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A Case Study from the Western Himalayas

Abundant rivers, streams, rivulets, and lakes are found in the Indian mountain region; ultimately, they flow down to meet the water needs of the population residing in the plains. Adequate efforts have not been made to harness the water resources that originate in the Himalayan region in order to address the increased need for small-scale energy for local use and sustainable livelihoods among the population living in remote and inaccessible mountain areas. Most of these areas are still without electricity, which plays a vital role in the development of any society. There is a need to ensure that local communities can benefit from energy just like people in the plains: they need to be empowered to tap and make the best use of local water resources, based on traditional knowledge of techniques to do this and improvement of time-tested technologies for better efficiency. This will allow them to produce added value and enhance their livelihood options.

Traditional watermills: dying wisdom

Traditional watermills have been in use in the Indian mountain region since time immemorial. This eco-friendly device that harnesses waterpower for local production is a symbol of local technical excellence and the traditional wisdom of the people inhabiting the mountain region. In India, experts estimate that the watermill originated somewhere in the northeastern region around the 7th century AD. The system worked harmoniously with nature for over 2700 years and is abundantly scattered across the

FIGURE 1 View of a traditional in-house watermill structure with water channel. (Photo by author)

Himalayas (Figure 1). The widespread use of watermills and their popularity owed much to their simple and cost-effective mechanism.

According to one estimate, there are nearly 200,000 watermills in the Himalayas from Uttaranchal, Himachal Pradesh, Jammu and Kashmir to the northeastern states of the country. In Uttaranchal alone there are about 70,000 watermills. As mentioned above the design of traditional watermills is centuries old. Their low output (5–10 kg of flour per hour) does not provide enough profit to the owners today.

In recent years, watermills have thus started to fall into disuse. This is probably also because they were serving only the remote rural communities of the Himalayan region and their potential remained hidden or was neglected. In the absence of appropriate technology, watermills were not used for any purpose other than grinding wheat, maize, and rice. The importance of watermills was further overshadowed by the introduction of diesel and electricity powered mills, and the inclination of the people towards high-speed grinding machines. Moreover, owners of traditional watermills were often forced to descend to the plains to seek more lucrative employment. They were unable to do anything to save their watermills.

The present article discusses the technology model developed and being replicated in Garhwal Himalaya, which has shown potential for improving the efficiency of traditional watermills, not only for flour grinding, but also to produce electricity to meet local energy requirements and promote multipurpose use of decentralized power and enhance local income.

Upgraded watermills: inducing economic potential

A watermill is a traditional device run on the principle of using the kinetic power of a water stream running on a gradient. Traditionally, the mill functioned in a single mode to grind flour. Watermills in the present discussion are upgraded as follows:

- Promotion of multiple uses of water for income generation; in particular, use for power generation and processing of agro-produce;
- Introduction of modern technology to ensure acceptability in the community;
- Ensuring that local repairing is possible;
- Promotion of local manufacture for larger multiplication and creation of employment.

Models using such modern technology have been developed by the Himalayan Environmental Studies and Conservation Organization (HESCO) in Dehradun, a science- and technology-based NGO. These models have won community approval and are widely accepted, as shown in the case study presented below. Their technology in terms of water use and management (upgraded watermills, agro-processing and electrification, nursery management, beekeeping, etc) has been standardized for hilly conditions.

The turbine is simply an upgraded local design. The new system replaced the wooden water wheel with a cast steel runner mounted on a steel shaft. The flat wooden fins of the water wheel have been curved to harness maximum energy (Figure 2). To allow free rotation of the wheel, a single steel ball bearing is used at the bottom of the water wheel, increasing efficiency to a significant degree. The other parts of the watermill—such as flumes that bring water from channel to turbine; wheels attached to the turbine to obtain the appropriate number of revolutions per minute for electricity generation; and other agro-processing applications such as dehusking and flour grinding—were upgraded depending upon the quantity of water and head availability.

A ball bearing instead of an axle increased efficiency by 70%, while innovations in the blades brought an increase of 120%. Altogether, these measures have increased the power and efficiency of the traditional single mode system to a significant degree, by 80–90%. Such changes have inspired improvements in numerous watermills across the Indian mountain region to generate power commercially and put it into grids (Figure 3).

FIGURE 2 Traditional wooden water wheel (top) and upgraded steel wheel (bottom). (Photos by author)

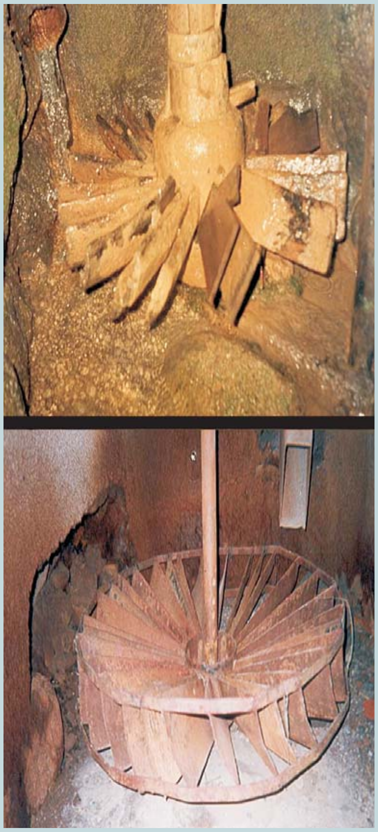

FIGURE 3 New steel runner and covered flume leading to much higher efficiency in using water power. (Photo by author)

Integrated technology model for multipurpose use

Given the abundant availability of land and water in the vicinity of improved watermills, water-millers have been encouraged to initiate floriculture-related activities linked to beekeeping for income generation. Low-cost bee boxes (which make use of the stems of the locally available invasive weed *lantana*) have been developed and introduced. It was found that 2–10 bee boxes can be maintained easily at one watermill site, which gives a return of about Rs 26,000 (US$580) per annum to the water-miller or local villagers who market honey.

Since water is an essential component for mills as well as for fisheries, a composite fish culture was made part of this integrated model to get the maximum advantage from available water. A tank of 1000 square feet (~93 m^2) was constructed, and

TABLE 1 Technology inputs and adoption factors of the improved watermill model (3–5 kW) for decentralized power generation and multipurpose use.

Upgraded technology/ new components	Multipurpose use (activities)	Adoption rate	Cost–benefit impact (in US$)		People's contribution
			Input	Output	
Watermills					
• Cemented channel • Flume covered with aluminum sheet • Change in runner or turbine • Use of single ball bearing • Stone dressing	• Flour grinding • Rice dehusking • Cotton combing • Power generation	**High** (increased output performance: > 6–8 times)	810–900	1130	• Land • Labor • 25% input cost with repayment of bank loan in 3 years
Other components					
• Fishery	• Carp breeding	**Medium**	225	495	• Land • Labor • Seed fish
• Nursery	• Ornamental plants and vegetables	**High**	45	225	• Land • Labor • Seed
• Apiculture (2 boxes with frames per family)	• Alternative use of *Lantana*, an invasive weed, to make bee boxes • Quality honey production	**High**	85	95	• Land • Labor

after appropriate treatment, different types of carp were introduced. The advantage of carp is that they are in demand, accepted by local people, and fetch a good income for pond owners and mill owners. This is not the first time they have been introduced and cultured in the region. In addition, integration of vegetable and ornamental plants in areas measuring ~90 m^2, with assured irrigation from the water channel of a watermill, provides further returns to water-millers and the local community. These activities are seasonal and can be integrated and managed locally.

The whole technology package of water management has focused on the watermills, which are abundant and scattered throughout the Himalayas. Technological upgrades with small and affordable changes have improved the functional efficiency of the watermill in a user-friendly way to generate power. Besides providing shaft power, watermills can now be converted into electrical generating systems that can be used by villagers for lighting at night and operating small-scale industry in the daytime. The entire scheme of integrated use of water shows how a water stream can be useful to the local community through various applications. Specifications for an integrated watermill package, including adoption factors, technology flow, and development indicators, are given in Table 1 and Box 1.

Community empowerment: adopting technology to improve livelihoods

Considering the economic incentives for households and communities as a whole, the adoption of this multipurpose model has had an important impact on socioeconomic conditions. Successful adoption of this model using modern technology has been reported from about 100 locations in Western Himalaya alone, while development agencies in other mountain regions are adopting it in remote villages with the support of extension agencies and the army. Enterprising millers who had set up diesel and electric mills are now switching over to the improved watermill model because of cost-effectiveness, multipurpose benefits, and the environmentally friendly way this system functions. Technology flows from village to village and other Himalayan regions were found to be very effective and efficient, but it was noted that this requires initial stimulus and continuous encouragement from local NGOs and development groups to empower communities with a complete technology package in partnership mode, ensuring forward and backward linkages.

A success story

According to Lal Singh, a resident of Dokwala Village located 25 km from Dehradun in Uttaranchal, a traditional watermill—the only source of livelihood for his family—was not able to meet all of the family's needs. Using the traditional mill system, they were able to grind only 10–15 kg of grains per hour. This did not even compensate for the labor input. With help and technical assistance provided by HESCO, he upgraded the watermill and the nearby site by adopting the multipurpose model:

"We adopted the improved watermill model and began to grind 25–30 kg of grain per hour, or 2–2.5 quintals per day. We also began to market our own flour in 10-kg bags with the brand name Jan ahar. Now, we have large numbers of consumers. The system has never troubled us and we find it economically viable, as a one-time input of Rs 36000 (US$ 810) has given us a return of Rs 6000 (US$ 135) per month. This covered my input costs within six months."

As a result, rapid technology adoption took place by upgrading 2 other watermills in this village. With good coordination among 3 mill owners and the village community, the entire village is now electrified, whereas it had earlier been without electricity. Watermills are running 8–10 hours a day for grinding flour, dehusking rice, or combing cotton. At night these watermills provide lighting. Three mills with a capacity of 2–3 kW each are meeting the electricity needs of a dozen families in Dokwala Village through innovative application.

This village is now a model for the entire Himalayan region. The good thing about this upgraded model is that it can be locally repaired. One-time low investment, and added value combined with

BOX 1

Technology flow

- *Extension to local artisans and unemployed youth*
- *Village-to-village in other Himalayan regions*
- *Creation of multipurpose common facility centers*

Development indicators

- *Human resource development*
  Local skills development (masons, blacksmiths)
  Local employment and prosperity
- *Natural resource management*
  Clean, eco-friendly energy
  Value addition by agro-processing
  Generation of additional income
- *Facilities*
  Electricity
  Communication facility
  Irrigation facilities
- *Socio-cultural values*
  Check on migration
  Conservation of traditional wisdom
  Local empowerment and self-dependency

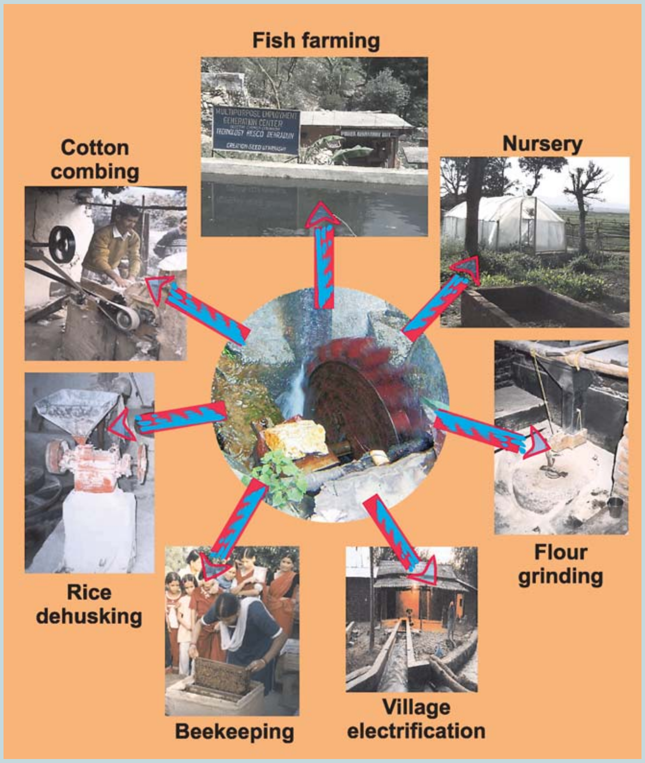

FIGURE 4 The integrated watermill model, showing how a stream can become a multifunctional source of power and community development. (Photos by HESCO, Dehradun, and author)

high income and employment opportunities, are other important factors in adoption and technology flow, as indicated in Table 1. The watermills have been in operation almost 5 years now, and have had some minor breakdowns, but people are able to repair and manage upgraded mills and other activities locally.

This study clearly shows that a community responds quickly to new income-generating opportunities and readily adopts new activities for economic benefits. Lal Singh, and other families in the village, are now making use of surplus water for multipurpose activities such as nursery cultivation, fisheries, and apiculture near watermills. This integrated technology model has empowered local communities to manage and make sustainable use of local resources, thus reducing the risk of migration to seek income-generating opportunities (Figure 4).

Impact assessment demonstrates that simple upgrading of watermills has impacts for both the water-miller, who can sustain and improve a declining business, and the end user, who saves time and money. This is particularly true for women, who previously had to wait for long periods to grind flour.

Replicability and outlook

This evidence suggests that if improved watermills could be directly used to generate power across the Himalayas, local power needs could be sufficiently met while surplus power could be transmitted to far-flung and remote mountain areas through small hydropower grids. Indeed, upgrading of existing watermills in the Indian mountain region would lead to considerable power generation, considering that each watermill has the capacity to generate 5 kW of power. It is estimated that 2 million people—or nearly 500,000 families with 4 members each—could directly benefit from technological upgrading of watermills and related activities.

The multipurpose use of this field-tested technology model, with careful approaches to innovation and transfer, can play an important role in the overall development of local areas in terms of commercial activities. For traditional activities in the mountains, there is a need to strengthen the knowledge, skills, and infrastructure already available and scale them up in a business model, in order to bring significant impacts in terms of better output and efficiency. A range of skilled and unskilled employment opportunities for pre- and post-installation services related to electricity supply and mechanical and civil work can be generated. If properly pursued, this opportunity would provide immense employment opportunities to local young people in mountain regions, who are currently migrating to bigger cities or industrial areas in search of jobs.

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The views expressed here are those of the author alone, and do not reflect the views of the organization to which he belongs.

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