Sustainable Water Resource Management in Cold-Arid Leh-Town: A Boon to Social Sustainability

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Abstract*: This paper discusses the dynamics of water resources management from unsustainability towards sustainability along with rejuvenation of age old ecological practices of water distribution in cold arid desert of Leh Town in Jammu and Kashmir, India. Being situated in the rainshadow area of the Himalayan region, the valuable water resources which are in shortage have been distributed equitably among the inhabitants through a systematic water distribution system prevalent from time immemorial. With the current changes in social and cultural mores the stress on water resources have been increasing which is contradicted by incorporating the modern methods of water resource conservation like watershed management in the area. Artificial glacier formation and afforestation drives in particular are also proving beneficial in restoring the sustainable practice of water resource utilization which is eco-friendly in every aspect. This has restored to a great extent the folkways surrounding the water resources especially irrigation in agricultural system which had lost sheen lately due to deficient water in the rivers. The social difference which had been made is very profound and immense particulary for the agricultural economy and reduced the reliance on groundwater completely which is being exploited at a very fast pace in the region without worrying about any repercussions in the overall environment. So this emphasizes to follow an ex-ante approach rather than an ex-post one ultimately balancing the equilibrium of environment and making resource utilization and conservation a parallel scenario thus restoring the balance of nature, society, economy in general.*

Key words: *cold arid, rainshadow, eco-friendly, watershed, afforestation*

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1. Introduction

Ladakh is precisely called the *cold desert* in true sense as it experiences an average annual temperature of around 4^0C from its Leh station and an annual precipitation mostly rainfall of around 96.4 mm in the east and 60 mm in the west.. Ladakh is a mountainous country situated in eastern part of the Kashmir valley. There is hardly any place in this region which is less than 2,500 meter high.

Water is thus a very valuable resource in such an arid area where the irrigation period is the short summer months mostly starting from the month of april-september and that too leaving the initial and final months for sowing and harvesting time. From time immemorial Ladakhis are living in-sync with the whole environment and exploring the meager resources judiciously for undertaking a sustainable livelihood.There is a regular flow of streams during summer seasons, which bring water from the glaciers. Water comes with great pressure from mountains causing gully formations. Ladakhis are expert in water harvesting, they make check dams for diverting water to their storage tanks. Storage tanks emanate small irrigation channels for irrigating individual fields [1]. Glacier melt water had therefore been the main source of water on which the main livelihood activities particularly irrigation and the related activities revolves. The current tides of *modernization* and *westernization* has bought changes in the present water dynamics with groundwater evolving as an important source of water especially in the Leh Town.

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2. Research Significance

During the earlier times the whole water management scenario was that of ecologically sustainable but the current diversion towards groundwater exploration is

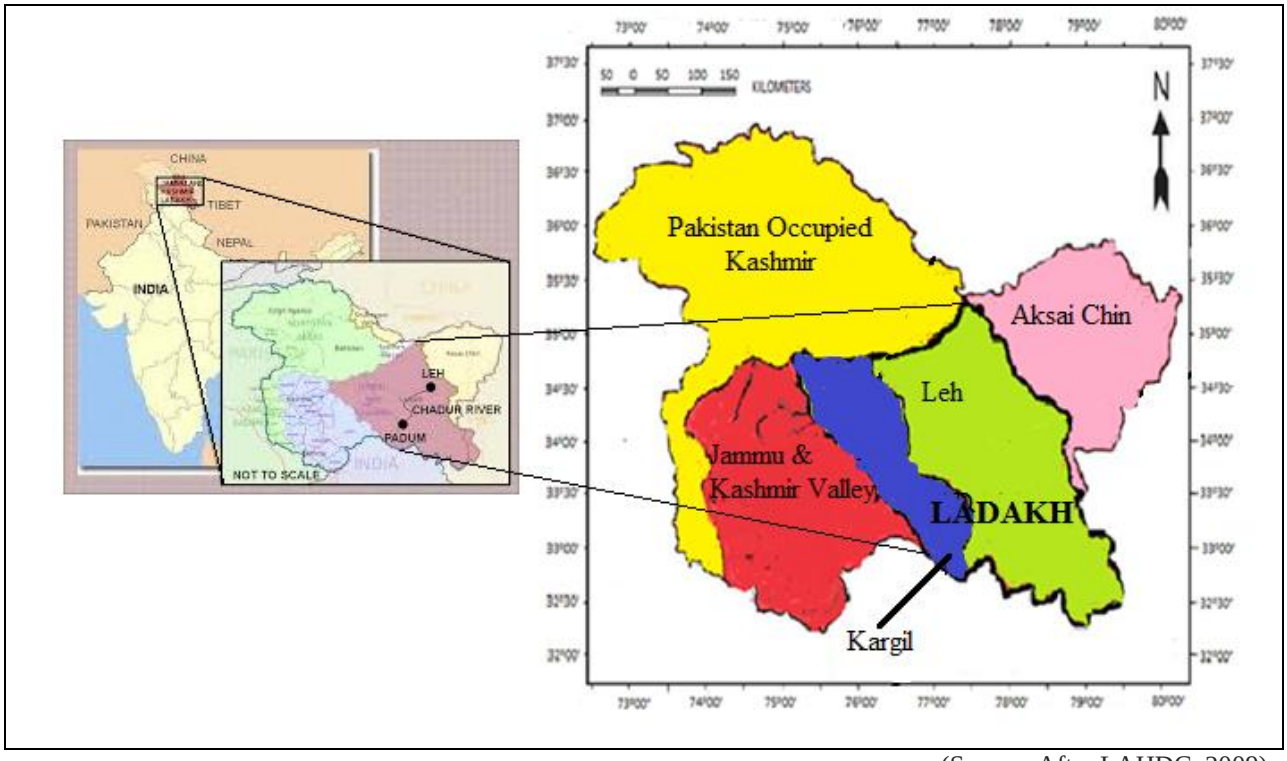
one of unsustainable nature with no proper guidelines on the exploration. Nowdays every commercial establishment in Ladakh particularly tourism based hotels, guest-houses and other tourism related estates have borewells. Drilling of a borewell is not regulated by any governmental organization except the non private ones. Thus the over reliance on groundwater is causing neglect of surface water bodies like streams and rivers and their pollution especially due to tourism propelled urbanization. The main aim of this paper is to highlight the sustainability aspect of the traditional water management practices along with the coupling of the new modern innovative and scientific technologies which will go a long way in solving the water woes of the study area thus paving an example for rest of the world.

3. Materials used for study

A detailed survey was undertaken among local people involved in traditional farming activities along with ample number of personal interviews of people of Ladakh particularly pertaining to the thickly tourism based urbanized areas of Leh Town. Statistical Handbook (2010-11) issued by Ladakh Autonomous Hill Development Council (LAHDC) [2]. Minitab 16 software for data analysis and representation. Field surveys along with expert suggestion of technical experts involved in building of artificial glaciers.

4. Study area intricacies

Ladakh is a part of the Central Asian Plateau a vast rocky cold desert, utterly deviod of natural vegetation. Leh District lies between $32^{0}20'$ N to $35^{0}15'$ N while 76°20′ E to 79°40′ E longitude Ladakh has a unique strategic location and touches international borders of Pakistan, China and Afghanistan (Fig. 1).



(Source: After LAHDC, 2009)

Figure 1 : Location map of the study area

Leh District lies in the region of Ladakh situated in the province of Jammu and Kashmir, India. The district is divided into 9 blocks and Leh Town is located in the Leh block of Leh District (Table 1).

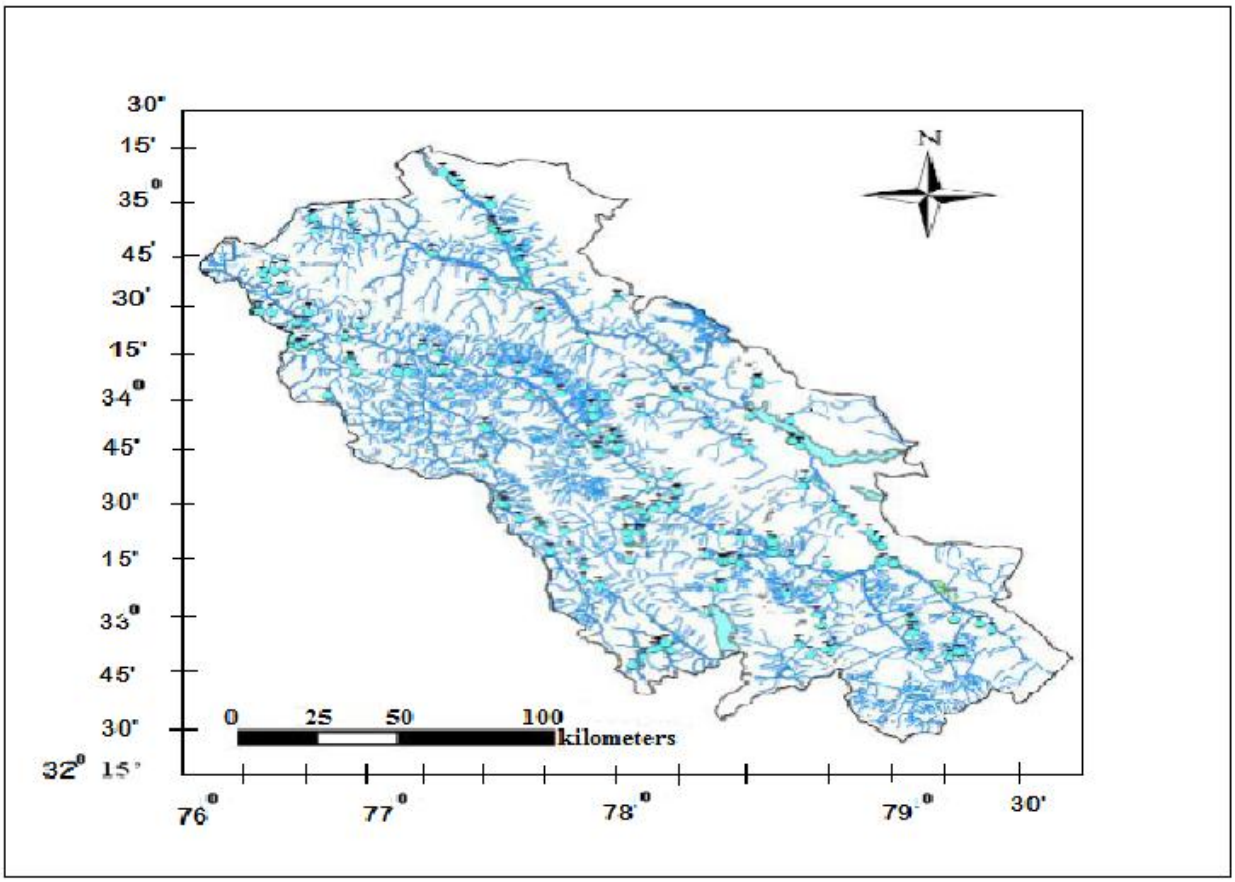
Table 1: Leh District at a Glance

S.No	Description	Reference Year	Magnitude
1.	Geographical Area	2011-12	45110
2.	Reporting Area	2011-12	51786
3.	Number of Tehsils	2011-12	03
4.	Number of Blocks	2011-12	09
5.	Number of Panchayats	2011-12	93

Table 2 : Distribution Channel

Main channel	*ma-yur*
Intermediate channel	*yu-ra*
Channel to field	*nang-yur*
Channel along top and sides of field	*yi-hu*
Channel down middle of a large field	*star*
Small near contour bunds across field	*nang*
Gaps on lower side of field	*tomik*
Control sluice by field	*ha (rKa)*
Stone for blocking sluice	*hardo (rKarDo*)
Sod or earth blocking sluice	*fang (sPang)*

The irrigation technology in Ladakh has been of very scientific nature from early times when agriculture developed in the region as early as tenth century A.D by the scholar saint Atisha [3]. Canal irrigation is a major testimony of scientific irrigation technology prevalent from a very early era. Wherever it is possible, farmers have skillfully diverted the water through construction of long canals, some of them running for few kilometres traversing through rocky mountains. These canals were constructed during early stage of the history of the region. The glacial melt waters form various rivulets called *kangs-chhu* (ice water) which join together to form a *togpo* (stream). Togpo water is discharged/diverted to a valley touching many villages, in which the main canal, called *ma-yur* (mother channel), is constructed. It is built along a mountainside that forms its retaining wall, and is lined with clay to hold the water. This may be termed the Ladakhi version of a dyke. Water from the *ma-yur* is further diverted into *yu-ra* (small canal), which irrigates the fields. The point from where togpo water is diverted into *ma-yur*, and *ma-yur* water into a *yu-ra* is called yurgo. Ska is the point from where *yu-ra* water is diverted to the field. Water in the ska is further guided through channels known as *snang*, which carry the water throughout the field (Table 2). The cultivated fields are generally on terraces and irrigation is through gravity gradient. Therefore, immense skill is required of the farmer to maintain the gradient of the field. The gradient should be such that it is neither steep nor flat, rather a gradient that allows smooth flow of water with enough seepage into the soil with negligible erosion [4]. The hydrology boasts of numerous surface water bodies due to the Himalayan glaciers (Fig. 2).

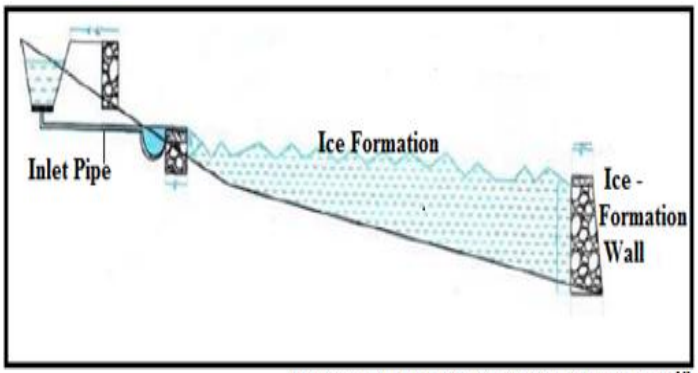


(Source : S.Gupta,2010)[5]

Figure 2 : Hydrological Map of the study area.

5. Artificial Glacier

The above distribution system is totally dependent on glacier melt water but due to the haphazard changes in precipitation patterns due to speculated climate changes and ever receeding glaciers the above water distribution system is in jeopardy. Here comes the role of scientific techniques like artificial glacier through which surface water can be harnessed in an cost-effective method ultimately keeping the ancient tradition of water management strong and viable in the current times innovated by a civil engineer of Ladakh, Chewang Norphel. Thus prevention of diversion and over exploitation of groundwater can be prevented to a much larger extent. Artificial glacier is a structure to retain water with a proper scientific design.



(Source : A.K. Garg, B.K. Singh and S. Kathju., 2009) [6]

Figure 3 : Artificial Glacier Design

The design of an artificial glacier structure is such that the head work of diversion channel need to be down in such a way that in the lean period i.e. in the month of November (when the discharge of the nalla reduces to the minimum level) it can enter the diversion channel simply by opening the head regulator gate, without blocking the main stream. The bed grade of the diversion channel should be steep enough as compared to normal channel bed grade. Through this arrangement the water does not block by freezing. First the water enters into the silting tank and after the silt settles down, the clean water will follow into the distribution chamber. In the distributing chamber pipes have been fixed interval of 5ft so that a smooth distribution water and be obtained. As soon as the water comes out from the pipe it starts to freeze. The number of pipes is dependent on the total volumes of water available for the particular stream. Finally as far as possible, it is essential to ensure that the water flows in small quantity with less velocity by spreading it over the entire area of the artificial glacier, so that it freezes instantly. If the water flows in one place, the volume and velocity of the water can be increased by forming bunds. On the other hand the terrain being very steep, the velocity of the waters to be very high with the result that instead of forming ice, it distorted the already formed ice. As such, regular monitoring of the water velocity/ formation of the ice is required.

6. Results and Discussion

An *exante* approach is a sustainable way for the management of valuable natural resources rather than an *ex-post* approach especially in matter of resources like water which is the medium on which our life exists. Integration of modern scientific technology particularly building of artificial glaciers with the age-old customs and tradition of water distribution prevalent in the study area is the answer to our current water crisis. Such types of innovative technology not only keeps our valuable indigenous knowledge intact but also helps in reinventing our great traditional culture and mores for the future generation. A boon towards prevention of groundwater over-exploitation and recharge. More research is necessary for artificial glaciers to be a viable option of water resources management in cold, high altitude regions. Ongoing artificial glacier projects are successful and serve their purpose well, but the technology that will be needed in future situations will be much different than the technology that functions today. Engineers must be able to integrate other forms of traditional and modern water resources management into current methods of artificial glacier creation. Additionally, more research must be put into ways of mitigating detrimental impacts of glaciers, such flash floods in the wake of breakage of glaciated lakes. Future programs must consider the challenges faced by planners, and come up with new ways to overcome these challenges. The world needs more sustainable methods of water resources management, and if enough time, money, and research are invested in its advancement, artificial glacier creation could be an integral part of the future of the world's water supplies. Along with an emphasis on revitalization of traditional sanitation practices which conserves water and utilizes waste as well [7].

7. Conclusion

The need of the hour is thus to have more innovative technology development in the future times and that too to integrate in such a way to make it more sustainable for the future generations to come. Artier is one of the building blocks which needs also improvement and more advanced development.

8. References

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