Analyzing the current situation of *Kuhls* and augmenting its integration with built environment: The case of Lower Himalayas

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***Abstract*— The paper primarily understands the context of *kuhls*, its significance and prevalence in the Himalayan belt civilizations. Kuhls or kools are natural resource cryosphere-fed communal water conveyance channel system and irrigation framework, local to precipitous Himalayan mountainous areas. They cater to the extensive ecological and geological emphasized role of underground water recharge, support the growth of riparian ecosystems along its course and soil conservation by decreasing the turbulent flow of water in perennial nalla. It is considered as Indigenous Traditional Knowledge System (ITKS) and has wired dimensions intertwined with sustainable development nuances of Environmental (Planet), Social (People) and Economical (Profit) considerations.**

In todays' rapid urbanization of Himalayan towns and growth centers, *kuhls* pertain serious threats to its deterioration via pollution and encroaching concretization construction practices. Observed change in the characterization, comprehension and contemplation of kuhls with transforming rural setup to urbanscapes, has hindered its core traditional coherence and ecological relevance. This has been proved and executed with substantial data collection by means of Participatory Rural Appraisal (PRA) tools and case study documentation. Naked analytical observation, photographs, open ended interviews and group discussions with the primary stakeholders were conducted. To protect and conserve the endangered kuhls and its abutting riparian ecological buffer, an attempt of awareness within the societal framework is vital and trivial. The paper sows' seeds for ideating methodologies for kuhls sensitive building byelaws norms and guidelines by allied professionals' collaboration and multidisciplinary research. Thus, the paper establishes itself as a call for contextual sensitive growth and development to foster vigilant citizens and concerned competent authorities building a sustainable and cohesively harmonious world.

***Keywords*— Kuhls, Himalayas, ITKS, Water channels, Groundwater recharge, riparian ecosystem**

I. INTRODUCTION

In mountain watersheds, irrigation has been practiced as an art for about 3000 years now. Historical records bear testimony to the existence of a number of irrigations works in different parts of the country. In the Himalayas, the perennial river Ganges made it relatively easy to divert its flow through inundation channels. In the hill region, the scope of boring tubewells, canals and even lift irrigation is limited. Such facilities are confined to the low laying areas. Therefore, the most common source of irrigation remains the small water channels locally called Kuhls. They account for 85.83 per cent of the total area under irrigation in hills. (*Chapter 2 - Soil and Water Management Techniques*, n.d.)

A. What are Kuhls/Kuls/Kools?

Kuhls or kools are communal water conveyance systems practiced in the Lower Himalayan belt region civilizations and settlements. Kuhls are local shallow surface channels found in precipitous mountain areas of Jammu and Himachal Pradesh, diverting water from naturally flowing streams (khuds) to cultivated fields for irrigation purposes. It is a community-based system of natural resource management framework. This cryosphere-fed kuhls irrigation system forms a major lifeline for agriculture and livelihood development in the Himalayan region (Ashraf & Akbar, 2020). A large number of mountain communities in the Himalayan region depend on glacier-fed kuhls system – gravity flow irrigation, for their sustenance (Ashraf & Batool, 2019).

Figure 1 Kuhls

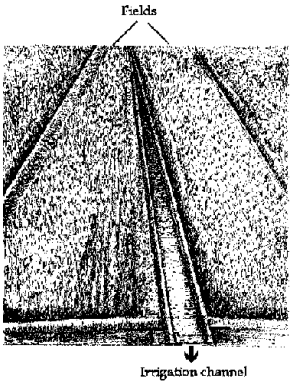


Figure 2 Well planned Kuhl irrigation water distribution system

Glacial water in cold deserts of Himachal Pradesh which forms the prime source of sustaining life in the region is brought to the field by making Kuhls (Water Channels) (Chapter 2 - Soil and Water Management Techniques, n.d.).

II. LITERATURE REVIEW

A. History of Kuhls

Kuhls (water channels) are built along the hill gradient for maintaining proper gravity for irrigation. The technique for the preparation of kuhls for irrigation purposes seems to have originated since Babylonian times, it is still one of the commonest ways of bringing water to the crops. In conversation with the local inhabitants, it came to the attention of the author that the kuhls, which are traditional irrigation systems, began functioning in the Himachal and Jammu regions under the supervision of local kings. These systems date back several centuries, illustrating a sophisticated understanding of water management that has supported agriculture in these regions for generations. Historical documentation and video evidence highlight the ingenuity and sustainability of these water channels, reflecting the engineering prowess and foresight of the rulers who oversaw their construction and maintenance.

B. Operational dynamics, science and mechanism

When the river has a steep gradient, the water diverted into a canal some distance upstream and led along a contour, it then flows to the fields by gravity.

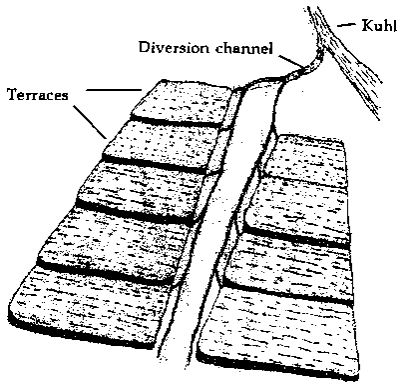


Figure 3 Kuhls existance and facilitation sketch

Figure 4 "Kuhls" - open channel irrigation system and adjoining agriculture fields

For the optimum harnessing of water for irrigation, water channels are constructed along the natural gradients. The irrigation channels (*kuhls*) are diverted from river tributaries by making use of the natural gradients thus the level of water is higher than that of the cultivated fields.

C. Construction and building materials

Traditionally and even now in the villages, these canals are made out digging land and pitching stones. They are built along the hill gradient for maintaining proper gravity for irrigation and running water mills (Chapter 2 - Soil and Water Management Techniques, n.d.). Earth, gravel, sand and stones configured the traditional method of construction with natural locally available building materials. The dimensions of its construction ranged from 2 to 1.5 feet in depth and 2-2.5 feet wide stretch. In dry temperate zones, kuhls, reform as wooden water channels, are generally made by making notches at the natural water sources and the water is diverted to the fields for irrigation to different terraces, using the natural gravitational flow of water. Since the topography of the area consists of very high slopes and rocky terrain, wooden water channels are used at many places as water passes from one place to another. In the lower areas of Himachal Pradesh, bamboo pipes are commonly used as irrigation channels on depressions/small nallah (Fig. 2.4). (Chapter 2 - Soil and Water Management Techniques, n.d.)

D. Ecological significance

Since these canals are unlined, they also recharge underground water through the areas it flows through seepage. They also support the growth of riparian ecosystems along its course. Kuhls also contributes in soil conservation by decreasing the turbulent flow of water in perennial nalla with indigenously developed management practices.

E. Socio-cultural significance

The water from the kuhls is also used to wash dishes, clothes and livestock and for drinking purposes too. It also caters to other livelihoods to the communities and families that run the watermills (Gherats) and the shepherds (Gaddis). Since the water mills run without electric power and operate with the force of water, the community gets to grind grains at a really low cost.

F. Economical aspects

Water from the kuhls is provided free of cost to the villagers, reflecting the agrarian-centric livelihood and mass population adherence in the region. These traditional irrigation systems are crucial for sustaining agriculture, which forms the backbone of the local economy. The kuhls ensure equitable distribution of water, fostering community cooperation and supporting the economic well-being of the village inhabitants. By facilitating access to essential resources at no cost, the kuhls play a vital role in maintaining the agrarian economy and enhancing the overall quality of life in these rural settlements

G. Agricultural contexts

Kuhls poses sustainable agriculture development in the mountainous region (Ashraf & Akbar, 2020). Farmers in the region since time immemorial have been using this kuhl system for irrigation. As a result, they produce a wide variety; major cereals to off-season vegetables - augmenting their productivity and income. In the arid arenas, agriculture livelihood of the communities depends on ice-melt water from high mountain glaciers which are highly vulnerable to changing climate (Ashraf & Akbar, 2020).

H. Flooding of glacial water for higher crop productivity and irrigation scheduling

Water is brought in channels from glacial melts for irrigating the fields. Flooding the fields with the glacial melt for improving crop productivity is also common. The deposition of fresh silt with un-weathered minerals (especially lime) from glacier sources of freshwater manages the soil fertility by removing toxic salts. The glacier melted water, often below 2°C temperature, also protects the crops from different kinds of diseases. Standardized irrigation schedule for different crops is followed (Khosla et al., 2018). Flooding with glacial water on the one hand removes the toxic substances and on the other hand acts as a disinfectant against pathogens.

I. Constitutional binds

Historically, the water channels were built and managed by the villagers as a united community shelf with no government assistance. Now, with the constitutional and legislative bodies into play, kuhls water rights, management and executional power controls lie in the hands of state local competent authorities (municipalities and panchayats). Kuhls are regulated under their respective geographic state laws and institutional rules and regulations. For instance, kuhls in Jammu come under the jurisdiction of "Jammu and Kashmir Water Resources (Regulation and Management) Act, 2010" - an act to consolidate the law relating to use of water, the measurement, construction, control and management and "The Jammu and Kashmir Irrigation Act, 1978", Act No. 10 of 1978, an act to provide for regulation of irrigation and drainage and for levy and assessment of water rates and matters connected therewith. (Jammu and Kashmir Irrigation Act, 1978, n.d.). In Himachal Pradesh, "The Himachal Pradesh Minor Canals Act, 1976", (Act No. 42 of 1976), published in the Himachal Pradesh Gazette (Extra-ordinary) dated 29th November 1976 vide notification No. 6-72/68-LR, dated 27th November, 1976, Government of Himachal Pradesh, Public Works Department - an act to make better provision for the control and management of minor canals and to provide for the levy of water charges thereon in Himachal Pradesh. (Himachal Pradesh Minor Canals Act, 1976, n.d.)

J. Community management framework

Participatory management is employed for distribution of water. The majority of the hamlets, which lie on the plateaus on the sides of Main River, get water from the streams which trickle down from the cliffs over-handing the plateaus. (Khosla et al., 2018). The water is led from field to field. This is a time-tested community mode for sharing the glacial water by making kuhls for ensuring cent per cent irrigation in otherwise dry and porous soils. The Kohli community plays a vital role in the management and maintenance of kuhls. Traditionally, they are responsible for overseeing the distribution of water, ensuring the channels are clear and functioning, and mediating disputes related to water usage. Their stewardship is essential for the efficient operation of these irrigation systems.

K. Kuhls – part of Indigenous Traditional Knowledge System (ITKS)

This indigenous knowledge, developed and adapted as a result of years of practical experience, continues to be in the process of evolution for the urge of better and sustainable livelihoods (Khosla et al., 2018). These ancient irrigation channels, designed and managed by local communities, post multiple trial and error attempts, ranging over generations of experimental knowledge accumulation, in understanding and developing these energy and resource efficient methodology and mechanism, exemplifying sustainable water management practices.

L. Kuhls – indigenous to Lower Himalayan civilisations

In intermediate and hilly regions of Jammu division, traditional community constructed and managed irrigation channels are used which provides sustainability to the efforts of water conservation and existing farming systems. These are locally known as kools and the system of irrigation is known as kool system. This system deepens a mature and adjustable social set up and thus has significant social implications. Farmers get sufficient timely and reliable water supply. Increased cultivation of new commercial crops and vegetables including high yielding varieties has extended the use of agricultural land and intensified the demand for water for irrigation purposes. The farmers are growing off-season vegetables using water distributed through the kool system in addition to the routine cultivation of major crops of the area. In Arunachal Pradesh also there is a tradition of such irrigation practices which are followed by the village community as a whole in carrying water from streams over large distances. Traditional methods of water conservation have also been reportedly being applied in the Silti Woreda area of Ethiopia including indigenous drainage ditches. (Slathia et al., 2016)

III. RESEARCH ESTABLISHMENTS

A. Need of the study

The inhabitants of the Himalayan belt have rich traditional knowledge concerning their crops, livestock and environment acquired through generational experience and experimentation with local resources. There is need to reinforce the traditional ethos and to build up a conservation society living in harmony with nature and making frugal and efficient use of resources guided by the best available scientific knowledge. Documentation of indigenous technologies of Himalayan civilization with regard to land, soil and water management, will go a long way in understanding, refining and assessing the technologies for the eco-economic rehabilitation. It will open the scope for scientific investigation of many sustainable technologies which are in vogue for the prosperity of the region and for which scientific explanations are not available (Khosla et al., 2018). Urban executions lack sensitivities for kuhls ecosystem and its inherent originality. Vivid awareness and knowledge gap in the urban neighborhood and implementation attitude of urban local bodies alarms the importance of this research paper.

Kuhls manifestation as nallahs in the emerging urban contexts, denotes their depletion and risked extinction by prevalent threats to its loss of existing utilization, optimization and interpretation. Henceforth, kuhls with their subtle flowing water sound, calls out loud for its aligned institutional setups and rearrangements for its revival and rejuvenation.

B. Scope and limitations of the study

From all the desktop study and literature review data skim through, it is clearly imperative that there has been accumulative previously research done and addressed its agricultural and anthropological dimensions. Future scope of the study branches out to more research seeking into its technical and analytical research database formation/ formulations and collection/ accumulation and findings. Currently in this chapter, due weightage has been done on qualitative comparison obtained adhering to naked visual observations. There is more expected technical data base required and sought out for future explorations and paves niches for more nuanced research areas.

IV. RESEARCH METHODOLOGY

Extensive field trips were made to verify the information; village walks with the community members were conducted to physically witness the structure and functioning of kuhls. Finally, a semi structured interview schedule was devised and administered directly only to those respondents who possess the skill in the construction of indigenous irrigation channels. This was followed to ensure that the correct knowledge regarding the construction and maintenance of this traditional irrigation system is collected for more accurate results for the researchers. The information collected was documented properly for reference and further replication of the traditional technology in the areas having similar topography.

To obtain and derive a vivid picture of the current situation and scenario of kuhls two case studies were been undertaken

1. Palampur, Kangra, Himachal Pradesh
2. Reasi, Jammu, Jammu & Kashmir (UT)

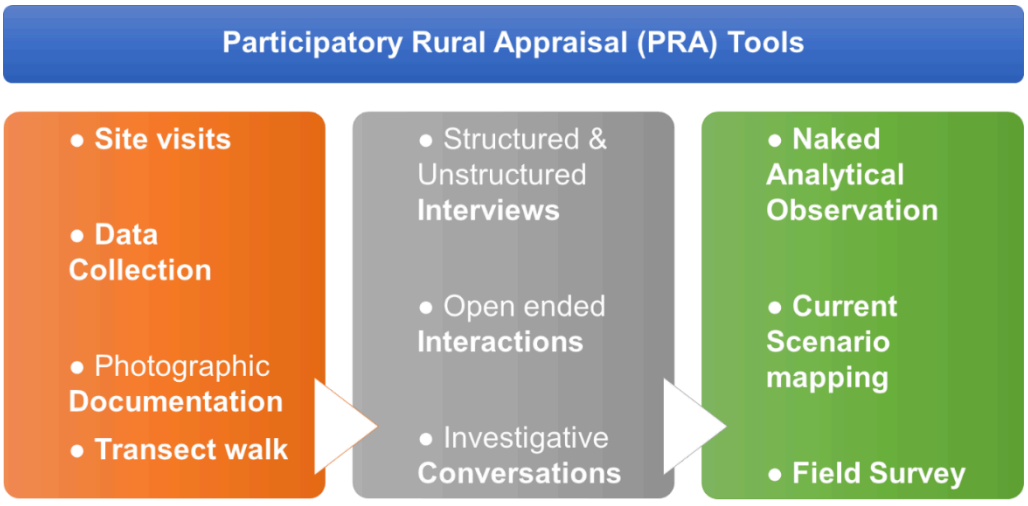


Figure 5 Research methodology flowchart

The selection of locations for the case studies fulfills the criteria mentioned by (Ridder, 2012): convenience, access and geographic proximity. Observed change in the characterization, comprehension and contemplation of Kuhls within the society (residents, competent municipalities/ authorities) with changing and evolving / transforming rural setup/onset to city/urban to peri-urban scapes, thus losing its core traditional coherence and relevance. This has been proved and executed with substantial data collection via photographs and RPtools, involving open ended interviews and group discussion with the primary stakeholders. Participatory Rural Appraisal tools that involve the approach that aims to incorporate the knowledge and opinions of rural people in the planning and management of development projects and programs.

The study involved a comprehensive approach to understanding the traditional water conveyance system of kuhls, integrating both primary and secondary data collection methods.

1. **Discussions and Interviews**:
    - Conducted structured and unstructured open-ended interviews.
    - Engaged in guided conversations with various stakeholders, including residents, farmers, and local officials.
    - Utilized semi-structured interviews, group discussions, and transect walks to gather insights.
2. **Literature Review**:
    - Undertook a close scrutiny of existing literature on traditional technologies as a preliminary step.
    - Reviewed agricultural articles and journals to understand the historical and current relevance of kuhls.
3. **Field Surveys and Observations**:
    - Carried out intensive touring and interactions with farmers and local residents.
    - Conducted site visits and observations to uncover nuanced, practical dimensions of the kuhls.
    - Employed photographic documentation and direct observation for data collection.
4. **Consultation with Locals**:
    - Engaged with the community to capture generational knowledge and experiences.
    - Acknowledged the locals' role in developing and adopting the concept of kuhls.
5. **Environmental and Conservation Approach**:
    - Adopted a sensitive environmentalist and natural conservationist perspective throughout the study.
6. **Data Synthesis and Analysis**:
    - Mapped the current scenario of kuhls in relation to their traditional management and water conveyance system.
    - Analyzed the ecological and social implications to propose sustainable development strategies.

The integration of these methods provided a holistic understanding of kuhls, emphasizing their importance in sustainable water management and community livelihood.

V.DESCRIPTION OF STUDY AREA

A. The Himalayas

The Himalayas, a colossal mountain range stretches for over 2,400 kilometers (1,500 miles) across India, Bhutan, Nepal, China, Pakistan, Afghanistan, Tajikistan and Myanmar (fultonk, 2011). It is a geological marvel harboring unique landscapes, flora, fauna, and cultural experiences, holding immense geographical and ecological significance. The mountains exhibit distinct characteristics and variations in vegetation and climate with increasing altitude. This formidable landscape, with its diverse ecosystems and iconic peaks like Mount Everest, can be broadly categorized into three distinct zones based on their height ranges: the Foothills, the Lesser or Lower Himalayas and the Great Himalayas. From the bustling foothills to the awe-inspiring peaks, the Himalayas put forward glimpses into the beauty and power of nature. (Manish & Pandit, 2018)

Table 1 Himalayan Altitude Ranges (feet)

Himalayan Segment	**Altitude**
The Foothills & Tarai	Up to 1,500 meters (5,000 ft)
The Lower or Lesser Himalayas	1,500 - 5,500 meters (5,000 - 18,000 ft)

The Great or High Himalayas	5,500 meters (18,000 ft) and above

Source : (Apollo, 2017)

The glaciated region consists of numerous high mountain peaks, glaciers and lakes scattered at various places. Water for irrigation is derived primarily from snow or glacier melt diverted through farmer constructed gravity-flow systems (Ashraf & Akbar, 2020).

B. The Lower Himalayas: Target study area

Categorized on the basis of different gradient altitudinal zonation. upper, middle and lower reaches of the mountainous slopes, two locations had been selected due to preferential reach and accessibility to the sites.

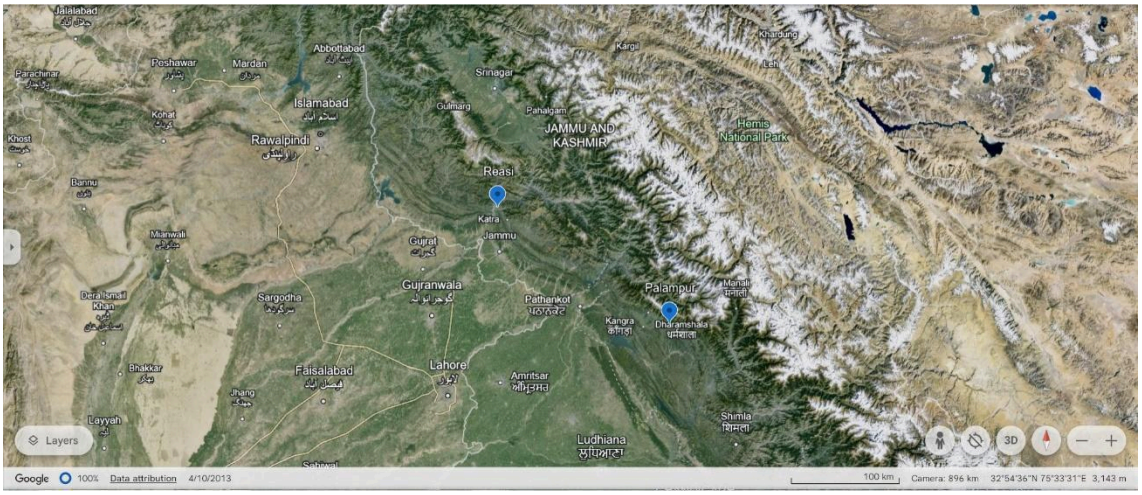


Figure 6 Locational mapping (Reasi and Palampur)

Table 2 Parametric background comparison (Palampur & Reasi)

Parameters & Description		**A. Palampur**	**B. Reasi**
Locational mapping	**City/ Village/Town**	Palampur	Gran mohr
	District/ Region	Kangra	Reasi, Jammu
	State	Himachal Pradesh	Jammu and Kashmir (Union Territory (U.T.))
Landscape	**Geography**	Dhualadhar Ranges	Shiwalik Ranges
	River stream	Neugal Khadd	Chenab River
	Valley	Chenab valley	Kangra valley
	Elevation	Approximately 600 meters (2,000 feet) above sea level.	Approximately 1,220 meters (4,000 feet) above sea level.
City/ town characteristics & visual fabric	**Description**	● picturesque landscape, nestled amidst the Shivalik hills. ● Rural ● Underdeveloped district ● The town features traditional architecture, bustling markets, and vibrant cultural heritage. ● Reasi's visual fabric is marked by ancient temples, lush green surroundings, ● The Chenab River, creating a serene and scenic environment.	● Lush tea gardens, pine forests, ● stunning views of the Dhauladhar range. ● The town's visual fabric is a blend of colonial architecture, vibrant markets, and serene landscapes. ● Its pleasant climate and natural beauty make it a popular tourist destination.

VI. FINDINGS & OBSERVATIONS

Over the years, earthquakes and floods have repeatedly destroyed villager's *kuhls*. More recently, increasing non-farm employment has drawn labour away from *kuhls* maintenance. Emigration of the younger generations to urban areas for availment of education and occupational opportunities have led to drastic loss of knowledge transfer within the community. They are misapprehension dumped with garbage and trash Concretization - use of concrete, has led to reduced water percolation and hampered ground water recharge and emerging/ calling for situation and possibilities of flooding/ hill urban

The intrusion of concrete and impervious building materials disrupts traditional water management systems like kuhls by altering natural water flow and reducing soil permeability. Material consciousness is essential in urban planning to maintain ecological balance. It involves selecting sustainable, permeable materials that preserve natural water channels and promote effective water management.

Kuhls play a crucial role in enhancing ecosystem resiliency and protecting communities by harmonizing with natural drainage systems. Their design respects and utilizes existing water channels, effectively mitigating the risk of extensive floods. By leveraging gravity and the natural altitude difference—from hilltops or glaciers to lower fields—kuhls facilitate a steady, self-sustaining flow of water without the need for external energy inputs. The kinetic energy required for water distribution is naturally derived from the potential energy of elevated sources, ensuring zero energy consumption and promoting ecological balance.

Table 3 Qualitive Comparison of current scenario in upcoming Himalayan towns

REASI	PALAMPUR

Figure 7 Photographic documentation of Kuhls deprecated condition (Reasi and Palampur)

VII. DISCUSSIONS,AND ANALYSIS

A. Pertaining threats to existence of kuhls

But unfortunately, during the past few decades there has been an appreciable divergence from the traditional systems resulting in environmental degradation and decline in socio-cultural values. Indigenous knowledge is being overshadowed by modern culture and looked upon as backward, irrational, mostly labour intensive, lacking scientific reasoning and documentation.

Regenerative and traditional environment-friendly practices were and are still being replaced by capital intensive modern technologies (Khosla et al., 2018).

It will open the scope for scientific investigation of many technologies which are in vogue for the prosperity of the region and for which scientific explanations are not available till date. It will further help in conservation of rich traditional knowledge hitherto practiced but now the most threatened resource of dry temperate region (Khosla et al., 2018).
During the literature online/ online repository of data on and about *kuhls*, only deals with – majority were from /the study aspect/ domain of agriculture and irrigation methods – into the fields, majority of the data was obtained from the researchers of agricultural sciences, in specific to irrigation methods, indigenously enticingly practiced in the Himalayas.

Under such conditions of unequal distribution of contribution of labour for maintenance, the farmers lost interest in participation in the maintenance with the increase in non-farm employment among the villagers. The water user associations or the *kuhls* committees appoint a water master (Kohli) for enforcing the rules for the distribution of water, solving water disputes as well as for maintenance and repair of the system. However, Kohli's authority has also been eroded. Now the coordination between the head and the tail end farmers has decreased because of increase in non-farm employment. (Sharma et al., 2015)

B. Increasing Non-Farm Employment and Decreasing People Participation

The rise in non-farm employment opportunities has led to a decline in local participation in the management and maintenance of kuhls. As individuals shift towards alternative livelihoods, often in urban or industrial sectors, the traditional community involvement in these irrigation systems diminishes. This reduction in participation affects the sustainability and efficiency of kuhls, as fewer local hands are available for upkeep and operation. Consequently, there is a growing need to adapt and innovate the management of kuhls to address the challenges posed by changing employment patterns and ensure the continued efficacy of these vital irrigation systems. The younger generations are emigrating from the region to urban hotspots for job and livelihood occupational opportunities. Thus, loosening the string of traditional and generational knowledge transfer. This reduced and diminished social sensitivity is clearly visible from the current scenario, executional management, parched outlook of kuhls.

C. Climate Change

Researchers and authors have highlighted significant ecological hazards to kuhls irrigation systems due to glacial retreat. An assessment using the [methodology name] hazard tool, as detailed by Ashraf et al., was employed to analyze the impact of glacial retreat on the Himalayan ranges of Pakistan. This methodology underscores the necessity for similar research in the Indian region, particularly in the Hindu Kush-Himalayan mountain ranges, to evaluate and address potential impacts on kuhls.
The *kuhls* irrigation system is highly vulnerable to climate change impacts like glacier retreat, glacial lake outburst floods, snow avalanches and landslides especially in the upper Indus Basin (UIB) (Ashraf & Akbar, 2020). The author emphasized and analyzed on the risks of glacier depletion, lakes outburst flood, snow avalanche and landslide hazards impacting cryosphere-fed *kuhls* irrigation system in 10 river basins of the UIB of Pakistan. combined effect of reduced snow precipitation and rising warm temperatures.
A depleting glacier Chungphare, eastward of Nanga Parbat has highly influenced the melt-water supplies to nearby Tarishing valley in the Astore basin (2017). The retreat of Passu glacier resulted in abandoning of its associated villages in the south owing to drying up of the *kuhls* (upper Hunza valley) (Ashraf & Akbar, 2020). Thus, in order to combat climate change's vicious impacts over the Himalayan civilization and settlements scape, its high time for all of us as a society at large to promote, adopt and practice sustainable hill development mechanisms. The depletion and retreat of glaciers often result in disruption of melt flows to *kuhls* system, which ultimately impacts the agriculture as well as livelihood of the local communities (Ashraf & Batool, 2019). The lesser sustainability of glaciers in the Himalaya basins like Astore and Jhelum would apparently be compensated by monsoon and change in rainfall pattern. A regular monitoring of the glacier resource and utilizing advance water conservation techniques would help in coping with negative impacts of down wasting of glaciers and provide long-term support to *kuhls* irrigation system in the Himalayan region in future.

D. Anthropological/ community resource management studies and framework proposals

The stresses within *kuhls* regimes which manifest as declining participation, increased conflict, and the declining legitimacy of customary rules and authority structures (Baker, 2008). Differential stresses of increasing nonfarm employment on gravity flow irrigation systems (*kuhls*s) in Himachal Pradesh, India. By fragmenting common dependence on agriculture, increasing nonfarm employment has created stresses within *kuhls* regimes which manifest as declining participation, increased conflict, and the declining legitimacy of customary rules and authority structures (Baker, 2008).
As a solution to reprography, the author gathers insights from current theories of common property resource systems to guide the development of an inductively derived explanatory framework. The framework accounts for the temporal and spatial variation of *kuhls* regimes in their degree of role specialization and organizational formalization, and the extent of state involvement in *kuhls* management (Baker, 2008). (Vyas et al., 2018) Agronomists have been undertaking studies in Palampur, command area of Lower Baijnath irrigation channel (*Kuhls*) to assess traditional irrigation systems and to explore the possibility of increasing farm income through optimum utilization of available farm resources. The study clearly highlighted scope for doubling farmers ’income through adoption of improved technology, diversification of farming system with cultivation of profitable vegetable crops, adoption of hi-tech ventures like protected cultivation and inclusion of improved dairy animals as

suggested through optimized model plans. The primary data were collected from sample farmers through a personal interview method using a pre-tested survey schedule. Around 71 percent of the area was irrigated by fetching *Kuhls* water on demand.

VIII. PROPOSALS FOR SUSTAINBLE SOLUTIONS

A. Kuhls integrated master planning

Kuhls Integrated Master Planning is a comprehensive approach to strategic project management and development. It involves a holistic methodology for planning, coordinating, and executing projects across various stages and disciplines. This approach ensures alignment with long-term goals, optimizes resource allocation, and enhances efficiency by integrating multiple planning elements into a cohesive framework. By incorporating advanced tools and techniques, Kuhls Integrated Master Planning addresses complexities and interdependencies, fostering better decision-making and adaptability. This strategy not only improves project outcomes but also aligns with organizational objectives, leading to sustainable success and a clear pathway for future growth.

B. A Sustainable way forward

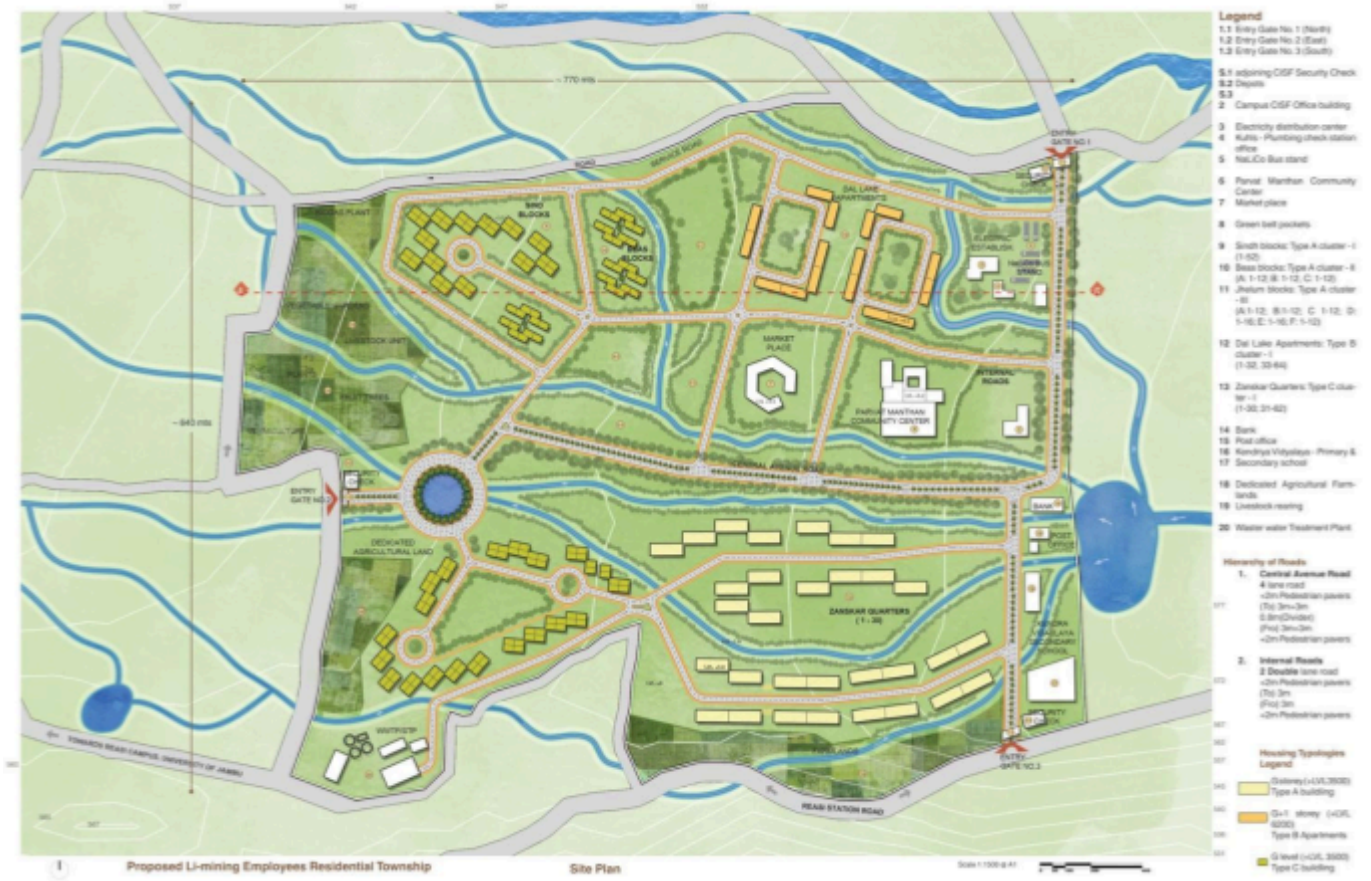
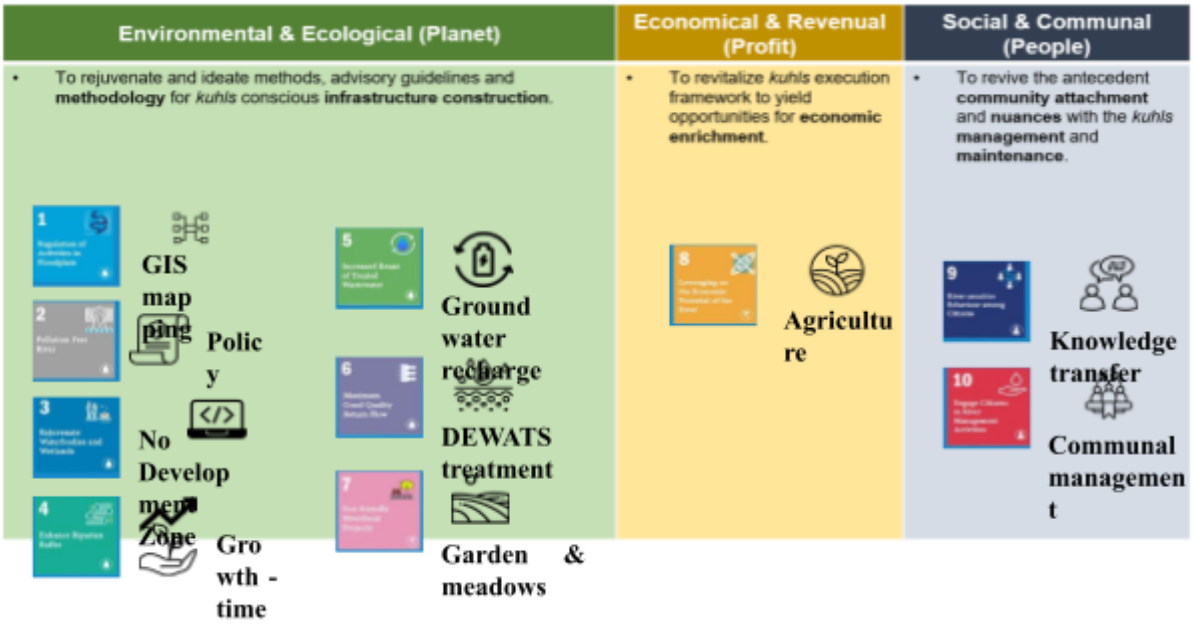


Figure 1 Kuhls integrated master planning - prototypic design proposal

Consultation to master & town planning organization,
Adherence with URMP objectives



IX. CONCLUSIONS AND INFERENCES

Thus, appreciated awareness initiatives are needed from the competent local bodies regarding their heritage indigenous traditional knowledge base within the invasive modern aspirations. Integrating kuhls into urban infrastructure offers a sustainable approach to residential water management. Designed to capture and distribute rainwater, kuhls reduce runoff, enhance groundwater recharge, and mitigate flooding risks. They serve as green infrastructure to foster biodiversity and add aesthetic value, contributing to the restoration of urban river ecosystems. This community-driven strategy promotes a harmonious coexistence between human settlements and the environment, instilling environmental responsibility. Engaging residents in kuhls construction and maintenance inculcates conscientious water natural resource usage and conservation. The research advocates for rejuvenation, revival and restoration of the traditional kuhls, aligning them with housing settlement master plans for sustainable urban river system management, combating climate change and pollution.

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DECLARATION OF CONFLICTING INTERESTS

The authors declare that there is no conflict of interest regarding the publication of this paper

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