Centre for Rural Technology, Nepal

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the **Ashden Awards** for sustainable energy

Upgraded water mills improve livelihoods in the Himalayan villages of Nepal

Summary

There are many traditional water mills (ghattas) on the fast-running streams in the remote villages of the Himalayan mountains and foothills in Nepal. These mills are used to grind grain to produce flour. Milling is an arduous, low-status job, and millers need to attend the mills up to 12 hours per day in a dusty atmosphere, in order to earn a living.

The Centre for Rural Technology, Nepal (CRT/N), with support from the Government of Nepal and the Netherlands Government, runs a programme to upgrade traditional water mills, so that they work more efficiently, can operate for a longer period of the year, and also be used for other activities apart from grinding. Millers with improved water mills can earn more income and have extra time for other purposes. The flour produced from water mills is of better quality than from diesel mills, because it does not get so hot during grinding. When there is sufficient capacity in the improved water mills for multiple users, families no longer need to travel the longer distances to diesel mills, so the use of imported diesel decreases.

At the end of 2006 over 2,400 mills had been upgraded, providing service to about 96,000 families or 720,000 family members. Upgrades are partly paid by the mill-owners, assisted by the programme subsidy. 237 of the upgrades have used a long shaft on the mill runner, which means that other mechanical equipment (such as oil presses and rice dehuskers) can be used, and 31 of these upgrades generate electricity using an induction generator. There are over 25,000 traditional water mills in Nepal, and they have considerable potential to power a range of services in remote villages. CRT/N is working with Kathmandu University on the development of cheaper generators, to make electricity services more affordable.

The organisation

The Centre for Rural Technology, Nepal, is an NGO which was established in 1989 by a group of professionals including Lumin Shrestha and Ganesh Shrestha, both of whom previously worked for the Agricultural Development Bank, Nepal. CRT/N is funded by selling professional services to clients and by grants and awards and currently employs 55 people, 20 based at their headquarters in Kathmandu and the remainder in the field. During the financial year 2005/06, its turnover was about £260k of which £73k was for the water mills programme.

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Context

Statistical information	
Population (2004)	26.6 million
Urban population (2004)	15.3%
GDP per capita US$ (2004)	$ 252
- at purchasing power parity	$ 1,490
Population living on less than $1 a day (2004)	24.1%
Population living on less than $2 a day (2004)	68.5%
Population with access to grid electricity (2000)	15.4%
Annual electricity consumption per person (2003)	91 kWh
Annual CO_2 emissions per person (2003)	0.1 tonnes
Population undernourished (2001-03)	17%
Population with access to an improved water supply (2004)	90%

Sources: UNDP, World Resources Institute

Nepal is famed for the stunning scenery of the Himalayan mountains, but life in the villages of the mountains and foothills is tough, with most people farming at a near subsistence level. Deforestation is still serious, although the active promotion of forest restoration is starting to show real benefits. Because of the difficult terrain, road access is poor, and journeys often have to be made on foot. Provision of services such as electricity and improved sanitation is very limited.

Many family members migrate to Kathmandu and other major cities for work, and migration has increased in recent years because of the long-running conflict situation. The situation also means that professionals (including technicians, nurses, teachers and doctors) are less willing to work in the villages.

The streams in the mountains and hills support many traditional water mills (ghattas), which use heavy grindstones to mill grains and make flour. Milling is arduous, low status work. Watermillers often have to work for about 12 hours per day in order to make a living, and the entire milling family lives on site and breathes in flour dust all the time. Traditional mills are largely made from wood, and most parts have to be replaced every two years. Diesel mills have come into the region, but are often distant from the hill villages, so people have to walk long distances to use them. A diesel mill produces flour more quickly, but the high grinding speed decreases the flour quality.

The Centre for Rural Technology, Nepal (CRT/N) with support from the Government of Nepal and the Netherlands Government is managing a programme of water mill upgrades, to speed up the rate of flour production, and enable them to supply mechanical and electrical power for other uses as well.

Technology and use

Traditional water mills (ghattas) have been used in Nepal for centuries to provide mechanical power for agricultural processing, such as grinding wheat. In order to power a traditional mill, water is led from a fast-flowing stream along a canal, and then down a steep chute or penstock into the mill house. The water, flowing at a rate of up to 100 litres per second, turns the wooden runner of the mill, which rotates a vertical shaft. The grindstones are attached directly to the shaft, on a raised floor above the runner. Grain is fed between the grindstones from a hopper, and flour pushes out from the sides. Key mill parts are made of wood, resulting in a lifetime of only two years.

With an operational efficiency of less than 25% and a typical mechanical output of 0.2 – 0.5 kW, these mills grind between 10 and 20 kg of cereal per hour. The mills are now unable to satisfy demand, which results in long delays for farmers to get their crops milled and a rise in the number of diesel powered mills.

The water mill modifications provided by CRT/N consist of replacing the wooden penstock with high density polyethylene pipe, and the shaft and runners with precision-made metal parts. Sometimes the canal is also upgraded for irrigation. The mill improvements increase the grinding capacity by more than 100%, to between 20 and 50 kg per hour, and also increase durability. The upgrades produce very little disturbance to existing environment.

Most parts are fabricated locally in approved workshops in Nepal, although shafts are imported from India. The new runner is hydraulically shaped and the blades are cupped to catch the water more effectively and thus improve the efficiency of the mill. Both are made from mild steel. Because the improved mill is more efficient, it can work down to water flow rates of about 10 litres per second rather than the average flow of 40 litres per second, and this extends the milling season into the drier months.

Most improved water mills (IWMs) have a short shaft linking the runner to the millstones, in a similar arrangement to the traditional mill. Some upgrades have a longer shaft that does not link directly to the millstones; instead, the grinding shaft is run from it using a belt drive. The advantage of installing a long shaft is that other equipment can also be coupled to the shaft, such as a rice-hulling machine, a saw mill or a generator to produce electricity. Induction generators are particularly suitable where there is a low head but high flow as is typical for these mill sites. They can generate 0.75 to 2.5 kW electric power depending on the site and season. This will supply the miller's own needs, and sometimes those of neighbours as well, either directly or by charging batteries.

CRT/N is involved with Kathmandu University on the development of a cheaper generator for IWMs, designed to work on the short shaft upgrade. This is an axial flux permanent magnet alternator design, and will supply up to 1 kW of electrical power. 500 W prototypes have been shown to work effectively.

How users pay

£1 = 130 Nepali Rupees [March 2007]

The millers pay part of the cost of the improvements, and the remainder is covered by the programme subsidy. The initial subsidy for the short shaft version was about 50% but this is being gradually reduced. Currently short shaft owners pay NR 11,000 to NR 16,000 (£80 to £120), out of a total cost of NR 20,000 to NR 25,000 (£150 to £190) improvement cost. The millers' contribution is usually paid partly in cash (sometimes raised as a loan from a local micro-finance organisation) and partly in kind, through providing transport and labour for installation.

The long shaft IWM costs NR 60,000 to NR 80,000 (£450 to £600), depending upon the type of end use undertaken, with a subsidy provision of NR 18,000 (£135). If a generator is installed this increases the cost further. This high initial cost has deterred uptake of long shaft IWMs: most of the

millers who have installed them already had other business interests which would benefit from the mill power, and thus had more cash income to pay. It is hoped that the use of axial flux generators will allow short-shaft upgrades with electricity generation facilities to be undertaken at a low cost, and thus make the benefits of electricity affordable to more millers.

The villagers who take their crops to the mills pay the full cost of the milling service. By tradition this is charged as a fraction of the grain milled, usually 1/15th to 1/20th, and payment is often, though not always, made in kind.

Training, support and quality control

CRT/N contracts manufacturing to twelve existing metal-workshops, which it has approved to produce parts for IWMs. Each workshop produces the components for 10 to 20 improved units per month. Service centres offer a one-year warranty on the parts that they install, after which users have to pay for servicing and repairs. The drive belt on the long shaft version needs replacing every six months, the grindstones every three to five years and the shafts every ten years.

CRT/N has established 16 local service centres, which promote the improved water mills, train the millers, and provide repair and maintenance services. Service centres consist of local NGOs, metal workers and Water millers' Associations and are authorised to provide service. CRT/N helps build capacity for both manufacturers and service centres, and continuously monitors them to ensure they are providing the required quality service. Eventually, it plans for the Watermillers' Associations to take over the servicing.

All the new mill parts have unique serial numbers, which are used to provide a traceable record in case of future faults.

Benefits

Over 2,400 traditional mills have been improved and are currently in operation. Each provides services to an average of 40 families, so indirectly benefits about 720,000 family members. 237 are long-shaft upgrades with auxiliary services, and 31 of these include electricity generation.

Owning a mill upgrade increases the income of a watermiller, because grain is ground more quickly so more customers can be supplied. In addition, IWMs can operate at a lower water flow rate than the traditional mills, which extends their period of operation into the dry season for up to two months each year. There are mills that now operate 6 to 12 months depending upon the availability of water. Users generally need the mill services throughout the year.

Income increases by at least 25% in the case of short shaft upgrades and more than doubles in the case of long shaft upgrades. On an average, the annual income of traditional mill owner ranges from about NR 40,000 to NR 50,000.

The milling efficiency of an IWM is high and thus millers can work shorter hours. The water mill upgrades have improved the self-respect and social standing of the mill owners, who have traditionally come from low-status social groups. As a result several millers' associations have been formed with the aim of improving their advocacy power as well as livelihoods, for instance through negotiating for quality services, marketing of products and water rights issues. The associations also provide education and training to the millers.

Owners of long-shaft IWMs can sell additional services such as rice-hulling, cutting timber and electricity, and this can substantially increase earnings. One miller who bought a top-of-the-range NR 100,000 upgrade including a generator, rice huller and irrigation pump is earning an extra NR 55,000/year from rice hulling, so will pay back the initial investment and running expenses in less than three years.

Mill customers generally have to walk some distance to get to the mill, so usually wait at the mill for their crop to be ground. Since the IWM has a higher throughput, this waiting time is reduced from about 3-4 hours to 1-2 hours, and frees up time for other activities.

Because IWMs grind more slowly than diesel mills, the flour does not get so hot and does not pick up the taste of diesel. This means that the flour has a longer shelf life, is more nutritious and has a higher market value. IWMs are usually closer to the villages than diesel mills, so provided that they have the capacity to mill grain quickly, people will use them in preference. Diesel mills have decreased business in regions with large number of IWMs, some have closed down and new diesel mills are not being started. A CDM study on the potential carbon reduction from IWMs estimated that each IWM could replace about half the capacity of a diesel mill and offset about 900 L/year of diesel, equivalent to 2.4 tonnes/year CO_2.

The local manufacturing of parts for IWMs results in an estimated 50 days work per unit produced, and the metal workshops earn about NR 500 profit on each unit. Additional employment in promotion, transporting and selling is estimated to be 25 days per unit. IWM parts last ten years, compared with approximately two years for traditional mills.

An unmodified water mill requires regular maintenance, which consumes timber at a rate of one tree every two years.

Potential for growth and replication

Approximately 2,400 water mills have been upgraded out of an estimated 25,000 in Nepal. Although there may not be sufficient demand to upgrade these for grain milling alone, there is real potential to provide power for other mechanical uses, and electricity. Currently more than 1,000 mills are upgraded each year. There is demand for the upgrades in all the hill districts of Nepal.

This technology is directly applicable in other countries in the Himalayas with traditional water mills, and CRT/N sees its potential in countries such as Pakistan, Afghanistan, Bhutan and Tibet. IT Power India (a previous Ashden Award winner) ran an upgrade programme in India.

Management, finance and partnerships

CRT/N is managed by a group of Directors including Lumin Shrestha, with Ganesh Shrestha as Executive Director. The watermill programme is run by CRT/N on behalf of the Alternative Energy Promotion Centre (AEPC) of the Government of Nepal and the Netherlands Government, and the programme is currently supervised by Lumin Shrestha. Because of the large geographical areas covered and the difficult terrain, day-to-day work is increasingly carried out by local service centres. These create awareness and encourage demand, carry out feasibility studies, purchase the materials, carry out the upgrades and carry out training and monitoring.

The Government of Nepal has emphasised the importance of this technology in its Rural Energy Policy – 2006. The Netherlands Government finances the programme and provides technical assistance through SNV/Nepal, the development agency of the Netherlands. Representatives of AEPC, SNV/Nepal and CRT/N meet frequently to monitor the progress of the programme.

This report is based on information provided to the Ashden Awards judges by CRT Nepal and findings from a visit by one of the judges to see their work in Nepal.

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