192.12 thousand hectares irrigated in Kashmir valley which is 56.7% of net sown area, rice alone is cultivated on an area of 136 thousand hectares (70.8%). The mean annual precipitation in Kashmir valley (Lower belt) is about 809.0 mm and





Monthly precipitation and evaporation pattern in Kashmir

more than double precipitation mostly in the form of snow on high altitudes is estimated. The average evaporation from the lower belts in Kashmir valley is 936.6 mm which is 127.6 mm more than average precipitation which indicates the main sources of water for all requirements is snow melt during summer months. The amount of precipitation received in the form of rain and snow occurring in four seasons of the valley is 27% in spring season, 23% in summer season, 7% in autumn and high amount of 43% in winter season. Canal supply water to the canals throughout the year and about 1,944,28 hectares of land in Kashmir are irrigated by canals.

#### Irrigation potential

The hill state have varied topography and great diversity in cultural, social and economic practices of its different regions. However, agriculture remains the backbone of the economy of Jammu and Kashmir with over 65% of its population dependant on agriculture and allied sectors. The farmers are now diversifying to cash crops such as flowers, vegetables, quality seeds, aromatic and medicinal plants and mushrooms etc. round the year. Net irrigated area in the region is just 24% and double and multiple cropping is followed on a larger scale

in the intermediate and warmer plain sub-tropical areas. In areas of irregular rainfall, irrigation is used during dry spells to ensure harvests and to increase crop yields.

Analysis of precipitation data of Kashmir valley for the last 25 years has revealed that rainfall was below normal in 57% of the years. In 39% of years, mild drought occurred and normal drought affected the district in 18% of the years. Normal drought occurs once in five years. In view of the uncertainty and erratic nature of the precipitation, it becomes very important to have an alternate source of irrigation in the form of surface water and ground water. The

importance of development of ground water resources in the valley which have not been exploited so far to its desired potential also holds immense potential for increasing irrigation potential in the state.

#### Water harvesting and management

Traditional recharge structure practiced in Ladakh is locally known as Zing. These are water harvesting structures found in Ladakh. These are small tanks, in which collects melted glacier water. Snow is an important source of water in cold arid regions, and the moisture from it is much more efficiently stored in soil than from rain.

Nevertheless, the snow resource is not always used to the best advantage because of blowing from fields and snowmelt runoff. With improved catchment, it is possible in some regions that the benefits of one season of snow water could match the soil water accumulation of a year's fallow. Various methods have been devised for retaining snow on the field namely stubble management (retaining tall standing stubble after harvest or alternating strips of tall and short stubble) and snow-ridging (collecting and compacting snow on fields into high ridges or windrows, which then serve to trap drifting snow). Artificial glacier since times immemorial, the melting water from the glaciers has been the only source of irrigation for 80% of the villagers in Ladakh. However, in recent times, Ladakh is



Zing water harvesting structures in Ladhak



Ice stupas at Leh



Development of artificial glacier at Phyang Leh

have observed decreased and untimely snowfall, retreating glaciers which have an impact on water supply both for irrigation purposes and domestic use. This is due to changing climate conditions (decreasing precipitation and increasing winter temperature). Winters are getting shorter and with less precipitation and whatever little snowfall is received melts away quickly much before it can be put to use in the barley fields in the sowing season.

Keeping the above facts and requirements in mind, locals have devised a unique system of water harvesting/conservation technique to augment water supply for irrigation. The artificial glaciers have been innovated and located as far as possible closer to the village and at lower altitude so that it starts to melt much earlier as compared to a natural glacier i.e. in April–May so as to supplement with additional irrigation water. During the winter months (November–December), the channel is built which divert/ guide the runoff water to the shady side of the mountain where it can slow down and freeze. A very new novel technology of construction of artificial glacier has been developed by Sonam Wangchuk known as Ice Stupas as shown in figure.

The ice stupas are constructed through gravity flow of water from a stream and utilization during water scarcity and shortage. The development of artificial glaciers is shown in figure. At each dip /slope

in the terrain, retaining walls is built which further slows down the water and facilitates the freezing of water in a form of steps, all along the slope into to an ‘artificial glacier’. All efforts are made to tap every drop of water; even the ones flowing below the frozen ice which would add to the surface run off that they are harvestings. This artificial glacier then melt in April and supplies water to the fields of the few villages just in time when the barley need to first water (locally known as Thachus).

#### Snow harvesting and artificial recharge

Snow water harvesting is a technique of preservation of snow and delaying the melting so that snow melt water is available for longer duration in a year. Selection of sites for snow harvesting shall depends on insolation of an area, wind direction, wind velocity and

relative Humidity.

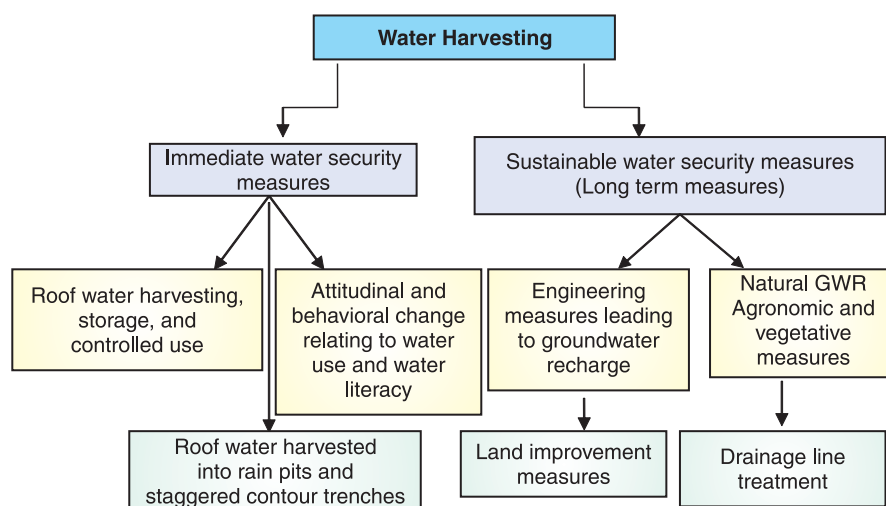
#### Water harvesting

Water harvesting is collection of water during rainy season, storage of surface runoff and storage water from streams. The following chart represent the immediate and sustainable solution of water. This approach can be used in all three regions of Jammu and Kashmir.

#### Technology for water harvesting

Traditional techniques include small ponds, dammed ponds, cemented/stone, construction of ‘Bauwris’, roof rain water harvesting, reservoirs/tanks/ponds and earthen check dam

New techniques are run-off harvesting-short-term storage, semi-circular hoops, trapezoidal bunds, nala bandhan (Mini earthen check dams), off-contour bunds or graded



Water harvesting

bunds, rock catchment, ground catchment, flood water harvesting – short term storage, diversion of run-off, check dams for aquifer recharge and sub-surface dams.

### Water harvesting structures

There are a multitude of water harvesting structures, the choice of which to use is dependent upon the water source, catchment area, storage and use. Techniques based on water sources include run off, direct rain water, snow mist, dew, surface spring, river and groundwater. Techniques based on storage include above ground tanks of all kinds, water troughs, ponds, reservoirs and wells. Various water harvesting structures and techniques that can be effectively employed in Himalayan region are discussed below.

**Hill spring out flow harvesting structure for irrigation/aquaculture:** The tapping of this source in polylined tanks can result in using this source for critical irrigation especially to orchards fields and vegetables and also for fish culture. The LDPE farm pond constructed to trap spring water is shown in Fig. 6.

**Inter terrace runoff harvesting:** At a number of sites small dug out and lined tanks for intra terrace water harvesting, can be constructed on the basis of requirement of the farmers. Water can be easily stored in these poly lined tanks and be used for bringing additional land under cultivation.

**Small sub – surface water streams:** Sub surface water streams keep on flowing in the valley in the upper portion of the watersheds round the year in which flow gradually reduces from September to June. Water flows down on the beds of gully/nalla/khad/choe and its discharge reduces due to seepage in the porous beds as it moves down. It appears after few hundred metres travel in the bed of Nala. The average flow rate varies between 0.01 to 0.1 cumec. The water from these sources can be harvested in constructed tanks of ponds for irrigation during stress periods.

**Contour bunds:** At a number of sites, earth bunds on the contours spaced at 5-10 m apart with furrow



LDPE farm pond for spring water harvesting at Kulgam

upslope and cross ties can be introduced for increasing water recharge in the area.

**Artificial glaciers:** Water from the artificial glacier melts much earlier in the year than the natural glacier. The early availability of water allows an early crop cultivation process. The process is able to take place in spring, whereas with the natural glacier, cultivation would take place 20-30 days late, thereby adversely affecting the crop yield. Collection of water at artificial glacier site begins in mid-November, at a slow pace. Water begins to freeze at 0°C. Stabilization of ice occurs within 24 hours, thereby converting in to glacier or ice block. Glacier remains in place until end of March, when temperature rises and the process of melting begins.

**Diversion and harvesting of spring water for irrigation/aquaculture:** The water diverted could be stored in poly lined tanks for irrigation to orchards, vegetables and aquaculture. The LDPE brick lining farm pond for runoff harvesting at Kulgam and Mansbal is shown in figure.

**Renovation of farm ponds:** These ponds can be utilized for bringing additional area under cultivation. The renovation can be done mostly with locally available materials like boulders and also with sand and cement mixture for lining of the ponds. The use of poly lining can also be utilized for reducing seepage in these structures. Proper lining material of these ponds is very

important for overall success of these structures.

**Zing water harvesting structures:** Water harvesting in cold desert of Ladakh can be done by construction of Zing (small pond or reservoir) diversion channel and artificial glacier. But, these ancient structures are in an extremely poor condition as the leakages are common. However, in artificial glacier, the water from streams is diverted towards a shady area through a channel at the base of mountains.

**Earthen check dams:** The earthen check dams of small dimensions can be utilized for storing and recharge of ground water, adhering to engineering principles. A spillway in these check dams can also be provided to provide lifesaving irrigation during stress periods. The check dams constructed at a number of sites can also be helpful in reclamation of gullied portion in these regions.

**Non-perennial streams:** A number of non-perennial streams can be diverted for storing water in water harvesting structures and the water can be utilized during water stress periods and for promoting fish culture in the selected sites.

**Trapezoidal bunds:** At a number of sites, trapezoidal shaped earth bunds can be utilized for capturing run off from external catchment and overflowing around wingtips. These bunds can store water and also improve the recharge of ground water in these areas through



LDPE brick lining farm pond for runoff harvesting at Kulgam

construction of these structures.

**Perennial streams:** There are number of perennial streams flowing in these areas which are being fed by snow melt and run-off occurring from precipitation in these regions. The water from these perennial streams can be diverted and harvested in water harvesting structures to be utilized during water stress periods. The location and size of the water harvesting structures can be standardized by making use of satellite imagery and also surface water models can be calibrated and validated for observing the potential of snow melt in the area.

### Impact

The benefits associated with technological intervention are summarized below.

- Water from the artificial glacier melts much earlier in the year than the natural glacier. The early availability of water allows an early crop cultivation process. The process is able to take place in spring, whereas with the natural glacier, cultivation would take place 20-30 days late, thereby adversely affecting the crop yield. This will provide lifesaving irrigation to crops in cold-arid regions of Ladakh.
- Water harvesting helps to increase the ground water recharging in the area as the existing springs in the

village produce more and more water through these techniques.

- The water harvested can be utilized for supporting eco-tourism in the area.
- Farmers will be benefited from the mode of action of the programme as the demonstrations of the technologies will be conducted in a participatory made with a close scientist-farmer interaction.
- It will improve the technical know-how of the farmers about utilization of excess run-off water.
- Suggestions/implementing corrections harvesting every drop of water for purpose of irrigation, plantations including horticulture,

pasture development, fisheries etc to create sustainable sources of income for the village community as well as for drinking water supplies.

- Reduction in runoff velocity and peak runoff velocities by increasing the time of concentration by virtue of the fabricated structures.
- Utilization of harvested water for irrigation in the moisture stress periods.

### Water resources to climate change

For climate adaptations of agriculture and water resources, following steps should be considered.

- Modification of irrigation techniques, including amount, timing or technology (e.g. micro irrigation systems).
- Adoption of water-efficient technologies to 'harvest' water, conserve soil moisture and reduce siltation and saltwater intrusion.
- Improved water management to prevent water logging, erosion and nutrient leaching.
- Modification of crop calendars, i.e. timing or location of cropping activities.
- Early maturing and drought tolerant crops may be grown
  - Change the methods of cultivation
  - Conservation tillage may be used instead of conventional tillage systems
  - Increased use of irrigation in areas prone to drought



LDPE farm pond for runoff harvesting at MLRI, Mansbal, SKUAST-K



LDPE farm pond for spring harvesting at Shalimar, SKUAST-K

### Impact of technology

Following impact can be seen through technological intervention of water harvesting in hilly area of Jammu and Kashmir

- i) Improvement in crop productivity ranging from 22 to 120%
- ii) Improvement in water use efficiency from 30 to 210%
- iii) Doubling of income
- iv) Development of sites of eco-tourism in these areas through utilization of excess water
- v) Promoting fish culture in the region
- vi) Saving of inputs in the form of fertilizers, pesticides, insecticides and other inputs
- vii) Improve the living conditions of people residing in these regions.
- viii) Reduction in sediment flow from the treated area for the same quantum of run-off
- ix) Promoting *in-situ* moisture conservation of water in the watershed through proper conservation measures
- x) The conservation measures adopted result in sustainable utilization of natural resources like

land, water, grass, forest and additional land being brought under cultivation

- xi) Improve irrigation potential from rainfed to irrigation
- xii) Reduction in floods and droughts
- xiii) Mitigate the effects of climate change

### Conclusion

The erratic and uneven distribution of precipitation both spatially and temporally, necessitates water harvesting to increase water use efficiency for sustainable agriculture. The locally adoptable low-cost technologies for water harvesting can be implemented as a viable alternative to conventional irrigation and drinking water supply schemes considering the fact that any land anywhere can be used to harvest rainwater. Rainwater harvesting, irrespective of the technology used, essentially means harvesting and storing water in days of abundance, for use in lean days. Mitigation and adaptive measures are needed to offset any future impact of climate change on agriculture and water resources.

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## Success Story

### Drought proofing in South Karnataka

Nagenahalli village, Tumkur district falls under central dry agro-climatic zone of Karnataka with an average rainfall of 690 mm. The village is characterized by acute shortage of water, soil erosion and preponderance of wastelands. During 2017, about 539 mm rainfall was received and deficit rainfall of 23 and 55% was recorded in June and July, accompanied by long dry spells of 22 and 13 days in June and July respectively, significantly impacting sowing of *kharif* crops, plant establishment resulting in poor crop growth.

Intensive rainwater harvesting was taken up under NICRA involving construction of 81 new farm ponds, repair of 59 existing farm ponds, 34 check dams to harvest as much water as possible and provide access to water for every farmer in the village. Similarly, trench-cum-bunding was done on 80 ha involving 100 farmers' fields in uplands of the village resulted in minimising crop losses in uplands due to drought. To cope with early season drought, short duration drought tolerant finger millet (ML 365 and GPU 28) and drought tolerant pigeonpea (BRG 2 and BRG 4) was demonstrated in the village. These finger millet varieties were planted in about 159 ha involving 179 farmers' and drought tolerant pigeonpea (BRG 2 and BRG 4) are being adopted in 82 ha benefitting 148 farmers. Enhanced water availability resulted in increase in green fodder availability resulting in higher incomes from the livestock.

The water harvesting potential of 1,96,560 m<sup>3</sup> capacity was developed for life saving irrigation during dry spells. Thirty two open wells and 29 bore wells were recharged and area under irrigation was increased by 75 ha of the village out of the total cultivated area of 190 ha and contributed to increase in income. The yield of ragi (ML 365) was 38.5 q/ha compared to that of local ragi 29.5 q/ha. Yields were superior and farmers gained additional income of ₹ 13,500 from finger millet alone. Similarly, performance of pigeonpea BRG 2 (12.6 q/ha) was superior to the local variety of pigeonpea (10.2 q/ha) with an additional income of ₹ 10,440 under deficit rainfall.

Source: DARE-ICAR Annual Report 2018-19



Drought proofing in South Karnataka

