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Review Article

Potential of Rainwater Harvesting for Non-Potable Uses in Jam-mu and Kashmir region- A Review

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1. Abstract

In North Western Himalayan region, most of the water received through torrential and high in-tensity rainfall, out of which mostly goes as a surface runoff. The paper reviews the present status and the future scope of rainwater harvesting especially with reference to the hilly mountain of Jammu and Kashmir. It inspects the rainfall climatology of the area and its irrigation potential so that the rainwater harvesting potential is exploited, which in turn will reduce the stress on the con-ventional sources for fulfilment of water demands especially the non-potable ones. It is found that the rainwater harvesting system needs to be implemented keeping in view the area of installation in terms of the social and economic status of the population, feasibility of the system installed and the overall benefits in the said area. The paper describes traditional and new techniques for water harvesting in Himalayan region.

2. Keywords

Rainwater; Storage tanks; Surface runoff; Water har-vesting structures

3. Introduction

The water demand has been increasing due to the robust popula-tion increase globally. But the water resources available are lim-ited. Worldwide water demand has increased six folds between 1990 and 1995 while the population was only doubled and the demand of the agricultural sector is almost 70% of the total de-mand Anonymous. 2003). this increase in the rate is more in the urban areas than the rural ones due to the immense urbaniza-tion and mass migration of population. This leads to the need of exhaustive planning and management of water resources and the exploration of the alternative ways of meeting the increased water demands. The urbanization has led to concrete and paved roof tops, which makes it easy to collect the rain water and its channelling. Rainwater harvesting has been the main source of water supply for potable and non-potable uses in the old days. The method of harvesting rainwater at that time was simple and did not require any treatment. The rainwater was mostly collected from roofs and some was collected directly. Traditional village tanks, ponds and earthen embankments numbering more than 1.5 million, still harvest rainwater in 660,000 villages in India and encourage growth of vegetation. India has a history of rainwater harvesting systems [9,10].

In the recent times, the global warming effects are predominant and the impact of climate change is affecting the water resources and the water demand fulfilment globally. This has led to the fo-cus of researchers and engineers towards alternative ways of op-timizing the use of water available with least draft on the natural resources. One of the common avenues is the rainwater harvest-ing because of its contemporary relevance and advantages. There are varying reasons for the adoption of rainwater harvesting to meet the increasing water demands globally; such as over half of the accessible freshwater runoff globally is already appropriated for human use, over 1 billion people lack access to clean drinking water and almost 3 billion of people lack basic sanitation services. The amount of accessible freshwater (per capita availability of freshwater) will decrease in the coming century, climate change will cause a general intensification of the earth's hydrological cycle in the next 100 years, with generally increased precipitation, eva-po-transpiration, occurrence of storms and significant changes in biogeochemical processes influencing water quality (Arora, 2006). In the next 30 years, projected increase in the population is much higher than the percentage of accessible run off during the same period. Under such circumstances, harvesting rain shall be crucial.

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4. Future of Rainwater Harvesting

The immense draft on the water resources globally due to the rap-id population growth and the climate change has led the research-ers and the community as a whole to focus on the judicious use of available water. Over the course of time, rainwater harvesting has come into limelight and is being perceived as a judicious way of water conservation and management. Rainwater Harvesting involves a detailed analysis of the water usage and rainfall events and magnitude with an aggressive approach over a considerably long period of time coupled with an effective forecasting. The increasing water demands can be addressed by computing the volumetric capacity of the precipitation events; these need to be evaluated over a long period of time. This long term planning will be an essential way of conservation and management of the lim-ited water resources available on the earth. The present rainwater harvesting techniques need to be modified scientifically in order to enhance the water collection and storage from impermeable surfaces as well as permeable roads, pavements, etc. Also, the con-veyance of this collected water needs to be planned in an efficient way with minimum loss and maximum benefits. One of the im-portant aspects to be focused on regarding rainwater harvesting is the misconception that the general population has regarding the water quality of the rains. This needs to be widely worked on and information regarding the rain water as a safe and viable option for non-drinking purposes need to be disseminated on a larger scale. The general non-drinking purposes for which rain water can be used directly without any treatment are irrigation, toilet flushing, waste water treatment, etc. If the rainwater is treated, it can be efficiently used for industrial purposes also.

The rainwater collection and storage will substantially reduce the load on the groundwater reservoirs and will also make the households and communities independent and self sustained to a large extend. Not only can the direct usage of the stored water be done; but it also becomes a source of recharge to the groundwater aquifers, if employed on a large scale. In addition to the water us-age, rainwater harvesting also eliminates the problems of surface flooding and storm water control, it greatly reduces the load on the surface drainage system.

Rainwater Harvesting has a large spectrum of benefits:

- In the domestic households, it can reduce the water bills as it can suffice almost all the non-drinking water uses such as gardening, cleaning, flushing, etc.
- Economically, the harvesting of rainwater requires low cost and also its operating cost is negligible.
- Rain water is free from chemicals, impurities in the areas free from hazardous industrial areas which leads to an increased food security by sufficing the irrigation requirements of the food crops.
- It reduces the demands on the municipal water supplies and makes the farmers independent and self-sufficient to a great extent
- Soil erosion is greatly reduced from the agricultural ar-eas.
- Water Pollution of the rivers and streams due to pol-luted overland flow is reduced
- Water pollution because of agricultural practices (chemicals, fertilizers, insecticides, etc.) is reduced and reduces the extent of flooding, especially during the rainy season

Depending on requirements and intent, available rainfall and storage space, the potential gains of rainwater harvesting should be compared with cost factors, short and long-term, and expect-ed demand. Installing a rain water harvesting system for water attenuation and flood control may; however, offer benefits in ad-dition to supply cost savings. The variables in equipment, instal-lation and maintenance costs are more easily quantified, where as future demand, rainfall volumes and long-term maintenance costs are much more difficult to determine. Numerous internet-based tools are available that provide information on potential water use from rainwater harvesting systems. These range from tools that are aimed at capturing rainwater for growing crops to meet growing demand for food, to tools designed to illustrate the cost savings of rain water harvesting systems in domestic situa-tions. Using algorithms to calculate water use and water saved, such tools use inputs such as building occupancy numbers, an-nual rainfall, roof area and roof type to calculate rainfall collect-ed, water demand and potential savings [15].

The system of rainwater harvesting is of great potential to prevent flooding and supplementing most of the non-potable uses of the population and making the communities self-sufficient and independent. Many studies have been conducted on the harvesting of rain water in commercial buildings and the urban households [11,16,17] conducted a research in the cities of developing countries; and concluded the need for clean water. It was found feasible to store rain water and two methods were used; runoff capture in the larger catchment and empowering roof and gutters in smaller catchments [6]. Generalized the spatial and temporal variability of water savings by rainwater harvesting. He evaluated the spatial and temporal precipitation associated with the behaviour of rainwater harvesting systems. The performance of the storage tank resulting from the monthly models correlated well with the performance of the daily model [19]. Assessed the feasibility of rainwater harvesting systems in high rise buildings for household and commercial purposes in several different cities in Australia. The system was tested in Melbourne, Sydney, Perth, and Darwin. Optimization of the harvesting tank and the volume of water that can be accommodated were calculated based on the daily water balance. The results indicated that the large water requirements could be met by the use of rain water. High economic and environmental performance was related with it.

The impact of the rainwater harvesting system on the surrounding environment was studied by [2]. Rainwater harvesting designs were made using the concept of eco housing. The environmental impact in terms of potential a biotic reduction, acid potential, eutrophication, global warming, human toxicity, ozone function reduction, and photochemical ozone effect were studied. The results indicated that a compact model provide a lower environmental impact. The effect of rain water harvesting on the groundwater recharge was seen in Kolar district, Karnataka where there is exploitation of the excessive use of ground water and the results indicated that the rainwater harvesting systems increased the groundwater recharge process [17].

Rainwater harvesting systems are economically feasible in most of the cases and provide huge financial benefits. Many researchers have performed the economic analysis of the harvesting systems [2,5,8,19] and found it feasible enough to be adopted by the communities. Social aspects of the rainwater harvesting were studied by [12] and were found satisfactory. Environmental aspects of these systems are the most bright as they reduce the stress on the available water resources and help in enhancing groundwater recharge.

5. Study Area

Jammu & Kashmir is situated between 32°17' and 36°58' north latitude and 73°26' and 83°30' east longitude. It is located in the extreme north of the country. It is bounded on north by China, on east by Tibet, on south by Himachal Pradesh, Punjab and on west by Pakistan. Geographically it is divided into four zones - the mountainous and semi-mountainous plain known as Kandi belt, hills including Siwalik ranges, mountains of Kashmir valley and PirPangal range and Tibetan tract of Ladakh and Kargil. It has a number of lakes, rivers, rivulets and glacial regions. The important rivers of Jammu and Kashmir are Indus, Chenab and Sutlej (Jhelum). There are extreme variations in climate in the state, due to its location and topography. The temperature of this state varies spatially. The coldest pace is Leh and Jammu is the hottest. In winter, night temperatures go down below zero and very often experience snowfall.

6. Rainfall Climatology

The climate of the state ranges from the scorching heat of the plains of Jammu Division to the snow-capped heights of Gulmarg and the mud peak of Mount Godwin Austin (21,265 feet above sea level). Broadly, the Jammu and Kashmir comprises of three distinct climatic regions: cold arid desert areas of Ladakh, temperate Kashmir Valley, and the humid sub-tropical region of Jammu (**Figure 1**). The mean annual rainfall in cold arid zone varies from 100 mm to 300 mm received by western disturbance. The annual rainfall in temperate region (Kashmir valley and PirPanjal) varies from 600 – 900 mm and added with snowfall. Mean monthly temperature is lowest in January and highest in July except in Jammu where highest temperature is experienced in June. Mean monthly temperature in January varies from –17°C at Drass to 14°C at Jammu. January 15 to March 15 is ice cold season when temperature in most of the areas in Kashmir is below 0°C. It snows during winter.

An exhaustive investigation into the rainfall events is necessary to exploit the potential of this system. The overall objective is to manage any available water, even though it is periodic in nature. This is an attempt to conserve and manage water as efficiently as possible knowing how precious water is and how limited the resource is. The urgency for an efficient rainwater management system is hastened by the expanding population in the region.

Jammu and Kashmir is divided into four zones. In the agro-ecological region based approach, recognition was given to the climatic conditions, length of growing period, land form and soils by **[19]**. The mean annual rainfall data for these zones is given as follows in (**Table 1**).

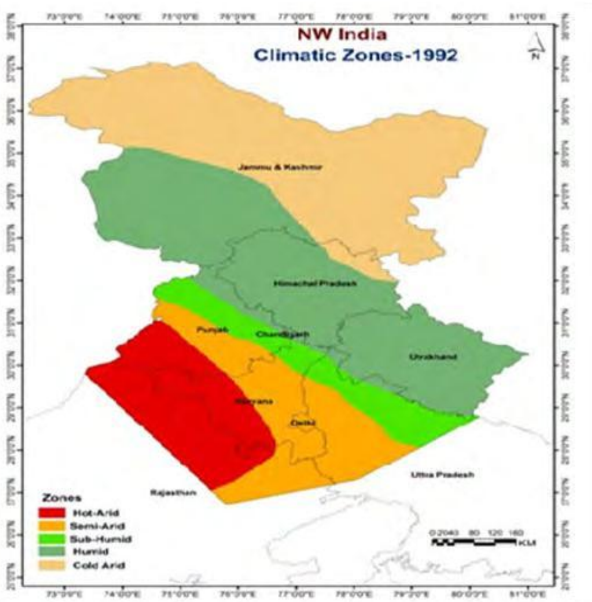

Figure 1: Climatic zones of Jammu & Kashmir

Table 1: Mean annual rainfall data in mm (Source: IMD, Pune, India)

Zone	Station	Annual Precipitation
Subtropical	Jammu	1088
	Udhampur	1510
Intermediate	Ramban	1118
	Kishtawar	865
	Akhnoor	1144
	Punch	1486
	Reasi	1668
Temperate	Srinagar	635
	Sonmarg	1710
	Awantipora	577
	Anantnag	608
	Kulgam	845
	Baramulla	904
	Budgam	570
	Shalimar	835
Cold Arid	Dras	556

It is clearly visible from the data that there is a lot of variation within the state, even within the same zones. Minimum rainfall occurs in the cold arid zone and maximum rainfall occurs in the temperate zone. Even in the temperate zone itself, there is a great variation in rainfall for different stations.

7. 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 the region during the first week of September 2014 turned into the worst disaster in the flood history of 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 maximum rainfall observed in Srinagar was 389.8 mm with a maximum precipitation of 179.8
mm on a single day of 4th September 2014. Indian Meteorological Department has reported heavy rainfall in all the basins of the Jhelum exceeding the average values by 2-9 times at different places. The discharge observed in the Jhelum river during this period was an extreme event surpassing the 1959 flood event after a gap of 55 years. The flash floods and cloudburst of August, 2010 and 2015 in the Ladakh region of the state resulted in huge losses to lives and property. The extreme rainfall event of August 2010 resulted in rainfall of 50 mm within a span of 10 minutes resulting in creating extra-ordinary runoff events killing more than 200 persons and millions of rupees damage to property and agricultural lands. Recent droughts which continued for almost three years have damaged some famous fruit crops ideal to certain micro climatic regions in Kashmir valley viz cherry of Nishat, HarwanDara belt, apple orchards facing southern places grown on Karewa lands, Almonds of Budgam District. It was observed that matured trees died down which was otherwise bearing fruits for the last so many years. A spell of dryness wreaks havoc with production, yield of saffron the major and exclusive cash crop of the state, that was 2.8 to 3 kg per hectare in early nineties dipped as low as 500 grams over the past few years due to consecutive droughts.

8. Kashmir Valley

The Temperate region of Kashmir valley has average annual pre-cipitation in the form of rainfall/snowfall as (650 to 1150 mm). The majority of precipitation is during the months from De-cember to May. The percentage of precipitation in the form of rain and snow falling during these months is 62% of the total precipitation falling. 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 soils prevailing in the region are siltyclay loam which is fairly permeable but because of steep slopes water does not get enough opportunity time to percolate down. Rice, wheat and maize col-lectively account for about 75% of the total area sown to different crops. The growth of irrigation potential is 19% which is lowest than rest of the country. The irrigation development in Jammu and Kashmir is shown in (**Figure 2**). Even though water use effi-ciency 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 809.6mm and 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 (**Figure 3**) 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 calculated in percent is as under 27% in spring sea-son, 23% in summer season, 7% in autumn and high amount of 43% in winter season. Canals form the most important system of irrigation (**Figure 4**) in the outer plains and in the broad val-ley of Kashmir. Moreover, the Jhelum and its tributaries are all snow fed and they never run dry. They supply water to the canals throughout the year and about 194428 hectares of land in Kash-mir are irrigated by canals. The time series of ET_0 on annual basis with linear trend lines of Srinagar is shown in (**Figure 5**).

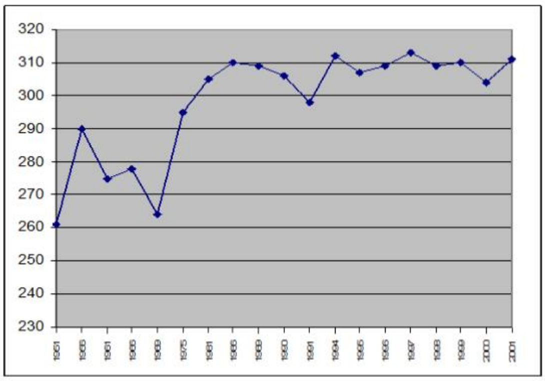

Figure 2: Irrigation developments in Jammu and Kashmir

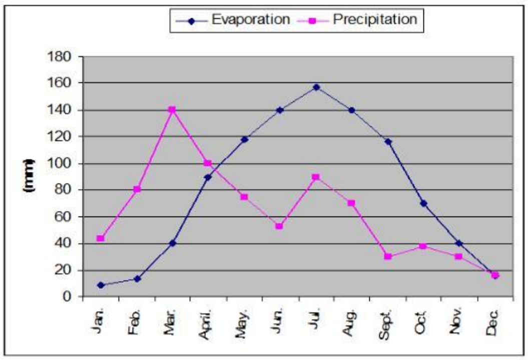

Figure 3: Monthly precipitation and evaporation pattern in Kashmir

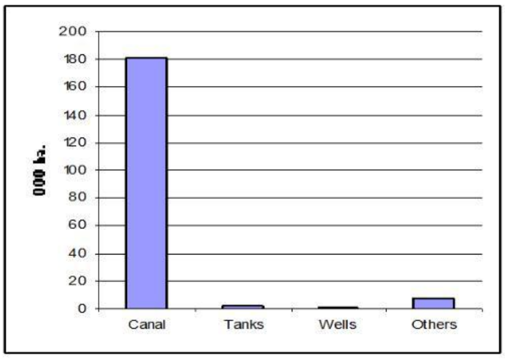

Figure 4: Sources of irrigation of Kashmir Valley (000 ha)

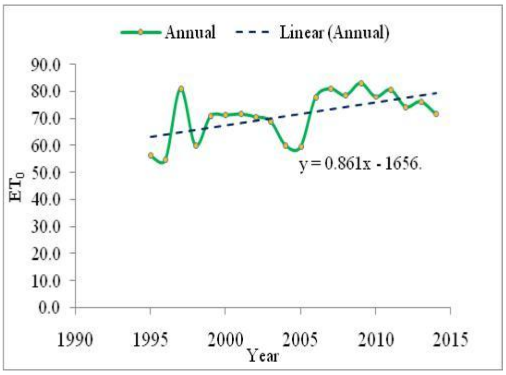

Figure 5: Time series of ET0 on annual basis with linear trend lines of Srinagar

Figure 6: Zing water harvesting structure

9. Irrigation Potential

The hill state having 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 percent of its population depends on agriculture and allied sectors. These sectors contribute around 27 percent to the State's income. The diversity in physiographic features, agro-climatic variations at macro and micro level, existence of cold arid, temperate, inter-mediate and sub-tropical zones. Over the years, the agriculturists and farmers have adopted several area specific and time specific cultivation practices to meet the requirement of their staple food crops. Rice, maize, wheat, pulses, fodder, oil seeds, potato and barley are the main crops of the region.

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 percent 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.

In Jammu and Kashmir State CAD programme is operational in different area *i.e.* Ranbir Canal, Doda/Rajouri/Gool-Sangaldhan and New Partap Canal CAD Project. Through restructuring the CAD programme almost all aspects of the water resources management which include development and management of the irrigation system up-stream of the outlets for scientific water utilization through various developmental and management works. The CAD programme can be used for better delivery system at farmer's level to improve water use efficiency. The net area sown in the state during 2011-12 was 746 thousand hectares whereas the gross area sown (total area sown under different crops) was 1161 thousand hectares. A slight increase was witnessed, during the year 2011-12, in the net area irrigated, as it increased from 313.99 thousand hectares in 2010-11 to 319.26 thousand hectares. A major constraint to the development of agriculture in Jammu and Kashmir is the fact that only 50 per cent of the ultimate irrigation potential of the state has been harnessed. The ultimate irrigation potential in Jammu and Kashmir has been assessed at 1358 thousand hectare, which includes 250 thousand hectare to be developed through major and medium irrigation and 1108 thousand hectare through minor irrigation.

9.1 Irrigation Potential in Kashmir Valley

Analysis of Precipitation data of Kashmir Valley for the last Twenty five years has revealed that rainfall is below normal in 57% of the years. In 39% of years mild drought occurs and normal drought affects 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. A number of canals like Zainageer canal, Shakful canal, martand canal, Sharabkul canal, nur canal etc are available which provide irrigation water to the agricultural land in Kashmir Valley. Zaingeer canal is one of themajor state owned canals in Kashmir division of the state. The canal has been running all along 50 years with uninterrupted irrigation to 4775 ha of its command area until 1982.Its gross command area (GCA) stands 6480 hectares while its culturable command area (CCA) is 4960 hectares. MadumatiNallah is a perrinelnallah with the catchment area of 225 Sq. kms with discharge at head 250 cusecs of water. It is a main source of water supply for Zainageer canal and is snow fed with maximum discharge of 3400 cusecs in the year 1995 and minimum discharge of 21 cusecs in the year 1996 famous canal.

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. The stage of ground water development in the valley is only 14%.In Kashmir valley recharge from rainfall is of the order of 161151 ha-m and recharge from other sources is 109165 ha. m. Groundwater in the karewas of Kashmir Valley occurs under both confined and unconfined conditions. High karewa plateau land is suitable for development of growth ground water as this is the recharge zone and karewas are mainly fine grained in nature. Most of the districts in valley are drained by major perennial river Jhelum and its tributaries. In the past development of ground water was mainly through dug wells and tube wells, base flow in nallas and also some springs has played a major role for sustainable domestic and irrigational purposes. In some of the areas, at present too these are the only sources of water. However, in recent years modern means of ground water development have been employed. Public Health Engineering has been constructing number of hand pumps and shallow-moderate depth tube wells for large-scale water supplies. The average depth range of ground water in the valley varies from 90 to 150 m bgl. The average discharge from the wells dug in Kashmir valley is 15 lps. The tube wells drilled down to a depth of about 150 to 200m are yielding about 150 to 200lpm discharge for a drawdown of about 15 to 20m. Some of the tube wells constructed in the valley area are yielding very good discharges varying between 500 lpm to 200lpm.The ground water quality is good with EC < 1500. The Local problems are Marshy Gases, silt, iron content and high artesian pressure. Chemically, ground water of the area is by and large fit for drinking and irrigation requirements except the presence of high Iron content in the ground water especially in the deeper aquifers which is one of the major problems in the area. Precipitation in the form of rain and snow in the district is the major source of ground water recharge apart from the influent seepage from the perennial rivers, streams and lakes, irrigated fields and inflow from upland areas. Discharge of ground water mainly takes place from wells, tube wells and effluent seepages of ground water in the form of springs and base flow in streams. Monitoring of water levels and chemical quality at representative areas to keep a check on any adverse effect that ground water development may have in future. Traditional resources like springs need to be revived, developed & protected on scientific lines for various use. The discharge of such springs can be sustained by construction of small check dams or subsurface dykes across the nallahs/tributaries in the downstream at favourable locations. Small ponds/tanks can be utilized for recharging ground water. These structures can be constructed for harvesting water and utilized for both recharging and meeting the domestic needs. In Valley areas, in addition to the traditional ground water structures like dug wells and springs, shallow to medium depth tube wells can be constructed for developing the ground water resources. Ground water resources can also be developed by constructing infiltration galleries (Percolation wells). In hilly terrain, springs and perennial nallahs are the major sources of water.Medium to shallow bore holes and hand pumps are useful ground water structures for meeting the domestic needs.

9.2. Irrigation Potential in Ladakh

Ladakh is the largest in area among the three main regions of the Jammu & Kashmir State viz., Jammu, Kashmir and Ladakh. Until 1979 a single district, Ladakh, is now divided in to Leh and Kargil districts. The Indus River and its major tributaries, the Shyok-Nurba, Chang-Chenmo, Hanle, Zanskar, and Suru-dras rivers, drain the region. Glacio-fluvial processes aided by freeze- thaw weathering have formed the high altitude landscape of Ladakh. Ladakh has an extremely harsh environment and one of the highest and driest inhabited places on earth. Ladakh’s climate is referred to as a “cold desert” climate due to its combined features of arctic and desert climates. These include wide diurnal and seasonal fluctuations in temperature, from -40°C in winter to +35°C in summer, and extremely low precipitation, with an annual 10cm to 30cm primarily from snow. Due to high altitude and low humidity (20%), the radiation level is amongst the highest in the world (up to 6-7Kwh/mm). Soils in Ladakh range from gravely and sandy loams on the alluvial fans to sandy and silt clay loams on the flood plains of Indus. The soils are characterized by low organic matter content and poor water retention capacity. The pH of soil ranges from 7.4 to 9.5. There is a potential problem of salinization especially on the flood plains of Indus. The district is the coldest and most elevated inhabited region in the country with altitude ranging from 2300 meters to 5000 meters. As a result of its high altitude locations, annual rainfall is extremely low. This low status of precipitation has resulted in scanty vegetation, low organic content in the soil and loose structure in the cold desert. A large-scale plantation has been going in the district since 1955 and this state of affairs is likely to change.

9.3. Water Harvesting and Management in Ladakh

Traditional recharge structure practiced in Ladakh is locally known as Zing which is shown in Fig.6. 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: (1) Stubble management: Retaining tall standing stubble after harvest or alternating strips of tall and short stubble. (2) 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 percent of the villagers in Ladakh. However, in recent times Ladakhis 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 changing climate conditions (decreasing precipitation and increasing winter temperature). Winters are getting shorter and with less precipitation and whatever little snowfall is received melt s away quickly much before it can be put to use in the barley fields in the sowing season.

Besides, due to short summer season they are able to cultivate only one crop per year and this need to be sown in the crucial month of April or May. If it is not sown at this time the crop cannot be fully matured which result in low yielding crops. However, at that time of the year there is not sufficient water in the streams as the natural glaciers are located at a higher altitude and further from the village and this start to melt only in the month of June which is too late for sowing. 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 the month of April–May so as to supplement with additional irrigation water. During the winter months of 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 SonamWangchuk known as Ice Stupas. The ice stupas are constructed through gravity flow of water from a stream and utilization during water scarcity and shortage. At each dip /slope in the terrain, retaining walls (something like a mini dam) 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 know as Thachus).

10. Rainwater Harvesting Potential

Jammu and Kashmir has huge potential for rainwater harvesting. Rainfall occurs during short spells and most of the rain falling on the surface tends to flow rapidly, leaving little for the recharge of ground water. During rain period high slope mountains increase run off velocity of precipitation and decrease the infiltration rate, followed by soil erosion in lower slope mountains and finally results floods in central plain area. During rainy period rivers increase in volume and surplus water overflows through the banks of river causing severe flood in the plain basin, that result in huge loss of life and property.

Rain water harvesting has an important role in reducing the impact of floods, building up of rainwater harvesting structures like percolation tanks, check dams, sub surface barriers, recharge wells, water spreading structure on upper reach of mountains will reduce the impact of flood during rainy season and stored water can be utilized for drinking purpose, agriculture and horticulture farming as most of the dry areas have no irrigation system. Water harvesting in dry areas will increase multi farming systems and will boost growth of agriculture and horticulture sectors and same time will reduce impact of floods in plain areas. Water harvesting has huge potential for developing sustained micro livelihood units in floriculture, horticulture, growing of medicinal plants and vegetable farming in high altitude areas of Kashmir.

Rainwater harvesting has huge impact on daily consumption of water in both rural and urban areas. Rain water can be harvested directly from the slanting roofs; this water can then be utilized for farming in rural areas and the non-drinking purposes such as cleaning Harvesting of rain water from slanting roofs is easy rather getting water from outside. Harvested water can be utilized for vegetables farming, cultivation of flowers in lawns and drinking water purpose.

Most of the newly developed urban areas face problems during rainy season as rain water block roads even may lead to epidemic in areas. The excessive concrete usage for paths, roads etc has retarded the infiltration of rainwater into the soil during the rainy period, which leads to flooding. The installation of water harvesting structures is of vital importance in reducing the dependency of the population on separate drainage systems.

The sloping roofs in the Kashmir valley have an advantage for the collection of rainwater directly. It needs to be coupled with just a storage tank for collection purposes. Rain water can be harvested either by storing rain water above ground for direct use or recharging ground water aquifers. It is important to ensure that the rain water collected is free of any pollutant else it may have impact on health, Precautions measures must be taken into consideration to ensure rain water quality.

There is a huge potential of every house hold to become independent rather depend on poor water system in the valley. Climate change in Kashmir has had severe repercussion on human habitation as decrease in glaciers dimension and increase in precipitation in the form of rain rather than snow will reduce the snow bank of Kashmir which is the main sources of water, needed for agriculture, horticulture sectors, main source of livelihood of 90% of the population in Kashmir weather direct or indirect. Water harvesting provides alternate solution for storing water, which is decreasing due to climate change in Kashmir thus safe guarding the future of the coming generation.

Despite the varied benefits of rainwater harvesting, there are several factors which affect the implementation of this system extensively. Rainwater Harvesting directly depends on the rainfall climatology. In the present times, where climate change has a great impact on the precipitation events, the frequency and the rain water potential do not meet the minimum water needs. In addition to the erratic rainfall, the quality if rain water quality has also drastically been reduced and now requires certain treatments even for non-potable uses. Rain water can be contaminated by impurities that exist in the catchment area. Also, due to the storage, the stagnation condition is created which may sometimes become breeding ground for insects if not covered properly.

Rainwater Harvesting has already been identified as beneficial and economical. Despite this, there is a very slow incorporation of these systems because of a number of reasons. These include uncertainties of economic benefits, lack of experience and the lack of evidences that such a system can be implemented.

The developed countries have issued regulations and guidelines on the implementation of rainwater harvesting techniques but the developing countries still lack in the perception of this concept on a larger scale. Calculation of the economic feasibility of rainwater harvesting systems is needed at the system design stage. In addition to the economic aspects, social aspects of the users also need to be evaluated so that the application of the system is done in accordance with the needs of the user. Socio-economic feasibility study of the rainwater harvesting systems has been carried out and has been applied to several sectors of water resources. The approach includes the cost benefit analysis, cost effectiveness, net present value, internal rate of return, payback period and life cycle cost analysis.

Previous studies focused more on the reliability of rainwater harvesting whether hydrologic and economic for certain conditions. In those studies, few studies look at a rainwater harvesting system that integrated with the region. An application of large-scale rainwater harvesting is considered as an adaptive strategy in the face of climate change-related water shortages [18]. In addition, previous studies have not been focused on standard model of rainwater harvesting implementation for certain social conditions of the region. Therefore, for purposes planning in the future, it is needed to make a typological model of rainwater harvesting system implementation for domestic purposes in urban areas in accordance with the socio-economic conditions of the region and its inhabitants. The development of the model based on water and soil conservation, rain water harvesting, and a good drainage system planning in a residential area. From the studies standardization for the application of rainwater harvesting system can be made.

11. Conclusion

The erratic and uneven distribution of rainfall both spatially and temporally, necessitates rain water harvesting to increase and sustain the agricultural productivity. Excavated dug-out farm ponds tanks are found most suitable for storing runoff in culti-vated lands. It inspects the rainfall climatology of the area and its irrigation potential so that the rainwater harvesting potential is exploited. It is found that the rainwater harvesting system needs to be implemented keeping in view the area of installation in terms of the social and economic status of the population, fea-sibility of the system installed and the overall benefits for the people.

References

1. Adhityan AHHC, Wong HJ. Alternate dual-mode working systems for the collection and use of rainwater in high-rise buildings for non-potable uses. Proc 8th Inter Conf on Rainwater Catchment Systems, Te-heran Iran. 1997; 3-9.

2. Angrillm S, Farreny, Ramon G. Environmental Analysis of Rainwater Infrastructures in Diffuse and Compact Urban Models in Mediterra-nean Climate. International Journal of Life Cycle Assess, Germany. 2011.

3. Anonymous. Agriculture and rural development sectors for Jammu and Kashmirstate NABARD. State Focus paper. 2003; (2002-03): 6-8.

4. Arora S. Preliminary assessment of soil and water conservation status in drought prone foothill region of north-west India. Journal of World Association of Soil Water Conservation J. 2006; 1: 46-54.

5. Eroksuz E, Rahman A. Rainwater Tanks in Multi-unit Buildings: a case study for three Australian Cities. Journal of Resources, Conserva-tion and Recycling. 2010; 54: 1449-52.

6. Fewkes A. Modelling the performance of rainwater collection systems: towards a generalized approach. Urban Water Journal. 2000; 4: 323-33.

7. Ghisi E, Cardoso KA, dan Rupp RF. Short-term versus Long-term Rainfall Time Series in the Assessmentt of Potable Water Savings by Us-ing Rainwater in Houses. Journal of Environmental Management. 100: 109-119.

8. Imteaz MA, Ahsan A, Naser J, DanRahman A. Reliability Analysis of Rainwater Tanks in Melbourne Using Daily Water Balance Model. Jour-nal of Resources, Conservation and Recycling. 2012; 56: 80-86.

9. Kumar R, Thaman S, Agarawal G, Sharma P. Rain water harvesting and ground water recharging in North Western Himalayan region for sustainable agricultural productivity. Universal Journal of Environmen-tal and Research and Technology. 2011; 1: 539-44.

10. Kumar , Jhajharia D, Ram D, Chander S, Kumar M, Shukla RM et al. Rain water harvesting in North-Western Himalayan Region- a case study. Journal of Soil and Water Conservation, 2012; 11: 323-8.

11. Marcelo MC, Enedir G. Analysis of Potable Water Savings using Be-havioural Models. Water Conservation, (ed., Manoj Jha) ISBN: 978-953-307-960-8, 2011. In Tech.

12. Nagaraj N, Pradhani U, Chengappa PG. Cost Effectiveness of Rain-water Harvesting for Groundwater Recharge in Micro Watersheds of Kolar District India. Agricultural Economics Research Review. 2011; 24: 217-23.

13. Pathak H, Aggarwal PK, Singh SD. Climate Change Impact, Adapta-tion and Mitigation in Agriculture; Methodology for Assessment and Applications. Indian Agricultural Research institute. 2012.

14. Sehgal JL, Mandal DK, Mandal C, Vadivelu S. Agro-ecological re-gions of India.Publication 24. NBSS & LUP (ICAR), Nagpur, 1992.

Suraj Bhan. Rainwater harvesting.Journalof Soil and Water Conserva-tion. 2009; 8: 42-8.

15. Tallal HA, danIqbal R. Save and Safe Water: Evaluation Design and storage period on water quality of rainwater harvesting system. Journal of environment and Earth Science. 2012; 2 (10).

16. Terry T. Domestic water supply using rainwater harvesting. Building Resarch and Information. 1998; 26: 94-101.

17. Trenberth KE, Jones P, Ambenje R, Bojariu D, Easterling A, Klein TD et al. Observations: Surface and atmospheric climate change. Chapter 3 in S. Solomon, Group I to the Fourth Assessment Report of the Intergov-ernmental Panel on Climate Change. Cambridge University Press. 2007.

18. Zhang Y, Chen D, Chen L, dan Ashbolt S. Potential for Rainwater Use in High Rise Buildings in Australian Cities. Journal of Environmental Management, United States, 2009; 91: 222-6.