CASE STUDY - Nepal

Improved Water Mills

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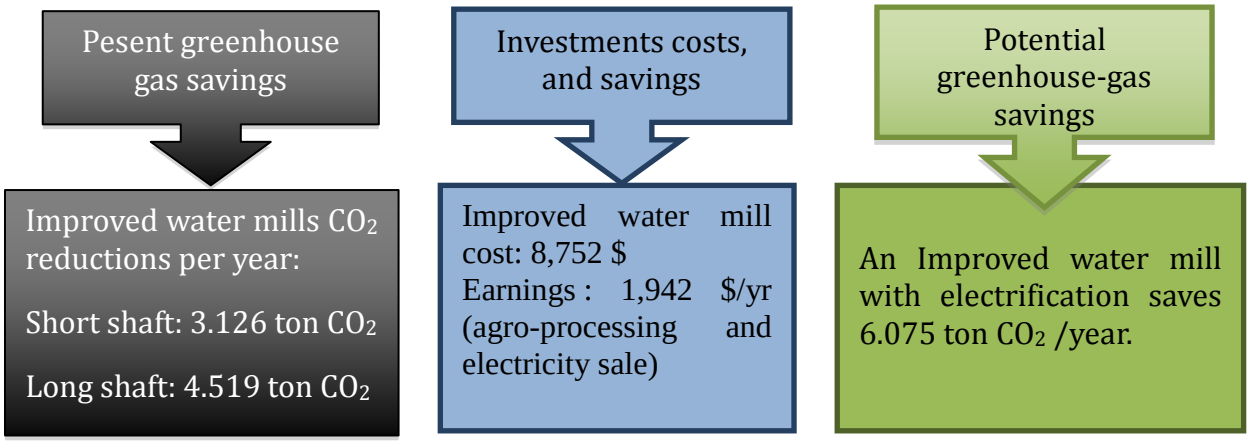
Summary

Improved Water Mills (IWMs) are one of the clean technologies being promoted by the Government of Nepal in cooperation with different stakeholders for about half a century. The installation and application of IWMs have helped the rural communities immensely in improving their livelihoods through user services like grinding, rice-hulling, husking, etc.; facilitating income- and employment-generating activities; and boosting the local economy as well as gender-mainstreaming and social inclusion.

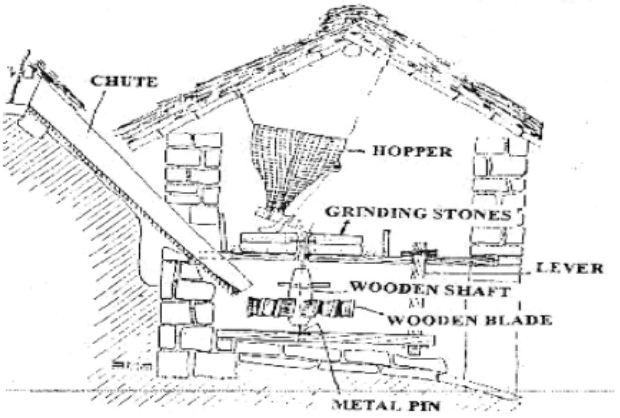
This case study summarizes the status of the Improved Water Mill (IWM) sub-sector, with its historical context of development and implementation as well as with its future potential development. Installation of improved water mills increases access to energy services, promoting socio-economic development of the rural communities in Nepal. It also contributes to a better climate, as it offsets fossil-fuel use. The case study was prepared by CRT/N, INFORSE's national focal point in Nepal.



Description, Development, and Background

Traditional Water Mill

Nepal, a landlocked mountainous country, has immense water resources. The power of falling water has been harnessed widely through the use of water mills, locally known as 'Ghatta', for centuries. They are used for grinding of cereals, mainly for maize and wheat.



Traditional Water Mill

The basic principle in operation of any water mill is the conversion of the kinetic energy of falling water into mechanical energy. After the diversion of stream water through a simple construction of stones or brushwood weirs, an earthen channel carrying about 40- 100 litres per second (lps) water is extended and led towards the water mill. In a traditional water mill, the water is then fed through a wooden chute made of a hollow tree trunk. A gate (a piece of flat stone) for safety overflow is opened when the mill is to be stopped. When the gate is opened, the water is diverted away from the water mill. A wedge is inserted at the end of the chute to direct the water to the runner. The centre-piece of the turbine runner is a massive boss in which a forged steel tip is driven into the lower cone.

The wooden blades of the turbine runner, with the peg on the other side, are driven tightly into the boss. The boss is coupled to its counterpart with a wooden wedge and then led to the shaft and key at the top. The whole runner rests on a steel plate with a conic depression. The shaft of the runner projects above the bottom of the grinding stone into which the key is inserted. The key exactly fits in the slot on the upper grinding stone and runs the mill. The grinding stone is made locally, and is grooved from time to time as per the requirement.

There are about 25,000 traditional water mills, comprising a major source of rural energy for agro-processing across the country. They have been used for centuries by the communities in the hills and mountain regions of Nepal.

Improved Water Mill

Improved Water Mill

The Improved Water Mill (IWM) is a modified version of the traditional water mill. It is an intermediate technology that increases the efficiency of the traditional water mill, resulting in increased energy output, thus helping both the millers and their customers. Replacement of wooden parts (rotor and shaft) with metallic parts is the main improvement made in the technology.

Two types of IWMs are in use: short-shaft, solely for grinding, and long-shaft, for grinding and other end uses such as paddy hulling and -husking, rice-polishing, sawmilling, oil-expelling, lokta (used for producing handmade paper)-beating, chiura (beaten rice)-making, and others. The technology can also generate electricity up to 3 kW, sufficient for lighting as well as for operating small electric and electronic home appliances.

Basic Functional Features of Traditional and Improved Water Mills

Comparison Parameters	Traditional Water Mill	Improved Water Mill
Operational Efficiency (%)	Below 25	30-50
Functions and Capacity	Grinding cereal grains only (maize, millet, wheat, rice, etc.), 10-20 kg/hr.	Grinding of cereals (maize, millet, wheat, rice, etc.) 20-50 kg/hr.
		De-husking/partial polishing of paddy (50- 70 kg/hr.)
		Expelling oil from oilseeds (10-15 kg/hr.)
		Generation of electricity (12V-DC, 220V-AC, 1-3 kW)
Repair/Maintenance	High	Low
Life Span	2 years	10 years

Source: Improved Water Mill Development in Nepal, A Status Review Book, CRT/N

History of Improved Water Mill

Pioneering Phase

The history of development of IWMs in Nepal dates back to the early 1980s, when the Research Centre for Applied Science and Technology (RECAST), a research and development wing of Tribhuvan University (TU), developed a prototype of an improved version of water mill. In the prototype, wooden paddles were replaced by hydraulically more efficient metallic blades, and a new bottom bearing was added. This prototype, with a closed chute and a covered chamber, was tested in a mill at Godavari, Lalitpur, Nepal. The technology was subsequently promoted among the farmers with involvement of a manufacturing company, the Kathmandu Metal Industries (KMI). The unit was called Multi-Purpose Power Unit (MPPU). A number of farmers adopted the technology; the experience of this effort was critical in improving the technology further and in promoting its social acceptance.

Market Development

The activities in the pioneering phase demonstrated that IWM could be a viable technology to address rural energy needs and, thus, rural poverty. In a bid to develop markets for IWM, the German Technical Cooperation (GTZ) came up with a programme to promote IWM in rural areas in 1984. The programme aimed at expanding markets for IWM through provision of financial incentives. Although there was some gap in the late 1980s, GTZ continued its support in the 1990s. Involvement of the Centre for Rural Technology, Nepal (CRT/N), as the implementer of the GTZ-supported programme marked the beginning of an institutional growth in IWM technology.

The market development for IWM continued even without donor support from 1993-96, when CRT/N continued to promote the technology on its own. Support from GTZ resumed in 1996, attracting a range of institutions, including development-oriented and financing agencies, towards IWM promotion. CRT/N was able to develop collaborative partnerships

with the Women's Development Division (WDD) of the Ministry of Local Development (MoLD), some national and international non-government organisations, banks, and local manufacturers.

Major Stakeholders and Partners

Over time, the IWM sub-sector has grown with the involvement of different players from public as well as private sectors. These institutions have been contributing at various scales and capacities to the promotion of IWM technology in Nepal. The emerging cooperation between these institutions exemplifies what one can call a best practice in public/private/civil-society partnership in community development. The public-sector institutions include the Alternative Energy Promotion Centre (AEPC) and the National Planning Commission (NPC). AEPC is the main executing agency of the IWM Programme, and is responsible for providing policy, coordination, and monitoring support to execute the programme. NPC, on the other hand, is more involved in policy development. Among the civil-society organisations, Centre for Rural Technology, Nepal (CRT/N) has been the major promoter of IWM.

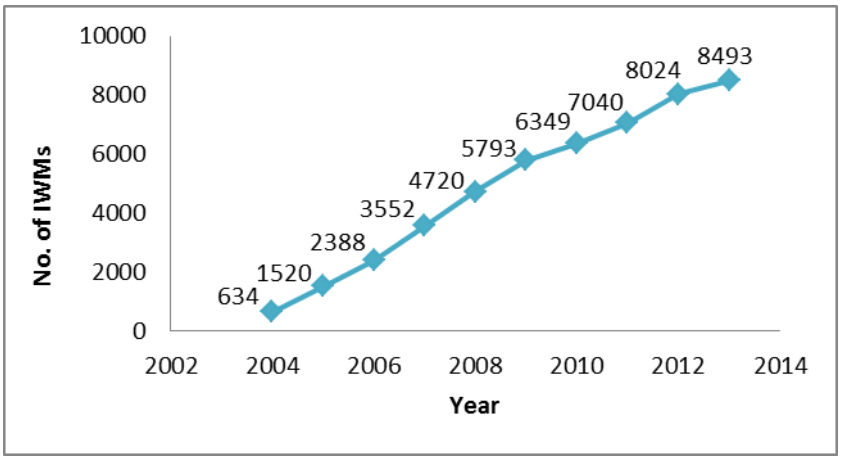
CRT/N has been promoting IWM since 1991. As a major implementer of the IWM Programme, it is responsible for overall management of the Programme. It coordinates with the programme partners, helps to ensure use of a quality-management system, monitors the programme activities, and facilitates the required flow of information. In the private sector, at least 4 different categories of institutions have emerged. CRT/N provides support for their capacity development. They include the kit-manufacturing companies, Service Centres, Ghatta Owner Associations (GOAs), and consulting firms.

Currently, 27 Service Centres, now called Local Partner Organisations (LPOs), procure standard IWM kits from the existing 14 manufacturing companies located in city centres in various parts of the country In some districts, GOAs have been recognised as LPOs, while in other districts, private companies and civil-society organisations have also been accorded that status. The range of services that they deliver includes feasibility studies, installation, and after-sales services. They also help to motivate IWM owners in the overall improvement of IWM management, facilitating subsidy applications for IWM owners and helping to arrange credit from micro-financing institutions. They also demonstrate the technology, and initiate end-use diversification. Micro-financing institutions in some of the programme districts actively promote IWM in coordination with LPOs and GOAs. In the city centres, a few private firms have taken interest in extending consulting services to AEPC and the IWM Programme. They have been involved in conducting studies and training sessions on IWM. The Community Electrification Sub-Component (CESC) of Alternative Energy Promotion Centre (AEPC) / National Rural and Renewable Energy Programme (NRREP) provides overall coordination and implementation support to the stakeholders. The AEPC/ Central Renewable Energy Fund (CREF) administers the subsidy for IWMs. The Regional Service Centres (RSCs) of NRREP, located in different parts of the country, coordinate local-level promotional activities, while the LPOs provide their services for supply and installation of IWMs. The National Capacity Builder extends technical support to the implementing partners in capacity-building in and knowledge management. Apart from the major stakeholders mentioned above, a number of support organisations, civil-society groups, financing interests, and academic institutions are contributing in their own respective ways to the development of IWM in Nepal. While some of them are directly involved in capacity-building or in financial or social-mobilisation support, others are involved in creating a supportive environment or in motivating the main stakeholders.

Potential Further Improvements / Installations

In 2012, there were 22,676 traditional water mills spread across 52 districts of the country. At the same time, there were 7,527 IWMs in the country (Source 1). It is estimated that there are still at least 25,000 traditional water mills located mainly in the mid-hill areas from east to west in the country (Source 1). A baseline study conducted in the 16 districts under the IWM Programme shows that about 90 percent of the existing traditional water mills can be improved. Considering this as the improvement potential factor, an estimated 20,400 traditional water mills (out of 22,676) could be improved.

The IWM Programme has reported that new installations of IWMs have also taken place in some of the districts, rather than just improvement of the traditional water mills. The annual growth trend of IWMs shown in the figure below reveals that 8,493 IWMs had been put into use across the country by 2013. Moreover, the key target of AEPC/NRREP has been to install 4,000 IWMs from July 2012 to July 2017.



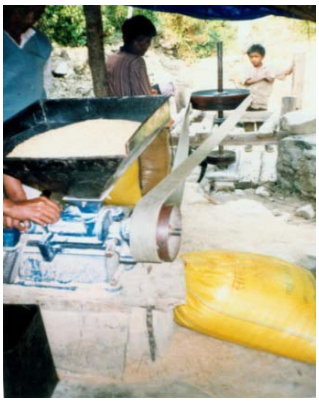
Cumulative Growth Trend of IWMs in Nepal

Source: Improved Water Mill

Effects on Poverty Reduction, Local Economy

User Services

An improved water mill serves, on average, 52 households at a time. Thus, altogether 441,636 households (8.1 percent out of 5,427,302 household in the country, *cf.* 2011 Census) are being served by the 8,493 IWMs installed so far. The services include use as theki-cutter, juice-extractor, choya-separator and tea-squeezer, besides grinding, rice-hulling, husking and polishing, sawmilling, and chiura-beating (Source 1). Likewise, around 871 household obtain lighting energy from 23 IWM electrification schemes, with total installed capacity of 62.6 kW.



Paddy Hulling from IWM

Employment

Promotion and installations of IWM have become good means for creation of economic, environmental, and employment activities in rural areas. According to the baseline survey conducted in 2012, around 7,572 people have been employed in IWM operation.

Technician Installing IWM

Rice Hulling from IWM

Income Level

The livelihood of the mill owners is based upon the income they make from the IWM that they operate. Income levels of mill owners can rise substantially with diversification of end-uses such as rice-husking, oil-expelling, sawmilling, generating electric power, etc. Reportedly, income level has risen even by 100 percent in the case of end-use diversification. It is also reflected in the improved living standard of the millers as indicated by various documented success cases. When the income from IWM operation is segregated, it is revealed that average annual income from the mill is only around NPR 39,000 ($411[2]) from short-shaft and NPR 85,000 ($895) from long-shaft, which are approximately 34 percent and 74 percent of total family annual income, respectively.

Boosting the Local Economy

The IWM has become an important hub in the value chain of various products in the rural economy, such as production of rice, flour, oil, furniture, etc. Moreover, the establishment of IWM has induced the institution of small cottage industries in rural areas. This has been possible due to the higher and more efficient output from the long-shaft IWMs. The time saved from using IWMs is also significant. With the time that is saved, the owners are able to devote their time to other income-generating activities like agriculture, cattle-farming, households, business, etc. The improved implements have also made it possible for the water mills to operate with lower flow rates, replacing the convention of closing the water mill during the winter seasons.

Gender-Mainstreaming and Social Inclusion

Women Operating Oil Expeller through IWM

Women's involvement in water-mill operation has been another distinctive feature of IWM. There are instances of women as mill owners and quite a few who help their husbands in the day-to-day activities of the water mill. According to the baseline survey conducted in 2012, 4.68 percent of IWMs are owned by women. This involvement has helped to improve the quality of women's lives and has given them some control over income. According to the impact study conducted in 2012, the IWMs, directly or indirectly, have changed in gender roles and relations to some extent. More and more women are being brought to public places as members of the workforce, service recipients, etc. The weakening of gender stereotypes in division of labour is noticeable within the workforce as well as on the assignment of the jobs of the service recipients, such as carrying and milling. Moreover, women do not face gender-specific problems in the mills.

The IWMs have reduced the drudgery facing women and children involved in agro-processing. Participation and leadership skills of women as well as socially excluded groups have improved. The IWM programme has played a role to reduce inequality between male and female by imparting technical skills as it provides economic and employment opportunities to rural people.

2 1 US Dollar = NPR 95, June 2014

Effects on Greenhouse-Gas Emissions (Fossil Fuels)

The IWM is powered by gravity-driven water, a renewable source of energy, which essentially does not produce air pollution or sound pollution. Therefore, the technology is environmentally sound and acceptable.

The technology has decreased dependence on traditional and conventional fuels. Operations of IWM have helped in replacing diesel-run mills in rural areas. A field survey shows that 8 diesel mills were displaced in Dolakha District alone (CRT/N 2011). Estimations show that each IWM could practically replace about half the capacity of a diesel mill. Therefore, each mill offsets about 900 litres of diesel per year, which eliminates 2.4 tonnes of CO_2 emissions.

It has been calculated that a short-shaft IWM reduces emissions by 3.126 ton CO_2/year; a long-shaft IWM cuts out 4.519 ton CO_2/year, and an IWM with electrification eliminates 6.075 ton CO_2/year. Studies show that operation of one IWM can reduce emissions by approximately 4.454 tons of carbon dioxide per year (Source: cdm.unfccc.int). Therefore, it can be estimated that the 8,493 IWMs installed by 2013 have eliminated 37,827.82 tonnes of CO_2 emissions per year.

The Designated National Authority (DNA) has already approved a Project Idea Note (PIN) submitted by Alternative Energy Promotion Centre (AEPC) for development of a CDM (Clean Development Mechanism) project on IWM. A Project Design Document (PDD) is in the process of validation (CRT/N 2011).

A Case Study: Improved Water Mill Enhances Rural Livelihoods

Mr. Chepang with his IWM

Mr. Dal Bahadur Chepang, a permanent resident of Jhatetar village, Kalikatar VDC of Makawanpur district, has 8 family members. Agriculture was the main occupation of his family, and he inherited a water mill from his father. Plenty of rice grew in the village, but lack of a rice-processing mill forced them to sell in the market at a low price and obligated them tp buy processed rice from the market at higher prices.

Mr. Chepang heard about Improved Water Mill (IWM) technology and its benefits during his visit to the Ghatta Owners Association, Makawanpur. Then he decided to improve his traditional water mill. A technician from a Service Centre surveyed his mill, then informed him of a government subsidy to improve it and of extensive services that could be available.

In 2009, his water mill was installed with long-shaft IWM, providing capacity for in grinding, rice-husking, and rice-polishing. He was happy about his increased income and about the new services that he provided to the villagers.

After two years, during a visit to the Service Centre, he came to know about IWM electrification. He then said, *"I looked back to my village, all the trouble we are having due to lack of electricity, the cost of kerosene used for lighting the house during night time and students suffering without light. It encouraged me to develop IWM as electrification project."* Later, he consulted with the technician of the Service Centre and gathered information about the provision of additional subsidy for electrification by the Government of Nepal (GoN) through Alternative Energy Promotion Centre (AEPC). But the subsidy

from AEPC was not sufficient to complete the entire project. So, he shared his idea with the villagers. The villagers agreed to operate the water mill for grinding and other extensive services in the daytime and electrification at night. They were ready to support him and were excited to know about electricity generation from IWM.

But, the available investment was not still enough to complete it. A series of dialogues and meetings was organized with local government agencies (District Development Committee, or DDC; Village Development Committee, or VDC), and the Poverty Alleviation Fund (PAF), and they shared their ideas of Public Private Partnership (PPP) for electrification. Finally, DDC Makawanpur, Kalikatar VDC and PAF provided NPR 300,000 ($31,581); 100,000 ($1,053) and 200,000 ($2,015), respectively, as financial support. He received NPR 240,000 ($2,526) as subsidy support from the AEPC and the remaining cost from the consumers. The users' committee was formed for timely completion of the project. Then the 'Kalikhola Ghatta Bidhyutikaran Aayojana' was completed, providing electricity to 80 households of Jhatetar. Electrification from IWM created new avenues in the village. Villagers of Jhatetar were also very happy as they do not have to live in darkness any more. They were able to finish their household chores easily and promptly; children were very happy that they could finish their school assignments in the evenings and no longer needed to wait for daylight. The generated electricity was also utilized by health-, post-, and police stations of Kalikatar VDC. Prior to electrification in the village, the villagers used kerosene lamps for lighting. The community was paying NPR 100 as tariff and the households with portable TV were paying NPR 150 as tariff for electricity per month, which the users were very happy to pay. So they were connected with the outer world and updated themselves with current news.

From IWM, Mr. Chepang was successful to earn NPR 112,500 ($ 1184) annually from agro-processing and NPR 72,000 ($ 758) from tariff for electrification. The income level of Mr. Chepang and his family is substantially increased with diversification of end-uses such as rice-husking, oil-expelling, sawmilling, generating electric power, etc., and he gave all the credit to IWM. Moreover, the IWM displaced a diesel mill in Jhatetar village.

Source: CRT/N Annual Report 2012

Conclusions

The impacts and benefits of improved water mill (IWM) technology have already been comprehended by the owners and the beneficiaries due to its diverse applications. Moreover, private-, civil-, and public-sector interests have grown to support the promotion and development of the IWM sub-sector, thus ending the energy poverty in the rural areas of Nepal. A more favourable policy environment is also taking shape, gradually. These and other factors sustain the uses of already established IWM and support dissemination of new IWMs in Nepal. Accordingly, this case study might be helpful and relevant to other developing countries as well to meet demands for energy and its end uses.

Currency: 1 US Dollar = NPR 95 (Nepalese Rupees), as of June, 2014.

Source 1: RETSC and CRT/N, 2012: Study made by Rural Energy and Technology Service Centre Pvt. Ltd. (RETSC) and Centre for Rural Technology, Nepal (CRT/N) with support from SNV Netherlands Development Organisation in 2012.