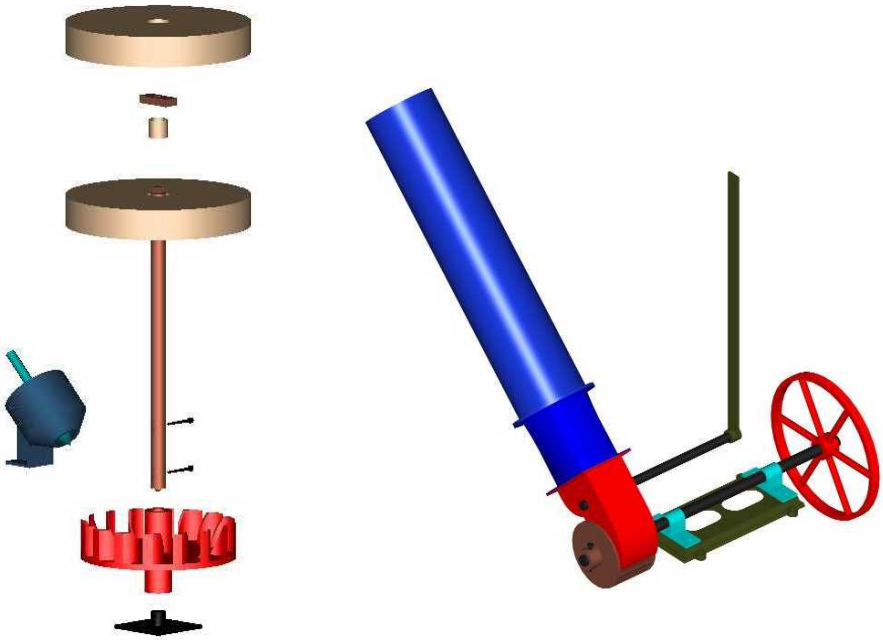
DFID

LOW-COST WATERMILL UPGRADES FOR INCOME GENERATION

R7658



Final Report

January 2002

ITP Ref: 00665/4
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Project title: **Low-cost watermill upgrades for income generation**

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Low-cost watermill upgrades for income generation

FINAL REPORT

1. GOAL, PURPOSE AND OUTPUTS OF THE PROJECT

1.1 Goal
The development and promotion of renewable energy sources, especially for rural communities

1.2 Purpose
To optimise and transfer low-cost micro-hydro technology to maximise income-generation from traditional watermill sites in India, and to build capacity for manufacture, implementation, and maintenance.

The target groups in terms of poverty alleviation are:
- watermillers struggling to maintain their livelihoods with traditional technology,
- rural families (especially women) who will gain affordable and local crop-processing services, reducing manual labour and laden travel by foot.

1.3 Background
The project followed on from the 'Watermills' component of the UNDP-GEF India Hilly Hydro Project for which IT Power developed prototype designs for two different types of development:

1. upgrading existing mills using a vertical-axis *new gharat* design, employing a cast steel runner and robust shaft and bearings.
2. replacing existing mills with a simplified *crossflow* turbine for operating a range of mechanical and electrical end-use equipment

1.4 Outputs
1. Working trial units to test the improvements to the new-gharat and the open-crossflow systems
2. Seven upgraded sites – 2 crossflows and 5 gharats
3. Design pack for both systems
4. Training course for watermillers
5. Web-site, with the design pack available for download

1.5 Detailed Objectives
The detailed objectives of the project were as follows:
1. To review the specific end-user needs in terms of the technical and economic performance required of the new systems, plus training needs for long-term sustainability.
2. To improve the design of the new-gharat system so as to replace the inefficient chute with a penstock and nozzle, permit flow control, develop ways of generating electricity for lighting, and improve maintenance features to ensure long component life.
3. To improve the design of the open crossflow system so as to permit flow control from inside the power-house, implement a modern design of flow-regulating valve, prove the system with up to 3 end-use machines, assess and implement safety aspects, and improve overall production engineering for ease of installation and maintenance.
4. To test various design modifications on test units at Gita Pumps (India) and/or Evans Engineering (UK).
5. To implement 7 new systems (2 crossflows and 5 new gharats) on a cost recovery basis using loan finance from Winrock International.
6. To develop a design package for each type of system.
7. To undertake local training of watermillers.

8. To disseminate the design package, including via the internet.

2. WORK CARRIED OUT

2.1 End-user needs

Detailed discussions were undertaken with HESCO and the Watermill Association on the local agro-processing needs and markets in different villages, and how micro-hydro could best be used to develop viable businesses. The Watermill Association compiled a summary of the local business opportunities and concluded that attractive end-uses would be:

- Rice hulling
- Oil expelling
- Spice grinding
- Juice extraction
- Wool carding
- Electricity for welding
- Electricity generation for running a café for tourists

An assessment of the market volumes available concluded that the biggest potential is for rice-hulling which can probably justify the construction of a 5kW crossflow mill on its own. Other end-uses then only need to pay back the marginal cost of the extra machinery.

2.2 New-Gharat design improvements

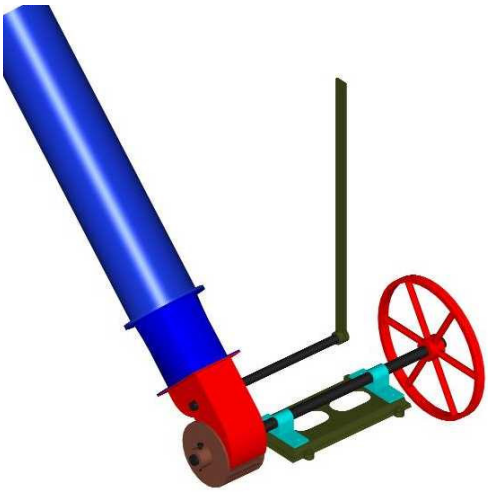
A number of design improvements were developed and tested during the project. The most important areas were as follows:

- The inefficient open chute was replaced with a penstock and nozzle.
- A spear valve and operating mechanism were developed to allow precise control of the flow to suit different seasons.
- The connection of the runner to the shaft was re-designed with two tapered pins so as to be more robust, easy to dis-assemble, and to prevent wear and loosening
- The bottom bearing was modified to permit regular greasing of the ball-bearing which will significantly prolong its life.
- A dynamo lighting unit was assembled from local components so as to run directly off the top mill-stone and light up the mill-house.
- A basic design of stone-dressing was transferred to the Watermill Association to enable millers to dress their mill-stones and absorb the greater power available.

2.3 Open-Crossflow design improvements

Design improvements to the crossflow were made as follows:

- A ‘tear-drop’ valve and re-designed nozzle were developed to enable accurate flow control and implemented so that the control lever could be operated from inside the powerhouse.
- The sealing of the turbine shaft passing into the powerhouse was improved to eliminate all leakage.
- Splash deflectors were fitted to divert flow away from the powerhouse wall.
- The powerhouse design was improved to make installation and maintenance more convenient.
- The runner was fixed to the shaft with 2 taper pins which can be knocked out with a hammer, replacing the keyway and bolt system which was tending to seize up.
- A low-cost method for connecting penstock pipes with socket joints was transferred to Gita Pumps and demonstrated at the 2nd crossflow installation.



2.4 Test modifications

Following preliminary testing at Gita Pumps, the initial modifications were trialled in 2 'live' installations (one open-crossflow and one new-gharat) at the Watermill Association demonstration site at Gadora in the UP Hills. This is a working site owned and operated by the secretary of the Association.

2.5 Implement 7 systems (2 Crossflows and 5 Gharats)

- The first crossflow was implemented at the village of Gadora in May 2000, the second at the village of Tangasa in May 2001.
- Two new-gharats were installed respectively at Gadora and Tangasa, alongside the crossflow systems. The 3 other gharat upgrades were implemented at the villages of Raitoli, Liswalta, and Bairagana.
- All systems were manufactured by Gita Pumps in Saharanpur, installed by the Chamoli Watermill Association and commissioned under the supervision of IT Power.

Figure 1 Gadora watermill site, with crossflow and new-gharat upgrades side by side

2.6 Develop design pack

- The design drawings for both systems were edited to include all modifications made throughout the project, and organised into a design pack for each system. The Design Packs contain annotated parts lists, assembly drawings, and component drawings (see Annex A).

2.7 Training

- A 5-day training programme was carried out from 10th - 14th December 2001 for watermillers, fabricators, engineering diploma students, and rural development NGOs.
- The training was conducted at the Tourist Rest House, Pipalkoti, Chamoli District, with practical sessions at both Gadora and Tangasa.
- The UK charity Engineers Against Poverty also collaborated in the training programme, and provided extra funds to allow the event to include more participants, to develop formal training manuals, and to cover travel and subsistence for the participants.

2.8 Dissemination

- A web-site has been established at www.itpower.co.uk/watermills with the primary aim of giving direct access to the Design Packs, which are both available as a free download. The site also includes short descriptions of the technologies (see Annex B).

- Articles disseminating key results from the project have been published in
  – Pico-Hydro
  – The International Journal of Hydropower & Dams
  – Renewable Energy from Britain
  – TPI News

  and a paper will be presented at the European Small Hydro Association conference in July 2002.

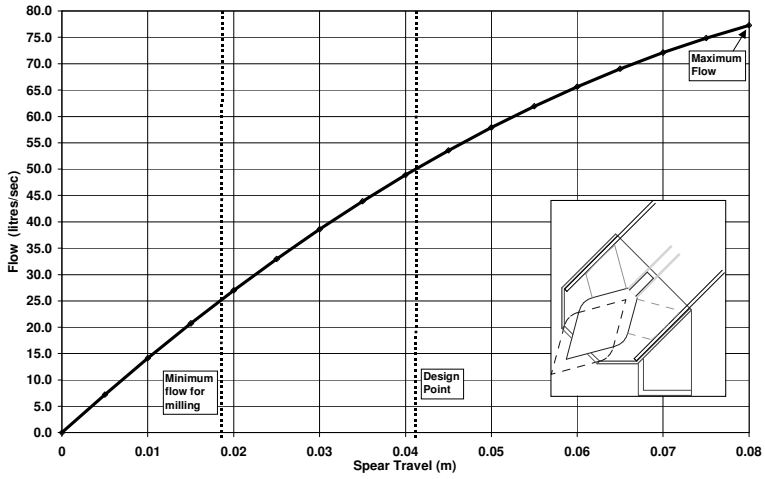
3. OVERALL RESULTS

3.1 Test Units

3.1.1 New gharat

- Spear valve: the prototype spear valve flow regulation system was installed at Gadora in November 2000 and worked exactly as designed. Figure 2 illustrates how the flow varies with travel of the spear out of the nozzle.

Figure 2 Spear valve performance (5m head)



- Milling Output vs Flow: Table 1 illustrates the milling output at Gadora as the spear valve was opened up to the design point, then closed again. Rate of output (kg/hr) was provided by the expert eye of the miller. However a spot-check of production was measured at 15kg/hour of wheat at 45 litres/sec, when the miller estimated the yield to be 20kg/hr. All other estimates may therefore be over-estimates (including estimates of what the mill was producing before the upgrade). However the increase in production was such that the mill-house was becoming overwhelmed with flour dust and the miller had to fabricate a cover to put over the stones.

Table 1 Wheat grinding tests at Gadora (27-Nov-00)

Spear Travel	Runner Speed	Flow (approx)	Grinding rate	
mm	RPM	l/sec	kg/hr	
15	0	20	0	
20	60	27	coarse	estimated
25	100	33	4	estimated
30	140	38	6	estimated
35	170	44	15	estimated
40	220	49	20	estimated
37.5	210	46	20	estimated
37.5	**200**	46	**15**	**measured**
30	170	38	15	estimated
25	160	33	8	estimated
20	90	27	5	estimated

- Lighting: the dynamo lighting worked satisfactorily and provided worthwhile lighting for an investment of only 250Rs (£4). However the need to reduce 'flying flour' proved to be greater than the need for light, and the dynamo was removed to permit the cover to be placed over the mill-stones. In reality it is quite rare for millers to mill at night. A more attractive option would be to use the gharat to charge a portable lantern which could then be taken home to use in the evenings.

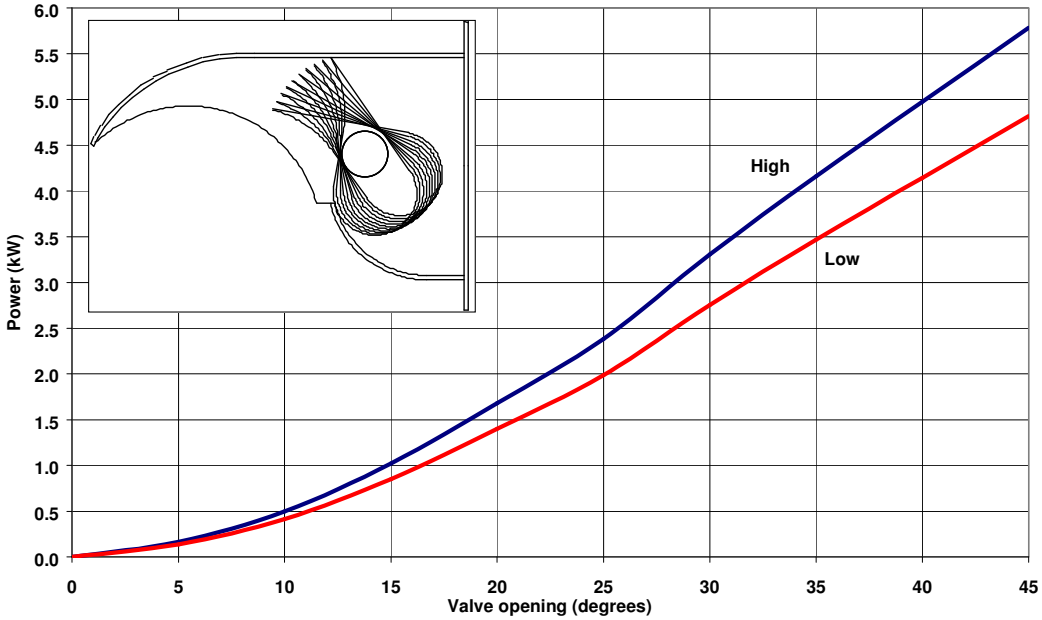
Dynamo lighting unit in operation

Stone cover from GI sheet (dynamo removed)

3.1.2 Open crossflow

- Tear-Drop Valve: the valve operates smoothly and effectively to increase or decrease the flow to the crossflow turbine and hence regulate the power to suit the load. The valve is easily operated from inside the mill-house by a push/pull lever, and is also the means for starting and stopping the turbine. The performance of the tear-drop valve is illustrated in Figure 3.

Figure 3 Estimated crossflow performance: shaft power vs valve opening




Assembly of nozzle, valve and runner


Crossflow assembly from inside the mill-house

3.2 Upgraded sites

3.2.1 New-gharat

- Economic Performance: The millers traditionally keep 5% of the flour as payment in kind, which they can sell for 5Rs/kg (7p/kg). Equating income against energy use leads to a value for the energy of 3.75 Rs/kWh or 5p/kWh. The full upgrade costs 15,000 Rs (£220). Current figures show that the upgraded millers are earning between 5000 and 15,000 Rs per year, and hence are on target to repay their loans.


New-gharat installation…

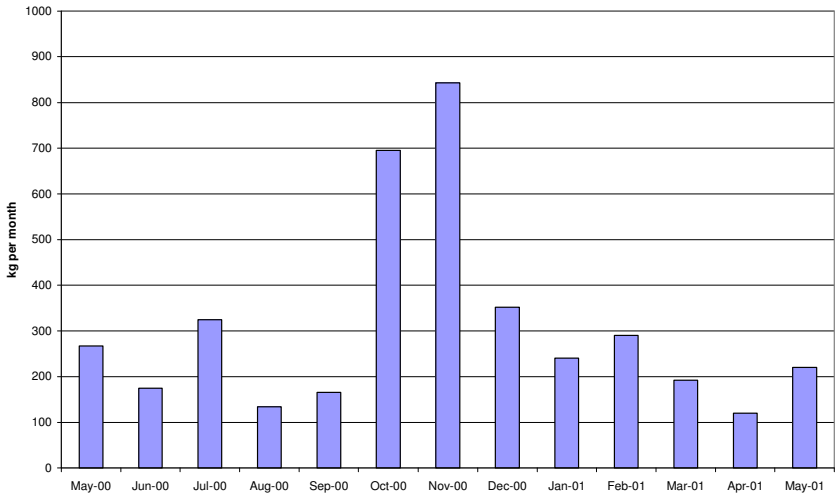

…operating the original mill-stones at double speed

3.2.2 Gadora crossflow

- The full installation cost at Gadora was 125,000 Rs (£2000, equivalent to £400/kW), of which 50% was required for the channel and powerhouse and 50% for the turbine and penstock. The miller and members of the Watermill Association also contributed significant unskilled labour.
- The system focused on rice-hulling as the primary income-generating end-use, although a 1.5kW generator and a spice-grinder have since been added by the miller. Figure 4 summarises the rice hulled at Gadora in the first year of operation.
- 1kg of paddy produces 750g of rice and 250g of husk. The miller charges 1 Rs/kg for whatever the customers take home ie. if they take the husk (for cattle feed) then they pay 1 Rs/kg for it.
- The value of the energy can be calculated to be 20Rs/kWh (30p/kWh) – 10 times what he would earn if he was trying to sell electricity. To pay pack the loan, the miller needs to aim for at least 150kg/day (typically 3 hours operation per day).

- Of the 120 families in Gadora itself, 60-70 have come to use the rice mill. 8 other villages are close enough to bring rice for hulling and villagers have started to switch to the crossflow-mill from the 3 villages that have nearby diesel mills, because of the higher charges and unreliability of the diesels.

Figure 4 Rice Hulling at Gadora



3.2.3 Tangasa crossflow

- All the difficult lessons were learnt at Gadora, and the Tangasa installation proceeded very smoothly. A number of design improvements were included at Tangasa.
- Since commissioning, the No.4 rice-huller has been de-husking at 50kg per hour from a shaft power of perhaps 3kW.
- HESCO also provided a 2kW generator which the miller uses to provide light in the mill-house in the evenings.
- Total scheme costs were as follows:

ITEM	**Rs**	
Crossflow machinery + penstock + transmission	66,000	(inc. 10% tax)
Equipment transport	6500	
Rice huller	3000	
Main civil works	47500	
Forebay/spillway improvements	3000	
TOTAL	**120,000**	**(£1850)**

Open-crossflow at Tangasa

No.4 rice-huller at Tangasa

3.3 Social context

A review of the social context of the watermills work was undertaken by Teresa Marston of IT Power India in June 2001. Her summary report is included in Annex C. Key conclusions and recommendations were:

- the agro-processing end-uses are saving significant amounts of time for the rural women who use them and boosting the use of the upgraded watermills in preference to diesel mills which are seen as unreliable.
- there is scope for integrating watermills developments much more closely with other rural development objectives, in particular regarding water supply.
- greater consultation with villagers before proceeding with the upgrades would help to improve the sense of community ownership and pride in the new technology.
- more detailed research on the socio-economic impact of watermill developments is needed to clarify the link between improving energy services for agro-processing and enhancing rural livelihoods.

3.4 Training course

3.4.1 Aims

The aim of the training course were to:

- increase the pool of local people with technical capabilities to support and expand the watermills upgrade programme.
- increase the knowledge and practical awareness of the available technology among watermillers in different districts of Uttaranchal.

3.4.2 Attendance

The training was spread over 5 days, and encompassed separate courses for 3 groups of participants:

- Watermillers
- Village Blacksmiths and local fabricators
- Technical teachers and Diploma-level graduates

43 watermillers, 14 technical teachers and diploma holders, 11 blacksmiths and 3 fabricators attended the training programme in December 2001. In addition, the Uttaranchal Renewable Energy Development Agency deputed 8 of its technicians from different regions to attend the training.

3.4.3 Manuals

Three illustrated manuals were prepared for the training course in both English and Hindi:

- A Water millers Manual, covering the technical and operational details of the new-gharat and open-crossflow watermill upgrades, plus business aspects.

- A Technical manual for the diploma students, which included additional sections on the theory of operation.
- A Design pack, with the drawings necessary to manufacture and assemble all the components for each system (now also available from the web-site).

3.4.4 Training Programme Schedule

The topics and practical activities covered in the training are summarised below for the 3 groups of participants:

DAY	MILLERS	TECHNICAL TEACHERS AND DIPLOMAS	BLACKSMITHS
1	Introduction	Introduction	
	Gharat components, function and assembly	Civil works (on site)	
	Crossflow components, function and assembly	Gharat and crossflow operation (on site)	
	Discussion on aims of participants and appropriateness of technology		
2	Small business management		
	Rice hulling: theory, operation and troubleshooting		
	Gharat and crossflow operation (on site)	Gharat components, function and assembly	
	End of course summary	Crossflow components, function and assembly	
		Head & flow measurement techniques (theory)	
3		Head & flow estimation (practical)	
		Site assessment exercise (practical)	
4		Feedback and discussion on site survey practicals	Introduction
		Accurate head & flow measurement methods	Gharat components, function, assembly & manufacture
		(practical)	Gharat components, function, assembly & manufacture
			Discussion on aims and skills of participants
5		Flow, Power and Speed calculations	Discussion on tools, skills and technical assistance
		Economic assessment of end-use applications	Mill-stone dressing (practical)
		Electricity generation and control	
		Design drawings	Design drawings
		Course feedback & discussion	Course feedback & discussion

3.4.5 Feedback

- There was strong interest from watermillers to receive the training, and there were many more willing participants than could be accommodated in this course.
- Millers were extremely attentive throughout the course and many have expressed genuine interest with the Watermill Association for upgrading their sites.
- A key barrier identified was the non availability of finance for watermillers. Many are willing to contribute substantial deposits, but few can manage to pay the full up-front costs.

4. IMPLICATIONS OF THE RESULTS OR FINDINGS FOR ACHIEVING THE OUTPUTS AND PURPOSE OF THE PROJECT

- The systems installed to date have exhibited excellent technical performance and the owners are very pleased with the output produced.
- The local manufacturer Gita Pumps has proven capable of producing robust machines of consistent quality, while incorporating continual design improvements.
- The technology is simple and, although very low-cost for hydro equipment (£400/kW for the crossflow, £200/kW for the new-gharat), it could become cheaper still with volume production.
- The implementation of the civil works for the schemes has been completed to a high standard thanks to the expertise and diligence of the local HESCO engineer (Mr Dobhal) and the capability of the millers themselves to improve and upgrade their channels and hydraulic structures.
- The Watermill Association and HESCO have both gained in confidence following the steep learning curve of the initial schemes.

- The new-gharat technology has typically trebled the output of the watermills and their economic performance has been sufficient to meet their loan repayments.
- For the two open-crossflow schemes, the economic performance has not yet reached the level required to pay back the loans in the 6-year timescale. This is partly because the schemes are still in their early stages and users need time to become aware of, and gain confidence in, the available services, but also because the poor harvest in 2001 greatly reduced the market after a promising start. There is also a social issue of persuading families of the value of saving the long hours spent de-husking by hand.
- Watermills were granted 'small-scale industry' status by the Indian Government on 30/5/2001. This is a significant step which, when the legislation has been implemented, will enable millers to access more favourable loan finance from rural banks.
- The training programme demonstrated the high level of commitment that the millers have for learning about the new technology and upgrading their mills. The watermillers have proven to be a highly practical group who have been able to adopt new technology with relatively little technical assistance.

5. PRIORITY TASKS FOR FOLLOW-UP IN ORDER TO PURSUE THE GOAL

A number of future needs have been identified as follows:

- further research on the socio-economic impact that the pilot watermill upgrades have made on the cross-section of owners, end-users, other millers, and the wider community. This will clarify the link between improving energy services for agro-processing and enhancing rural livelihoods.
- a detailed market assessment to define in greater depth the market characteristics and business opportunities for further upgrades. This is an important pre-requisite for persuading rural development banks to support loan applications.
- a business model detailing one or more financing and rural credit mechanisms which would be appropriate for applying to the 2 levels of watermill upgrade, with the aim of persuading rural development banks to adopt the financial instrument(s) that are developed.
- an information campaign to raise greater awareness of the technology, the results of the pilot projects, and the business opportunities for millers, and so stimulate future demand.

6. SUMMARY OF FINANCIAL EXPENDITURE

	LABOUR	OVERHEADS	MATERIALS	TRAVEL & SUBSISTENCE	TOTAL ex vat	**TOTAL inc vat**
TOTAL EXPENDITURE	47659	25970	1723	8735	84087	**98802**

7. NAME AND SIGNATURE OF AUTHOR OF THIS PROGRESS REPORT

Oliver Paish
Project Manager

Signed:_____

OUTPUT TO PURPOSE SUMMARY REPORT				
Title: Low-cost watermill upgrades for income generation **Country:** *India* **MISCODE:**				
Report No. *R7658 Final Report* *ITP Ref: 00665/4*		**Date:** **Jan 02**	**Project start date:** *01/05/00* **Project end date:** *31/12/01*	**Stage of project:** *Completed*
Project Framework				
Goal statement: The development and promotion of renewable energy sources, especially for rural communities				
Purpose statement: To optimise and transfer low-cost micro-hydro technology to maximise income-generation from traditional watermill sites, and to build capacity for manufacture, implementation, and maintenance.				
Outputs:	**Objectively Verifiable Indicators:**	**Progress:**	**Recommendation/ actions:**	**Rating:**
1. Two working test units 2. Seven upgraded sites 3. Design pack for both systems 4. Training course 5. Web-site	1. Test units of new-gharat and open-crossflow operating by Month 8. 2. Two open-crossflow and five new-gharats implemented with loan finance by M14. 3. Hardcopy and electronic versions of design pack available by M16. 4. One-week training course for 5-10 NGOs and 20-40 watermillers completed by M17. 5. Web-site operating by M18.	• Both test units implemented at Gadora, May 2000, after functional tests at Gita Pumps. • Two open-crossflow installations completed at Gadora (May 2000) and Tangasa (May 2001). • Five new-gharats implemented at Gadora, Tangasa, Raitoli, Liswalta, and Bairagana • Design pack completed and disseminated December 2001 • Training course with 80 participants completed 10th-14th Dec 2001 • Web-site operating since January 2002	• Watermill Association to continue monitoring the technical and economic performance of the new systems and provide feedback to IT Power and Gita Pumps. • IT Power to disseminate the project results and maintain the web-site.	
Purpose: To optimise and transfer low-cost micro-hydro technology to maximise income-generation from traditional watermill sites, and to build capacity for manufacture, implementation, and maintenance.	1. Local women/families using mill upgrades for agro-processing. 2. Millers pay back loans on time. 3. NGOs and workshops request design package. 4. Local workshops undertake maintenance, spare parts, copy of turbines.	• Over 50% of families at Gadora now using crossflow mill; awareness growing among 8 nearby villages. • New-gharat owners achieving satisfactory income and able to payback loans to schedule. • Crossflow owners still developing their customer base and hampered by poor harvest in 2001; nevertheless paying back 75% of income as loan repayment. • 3 local fabricators and 11 local blacksmiths trained in maintenance activities and fabrication of spare parts	• Watermill Association to assist millers in marketing of produce, with the aim of developing a 'watermill' brand to promote wider sales. • IT Power to respond to queries from fabricators attempting to manufacture components. • IT Power to seek follow-up funds to develop a business model and market assessment for persuading rural banks to adopt loan schemes for watermillers.	

ANNEX A

Design packs for the New-Gharat and Open-Crossflow

ANNEX B

Print-out from the web-site

www.itpower.co.uk/watermills

ANNEX C

Social impact report

Teresa Marston, IT Power India

Introduction

The focus for the analysis was:

- social sensitivity to water
- its management
- the consultation required to optimise the miller's activity in using the water source
- its impact on the population and
- the potential use of energy from the watermill.

Participatory rapid appraisal (PRA) techniques were used in meetings where possible, as the information source for consultation and recognition of activities (women's programmes, seasonal calendar of harvest, cropping pattern) with translation through the help of a local NGO.

The analysis is based on the outcome of 6 interviews and 5 group meetings, with cross checks and informal questions to confirm information. On the basis of these discussions, some wealth indicators evolved to assess the comparative status of populations. These include:

- the size of landholdings
- the availability of grain for milling or dehusking
- the potential for villagers to procure gas connections and stoves as well as payment for the transport of gas cylinders.

Background to rural livelihoods in the hills

With a rigorous winter climate and an average landholding of 0.8 ha, the average agricultural family lives a precarious existence, with the majority below poverty line. Irrigation is not available to more than 10 per cent of the cultivated area. Historically, villagers with sufficiently irrigated land rarely migrated to the plains.

Drinking water availability is often at crisis point: as early as 1952, the need to provide drinking water to the hills was considered to be a matter of priority. The 1999 Chamoli earthquake saw the disappearance of many traditional water sources underground.

The Kumaon and Garhwal Act of 1975 terminated the customary rights of individuals and village communities to manage their own water resources. Drinking water is often piped, but those supply systems are frequently fractured or out of use.

This is the context for the upgrade of watermills in Chamoli district.

Analysis of impact of present upgrade at Gadora

Gadora, a village of roughly 120 households in Chamoli district, can be favourably compared to many villages in the same district. The village inhabitants have on average a higher income than the norm, many being government civil servants, and some possess larger landholdings. Of 65 families, only 4-5 do not have a gas burner and connection. Some houses are electrified, many have TVs.

The centre of the village is graced with larger Brahman owned houses with paved meeting places. The lands below and above the village are well organised with maintained access paths. It contrasts with Tangasa (see below) in its wealth and general standing, as well as in its proximity to the road.

The proportionally larger landholdings provide more grain for milling or dehusking. This could further be improved by better management of water, which is more readily available at Gadora.

There are at least 4 watermillers who reside close to Gadora. Villagers claim to have little technical knowledge of the 2 upgraded watermills (the first has hulling and grinding, the second only grinding), or of the loan repayments. Their initial comments centred on the fact that the bran is not readily returned with the hulled rice. Mr Mittyal, the Gadora watermiller, later explained that this is a question of choice and payment.

Amounts of grain depend on the size and quality of farmers' landholdings, as well as climate. Women at a meeting estimated that they have taken 11 quintals (1100 kg) for rice hulling at Gadora Bridge. At this meeting 10% stated that they may have sufficient rice/wheat for the yearly family consumption, but 90% buy wheat flour, or wheat and rice from the ration store or market. Tillottanan Hatiwal, President of Women's Association, never has to buy rice.

At the 2 village meetings and during informal interviews, women, millers, and local residents claimed that crops have considerably decreased due to unfavourable climatic conditions (rain at the wrong periods, etc.). These statements are important to analyse livelihoods at risk. For many landowners their present situation which is below the poverty line will become even more tenuous unless water management is improved, land is irrigated and production progressively increases.

Potential impact at Tangasa

Tangasa is roughly 3 kms from the main road. The village suffered damage during the Chamoli earthquake. Only 5 of 32 houses have been repaired, those rebuilt benefited from close relations with government officials. The village suffers from real water problems, solved in part by the payment of a water caretaker (10 Rs/month) who manages the water supply and repairs leaks. Tangasa is situated 3 kms away from the watermill. Of the 32 houses only 3 have gas connections.

The old watermill has been upgraded with a new runner, and a new crossflow mill has been established next to it for hulling rice using the same water supply.

At Tangasa, the decision to upgrade the watermill was made by the miller and the Chamoli Watermill Association. There was little consultation with the villagers. Because the watermill had been out of use, a new diesel chakhi (mill) had been established with a KVIC loan which had been earning revenue from the villagers for almost one year. The upgrade and subsequent re-use of the watermill has created some dissension among the younger members who collect at the tea house above the mill, and will at least affect the diesel chakhi's loan repayments. Since the watermill has only just been refurbished, it remains to be seen whether this local competition in flour-milling will cause long-term negative, or positive, effects. The chakhi currently only mills flour, so there is no conflict with the new crossflow mill at Tangasa which will be used for rice-hulling. Previously all hulling was done by hand, or by transporting the rice 8km by foot or bus. However the diesel mill is at liberty to diversify into other end-uses, and may choose to compete on hulling as well, or move into oil-expelling, for which there was expressed demand.

Criteria for Watermillers Association (WMA) selection of sites for upgrades

The approach used by the WMA has been to base decisions on sites for upgrades on:

- the adaptability of the technology to the site
- the motivation of the watermiller

- the potential income-generating end uses for the power

This is an approach inherited from previous projects financing watermill upgrades in Uttaranchal (UNDP-GEF Hilly Hydro).

The initial aim was to demonstrate and promote the new gharat runner and the crossflow turbine to show the potential for improved agro-processing using the existing water channels.

Site selection took careful account of the potential income-generating end uses for the power and the WMA's assessment of local ability/willingness to pay for services. However there was little involvement of the villagers, other than watermillers, in the decision-making process. Such socio-economic factors as cohesiveness of villagers have not been investigated to date and no base line was established to enable systematic analysis of the impact of the upgrades.

Income-generating activities

Encouraging income generating activities hinges on potential or identified markets, which can be easily serviced by the population at little social cost. At Gadora there is a ready market emanating from the pilgrimage sites of Badrinath and Hemkunt, where hotels, restaurants and shops along the way sell local products.

Only the more wealthy women will be able to participate in income generating activities. The largest part of most women's days is spent fetching firewood for cooking, with some heating water in the winter and on collecting fodder for livestock. Poorer women are reduced to barter their small provisions against agricultural tools and other more basic needs.

The sale of flour from the mill involves the miller in some transactions and will require packaging and marketing. Stone ground flour is appreciated and may even be prized at markets further from the villages. The idea of the WMA promoting their own quality flour in printed bags could extend further to other local products presented under a generic quality label (eg. 'fruits of the mountain'). This could include: jams, pickles, juices, possibly presented in gift baskets.

Services from upgraded watermills

The watermills are rarely physically integrated within the villages that they serve, villagers climbing down or up to the mill with their loads. Upgraded watermills save time for milling flour and hulling rice, earning revenue from rice hulling and occasionally, from flour. Traditionally the miller is remunerated in kind for flour milling, a tacitly agreed amount of flour left behind in payment, but rice hulling is charged at Rs 1.50/kg. Rice hulling is currently only seen as a big advantage by larger landowners and to women who have the means to save labour so as to be more productive with other activities. Thus smaller landholders hull rice manually, (2 kilos in ½ hour), but take wheat and pulses to the gharat or to the chakhi (diesel mill) for milling. They carry often no more than 2-3 kgs of grain/flour at a time. Rice for hulling is often in the region of 15 – 20 kgs per load, brought to the mill by the men.

Electricity could be provided as a service from the mill to the community, but in most locations it would only be feasible to do so, for example, at a community centre close to the watermill. Services could include lighting, water heating and could sustain regular provision of health services, or be used by groups for income generating activities, evening classes, etc. However, villagers should be included at the planning stage in order to involve all stakeholders, including the poorest inhabitants and receive the consensus of the women. This will require extensive basic work, and should encompass energy and water supply, so that the watermill becomes a component of the total village plan. Women's projects, either existing or planned, should be promoted. For example at Pakhi village near Gadora, a micro-hydro project would provide the opportunity to supply valuable hot water for fruit transformation and for villagers to bathe in the extreme winter temperatures. The service would in addition decrease the number of hours spent collecting firewood for this purpose. Cooling could also

eventually be envisaged: vegetables, fruits etc. need either conservation (cooling during the summer season) or transformation into juices, jams, etc.

The miller could provide not only energy from the mill, but inputs to integrated water management activities which would include water harvesting, improved water channels (loss of water etc.) and restocking of watertables. Such activities were undertaken under the EC's Doon Valley Watershed Management Project.

Payment of energy services

What economic pursuits can be taken up by women in which they would or could pay for energy services? In optimum conditions at present they earn 100 – 125 Rs/day. Rural women do not rate their own time, including the time needed to collect the raw materials which they use. To support the development of activities, market identification is a priority, coordination of raw material supply and commercialisation, and training for quality production essential.
Villages may each have their own potential and their own need; some, especially where the Bhotia and Rurhia tribes are involved, have good potential to promote use of wool, fibre, cane, dyes etc. and other locally available substances could be used (kapok, medicinal herbs, oleaginous plants etc.).

Suggestions for improved interaction with villagers

PRA work with different groups of populations would assist in identification, recognition and planning uses for the energy, as well as evaluating income generating potential, community needs and water management issues. All actors, including the watermiller and the WMA would be involved at the outset. This work could expand into exchange and visits between villages. Results would be examined and discussed at the village meetings for general approval. Appraisals could uncover competence, availability, the potential for associations and groups to work together, what they should promote, how to overcome major problems together (such as alcohol), strengthening village capacity, so defining the tasks for sustainability and improving livelihoods.

Villagers should be in a position to understand the limitations of technology, and as a result confer ownership, take decisions about benefactors and payback mechanisms, improve land and water use, facilitate involvement of associations and weaker groups, and become stakeholders in the potential energy source. Such activity requires substantial support from a local expert with considerable experience using such techniques.