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Waterpower Technology in India: Traditional Knowledge

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Introduction

One of the areas in which India's traditional knowledge systems have developed and survived from pre-historic to contemporary times is that of the development and management of water resources. In the context of South Asia, a wide variety of engineering and water-related systems were developed at different geographic locations over different periods. Though the early history of the watermill in India is obscure, the ancient Indian texts dating back to the 4th century BC refer to the term cakkavattaka (turning wheel) and subsequently different forms of water lifting devices. According to Greek historical tradition, India received water-mills from the Roman Empire in the early 4th century AD. Around 1150, the astronomer Bhaskara Achārya observed water-raising wheels and imagined such a wheel lifting enough water to replenish the stream driving it, effectively, 'a perpetual motion machine'. The same machine has given rise to Traditional watermills, which have been in use in the Indian mountain region since time immemorial. This 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 BC. The system worked harmoniously with nature for over 2700 years and is abundantly scattered across the Himalayas.

Water-lifting devices in ancient India: Origin and Mechanism

As it is in modern times, agriculture was one of the main industries in ancient India. Irrigation has been one of the chief needs in developing agriculture. The oldest evidence of the existence of water-lifting devices is furnished by the 'scored pottery' unearthed from the Mohenjo- Daro and Harappa excavations. In the opinion of Sir John Marshall, they were made for attachment to an appliance for raising water, similar to the modern use of water-wheel in Near and Middle East.

Mention of wells, canals and dams in the Vedas indicates that Vedic Aryans did not depend on rainfall alone for agriculture. Besides artificial devices, in areas where natural supply of water was scarce, people had to depend solely upon deep-sunk wells. The hymns of Ṛgveda and Atharva Veda mention aveta signifying a well, aśma chakra which was a mechanical stone wheel device for drawing water from deep wells as well as ghaṭi-chakra or ghaṭiyantra for lifting water.

As early as the fifth century B.C., mechanical devices, worked by animals, particularly bullocks, were known and used in India. In Aṣṭadhyāyi, Pāṇiṇi, the celebrated grammarian, has mentioned the yugavaratra to mean the yoke and the rope or strap by which the bullocks were driven for raising water. He has also described two types of wells, the karkandhu and the shakandhu, the latter being a type of water-wheel probably used by the Śaka tribe. In order to lift water from wells during irrigation, udamchana, a large earthen bucketwas used.

During the reign of Chandra Gupta Maurya there was an elaborate system of irrigation as is attested by Kauṭilya'sArthaśāstra and the Indica of Megasthenes. Megasthenes has described at length about the facilities provided for irrigation, while Arthaśāstra records the variation of water- rates with the modes of irrigation, which were four in number, viz.

* *Hastaprayartima* - drawing with the hands and carrying it to the fields in pitchers, etc.,
* *Skanda* - the shoulders or the necks of bullocks,
* *Śrotoyantra* - a mechanism for lifting water in channels flowing into the fields,
* *Udghāṭam* - the water-wheel for raising water from river, etc.

Bhoja's *SamarāṅgaṇaSūtradhāra* describes a few types of water machines (vāri-yantras), but does not provide a systematic classification of all of them.

Water lifting mechanisms were prevalent in the southern part of the Sub-Continent from the very early centuries of the Christian era. The application of water-lifters and other simple devices in South India is mentioned in the following Tamil works such as

- * *Ahanāṇūṛu,* a *Sangamliterary* work,
- * *Maduraikāñchi,* one of the ten Idylls *Pattuppāṭṭu.* Here it is mentioned that *tev* and *edā,* denoting palleaf baskets, were responsible for the continuous water-logging in the paddy fields.
- * *Silappadikāram and Maṇimēkhalai,* the two Tamil epics. In the former, the poet *Illaṅgo Adigal,* while giving a detailed account of the *Kāvērí* describes the modes or devices of irrigation, particularly the bucket, the water-lifts and palm-leaf baskets,
- * The *Periyapurāṇam,* a compendium of biographical sketches of the 63 *Śaivanāyanārs* (saints), also makes reference to *edā-pēridā-k-kollamun-kavitu.* Here the term *pēridāstands* for a 'large basket'.

A number of early Tamil epigraphs mention *ēttapuḷam* and *ēttapādam* to categorize lands irrigated by means of picotahs (water-levers). Depending upon the extent of wet-fields under irrigation, *kuṛṛēttam* indicates 'small picotah' and *pērēttam* stands for 'large picotah'. An epigraph from Tiruvoṛṛiyūr (Madras) of PallavaKampavarman tells of *Tengēriinnilattirkēnālēttameduppadāga,* the cultivable lands on the banks of the tank *Tengēri,* to be irrigated by four picotahs. Another record from the same place of the Pallava king Aparājita mentions about 'the land irrigated by two large picotahs' which by their description must have irrigated large area of land. It also refers to two *jala-yantra* (water-levers), which were apparently added as additional means of irrigation in the village. The Rāyakoṭa plate of Skandaśiṣhya (fourth year) records that such water-levers were also known as *ētta-ppādam.*

In the light of all literary and epigraphic evidences, the methods of irrigation employed by the ancient Indians can be arranged under three broad heads as follows:

Intermittent or discontinuous water-supply from streams, canals and wells

The three types, the basket, the bag or bucket moved by pulley-wheels and the water from wells by animal power, come under this category.

- * *Basket* - There are definite instances as proof of the widespread use of baskets, in ancient South India. Piḷā or edā, otherwise known as iṛaikūdai in Tamil, was a basket specially employed for bailing out water from deep channels or streams to nearby fields. It was knitted out of palm-leaf to get the required shape of a basket (kūdai), with a thin rimmed wide mouth and a shallow bottom. The common utilization of palm-leaf baskets, in ancient South India, as it is done even today was due to the easy availability of palmyra trees and that the baskets were fairly leak-proof and durable. In the Northern region its use was completely absent probably because of the non-availability of palmyra trees.
- * *Pulley-wheels* - The earliest reference to ancient Indian pulley-wheels of stone or wood, similar to those used in modern times, found in the Ṛgveda was known as aśma chakra. Here the water was raised by a wheel (chakra) of stone (aśma) with a pail (kōśa) attached to it. When raised it was poured into troughs (āhāva) of wood. In the Tamiḷ country, the wells fitted with such pulley- wheels for drawing water from them were known as kiḷār. Among the devices invented by the ancients, the pulley-wheel was the simplest one for practical purposes. It was a one-man job to draw water from the well for increasing the flow of water. It is thus obvious that the pulley and rope gave rise to the 'mhōte' of Northern India, which was used for irrigating fields, the rope being drawn by bullocks.
- * *From wells by animal power* - Irrigation from wells by means of animal on draught-plane came to be known and practiced in ancient India as early as the fifth century B.C., as indicated by the word *yugavaratra,* meaning the yoke and the rope or strap by which the bullocks were harnessed for raising water from wells. Though it is clear that harnessing animals to the task of drawing water from wells had been conceived early, as is evidenced by the mention of *skanda,* meaning the shoulders or the backs of bullocks in *Kauṭilya'sArthaśāstra,* yet no ancient representations are traceable of a beast pulling up the bucket. Since *kapilai-ēttam,* the water from wells worked by bullocks is not mentioned either in early *Tamiḷ* works or in the numerous inscriptions of South India, it may be assumed that this important method may have been introduced in South India with full improvements, at later

stages as an additional means of distributing water for irrigation.

In a typical bullock mhōte, a pair of bullock move down from the slope, specially constructed to the wall of the well, lifting behind them a bucket or a leather bag which is discharged into the connecting channel by means of a rope. After discharge, the bullocks walk up the slope until they reach the top by which time the bucket will have reached the surface of the water and got filled; and then the process is repeated. This method is not free from the application of human labour, for the man who sits on a seat in between the animals has to properly conduct the animals during the process. In spite of its discontinuous and insufficient water flow, the time consuming nature of animal operation and overall low efficiency, this mode of irrigation stimulated the invention of the semi-mechanical and full mechanical devices.

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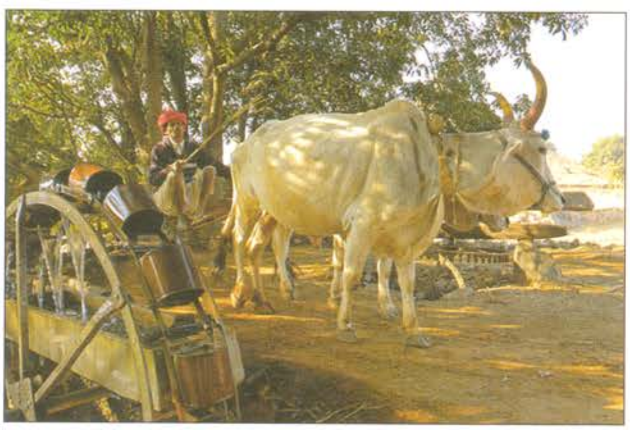


Present existence

In the rural area around Udaipur there are many water mills used to irrigate the lands. This one is powered by two cows. The farmer is behind them yelling to keep the cows going.

Semi-mechanical Devices: The Balanced - bucket

In ancient India two types of balanced-bucket, semi-mechanical in operation and design, were in use. One was efficiently operated with counterweight, and the other one balanced by the weight of human body.

* *With counterweight* - Referred to as the tēra or the tiryakayantra in the Ṛgveda, the semi-mechanized water-hoist was known as shadoof in Egypt, dāliya in Iraq, picotah/ēttam/rāṭaṇamin South India and lāt in parts of North India. It was worked by a pair of long, tapering and nearly horizontal beam fixed across two vertical pillars about 8 to 10 feet high, set up less than a yard apart above the ground. Sometimes, granite stone pillars acted as the vertical beams instead of palmyra ones. A leather bag of considerable size or a bucket made either of earthenware or metal is hung from the larger and thinner end of a rope or thin bamboo pole, while a block of stone was secured tightly to its shorter and thicker end, as the counterbalance. According to Ernest Mackay, the large sized bricks (11.7"x5.7"x2.73") having a cut-hole of about 2.5" diameter in the centre, recovered from the excavations at Mohenjo-Daro 'may have been used as a weight for some form of apparatus', possibly the water-lifting devices.

* *Balanced by the weight of human body* - This is the same as the previous one, the only difference being that it is operated with the application of human labour. The tapering horizontal pole is worked by trampling along the pole instead of the counterweight placed at the other end. The man who stands and tramples the pole must have sure balance and adequate previous experience to operate the device and therefore it requires considerable practice. It was commonly used in parts of South India, including Madras.

The change from the system of animal power to mechanical was an achievement, but the output was limited by the depth of the well. The shadoof with its rhythm of rise and fall, dip and empty, to which the ancient labourer must have sung, as does his modern descendent, can prove to be much quicker and more efficient than any non-mechanical type of water-lift.

Continuous water supply by water-lifting machinery

Wheels of pots or water-wheel - Technologically speaking, the next and last stage was the fully mechanized water-hoist moved by a water-wheel or wheel of pots, put into practical application as early as the second millennium B.C. From the pottery excavated at Mohenjo-Daro, Sir John Marshall opines that 'some arrangement for drawing water for irrigation, by means of an endless rope working over a wheel, with pottery vessels attached to it at intervals was in use in Sind and other parts of Western India from early times, though it may not have taken the form of modern wheel'. But the excavation finds at other Chalcolithic sites unmistakably show that 'only one type of jar has been found broken in large numbers. Jars of this kind average about six inches in height, have a pronounced, pointed and deeply scored belly and are certainly too large to be grasped comfortably in one hand'. According to E. J. Mackay, 'they are frequently coated with a thin cream wash, they all have deep spiral grooves round the middle, which would have served to give greater security if they were attached to some kind of water-wheel'.

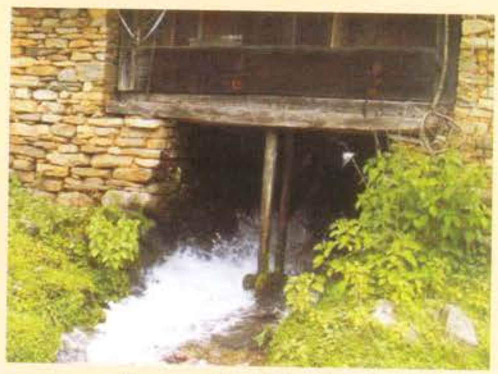
The spade of the modern archeologist has not exhumed relevant material evidences, other than pottery, to throw light on the water wheel and its essential parts. So we are unable to reconstruct the actual model of the water wheel used in the Protohistoric period. Yet, the documentary references of ghaṭi chakra in the Ṛgveda and udghāṭam in the Arthaśāstra prove that there was an indigenous method of raising water by using wheel of pots and having specific names from very early time.

Sir John Marshall believed that the modern Persian wheel, exclusively confined to Balūchistān, Sind and the Punjāb and some parts of the Bombay presidency, may have been an improvement introduced into India from Persia. Had this been true, it would have retained its original name, of dauwaryah or charkidauwar. Since the device still bears the same Sanskrit name ghaṭi chakra to the present day, it is reasonable to infer that the wheel of pots had its own independent origin in India in the ancient period.

Traditional Watermill of Himalayan Region

Watermill is a centuries old technology, which is still widespread over the hilly territories of Uttaranchal, Himachal Pradesh and North East India and other Himalayan region of Nepal, Tibet and Afganistan. The origin of water powered mill for grinding cereals were adapted to mountain areas with streams rushing down gullies and their design was perhaps suggested as much by experience of waterwheels used as water lifting device. We might expect the first water mills to have seen made in a mountainous districts in the Himalayan mountain range, where people had experience of all these devices and also mill stone for rotary hand mills.

Himachal Pradesh



Arunachal Pradesh

The Himalayan region covers mainly eight countries i.e. India, China, Nepal, Bhutan, Bangladesh, Myanmar, Pakistan and Afganistan. In Indian perspective Himalayas consist of four ranges extending about 2 500 kilometres from Arunachal Pradesh on the Tibetan border in the east to Jammu and Kashmir in the West. The mountains in the range are between 5000 metres and 9000 metres in height and fall steeply through sheer-sided gorges and river valleys to the northern Indian plain over only a few hundred kilometres. Nineteen major river systems, including the Brahmaputra and the Indus, rise among the mountains. The physical geography provides excellent hydropower potential, which was recognised very early in the history of use of waterwheel as motive power for mechanical

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systems and modern day hydropower.

Life in mountain ecosystems all over the world have certain commonalities such as fragility, inaccessibility, marginality and diversity and these have a huge impact on the everyday life of people living there. Survival needs in these difficult and unique biophysical conditions have resulted in the evolution of 'human adaptation mechanisms' or the knowledge systems. These systems and practices have emerged through the process of continuous observations, experiences and experiments and adaptation by the people. Himalayan region is also a rich storehouse of such practices, which have evolved over the years and form a crucial component of their survival strategies in these difficult situations.

Chherna village in Himachal Pradesh

Saili village of Kathua District, Jammu & Kashmir

Image: The Tribune, Online Edition, 25 August, 2009

Watermills, one of the most prominent indigenous technology are in use in the Himalayan region since time immemorial and existing even today. The Himalayan region has a rich ancient tradition for tapping hydro-energy from the hill streams and rivers through the device of watermills. The watermills popularly known as 'gharats' in Himachal Pradesh, have traditionally been used for rice hulling, milling of grains and other applications.

Sankhri near Dehradun

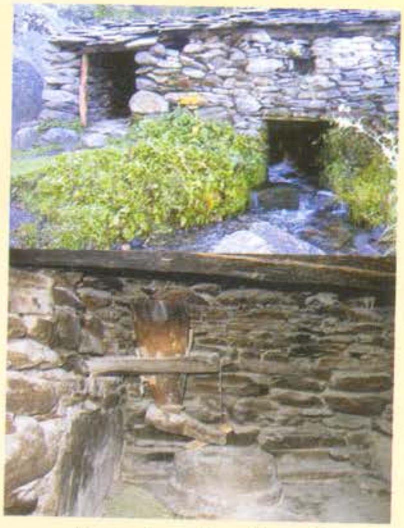

Image by : Ajeet Dyondi

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 countryand many thousands more in Nepal, Pakistan, Myanmar etc. In Uttaranchal alone there are about 70,000 watermills and 50% of which are in use at present. 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 theinclination 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. Moreover, the insufficient flow of water and seasonal variation in recent past has forced to close down such traditional mills.

Pakistan

Image by : Karl Schuler

Bhutan

started coming in and large hydro electricity projects. Cheap electricity from these large projects made these mills obsolete. The large factories started producing flour at a much cheaper rate added to the misery to the water flour mills.

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

Nepal

Image: Centre for Rural Technology, Nepal

Afghanistan

Image: Remote Hydro Light, Kabul, Afghanistan

Tibet

Image by Antoine Taveneaux

In the 19th Century, the technology improved further and millers started using the shaft to drive multiple other shafts though gears and started using them for multiple functions using different gear ratios. In the early part of the 20th century, industrialization had 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

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the plains: they need to be empowered to tap and make the best use of local water resources, based on traditional technology 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.

These water mills or Gharats are of the vertical shaft type, evolved over thousands of years and are used essentially for grinding wheat, rice and maize and also to extract oil. Due to lack of technology they have not been upgraded to produce electricity. Assuming that each one of these mills generate only 5 KW, collectively they would generate 2500 MW of power and employment to 15 million people. With a little modification the power generating capacity could be much more.

The most elementary use of hydropower in the Himalayas has been in the traditional watermills (or gharats) for grinding grain. The widespread use of gharats and its popularity owes much to its simple and cost-effective mechanism. Uttaranchal, in Indian Himalayas is a mountainous state with rugged terrain. There are several perennial streams, rivulets and rivers in this part of the country where in traditional watermills (or gharats) located at the bank of these streams and rivers have been the parts of villager's life and used as important source of energy from centuries for grinding their food grains. As the low efficient traditional water mills could not cater the increasing processing needs of people, diesel mills are entering in the potential areas. Many of these are currently being abandoned by the water millers for better income generating opportunities and the existing ones face stiff competition from the diesel mills.

In the olden days, possession of Gharat as an important item of household was not only a significant achievement of the family but also a matter social prestige and pride. The owner of Gharat in those days happened to be a socially dignified and a rich person. He was given privilege of a person with distinct social status. Among the Rawain community of Uttarakhand and Himachal Pradesh, the socio-economic status of a person who owned Gharat in those days was given due regards by the villagers and the neighbouring communities.

Appropriate site where perennial sources of water are available could only maintain or run a mill. Therefore, the owner of that land in most of the cases runs Gharat to meet the requirement of the village or surrounding community. This was perhaps the reason that owner of Gharat among the Rawain community occupied a respectful position in their society.

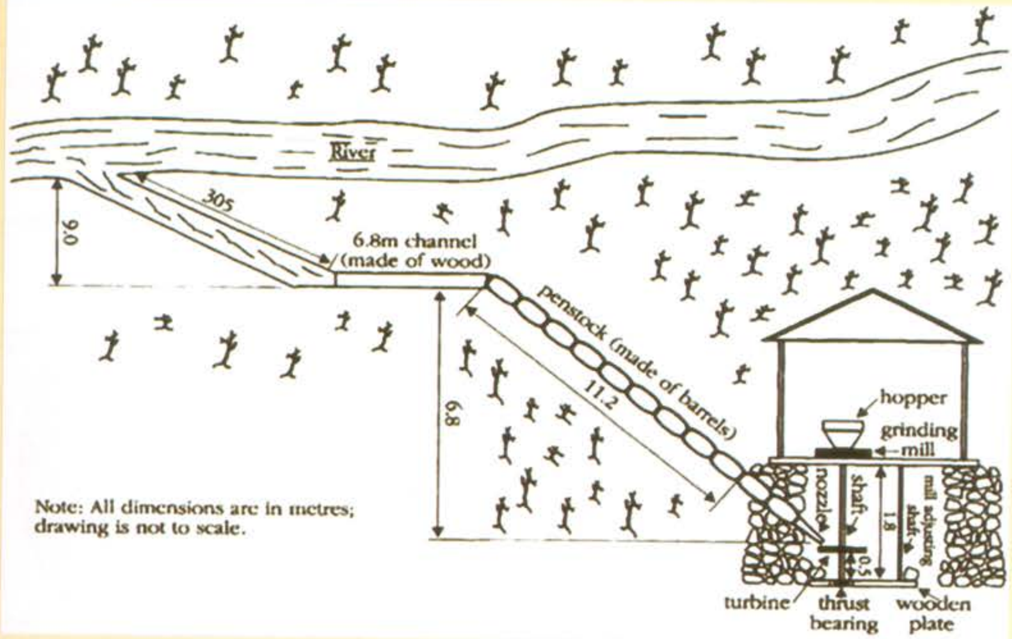
Construction of Watermills

Natural sources of water available in these undulating hilly terrains that are flowing turbulently through out the years are used for operating the mills. The simple devices used in running the mill are locally manufactured by the folk and rural people who inhabit in this region. Installations of these kinds of traditional mills are mostly found to the site where perennial source of water is available.

3D Max image of a typical Gharat of Uttarakhand

(Drawn by Sayantam Sengupta)

These running streams carrying large volume of water is managed to pass through a canal locally constructed at an elevated point from where water can be dropped with desirable amount of force. From this elevated blades of wooden turbine, it starts rotating and further allowing the entire parts of the devices function as a mill, which is unique of its kind. Interestingly, all these simple devices work very efficiently.



A typical layout of a watermill

point, a long wooden canal is mounted in an inclined position allowing the water to fall and hit the blades of wooden turbine.

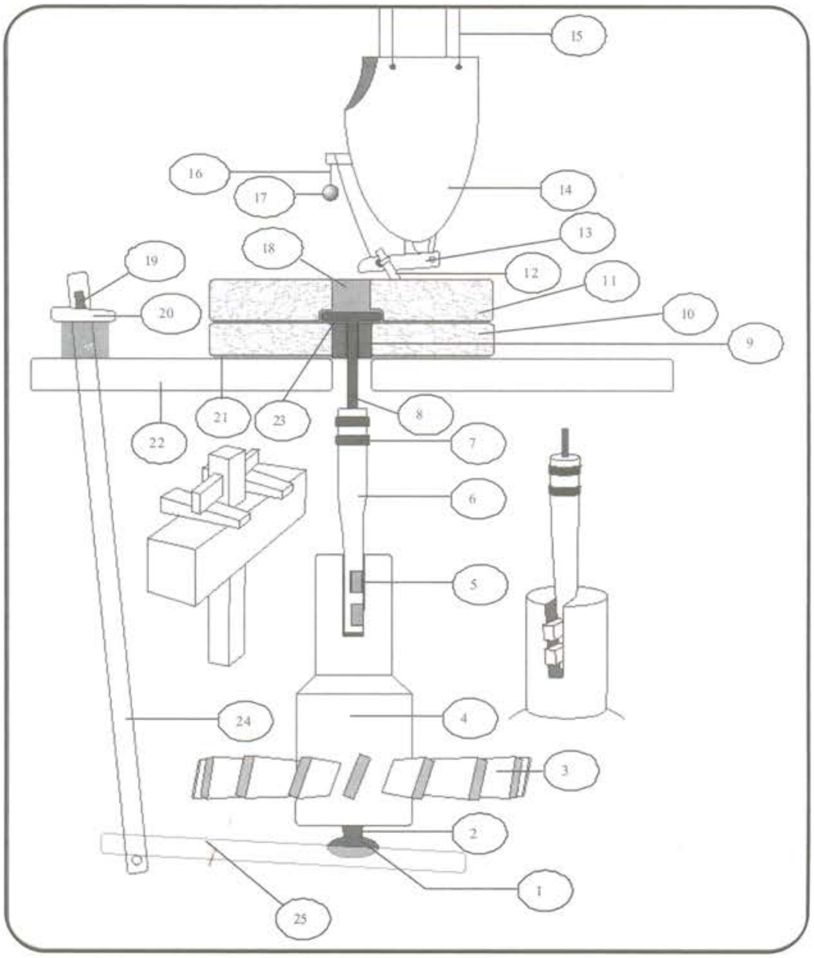
Jhaleri (wooden turbine with multiple wings or blades)

Image: Mountain Research and Development Vol 26 No 2 May 2006

This wooden turbine contains multiple wings/blades and it is positioned in a manner that the lower end of the wooden canal faces the blades. When water hit the

The traditional Gharat used in the Gundigaon village of Uttarakhand has not been replaced by any kind of mechanical innovations. It consists of wooden parts like Panyala (wooden canal), Jhaleri (wooden turbine with multiple wings or blades), Ghate(grinding stone), Chada(wooden and iron lever with gear), Reedi(wooden funnel used to stuff grains for grinding) etc. and all these tools work with their elaborate mechanical functions allowing the grains to grind simply by using the engergy of water.

Fast flowing water is collected at an elevated point from the low lying shed of Gharat. The water is then droped down by Panyala inclining to that level which can give sufficient amount of energy to rotate the turbine and the big size upper wheel of stone. The water wheel, so call Jhaleri is interconnected through a wooden lever that gives mechanical energy to rotate the stone grinder. Another shaft of lever (excelled with wooden or iron gear), fixed near the rotor is vertically mounted to propel and adjust the upper portion of grinding stone. This lever is mainly used for adjusting the stone wheel (grinder) to lift up and down so that the grains could be grinded either in coarse or fine manner. A funnel shaped Reedi with Lalthou (controlling knob) is mounted vertically above the stone wheel grinder for pouring desired quantity of grains. The grains that are stuffed inside the Reedi gets passed on to the centre hole of the stone grinder only after the controlling device called Lalthou gets vibrated with the friction of grinding stone wheel. When grains are droped uniformly into the cavity of grinding stone, it subsequently gets crushed with the stone wheel resting at lower portion of the rotating Ghate. The grinded cereals ready for consumption are than collected and distributed to the concern person who came to grind their cereals or grains.



Detail of parts definition of a traditional water mill

1. Stone socket
2. Stone pivot
3. Vanes (Jhaleri)
4. Crown
5. Wedges
6. Upright Shaft
7. Iron Rings
8. Stone Spindle
9. Wooden Boss
10. Bed Stone
11. Runner (Ghate)
12. 'Damsel'(Lalthou)
13. Shoe
14. Hopper (Reedi)
15. Rope
16. Cord
17. Check Weight
18. Eye
19. Teeter Yoke
20. Wedges
21. Layer of Clay
22. Floor
23. Rind
24. Tentering Rod
25. Sprattle Beam

Millstone Nomenclature

Millstones come in pairs. The base or bedstone is stationary. Above the bedstone is the turning runner stone, which actually does the grinding. The runner stone is supported by a cross-shaped metal piece fixed to a "mace head" topping the main shaft or spindle leading to the driving mechanism of the mill.

The Basic Anatomy of A Millstone (runner stone)

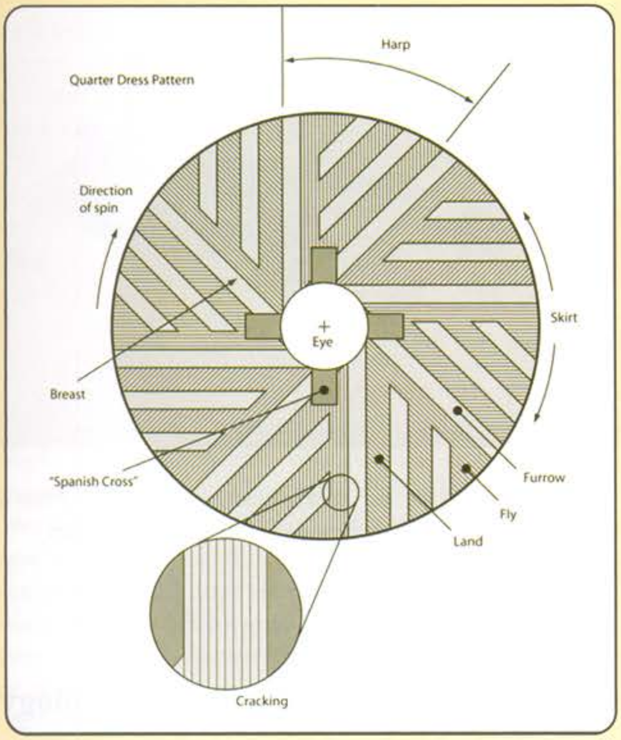
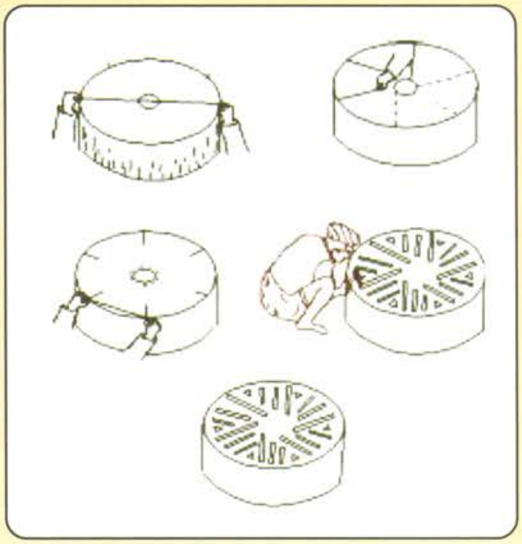


Image: Millstone Anatomy by Stevegray, March 2006

Steps of Dressing of Grinding Stone



Dressing of stones is very important to increase the output of the water mills. Stones grooving are necessary to be made scientifically. It is very necessary that grooves should be maintained time-to-time and proper.

Image: Alternate Hydro Energy Centre, Indian Institute of Technology, Roorkee

The pattern of harps is repeated on the face of each stone, when they are laid face to face the patterns mesh in a kind of "scissoring" motion creating the cutting or grinding function of the stones. The surface of a millstone is divided by deep grooves called furrows into separate flat areas called lands.Spreading away from the furrows are smaller grooves called feathering or cracking. The furrows and lands are arranged in repeating patterns called harps.

A typical millstone will have six, eight or ten harps. The grooves provide a cutting edge and help to channel the ground flour out from the stones. When in regular use stones need to be dressed periodically, that is, re-cut to keep the cutting surfaces sharp.

Millstones need to be evenly balanced, and achieving the correct separation of the stones is crucial to producing good quality flour. The experienced miller will be able to adjust their separation very accurately.

A blacksmith shaping a new grindstone for an updated water mill in the Himalayan state of Uttaranchal
Image: IT Power-India (ITPI)

Portrait of an old man dressing a Millstone (From the collection of the Smithsonian Institution) 19th century

Validation of Traditional Water Powered Mill as Appropriate Technology

It is felt that an urgent need to intensify the efforts to raise the concern levels, improve the opportunities and options of livelihood based on people's knowledge systems and build up an environment to promote the inclusion of this knowledge system in the development process, to improve its efficiency, effectiveness and sustainability, which is particularly potent in the region.

Many of traditional and /or local systems of water-collection, storage, and development and management of water-resources, unfortunately, fell into disuse with the onset of 'modernisation' during the colonial period.The system came to an end after the advent of the British. Elsewhere too, the traditional methods were over-shadowed, reduced in status, or openly discouraged due to the invasion of 'Western' technology. The situation did not alter with the coming of Indian Independence, and the process has continued into the late 20th Century, with a basic reliance on big dams, inter-basin transfers and surface transport of water through canals and watercourses. Fortunately there has been a revival of interest in traditional water systems in recent years, both for theoretical and practical purposes, especially by development activists, scientists, environmentalists and many others associated with the cause of sustainable development. Issues emerging from the debate on environmental protection and community empowerment have resulted in a strong need to have a fresh look at these older and time tested practices and utilize their benefits for meeting the present day needs of rural and urban areas.

Appropriate Technologies are small-scale, more labor intensive than capital intensive, culturally relevant, and sustainable technologies appropriate for particular environmental conditions, social contexts, and economic situations. It also includes the recognition that technologies can embody cultural biases and sometimes have political and distributional effects that go far beyond a strictly economic evaluation. Appropriate Technologies are not appropriate for all situations, but are more about local people using local knowledge and resources to meet their needs without compromising the ability of future generations to do the same. Therefore it involves a search for technologies that have, for example, beneficial effects on income distribution, human development, environmental quality, and the distribution of political power in the context of particular communities and nations.

The importance of peoples' knowledge is being increasingly recognized the world over and there is many reasons for doing so. The living knowledge or the wisdom which people have gained and developed through years of careful observation, experience, experimentation and adaptation has helped them survive and secure their livelihoods in the difficult and unique biophysical conditions of the mountains. It is undeniably ironical that despite being an invaluable resource there has been a gradual loss of faith of people in their own knowledge system and practices, and at the same time there has been its increasing recognition at the global level.

Decreasing faith, lack of documentation, severe competition from highly promoted and subsidized products etc. as well as the growing globalization of markets and appropriation of resources and knowledge by global forces is leading to a gradual erosion of knowledge. And the tragedy of its depletion is most obvious to those who are dependent on it and do not have access to cash income to eke out an existence, i.e. the most marginalized and excluded in the society. Having played a crucial role in the survival of people especially the marginalized groups, in harsh but vulnerable conditions, it holds great potential but also faces innumerable challenges.

With the intervention of modern electrical and fuel-operated mills, the use of Gharat in this mountainous region declines to the level of extinction. It is important that such kind of traditional devices which are sustainable in all its forms need properly documented and preserved as an important asset of Himalayan Culture.

Therefore, there is an immediate need to act on popularization and dissemination of knowledge of our age-old traditional technology and the initiative taken to revive and implement the modification towards the appropriate technology for self-reliance of the marginalized hilly community to overcome the impediments to implementation of the revival and revamping programe to make 'gharat' a symbol of changing lives in hills.

The potential of this traditional technology of waterpower has got relevance even in present context. The study of this traditional technology is not just an abstruse study but has also direct relevance to the socio-economic and environmental problems of Himalayan regions of Uttaranchal and Himachal, as also of the Southeast Asia at large.

This traditional water power technology will not only improve livelihood prospects and opportunities but also empower people- the holders and users who happen to be mostly women and the marginalized, it being within their access and control - in areas pertaining to food security, natural resources and other vital economic and social activities, their active participation in development dialogue and also mainstreaming People's Knowledge into the overall development process.

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