***Gharat*: an environment friendly livelihood source for the natives of western Himalaya, India**

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Abstract

The native people of the Himalayan region use an indigenously designed watermill locally called as '*Gharat*'. The '*Gharat*' is made from the natural resources that are easily available in the area and operates through the water force coming from glaciers, perennial streams and rivulets. Thus, it is an environment friendly source of livelihood for the '*Gharatis*' (the owner of *Gharat*). In the present communication, an effort was made to document the status of *Gharats* in the high-altitude Himalayan regions of Pangi and Tissa of district Chamba. Field surveys were conducted in a total of twenty remote villages of Pangi and Tissa regions (ten in each site). Information was collected on pre-designed semi-structured questionnaires from local people that primarily consisted of *Gharatis*, elderly informants and the inhabitants living in the vicinity of *Gharats*. All possible reasons responsible for the increase and reduction in the number of *Gharats* in the study areas were also documented by interviewing the informants. The study revealed that in the Pangi region number of *Gharats* have increased and are in good condition whereas there is a drastic decline in the number of *Gharats* in Tissa. The informants in Pangi gave maximum responses favouring motivational factors while in Tissa maximum responses were obtained for demotivational factors. Based on these responses, we prioritized the corrective measures for improving the efficiency of *Gharats* and restoration of this age-old indigenous and environment friendly technology. This will surely enhance livelihood security of the inhabitants besides optimum utilization of the natural resources in the Himalayan region.

Keywords Environment · *Gharat* · Himalaya · Indigenous · Livelihood · Sustainability

1 Introduction

Human sustainability lies in following laws of nature that are governed by mass and energy balance (Pereira, 2009). It is important that natural resources are used in a sustainable manner with balanced interaction of humans with technology, economic growth, environment and resources. The use of renewable natural sources can help

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combat the growing environmental problems in a long way (Nautiyal et al., 2011). Among the varied renewable resources like photovoltaic, solar thermal, tidal and wind energy, the hydropower stands out for its feasibility due to which its potential is harnessed around the world (Pérez-Sánchez et al., 2017). The *Gharat* (watermill) is one such indigenous technology that operates through the energy derived from flowing water coming from glaciers, perennial streams and rivulets and is used for the production of flour, lumber, textile or metal shaping.

The usage of rotary hand mills (quern) by primitive man for crushing and grinding food materials can be considered as an emergence of watermill. The oldest hand mills date back to the Palaeolithic period that were used to grind the tuberous roots and their further expansion occurred during the Neolithic period when human beings adopted a sedentary lifestyle over the nomadic and initiated the agricultural activities (Sánchez-Jiménez & González, 2018). As Wheat cultivation came in existence in the Middle East between 10 and 8th millennia BC (Moritz, 1958), each family employed its own hand rotary mills (two stones) to grind grains. As the demand for flour increased with rising human population, man started to explore the ways to harness energy resources like water to operate large rotary stones for grinding (Boomgaard, 2008). The first reference of a mill driven by water was given by a Greek writer Antipater of Thessalonica in his writing in 85 BC (Rojas-Sola et al., 2006). The ancient water mills emerged simultaneously in two forms, the 'Greek Mill' with the horizontal waterwheel and the 'Roman Mill' with a vertical waterwheel. Until the mid of the twentieth century, some watermills continued to function while others got mechanized that ultimately led to the disappearance of the large number of classic horizontal watermills (Rojas-Sola et al., 2006). In the past, water mills were known to perform different functions like in Greece these were called as 'Norse Mill' and were used to grind grains, while in Syria these were called as 'Noriahs' and were used for running mills that processed cotton into cloth.

It is evident that the Himalayan region is a hub of diverse natural resources and its inhabitants exhibit a high diversity of cultures, traditions, resource use and stewardship practices with significant ecosystem-human interdependencies due to inaccessibility and heterogeneity of mountain systems (Bhatt et al., 2018; Everard et al., 2020; Huddleston et al., 2003). Despite blessed with the rich natural resources, the region is inhabited by around 175 million people who are still living below the poverty line (FAO, 2005; Sharma et al., 2010). This is mainly due to difficult terrains, environmental hazards, poor communication, transportations and low level of scientific and technological interventions in the mountain areas (Körner et al., 2005; Lal et al., 2019; Rao, 1997). The natives of high mountain areas have developed several indigenous technologies using locally available natural resources and their traditional wisdom. Some of these include Charkha (spinning wheel), Takali (spindle) made of wood or metal, Khaddi (wooden weaving machine) and *Gharat* (Panchakki/ watermill) (Lal et al., 2019; Rana et al., 2020). Water is one of the very useful natural resources found abundantly in the Himalayan region (Xu et al., 2009). This natural resource is employed for driving *Gharat* and used in processing of food grains by the inhabitants in remote villages throughout the Himalayas. Around 2,00,000 watermills have been reported in the Indian Himalayan region which still rely on an ancient design of an impulse-type turbine (Anonymous, 2001; Sharma et al., 2008). The watermill is known by different names like '*Chuskor*' in Arunachal Pradesh, '*Rantak*' in Ladakh, '*Gharat* or *ghat*' in Uttarakhand but most popularly known as *Gharat* in the entire Indian Himalayan region (Behari & Bhardwaj, 2014; Slathia et al., 2018). Today traditional watermills have survived on a small-scale in rural regions of the world like the Himalayas, which are serving mountain inhabitants till date (Vashisht, 2012). This simple technology is still a source

of income for many people in the remote areas that is used to process good quality flour (Sinha et al., 2008).

The state of Himachal Pradesh is one such Himalayan region where around 89.96 per cent population lives in remote rural areas. The major occupation of the people is agriculture and the major crops cultivated are wheat and maize (ENVIS, 2011). Being a hilly terrain, the state has a number of perennial water sources that are functional throughout the year and people of the region use 'Gharat' for processing food grains. Therefore, the present study was undertaken in Chamba region of Himachal Pradesh with the following objectives (1) Assess the present status of *Gharats* in the study areas, (2) Document the number of crops that are processed at the Gharats, (3) Resource use in the construction of *Gharat* and its working technique and (4) Responses of the informants pertaining to motivational and demotivational factors about *Gharat*. The present study would be useful in providing corrective measures for the restoration of this dwindling indigenous technology in one hand and securing the livelihood of the inhabitants on the other.

2 Materials and methods

2.1 Study area

Himachal Pradesh is located in the heart of the western Himalayan region. Chamba is one of the districts in the state between 32° 11' and 33° 13' North latitude and 75° 49' and 77° 3' East longitude, with an estimated area of 6522 Km² and altitudinal range from 800 to 5200 m amsl. The region is bound on north-west by Jammu and Kashmir, on the north-east and east by Ladakh, south-east by Bara-Bhagal area and in the south by district Kangra of Himachal Pradesh and Gurdaspur district of Punjab (Census of India, 2011). The region is rich in floral and faunal diversity. Surveys were conducted in the selected villages of Pangi and Tissa regions. Pangi is an isolated valley that is geographically divided into three major regions, i.e., Saichu, Sural Bhatori and Hudan Bhatori. The Saach Pass is the gateway to this valley located at an altitude of 4400 m. Chandrabhaga river flows through the region and it remains secluded from rest of the district during winters due to heavy snow-fall. Two tribal communities Pangwals and Bhots inhabit the area. In the Tissa region, Gujar tribal population inhabits the area besides other indigenous communities. River Ravi flows through the Tissa region.

2.2 Data collection

Field surveys were conducted in the 20 selected villages of the Pangi and Tissa regions (10 each) from the year 2016–2019. Information was collected through field observations and personal interviews with the *Gharatis* (owners), artisans, elderly informants and inhabitants living in the vicinity of *Gharats* through a semi-structured questionnaire. Information was collected pertaining to the status of *Gharats* in the villages [number at present (i.e., 2016–2019) and before 2016], resources used in the construction of the *Gharat*, its operational technique, parts of the *Gharat* in the local dialect, crops processed in the *Gharat* etc. The *Gharatis*, (owners of the *Gharat/s*) were specifically interviewed pertaining to various parts of the mill and bioresource use for its construction. A local guide was hired who helped us in easy communication with the people by translating local language into

Hindi. Prior to the interview process, the informants were made aware of the objective of the study and their consent for participation was taken.

2.3 Motivational/demotivational factors

Further informants were asked about the motivational/demotivational factors responsible for the increase or decline in the number of *Gharats* in the region. These were later classified into various indicators or responses (Table 1). The number of responses that favoured each motivational factor was then evaluated based on percept responses. Based on the responses of the informants on motivational and demotivational factors, we proposed the corrective measures. It is presumed that these will help the policy makers, conservationists and environmentalists to take appropriate decisions while framing policies for the conservation of *Gharats* in these regions. Data thus collected were entered and analyzed in Microsoft Excel and descriptive tools (averages, frequencies and charts) were applied.

3 Results

3.1 Status of *Gharats* in the study sites

A total of 20 villages were surveyed for collecting information from a total of 95 informants from both the selected sites. In the Pangi region, surveys were conducted in the Dharwas, Hudan, Kiryas, Karhoti, Kawas, Kumar, Kuthal, Punto, Sach and Sural villages while in the Tissa region Chanju, Devikothi, Gwari, Jungra, Khushnagri, Salela, Sanwal, Satyas, Shaktinala and Tarela villages were surveyed (Fig. 1). The results showed that in the Pangi region new *Gharats* have been constructed in some of the villages. Newly built *Gharats* were found in the villages like Hudan, Karhoti, Kawas (1 no. each), Kumar (5 no.), Kuthal (4 no.) and Punto (3 no.). In some villages of Pangi, a minor decline in the number of *Gharats* was also observed which were damaged due to natural calamities like cloudburst, avalanches, flood occurring during winter season. In the village Kriyas, a total of 12 *Gharats* were present before 2016 out of which only 7 were found functional. In village Dharwas out of 6 *Gharats*, 1 was non-functional while 5 were still operating well and in Sural out of 9 *Gharats* 3 were non-functional. While a major decline in the number of *Gharats* in almost all the surveyed villages was found in the Tissa region. In the villages like Devikothi and Satyas, not a single *Gharat* was found operational while in the Tarela village out of 12 functional *Gharats* in the past, only 2 were found operational at present. In the Sanwal village where there were about 15 *Gharats* in the past, presently only 7 *Gharats* were operational while in Shaktinala village out of 12 functional *Gharats* in the past only 5 were found operational. In the Changu village where 15 *Gharats* were functional in the past, only 7 were found functional (Table 2).

3.2 Commonly grown crops and their significance in the study areas

The inhabitants of Pangi region follow rich culture and celebrate a number of fairs and festivals throughout the year. During ceremonial occasions, they prepare a number of dishes that are made from the flour of different crops grown in the area. Variety of cereals/pseudo cereals are cultivated and consumed by the Pangwals that include *Amaranthus paniculatus*, *Eleusine coracana*, *Fagopyrum esculentum*, *Fagopyrum tataricum*, *Hordeum vulgare*,

Table 1 Motivational/demotivational factors and responses of the informants pertaining to *Gharats*

S. No.	Motivational factors	Indicators/responses
1	Socio-Culture	Used since generations and now has become part of our traditions, and spot of social cohesion
2	Healthy and tasty	The flour from the Gharat is tasty and healthy
3	Economically viable	Economically very affordable as different bioresources easily available in nature for its construction and maintenance
4	Environmentally best fit for the region	Gharats are sustainable and reliable as electricity supply is not proper Most conducive for hilly conditions, terrains and aspects with good water supply
5	Source of Livelihood	Good source of income
6	No other option	Only Gharats are the available option in the region
S. No.	Demotivational factors	Indicators/responses
1	Socio-Culture	People are more inclined toward market and packed flour due to modernization
2	Economically non-viable	Outmigration of people for jobs and decreased social cohesion More investment in repairing and maintenance is required due to its technical failure while low income is generated
3	Environmental	The construction of hydro-electric projects and other environmental factors have caused decline in water sources
4	Distant location from villages	The Gharats are established far from villages and the roads are not proper
5	Changed cropping patterns	Limited crops including minor crops are cultivated in the area leading to decreased use of Gharat
6	Other options are available in the market	Electricity operated mills and packed flours are available nowadays

Fig. 1 Map of the study area in India showing (in red and green) the location of surveyed villages

Table 2 Status of number of *Gharats* (water mills) in the past and present in the study area

Name of village	Altitude (m)	No. of Gharats in the past (before 2016)	Present number (since 2016)		Status (D-decline)/ (I- increase)
			Functional	Non-functional	
<i>Site 1-Pangi</i>					
Dharwas	2378	6	5	1	D
Hudan	3676	5	6	0	I
Karhoti	2650	0	1	0	I
Kawas	3622	0	1	0	I
Kriyas	2870	12	7	5	D
Kumar	3051	0	5	0	I
Kuthal	3303	0	4	0	I
Punto	2640	1	3	0	I
Sach	2935	1	1	0	–
Sural	3347	9	6	3	D
<i>Site 2- Tissa</i>					
Chanju	1871	15	7	8	D
Devikothi	2524	12	0	12	D
Gwari	1378	10	4	6	D
Jungra	2100	16	10	6	D
Khusnagri	1715	17	8	9	D
Salela	1873	3	1	2	D
Sanwal	1930	15	7	8	D
Satyas	1852	20	0	20	D
Shaktinala	2084	12	5	7	D
Tarela	2900	12	2	10	D

Panicum miliaceum, *Paspalum scrobiculatum*, *Triticum aestivum* and *Zea mays* (Table 3). Different types of breads called 'Thothe' and multigrain delicacy called as 'Sattu or Totu' are made from the flours of these crops. Besides this, the Pangwals indigenously process and extract oils from the kernels of *Prunus armeniaca* and *Juglans regia*. The kernels after sun-drying are grinded in the watermill to obtain its flour. The flour obtained is mixed with water to make a gruel which is then put on fire. On heating the oil starts to separate and float which is then transferred to another container and is used in day-to-day cooking. During summers, grinding of grains at the *Gharats* is a busy affair in this region as every household stores the required stock of flour for the whole year. The *Gharats* become non-functional in the region after the onset of winters (December to May) primarily due to heavy snowfall and freezing of water sources, avalanches and landslides. People in the region frequently use hand operated stone mills to make flour from the kernels at home. Thus, the hand operated stone mills called 'hatath' are of extreme importance and usage during this period (Fig. 2a). In the Tissa region maize and wheat are the major crops grown and the inhabitants use its flour to make chappatis (bread) or halwa (sweet delicacy). The cultivation of other crops like barley and millets has declined in the region over the period of time. The electric flour mill has been installed at many places in the Tissa region (Fig. 2b) and people also procure packed flour from the ration depot.

3.3 Resource use pattern in the construction of *Gharat*

A mill is installed inside a small chamber that is constructed using locally available natural resources, such as stone, mud, wood, bamboo slate and cowdung. The stones are piled one above the other in a regular pattern to form the walls. On the inside, walls and floor are smoothened using mixture of clayey mud and cowdung that is well plastered. On the roofs are placed large logs of wood or bamboo as per the availability of material and then covered with slates, flat stones, sandy soil mixed with dry grass etc.

The whole structure of the mill that consists of various parts is then installed inside this chamber. The installation process is the collaborative work of the local carpenters and blacksmiths. The species of gymnosperm wood (*Cedrus deodara*, *Picea smithiana*,

Table 3 Plants grown and processed in the *Gharats* in the study areas

S. No.	Crops		Part processed	Pangi	Tissa
	Scientific name	Local name			
1	<i>Amaranthus paniculatus</i>	Siul/bhavri	Grains	C, P	C
2	<i>Eleusine coracana</i>	Koni	Grains	C, P	–
3	<i>Fagopyrum esculentum</i>	Bhares	Grains	C, P	–
4	<i>Fagopyrum tataricum</i>	Phullan	Grains	C, P	–
5	<i>Hordeum vulgare</i>	Elo	Grains	C, P	C, P
6	<i>Juglans regia</i>	Akhrot	Kernels	C, P	C
7	<i>Panicum miliaceum</i>	Chinay	Grains	C, P	–
8	<i>Paspalum scrobiculatum</i>	Kodra	Grains	C, P	–
9	<i>Prunus armeniaca</i>	Khumani	Kernels	C, P	C
10	<i>Triticum aestivum</i>	Gehun	Grains	C, P	C, P
11	<i>Zea mays</i>	Makki	Grains	C, P	C, P

Abbreviations: 'C' = cultivated; 'P' = processed; '–' cultivation abandoned

Fig. 2 **a** Traditional stone hand mill (*hatath*) in Pangi. **b** Electric flour mill in Tissa

Pinus roxburghii and *Pinus wallichiana*) and angiosperm wood (*Quercus leucotrichophora* and *Quercus semecarpifolia*) are used to make the various parts. The local craftsman (3–4 people) sculpts the granite stone into circular shape with the help of iron tools to make mill panels. The turbine locally called as ‘garad’ is mainly made of walnut wood (*Juglans regia*) as it is water resistant and does not easily rotten in water. The dusting of floor before initiating and after completing the grinding process is done using a small broom made indigenously from needles of *Pinus* spp.

3.4 Parts of *Gharat* and operational technique

Panchakis or watermills are often built on the banks of the Sadanira (perennial sources of water) at a lower height from the water source. The water from the source is diverted through a water channel locally called as ‘gool’ that is wide from the origin while it narrows toward the turbine to attain a strong flow. A wooden filter is placed in between to prevent the entry of unwanted materials like rocks, twigs etc. that can otherwise obstruct or break the wooden turbine. From gool, the water flows over the wooden/metallic plank connecting from main source till the turbine. Two mill panels (puddle and talli) that are made of stone are placed inside the compartment such that it simultaneously shares an edge with the wheels of the turbine that is placed at the lower end externally. The lower steering wheel is heavy and stable while the upper one revolves with the help of shaft connected with the turbine. The grains are added in a conical-shaped wooden container (daal). The grains of cereal constantly fall in between the puddle (grinding stone) and talli (lower stone) with the vibrations are produced by the grain releasing regulator (reedak). The leveller (kusa) controls the texture of the flour (fine to coarse) and also acts as balance between the puddle and the talli. The pressure of water makes the wings of the turbine (garad) to rotate intensely and thus the whole system operates (Fig. 3). The intensity of flow of water determines the speed of the turbine on which depends the grinding speed of the puddle. On an average if water availability is good then upto 5–10 kg of flour is produced per hour by a *Gharat*.

Fig. 3 Pictorial representation of traditional flour mill (*Gharat*) and its parts in local language

3.5 Motivational factors about *Gharat* as per the informants

On the basis of interviews conducted, the informants including the *Gharatis* revealed many motivational factors which highlight the benefits of *Gharats* to these people. Maximum motivational responses were obtained in the Pangri region with large number of responses coinciding for environmentally best fit for the region (47 responses), absence of other options (45 responses), socio-culture (43 responses) and source of livelihood (42 responses). In the Tissa region, the informants gave maximum responses for source of livelihood (27 responses) followed by non-availability of other options (23 responses)

and economical (15 responses) (Fig. 4). The various categories of responses have been discussed elaborately.

3.5.1 Social significance

People of the region believed that *Gharat* has a social significance that adds to its popularity and importance for rural population. The people considered the place as a spot of interaction and exchange of information among the people living in nearby villages which added social cohesion among people. By the time, grinding process continued the women folk carried out activities of spinning and knitting of woollen garments. The men were engaged in making ropes and cordage from the fibres obtained from the stem of bamboos, *Grewia optiva*, *Cannabis sativa* and *Girardinia diversifolia* in the *Gharats*.

3.5.2 Better taste of the flour

Maximum informants of higher age group believed that flour from the *Gharat* was of better quality and taste than the packaged flour brought from the market or the one grinded through electric mill. The people considered the flour nutritious and delicious. In the Pangri region, maximum informants revealed that they had only eaten the *Gharat* obtained flour since childhood and had never tasted the packaged flour.

3.5.3 Economically viable

The informants in both the study sites believed that *Gharat* is a simple indigenous technology that is environment friendly made from available local resources that makes it cost effective.

3.5.4 Environmentally best fit for the region

Due to difficult terrain, tough weather conditions and irregular supply of electricity in these high altitude areas, the inhabitants of the region believed that *Gharats* were the most suitable option to meet the needs of people.

Fig. 4 Distribution of responses for the motivational factors for *Gharat*

3.5.5 Source of sustenance and livelihood:

These are a source of sustenance and livelihood for many inhabitants in the area. The *Gharat* owners besides operating *Gharat* were also engaged in other activities like agriculture, livestock rearing, weaving and spinning etc. The *Gharati*'s generally took one tenth of the grains or money in return for the grinding activity.

3.5.6 Only available option for the inhabitants

Most of the informants especially from Pangri believed that they are solely dependent on *Gharats* for grinding grains or used stone querns as no other option is available for them.

3.5.7 Success story from the area

During an interview with an elderly informant named Mr. Balku Ram basically a farmer from village Dikriund in Tissa region, a success story was being documented. The person has constructed a self-owned *Gharat* on the hill top which is operated by releasing water from a cemented tank built at higher elevation from the *Gharat* (Fig. 5 a, b). The water in the tank regularly gets filled through water supply from the IPH department and rain water. As the water is released from the outlet, the *Gharat* is operated to grind maize and wheat grains to obtain its flour and on the other side the discharged water from the turbine is directed to irrigate the apple orchard of this farmer (Fig. 5 c, d). This can be considered as the best technique for optimum utilization of water resources as well conservation of the indigenous technology- '*the Gharat*'.

Fig. 5 **a** Indigenously built '*Gharat*' on a hill top. **b** Local builder Mr. Balku Ram. **c** Cemented tank built on the hill top for water storage. **d** Apple orchard of the informant

3.6 Demotivational factors about *Gharat* as per the informants

There are number of reasons responsible for the abandonment of the watermills that were documented in the present study. Maximum responses under demotivational category were obtained in the Tissa region. Highest responses were obtained for declining water sources (38 responses) followed by economically non-viable (37) responses and lack of socio-cultural cohesion (35 responses) (Fig. 6). In the Pangi region, informants gave maximum demotivational responses for distant location of *Gharats* (10 responses) followed by changing cropping patterns and other options available in the market (7 responses each).

3.6.1 Socio-culture

In Pangi region, social cohesion among people is tremendously observed as they celebrate number of fairs, festivals and ceremonies that keep them connected. The perspective of the people is changing in the Tissa region as people are becoming less social and more confined. This may be attributed to increased modernization and out-migration of the people from the villages to cities causing decrease in the rural population.

3.6.2 Economic-viability

People are more inclined toward other occupations due to low income obtained from the *Gharat* that make it a less popular profession. Declining interests of the younger generation toward the age old occupation of water milling due to modernization is also another factor responsible for the decline.

3.6.3 Geographical and environment issues

Distant location of *Gharats* from the habitation sites causes people inconvenience to reach in the absence of proper roads. Various environmental issues like low precipitation, decline in the number of water sources, flash floods and sliding glaciers are other issues.

3.6.4 Declining water sources

The various developmental activities like construction of building, roads and hydroelectric projects have resulted in drastic reduction in the number of *Gharats* due to changes in the

Fig. 6 Distribution of responses for the demotivational factors for *Gharat*

path of water sources in the area. Other environmental issues like lesser rainfall, snowfall etc., and increasing temperature are other causes.

3.6.5 Distant locations

The long distances with poor road connectivity of the *Gharats* from the villages has made *Gharats* less popular among the inhabitants of the region.

3.6.6 Changed cropping patterns

The availability of food grains for grinding has decreased because of changed patterns of crop cultivation and food habits of the people. People are less interested in growing minor food grains and are more dependent on readymade flour from the market or ration depot.

3.6.7 Other competitors

The difficult competition to the watermills from the diesel mills has made them less popular among the people in the Tissa region. In the Tissa region, this was more prevalent attribute as compared to the villages of Pangi region. The people of Pangi region in the absence of modern facilities, disrupted electricity supply and abundant water resources in the region consider *Gharat* as a more reliable source.

4 Discussion

Due to scarcity of non-renewable resources of energy and the shortcomings of conventional electrification, the potential of renewable energy sources for energy supply in rural areas is held in high esteem (Haanyika, 2006). Thus, a wide array of renewable energy technologies like biomass, hydel, solar etc. have been harnessed especially for rural areas (Benecke, 2008). At one time, the *Gharats* were considered as the life line and an integral part of the villagers inhabiting rural mountain areas. Many places of district Chamba, which were accustomed to grinding flour and other foods of antiquity, are witnessing a decline in the number of *Gharats* at present. This decline in the number of *Gharats* is at a rapid pace in some villages of Tissa while in the Pangi region the *Gharats* are still meeting the needs of indigenous people. Many attributes are responsible for the increase or decline in the number. The inhabitants in the far-flung villages of the Pangi region believed that the *Gharat* was the most viable option due to geographic constraints and also a good source of livelihood as large population is dependent on *Gharat* for grinding flour in this region. The Pangwals believed that *Gharat* was a traditional spot of social cohesion. The cultivation of wide varieties of traditional crops that are used by them to prepare different dishes during festivals and ceremonial occasions also keeps the activity of grinding in *Gharat* intact. The motivational reviews also revealed that the people of the region believed that the flour from the stone grinded mill was of superior quality and taste as compared to the flour obtained from the electric driven mill. Studies conducted in the past have proved that taste, texture, flavour and standard of the flour from the watermill to be far superior to the flour produced through modern mills (Mortiz & Jones, 1950; Leonard, 1990; Gelinas et al., 2004; Tun-dup, 2012). As expressed in '*The Bread Book*' (Leonard, 1990), the stone-ground flour is

preferred by many bakers and natural food advocates because of its texture, sweet and nutty flavour, and better baking quality than steel-roller-milled flour.

The reasons for the deterioration of watermills are many but more prominent being the environmental, economical (technological) and socio-cultural factors as documented in the present study (Vashisht, 2012). The construction of various hydro-electric projects have led to changed water courses causing decline in the number of water mills due to which the *Gharatis* find difficulty in operating *Gharats* (Sharma & Rana, 2014; Slariya, 2013; Wilson, 2007). Various developmental activities have caused excessive deforestation and reduced flow of mountain streams (Agarwal, 2006; Vashisht, 2007). The *Gharat* owners due to low-income, institutional issues and tough competition from electric mills have started abandoning watermills (Paish et al., 1997). The various technological gaps include slower speed, and increased time consumption of the *Gharat* which needs improvization by simple efforts (Sharma & Rana, 2014). The channel gradient can be increased, and the turbine as well the grinding stone can be modified quality wise to improve the speed and efficiency of the mill. The wooden parts like the turbine, rotor and shaft can be replaced by the metallic parts to increase the operational efficiency of the *Gharat* (Pujol et al., 2010, 2015; Shrestha et al., 2014). In the Tissa region, the increased popularity of the electric mills has caused deterioration of the watermills. But it is believed that in due course of time, electric mills run by other resources like kerosene, diesel and petrol etc. that have become popular among the people will prove to be unsustainable in the future (Tsering et al., 2015). The traditional cultural practices are changing and so are the cropping patterns in the Tissa region as people are more inclined toward growing horticulture crops/ cash crops over minor crops in the region (DOA, 2009; Soni et al., 2016).

It is beyond doubt that mountain environment requires appropriate technologies that are locally suited and resilient to environment while sustaining livelihood of the local population. In the present context where the conservation of natural resources is of a great concern, this indigenous technology can prove to be a sustainable means of energy utilization. Mechanical modification in the *Gharat* can be done for electricity generation by adequate flow of water that can produce at least 5.0 kW of power at the shaft. This can help in provision of electricity for small number of rural households. This can increase the efficiency of the *Gharat* that can function even at night by self-electrification and other works like oil extraction, sawing, agro-processing, wool carding, juice extraction etc. can be carried out to enhance the income of the *Gharatis* (Garg et al., 2015; Hussain & Hussain, 2014; Sharma et al., 2008; Slathia et al., 2018). Successful modifications of the watermills have been done in the past in various villages of Jammu and Kashmir, Sikkim, Uttarakhand etc. for conservation and sustainable development of traditional knowledge system.

It is essential that government agencies should intervene in the matter and frame policies for skill enhancement, value addition, access to markets and adoption of effective economic and environmental measures to leverage benefits to common people. Maintenance of a GIS database of watermills will enable to track the location of *Gharats* and help restore the existence of such traditional knowledge that has reached brink of extinction. People's participation is a crucial factor for sustainable development and thus it is important to ensure that these knowledge holding communities are well communicated and their knowledge documented (Jasmine et al., 2016; Roy et al., 1992; Singh & Sureja, 2006). The indigenous people should be made aware of declining traditional asset- '*the Gharat*' by improving its accessibility and visibility for increasing interest among the people. It is essential to learn from the best practices that the indigenous people of the area have developed to survive in the mountain regions (Agarwal, 2006) and make concerted efforts to preserve old traditional knowledge before it is vanished forever (Tsering et al., 2015).

5 Conclusion

Gharats have always been a source of livelihood for people living in remote areas of Himalayan region and an integral part of the cultural heritage. The present study revealed that though the number of *Gharats* is operating well in the Pangi region, the number has declined considerably in the Tissa region. A number of factors are responsible for the increase or decline in the number from environmental to technological. Therefore, there is an urgent need to revive the watermills to save the indigenous and environment friendly technology being practiced for ages by the indigenous people. At this time of pandemic when the world is battling with covid-19, people have migrated back to their native villages, cities and countries. As per the resolution taken up by the Government of India popularly called as 'Make in India', it is important to find possible indigenous sources of livelihood for the people. It further requires restoring and reviving the dwindling traditional techniques sustainable to Himalayan region and its indigenous people besides taking up other small-scale projects for boosting the economy of the nation. Activities on training, capacity building and subsidy provision by government shall be of immense help for the inhabitants to undertake such projects. Popularization of niche mountain products as highly valuable products and the development of value chains can harness immense benefits to the mountains communities. Thus, a concerted effort is required collectively by the government, institutions and the public to work for the restoration of this historical heritage.

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