Enabling Appropriate Technologies for Water Management and Improved Livelihoods in the Remote Uttarakhand

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Key words: Gharats, Microhydel, Roof Rain Water Harvesting Tank (RWHT) and Solar power

ABSTRACT

Mountain environment requires appropriate technologies that are locally suited and resilient enough to encompass ecological balance and sustain livelihoods of the local population.. In the light of the above, Himmotthan Society[1] has worked on a few concepts such as *Gharat* (traditional water mills), Roof Rainwater harvesting and Solar Powered pumping. The present contribution encompasses the pilots on innovative technologies enabling improved quality of life, drudgery reductions and sustained income opportunities to rural communities whilst the constraints encountered during the pilots and scale up strategy. Broadly the paper covers **three case** studies which could further be explored and discussed.

[1] Himmotthan, Dehradun, is a non- profit organization, registered under Societies Act 1860, primarily working as a nodal agency to implement, monitor and coordinate The Tata Trusts' Himmothan Pariyojana in the central Himalayan region of Uttarakhand and Himachal Pradesh.

INTRODUCTION

Rural communities in the Himalayan region have always relied on biomass energy for domestic uses and hydropower, animate energy, human muscle power for mechanical works such as milling grain, ploughing fields, and transporting goods. However, various studies[2] have shown that the present pattern of energy supply is not sustainable to meet the increasing energy requirements due to the rapid increase in population and the growing aspirations of mountain communities for better living standards.

Since ages, the Himalayan people have developed indigenous devices in the form of watermills, locally known as *gharats* to harness hydro-energy – a renewable source of energy. Around 15,449 traditional watermills (*gharats*) have been estimated in Uttarakhand. Of these, 65% are in operation, 25% are run seasonally, and 10% are reported to be defunct[3]. However, in recent years, many of these were being abandoned by the *gharat* owners because of very low income, institutional issues and tough competition from more effective diesel powered mills in nearby towns[4].

STUDY AREA & METHODOLOGY:

In previous years many efforts were made on up gradation of *Gharats focusing mainly on the technological aspects*, however, the institutional and enterprise issues were untouched. Himmotthan Society initiated a pilot project primarily focusing on three aspects (i) Institutional arrangement; (ii) Drudgery reduction; and (iii) Enterprise promotion. An initial survey was conducted in 2011 and 40 odd *Gharats* were identified in the area at various stages. Finally two units at Ganeshpur and Bon villages in Uttarkashi district were selected for piloting.

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[2] Rijal, K. Energy Use in Mountain Areas- Patterns and Trends. In: Energy Use in Mountain Areas: Trends and Patterns in China, India, Nepal, and Pakistan. ICIMOD, Kathmandu, Nepal.1999; 19-48.

[3] UREDA, Uttarakhand Jodha, N.S. Adaptation Strategies against Growing Environmental and Social Vulnerabilities in Mountain Area. Himalayan Journal of Science. 2005; 3 (5):33-42. Kumar, P. Development Dilemma in Uttarakhand-Can Microhydels be a Solution? Wastelands News, SPWD, New Delhi, 1998; (2): 23-33.

[4] Paish, O., Armstrong-Evans, R., Saini, R., Singh, D., Kedia, D., The Development of Traditional Himalayan Watermills for Achieving Sustainable Village-Scale Micro-Hydropower. First International Conference: Renewable Energy-Small Hydro' Hyderabad, India. 3-7 Feb 1997.

Photo - 1 Gharat owner using traditional watermill in Ganeshpur, Uttarakashi

Traditional Watermill (Gharat)

The indigenous watermill technology has evolved from local designs and is based on local materials with low capital cost, negligible running costs, and easy maintenance. The slow speed of grinding also ensures that the flour does not loose its nutritive value. Thus, the *gharat* is generally set-up along the bank of a perennial stream close to the village. The aspects of safety, slope gradient, and distance from the village are taken into consideration at the time of installation of *gharat*. The water of the stream is diverted through a diversion channel (*gool*) up to the site of the mill-house, which is generally constructed at the point where a waterfall of 2 to 6 meters is achieved from the channel. A long wooden chute consisting of an open channel made either of wooden planks or carved from a large tree trunk is narrowed down towards the lower end forming a nozzle. The force of the water let through the chute strikes the blades and rotates the wheel, which in turn, rotates the wooden shaft. The average power output of a *gharat* ranges from 1.0 KW to 1.5 KW and the grinding capacity ranges from 4-8 kg flour per hour depending on water availability and types of grains (*Photo- 1).*

Apart from the technological aspects, *gharats* also have important social dimensions[5]. Although, the *gharats* are owned and managed by individuals but, these are considered a common property of the entire village. Traditionally, the village people have been contributing voluntary labour to

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5 Ramesh C.Sharma, Indigenous Device for Sustainable Development of Renewable Hydro-energy in Uttrakhand Himalayas

the *gharat* owner at the time of its installation/repairs and in return the *gharat* owner used to grind grains free of cost on the occasion of social and religious ceremonies of the village. The *gharats* are operated on barter basis; *gharat* owners collect grinding charges in kind (generally one-tenth part of the ground material). This technology is so simple and widely accepted that every person including children, and women can operate *gharat* even in the absence of the owner. *Gharat* also played an important role in sharing of learnings and dissemination of information among the people, as the *gharat* has been the meeting point for villagers since ancient times.

The study has also revealed that generally there were more than two *gharats* in each village depending on population and availability of suitable sites for installation of *gharats* earlier up to 1970s. Presently, only 25% families of Ganeshpur and Bon are using *gharat*. In migratory villages, all the families are dependent on market for purchase of wheat throughout the year, while, in the semi-migratory and permanent villages, 80-85% families are dependent on market for 7-8 months. These families either purchase wheat flour directly from the market or purchase wheat grains from the public distribution shop (PDS) or private ration shop or depend on diesel mill for grinding.

All *gharat* owners of Ganeshpur and Bon village belong to the category of marginal farmers, the average land holding of these families vary from 1 to 2 acre. The income of traditional *gharat* owners from the *gharats* varies from Rs. 2,000 to Rs. 2,800 per month, average monthly grinding was around 19 quintals, monthly operational days were 15-18, and generally they used to grind wheat, which is insufficient to fulfill their families' basic food requirements. Therefore, apart from running traditional watermills, the *gharat* owners are also engaged in other activities (agriculture, woollen works, livestock rearing, labour, etc.) to meet out their daily needs. Considering the annual aggregate income from milling, agriculture and livestock farming, the *per capita* income of a *gharat* owner's family varies from Rs. 66-93 per day. Due to under utilization and poor financial output from the *gharats,* the owners of these mills are loosing interest to operate and maintain the *gharats*.

Lesser Dependence on Traditional Gharats

The results of the attitudinal survey of *gharat* owners in the project sites reveal that a number of factors related to socio-economic, technical and policy issues and resource availability are responsible for decrease in number and efficiency of *gharats* in the respective areas. Most important factors identified are:

- Increase in migration of the people from villages and adoption of other occupations (business, service, contractor etc) against agriculture especially in lower valleys villages.

- Increase in road network and availability of diesel mills at local market places near the road head.
- Decreased availability of skilled labour for setting up new *gharats* and repairing of existing *gharats.*
- Decrease in community spirit for sharing of labour in the installation/repairing of *gharats,* unavailability of required timber for *gharat*.
- Decrease in spring water flow and low outside support for improvement/modifications in the traditional *gharat* technology.
- Decrease in productivity of subsistence crops and increased dependence on market for ration.
- Changes in feeding habit, preference for wheat flour over coarse millets, and
- Insufficient income from *gharat* and increased dependence on other sources of income.

Himmotthan's Initiative for Up-gradation of Traditional Gharats and Practices:

The pilot was designed to provide technological inputs, institutional support and enterprise promotion. Two *gharats* were selected in Ganeshpur and Bon villages in Uttarkashi. The technical support was provided by Himalaya Trust, who have requisite skill base on the technology. The *gharats* were installed and tested in 2011, following which a series of trainings were provided to the *Gharat* owner and village institution named as *Vinayak Water Based Enterprise Development Federation* formed in June 2011.

Improved Gharats for Milling: During this pilot two improved *gharat* have been developed, primarily to increase the milling output of the traditional *gharat*. The up-gradation of traditional *gharat* for mechanical purpose involves replacing the open wooden chute with a PVC pipe and spear valve and replacement of the wooden runner with a steel casting and ball bearing which fits under the existing mill-house and the same millstone could be used for grinding. New house was constructed having sufficient storing capacity and working space.

Photo -2 New House and Improved Gharat in Ganeshpur

These modifications increased the efficiency of traditional *gharat* by 40 to 50%. A few key outcomes are as below which have been compared against the baseline data collected at the time of inception of the pilot.

***Improved Gharats for Electrification*:** Another type of modification in the traditional *gharat* has been done for mechanical plus electricity generation. This type of modification is appropriate in those *gharats,* where adequate flow of water and head are available to produce at least 5.0 KW of power at the shaft. The major modification is the replacement of wooden runner with cross flow turbine. The main turbine components consists simply of cross-flow runner (one-piece casting), shaft bearings and housings, cast bedplate and drive pulley. The turbine is attached to an alternator for electricity, generally for lighting and to other machine directly for grinding, threshing, oil extraction, etc.

In Ganeshpur, Uttarakashi one *gharat* has also been improved to produce 4 K W electricity. The electricity generated by the up-graded g*harat* was used by the villagers for organizing last year's Ramlila in the village. During the past year the *gharat* was run to its full capacity for six months and overall 840 families are being benefited from the *gharat.* The operation and maintenance procedures of improved *gharat* are simple and are carried out with locally available resources and expertise. *Vinayak Water Based Enterprise Development Federation* is responsible for all Operation and Maintenance (O&M) and collecting monthly changes from the families for O&M and all assets are insured.

Key points associated which limit upscaling and wider usage of improved *gharats*, are as follows:

a) Although, after modifications, the grinding efficiency of the upgraded *gharats* increased up to four to five times, there is no substantial increase in the quantity of food grains availability for grinding because of constant decrease in the land area under cultivation and productivity of subsistence crops. Hence, there is a very little increase in the income of the improved *gharat owners* from grinding. Therefore, for long-term sustainability of the *gharats*, in addition to upgradation of *gharats,* it is equally important to strengthen forward and backward linkages of *gharats*.

b) *Gharats* are owned by individuals; therefore, it is entirely dependent on *gharat* owner's interest to upgrade the *gharat*. Moreover, the economic benefit of improved *gharat* mostly goes to the individual family rather than the community. Traditionally, the *gharat* owner used to collect grinding charge in kinds, which was very convenient for the poor families and in return, these families used to contribute free labour to the *gharat* owner at the time of repairing of *gharat*. However, after making improvements in the *gharats*, the *gharat* owners started collecting grinding charge in cash, which is almost equal to the diesel mills. This would weaken the age-old social inter-linkages of village people associated with the *gharats*.

c) *Gharats* are generally situated at a distance of 1-3 km from the village, in isolated places, especially along the banks of rivers/streams, which are highly inaccessible. Traditionally, village people carried food grains on their back for grinding. Upgradation of *gharats* on such sites would be uneconomical because of unavailability of road/transportation facilities; it would further increase transportation charges.

d) The energy generated from the improved the *gharats* is best used when the larger part is consumed on the spot as mechanical energy, without the intermediary of electricity generation and transmission. This is applicable to decentralized agro-processing, sawing, and water lifting, etc. However, *gharats* are generally situated far from the village in this situation; it is uneconomical to take the energy up-to the village because of transmission losses and high unit costs.

CASE -2

This note highlights the relevance of Rooftop Rainwater Harvesting in Chured-Dhar village, Tehri District of Uttarakhand

More erratic and extreme rainfall events lead to longer dry periods sometimes and high water availability at other times in the hilly region of Uttarakhand. Owing to the longer dry periods, available water sources are no longer sufficient, and groundwater levels have dropped even further, resulting in longer distances to fetch drinking water. This confirms the importance of efficient and effective storage of as much water as possible during the rainy seasons. Rooftop Rain Water harvesting is a traditional practice that dates back hundreds of years, is relatively cheap to implement as compared to gravity piped water scheme. Storage in above-ground Ferro-cement tanks is a technically viable option. In general, Ferro-cement tanks have an estimated lifespan of 15 to 20 years, provided the systems are well-maintained. Since 2001, Sir Ratan Tata Trust (SRTT) supported Water Supply and Sanitation (WATSAN) program is providing potable water supply via gravity piped water supply where source/spring is available and Rain Water Harvesting Tanks (RWHT) where the source/spring is not available and rainfall rate is up to desired mark.

Intervention:

Village Chured-Dhar in Tehri District, Uttarakhand is such a village where no gravity source was available. Keeping in mind the average 1,395 mm[6] rainfall in the district, the village was selected in 2003 for RWHT intervention under Himmothan Pariyojana, 59 individual households, RWHT were constructed with community participation having a capacity of 7,000 liters. Post the project intervention, water demand during most part of the year is satisfied from harvested rainwater. Hence, all efforts are being made to collect quality rain water from roof run-off. The following technical and management strategies are being used to satisfy the water demand; (i) Collection of rainwater from the roof; (ii) Cleaning the roof at least twice a month and prior to every rain (especially during the intermittent-rain period). Also more frequent cleaning of the roof during times of high winds; (iii) Having a filter at the bucket installed at the roof of the tank pipe interface and use of the first-flush device effectively; (iv) Cleaning and refitting the filter before the wet season; and (v) Chlorination of the rain water stored in the tank. All these strategies are adapted to maintain the quality of water for consumption purposes. However, when water depletes in the tank, households adopt water-conserving practices and also engage in bringing water from other sources, such as hand pumps fitted on the road head, usually for washing of clothes and for bathing. During scarce period some hoard water at home in barrels for other household chores besides drinking. This indicates that even during water-scarce periods good quality of drinking water is available in RWHTs.

[6] Central Ground Water Board Report 2009-10

RWHT has fulfilled their requirement of water, several independent reviews have reported that all RWHTs installed in the village are well maintained and are in effective use. The nearby communities are also demanding such programmes for their village. Women drudgery is reduced by several hours which they earlier used to spend on fetching water for domestic purposes. Village children's attendance especially of girl child has increased in the school, village households are spending less amount on medical bills. During the wet season when surplus water is available villagers use the surplus in maintaining their kitchen gardens. Communities have their own strategies to meet their water demand effectively.

Key issues associated with upscaling of the model:

- Some time people are reluctant using RWHT water for drinking, even after chlorination.
- Rainfall is very erratic, hence difficult to estimate the water demand/availability.
- Limited availability of local skilled masons to scale up the model to other households, post the project intervention.
- Land and local material availability, there is no effective institutional arrangement, as RWHT is individual owned.
- Non availability of loan product/ Financing model by mainstream banks to promote RWHT.

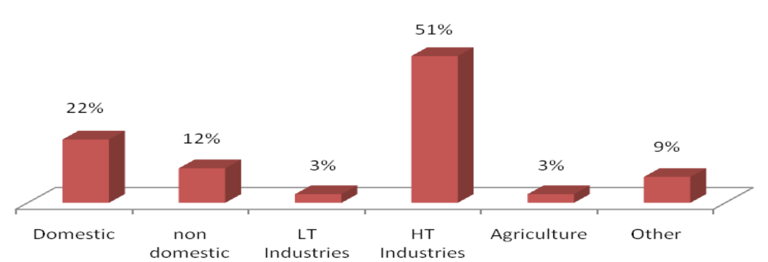
Case -3

Solar Energy is a boon for marginal farmers. This pilot is at its final stage of testing and as this is linked to case-2 hence, worth discussing:

Rationale: Energy is central to all development and economic growth. Almost all forms of conventional sources of energy have been known to cause serious problems pertaining to ecological and environmental issues and natural resources depletion. It is now a well-established fact that there is significant relationship between the form of energy and its consumption pattern in the rural households. The time spent in the collection of firewood and biomass and its traditional mode of utilization for meeting domestic energy needs are the major contributors of drudgery, misery and health problems among rural women and girl child.

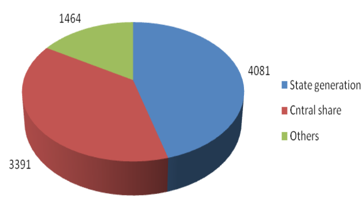
Power scenario in the state: Uttarakhand has a potential of generating up-to 20,000 MW power through hydro projects against which only 3,164 MW has been harnessed so far. Currently there are 45 hydro power projects of different capacities being operated by public and private sector. The state policy for small hydro projects up to 25 MW was revised in January 2008 to include power projects based on Biomass, Solar Energy, Wind energy,

Fig. 2.1 Electricity consumption



Geothermal power etc. in addition to hydro power. Despite the great potential of generating power, Uttarakhand is net importer of power, but generates seasonal surplus. The demand for energy is increasing day by day. During an eight year period from 2002 to 2010 the energy consumption has grown more than five times in the state. Sources of energy supply and consumption pattern based on the use for the year 2009-2010 is indicated in the fig 2.1 and 2.2.[7]

Fig 2.2 Share of electricity



Project Intervention: Solar power is an important, although currently underutilized, energy resource in India with the potential to offer an improved power supply (especially in remote areas, Uttarakhand could be one of them) and increase the security of India's energy supply. On an average, the country has 300 sunny days per year and receives an average hourly radiation of 200 MW/km^2.

Taking into consideration the solar potential, The Trust/Himmotthan with collaboration of First Solar and Tata Power Solar is implementing a pilot in Tehri district, which is nearing completion. Himmotthan Society is leading the process of implementing the pilot, along with the local community. The pilot would cater to 45 households benefiting 225 people. Community contributed about 10% in the form of cash/labour against capital cost needed for various construction works and would take over 100% operation and maintenance. The current pilot project is focusing on 182 mts single lift which would primarily address to drinking water issues.

Village Chured-Dhar in Tehri District has been selected for this pilot where in 2003-04 through Trust support 59 RWHT were constructed under Himmothan Pariyojana and Village Water Management Committee was formed. The committee is actively involved in this pilot and would ensure 100% O&M post project. This project is a part of Himmotthan's integration and cluster approach (bringing in multiple inputs to a cluster to improve the quality of life).

Expected Outcomes: Village households would access 40 lpcd water everyday; (ii) promotion of clean energy system, which would need low O&M; (iii) pilot would open avenues to promote sustainable irrigation to promote agriculture in a cluster based approach; and (iv) installation of solar system would lead to benefits such as achieving cleaner environment.

[7] Source: UERC 2009-2010, It is clearly evident that state is generating only 4,081 MU electricity which is 52% of its power needs from its own sources.

Key findings: Solar energy has immense potential, although currently underutilized in India, it has potential to offer an improved power supply to remote villages where grid electricity is not available, whilst offering easy O&M facilities. It is further advisable to develop medium size projects which could further be divided into following sub categories (i) up-to 40 mts; (ii) up-to 60 mts; and (iii) up-to 100 mts. Projects should be design on multiple functioning such as Drinking water, water for animals; and water for irrigation (micro irrigation).

CONCLUSION

Within Uttarakhand, there is a marked inequality vis-à-vis development indicators between the hills and the plains. The hill districts palpably lag behind; development has predominantly been in the plains, whilst all the hill districts have subsistence farming as their main economic activity. Due to subsistence livelihoods, migration and a remittance economy are predominant in the hill districts. They are land-locked, with huge distances between the markets and resources. Keeping in view these constraints, promotion of appropriate technologies aimed at using local resources to augment livelihoods of the hill people in a sustained manner and improve their quality of life should be the major focus of all rural development programmes especially those in remote locations.

Further, the dependence of village people on non-commercial energy sources such as fuel wood is very high while the share of commercial energy is very less in the total energy demand pie. The usage of renewable energy sources such as biogas, solar in the hill regions is still insignificant as compared to its potential. Increase in degradation of forests cover, especially closer to settlements is not only as a result of inappropriate forest management practices, but also due to a lack of alternative sources of energy for cooking, home heating, and lighting. It is therefore, important to promote a mountain sensitive energy planning and implementation process to supply energy for growing population without a detrimental impact on ecology.

Historically, the people of the area have been using hydropower energy from the perennial stream and rivulets through indigenous watermills (*gharats*) for grinding. The efficiency of traditional *gharats* can be increase up to 5 KW *gharats* by minor technical modifications as discussed in sections above. These improved *gharats* can play an important role in terms of meeting domestic, commercial and industrial energy demand of the scattered villages. For sustainability and wide replicability of improved *gharats,* it is also important to strengthen the institutional and forward and backward linkages associated with traditional *gharats.*

Water management through innovative technology such as RWHT and solar pumping can be used as a full package, which can help promote wise use of water and help improve productivity whilst ensuring potable water supply to remote locations excluded from the grid electricity. Proper institutional mechanisms which could take care of O&M once project period is over should be an integral part.