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TURNING TRADITION TO NEW ENDS: IMPROVING WATER MILLS IN NEPAL

Towards an 'Energy Plus' approach for the poor: A review of good practices and lessons learned from Asia and the Pacific

Case Study 8

ENVIRONMENT AND ENERGY

We would like to take this opportunity to recognize the partners who have made financial and other contributions to the energy sector project described in this report. These include the Centre for Rural Technology, Nepal (CRT/N), the Directorate General for International Cooperation of the Netherlands (DGIS), the Netherlands Development Organization (SNV) and the Alternative Energy Promotion Centre (AEPC). In addition, the project would not have been possible without the co-operation and the contribution of the Government of Nepal.

Alternative Energy Promotion Center

Making Renewable Energy Mainstream Supply to Rural Areas of Nepal

"UNDP partners with people at all levels of society to help build nations that can withstand crisis, and drive and sustain the kind of growth that improves the quality of life for everyone. On the ground in 177 countries and territories, we offer global perspective and local insight to help empower lives and build resilient nations."

Cover photo courtesy of UNDP/Energy Access for Poverty Reduction

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Acronyms

AEPC	Alternative Energy Promotion Centre
CDM	Clean Development Mechanism
CO_2	carbon dioxide
CRT/N	Centre for Rural Technology, Nepal
DDC	District Development Committee
DGIS	Directorate General for International cooperation of the Netherlands
EUR	euro (currency)
GHG	greenhouse gas
GOA	Ghatta owners' association
GoN	Government of Nepal
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit (German Company for International Cooperation)
IWM	improved water mill
kg	kilogramme
kW	kilowatt
LS	long-shaft
MFI	microfinance institution
MDG	Millennium Development Goal
NGO	non-governmental organization
NPR	Nepalese rupee (currency)
PCC	Project Completion Certificate
RE	renewable energy
RET	renewable energy technology
SNV	Netherlands Development Organization
SS	short-shaft
TWM	traditional water mill
TYIP	Three Year Interim Plan (2008-2010)
USD	United States dollar (currency)
VDC	Village Development Committee

Synopsis

Project title: Improved Water Mill Programme

Country and region of implementation: Nepal (19 hilly and mountainous districts)

Focus area (technology/energy service): Improved water mill, meeting rural energy needs through increased productivity and provision of additional end uses

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Duration: 2003–ongoing (information in this case study is based on what was reported in December 2010)

Cost: EUR 1,316,125

Project brief: The Improved Water Mill (IWM) programme promotes a simple and versatile technology that uses water resources to produce 3-4 kW of mechanical and electrical power. IWM improves upon the traditional water mill by replacing its parts with more efficient ones, thereby increasing agro-processing efficiency and adapting the mill to other end uses, including electricity generation. By promoting a variety of end use options, the IWM programme has a positive impact on rural households by promoting micro-enterprises, generating incomes and employment opportunities, reducing drudgery for women and allowing more free time for engaging in other activities. The programme also sets up and strengthens watermill owners' associations, which promise to be the main vehicles for future IWM technology dissemination.

The programme is currently being implemented in 19 districts in Nepal, with further potential in another 34 districts. More than 6,000 IWMs have been installed to date. The programme faces several challenges, however, including sustained financing and an insufficient demand for long-shaft IWMs.

The IWM experience demonstrates that applying a market-driven approach to expanding energy services for the poor is a complex process that requires many interacting components to come together. These include affordable technology, access to financial services for potential buyers, clear boundaries delineating programme responsibility and ownership, and private sector motivation to serve the poor.

Acknowledgements

Turning tradition to new ends: Improving water mills in Nepal is one of 17 case studies which, together with a report titled 'Towards an 'Energy Plus' approach for the poor: A review of good practices and lessons learned from Asia and the Pacific' and an Action Agenda Note, comprise a review of good practices and lessons learned in energy service delivery to the poor. Commissioned and facilitated by the United Nations Development Programme Asia-Pacific Regional Centre (UNDP APRC), this case study identifies key characteristics that have helped poor households and communities gain access to modern energy services, and to derive valuable lessons for future energy access activities. This case study is the product of an intensive collaborative process and we wish to acknowledge the many contributors, without whose generous support this work would have been impossible.

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Preface

Asia-Pacific has achieved remarkable economic growth and socio-political progress in the past two decades, with almost every country in the region experiencing a concomitant decline in poverty.

Despite this progress, 800 million people in the region remain without access to electricity and almost 2 billion rely on the traditional use of biomass for cooking. In Nepal, for example, only 40 percent of the population has access to electricity due to the mountainous nature of the country. Rural electrification stands at 29 percent, but even urban areas face acute power shortages. Some 88 percent of the population relies on traditional biomass fuels for cooking and heating.

The poor often live in subsistence economies that do not generate cash surpluses, limiting their purchasing power and opportunities to shift to modern energy services. As a result, they have to invest more of their income and time in obtaining energy, and tend to use traditional energy services and fuels. Women and children are particularly affected, spending many hours a day collecting fuelwood and preparing meals in the kitchen. Smoke from inefficient stoves in poorly ventilated homes kills 1.6 million people worldwide every year; the majority of victims are women and children younger than five years. Indoor air pollution is the fourth-biggest killer in the developing world.

Asia-Pacific countries have applied many cutting-edge practices in providing energy access to the poor, including innovative financing mechanisms. Apart from satisfying basic needs, energy services can act as an instrument to empower women and disadvantaged communities; as an entry point to mobilize communities to take charge of their own development; and, most importantly, as a means to livelihood enhancement and poverty reduction. However, the scale of expansion of energy access projects has been far from sufficient.

UNDP has been working with its country partners to address these energy poverty issues, aiming to meet user needs, broaden energy supply options and link these efforts in achieving the Millennium Development Goals. Between 2009 and 2011, the UNDP APRC reviewed 17 energy access programmes and projects implemented by various development agencies and the private sector in the region. These projects were documented as 17 case studies (including this report), a report titled 'Towards an 'Energy Plus' approach for the poor: A review of good practices and lessons learned from Asia and the Pacific' and an Action Agenda Note. Together, these documents provide practical guidance for policymakers and development practitioners in designing and implementing future programmes and projects that ensure the delivery of low emission, affordable and reliable energy services for poverty reduction.

This case study documents the experience of the Improved Water Mill programme in Nepal, which promotes a simple and versatile technology that uses available water resources to produce 3-4 kW of mechanical and electrical power to meet rural energy needs. The study shows that expanding energy services for the poor needs to combine an appropriate and affordable technology with access to financial services, private sector motivation and a clear formulation of responsibilities and ownership.

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1. Background

Ranked 138th on the United Nations Human Development Index, Nepal is one of Asia's least developed countries.[1] In 2006, the Government of Nepal (GoN) and the Maoists agreed to end a decade of civil war. Following constituent assembly elections in April 2008, in which the Maoists won the largest number of seats, the monarchy was abolished and Nepal became a democracy. Nevertheless, the political situation remains unstable.

Geographically, Nepal is divided into three topographic regions: the high hills (mountains), the mid-hills and the Terai (the plains). The high hills cover 35 percent of the total land area, the mid-hills 42 percent and the Terai 23 percent. Population distribution for the three regions is 7.3 percent, 44.3 percent and 48.4 percent, respectively.[2] The three regions present a great diversity in terms of indigenous peoples, cultures, lifestyles and economic status.

Promotion of renewable energy technologies (RETs) through subsidies and other support has been assigned a high priority by the GoN, which aims to use RETs to meet the energy needs of the rural people. This commitment is expressed in Nepal's *Rural Energy Policy 2006:*

> In the context of Nepal's rural areas, clean and reliable energy technologies seem to be less expensive and require less time to develop. Effective management of national energy sector and energy development and expansion in rural areas will contribute directly to the improvement of the overall rural population's living standards through maintaining ecological balance, saving time in fuel wood collection, generating additional employment opportunities, improving health and increasing access to education for rural children.[3]

The GoN has prioritized RETs that meet the following criteria:

- least cost options;
- maximum utilization of local resources;
- provision of multiple end uses;
- potential for local manufacture and repair; and
- maximum benefit to socially and regionally disadvantaged populations.

The Alternative Energy Promotion Centre (AEPC), established in 1996 under the Ministry of Environment, Science and Technology (MoEST), is the lead agency for promoting RETs in Nepal.[4] Various ministries are responsible for other energy sources, including the Ministry of Energy (electricity), the Ministry of Commerce and Supplies (fossil fuels) and the Ministry of Forests and Soil Conservation (biomass).

1.1 Current energy access in the country

Low per capita energy consumption. At 14.8 gigajoules per year, Nepal has the lowest per capita energy consumption among the South Asian countries.[5]

Renewable energy, used and potential. Only 0.7 percent of the energy consumed in Nepal comes from renewable energy (RE) sources.[6] This is despite the fact that Nepal is endowed with one of the biggest hydropower potentials in the world (83,000 MW, of which an estimated 43,000 MW can be feasibly tapped). Only 1 percent of this potential has been harnessed so far.

1 UNDP, 2010.

2 CBS, 2003.

3 MoEST, 2006.

4 The MoEST was reorganized as the Ministry of Environment in 2009.

5 WECS, 2006.

6 MoF, 2009.

Access to energy. Currently, 40 percent of the country's population has access to electricity. Rural electrification is at 29 percent, and even urban areas face power outages of up to 16 hours per day during the dry season.[7] Rural energy needs are mostly for cooking (with fuel derived predominantly from biomass), agro-processing, lighting, and communication equipment operation.

Reliance on traditional energy. Nepal draws largely upon traditional energy sources, with biomass making up 87.8 percent of the total energy consumed. Commercial energy comes mostly from fossil fuel and electricity (11.5 percent).[8]

Implications of prevalent energy-use patterns. The excessive reliance on biomass has adverse impacts on human health and exacerbates on-going resource degradation. Women are most adversely affected, as they are responsible for kitchen-related and agro-processing activities, including fuelwood collection.

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Women and girls spent much time at traditional grain-grinding and hulling facilities.

Challenges in expanding energy access to the poor. The expansion of energy access for the poor in Nepal faces a number of barriers:

- difficult topographic conditions, low population density and limited purchasing power among rural people make extending the electric grid and expanding access to petroleum products extremely difficult in mountainous and hilly areas; and
- low educational and training levels among rural people and lack of investment in RETs prevent effective promotion and sustainability of these technologies.

2. Programme overview

The improved water mill (IWM) is an intermediate technology that increases the efficiency of traditional water mills (TWMs), hereby increasing the output of agro-processing facilities and providing more effective electrification (for details see Box 1). The history of IWM technology development in Nepal dates back to the early 1980s, when GIZ initiated a project aiming to disseminate IWMs.[9]

The current national IWM programme (the subject of this report) was established in 2003 and has extended operations from the initial six years until mid-2012. The programme is implemented by the Centre for Rural Technology, Nepal (CRT/N), a non-governmental organization (NGO) involved in developing and promoting rural technologies.[10] The programme is funded by the GoN and the Directorate General for International Cooperation of the Netherlands (DGIS), with EUR 1,316,125 contributed to the current phase of the programme.

[7] MoF, 2009.

[8] MoF, 2009.

[9] Deutsche Gesellschaft für Internationale Zusammenarbeit (German Company for International Cooperation), then GATE (German Technical Cooperation/German Appropriate Technology Exchange).

[10] CRT/N has engaged in the promotion and dissemination of IWMs since 1990. It also promotes other RETs (including improved cookstoves via its Biomass Energy Support Programme), the networking of different energy-related programmes and organizations, and carbon-financing activities.

2.1 Objectives

General programme objectives are:

- improving living conditions of water mill owners and users by meeting their energy needs and increasing productivity; and
- a stronger institutional capacity to expand the energy sector's reach to remote hilly and mountainous areas.

Specific programme objectives are:

- improving the livelihoods of water mill owners and users, particularly women and girls;
- strengthening institutional capacity to promote a sustainable IWM sub-sector;
- increasing the efficiency of IWM technology; and
- up-scaling the IWM programme in the region.

Target groups include water mill owners and users (particularly women and girls), service providers (mainly *ghatta* owners' associations or GOAs), IWM service centres and IWM manufacturers.[11]

The programme target was to install 7,000 IWMs in 19 districts by the end of 2010. These were to include 5,950 short-shaft (SS) mills and 1,050 long-shaft (LS) mills, including 125 LS mills for electrification. AEPC plans to extend the programme to 40 districts for the improvement of 4,000 additional mills.

Box 1: IWM technology

IWM is a high-flow and low-head technology that transforms the kinetic energy of running water into mechanical energy or motive power. Abundant water resources and hilly topography makes it an appropriate technology in rural Nepal. IWM improves the capacity and efficiency of TWMs by replacing certain wooden parts (rotor, shaft and chute) with more efficient, hydraulically designed metallic ones. IWMs provide energy services to households at low investment and maintenance costs, and construction requires a relatively short time (as discussed in Section 3).

SS IWM systems improve the efficiency of traditional grain-grinding facilities. LS IWM systems can also support additional end uses, including paddy hulling, paddy husking, rice polishing, saw-milling, oil expelling, *lokta* beating, *chiura* production and electric power generation capacity of up to 3 kW.[12] Currently, 13 different types of end uses can be successfully coupled with LS IWMs.

2.2 Institutional set-up

The roles of programme stakeholders are described below.

AEPC. AEPC is responsible for donor coordination, subsidy provision (from the GoN) and administration, and maintenance of national database and management information system for Clean Development Mechanism (CDM) administration for the IWM programme.

Netherlands Development Organization (SNV). SNV channels DGIS funding to the programme (including funding for the subsidy) and provides technical advisory services to build capacity within the sector.

CRT/N. CRT/N is the programme implementing agency. Apart from programme management, it provides technical services (including training) to service centres, GOAs and manufacturers; monitors field level activities; facilitates institutionalization of GOAs; coordinates with district level agencies; and conducts research and development.

[11] *Ghatta* is a traditional water mill.

[12] *Lokta* is a material for making handmade paper. *Chiura* is beaten rice.

Manufacturers. Private sector organizations pre-qualified by AEPC are involved in the production and delivery of IWM appliances (e.g. IWM kits and equipment). There are 17 pre-qualified manufacturers located around the country.

Service centres. These local-level organizations install IWMs and are responsible for after-sales service and promotional activities. There are currently 16 service centres working in the 19 programme districts. Development of service centre capacity aims to create a sustainable institutional set-up at the local level, hence ensuring continuity in the delivery of quality services to mill owners. Capacity-building activities include building strengths in community mobilization, information dissemination, installation, technical supervision and provision of quality after-sales services.

GOAs. Generally speaking, GOAs' role is to protect the rights of mill owners and users. GOAs are being developed to play a key role in IWM installation, and business management and product marketing for members. The programme supports their formation and development. 15 out of 16 GOAs are registered with the District Administration Office, while four GOAs are simultaneously performing the role of service centres.

As the programme is phased out, GOAs are expected to serve as the main vehicles for IWM technology dissemination. Some GOAs have been instrumental in including *ghatta* improvement in yearly plans of district development committees (described below), and in mainstreaming local-level initiatives. GOAs and local service centres are also expected to take over IWM promotion and information dissemination. Some GOAs also provide strong advocacy inputs in areas such as water rights.

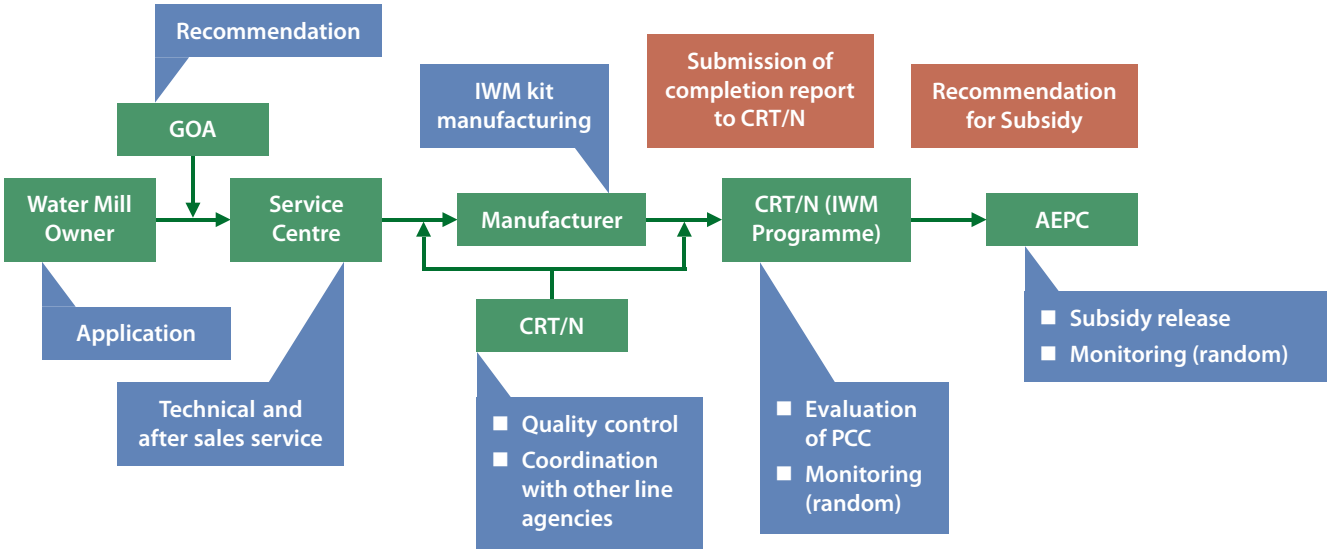
District development committees and village development committees (DDCs and VDCs). DDC is the district-level government body, while VDC is its village-level counterpart. DDCs are encouraged to incorporate IWM installation into their energy plans, support promotional activities and contribute funds. VDCs are encouraged to support GOAs and represent their interests at the district level.

3. Implementation strategy

3.1 Project activities

The programme has followed a multi-stakeholder, public-private partnership approach. Programme activities are illustrated in Figure 1.

Figure 1: IWM programme activities



Source: CRT/N, 2008.

Selection of candidate districts. The selection of districts is based on secondary information regarding availability of water resources, suitability of terrain, number of TWMs, potential for end uses, markets and physical accessibility. DDCs are informed about the programme and their support sought.

Selection and training of service centres. The selection of potential service centres in programme districts is based on technical, managerial and service coverage capacity. Service centres are then trained in survey, installation and data collection for baseline preparation. Programme initiation meetings are organized to brief all stakeholders and line agencies working in districts regarding necessary coordination.

Performance-based modality. The current modality is performance-based, and centres around local service providers (service centres and GOAs) involved in installation and after-sales service of IWMs. The service providers are monitored by CRT/N. The subsidy for IWM installation is released by AEPC only after IWM installation, submission of a Project Completion Certificate (PCC) by the service provider, and its approval by CRT/N. This practice increases cost effectiveness and motivation to install IWMs.

3.2 Financing mechanisms

An IWM installation costs approximately NPR 25,000 (EUR 234) per SS system and NPR 60,000 (EUR 560) per LS system.[13] The current subsidy rate for installation is NPR 12,000 per SS and NPR 27,000 per LS, i.e. roughly 45 percent of the cost. The electrification subsidy is NPR 60,000 per kW, while the actual investment cost is about NPR 180,000 per kW. Operational cost varies according to the type of end use.[14]

The DGIS and the GoN provide 80 percent and 20 percent of the subsidy, respectively. It has been agreed that the GoN will increase its contribution by 2 percent annually in the coming years.

An example of economic costs and benefits of an IWM electrification system is provided in Box 2.

Box 2: IWM electrification system in Baitadi District

Before the installation of IWM electrification, villagers were using kerosene for lighting. Around 1.5 litres of kerosene was consumed per household per month. At NPR 70 per litre, the 35 households of the community spent about NPR 44,100 (USD 555.2) on kerosene annually.[15] This expenditure was reduced to NPR 21,000 after the community installed an LS IWM with 3 kW electrification.

Installation costs

Breakdown of investments	Investment (NPR)	Percentage	Remarks
Subsidy for electrification and LS IWM component (NPR 120,000 + NPR 18,000)	138,000	25	
VDC	100,000	18	
DDC	125,000	22	
Development organization	25,000	4	
Labour contribution	171,500	31	Civil works (new power house and canal)
Total	559,500	100	
Per kW cost	186,500		Higher than average per kW cost due to new civil structure

[13] NPR 1 = EUR 0.00934, as of 23 September 2011 (www.xe.com).

[14] CRT/N, 2009b.

[15] NPR 1 = USD 0.01259, as of 23 September 2011 (www.xe.com).

Box 2: IWM electrification system in Baitadi District (continued)

Income and operational costs

Annual income	NPR	Annual expenditure	NPR
Subsidy Grinding	91,250	Salaries for operators	18,000
Hulling	12,600	Repair and maintenance cost	6,000
Electrification	21,000	Total	24,000
Total	124,850		
Profit (NPR)			100,850
Payback period (years)			5.5
Plant factor			75%

High initial investment cost a hurdle. Though the IWM technology offers a payback period of four to five years for most end uses, the high initial investment cost presents a hurdle to widespread adoption. Ninety percent of water mill owners and users are farmers living in rural areas. The average per capita annual income of an IWM owner is about EUR 108, considerably lower than the national average of EUR 328.[16]

Making IWMs more affordable. Earlier efforts to mobilize microfinance institutions (MFIs) to extend loans for IWMs did not succeed, primarily because of the perceived associated risks. The programme and GOAs are now jointly developing a pilot revolving fund, with each contributing 50 percent of the total amount. The fund is managed by GOAs, and offers mill owners loans to a maximum of 90 percent of total machinery costs (excluding subsidy and transport costs). A prospective mill owner applies for a loan, and, after a GOA feasibility study and upon the recommendation of the local mill owners' group, the GOA extends a loan to the mill owner for a term of three to five years on a monthly repayment plan. Loans are provided at 16 percent annual interest, which is expected to cover operation costs including cost of capital (interest rate 4 percent). Discussions are also ongoing with district-level MFIs to provide loans for IWM projects.

Reducing perceived risks of investment. Financial risks are minimized by ensuring that only high-quality IWM systems are installed. All systems must meet safety and quality of electricity supply standards, and only those installed by technicians pre-qualified by AEPC are eligible for subsidies.

Repayment capacity is a consideration in financing, and prospective borrowers must submit business plans demonstrating the financial viability of the IWM. To mitigate risks posed by natural disasters such as floods, landslides and earthquakes, support is being extended to GOAs to pilot a micro-insurance scheme under which IWM machinery would be insured.[17]

Participation of local community: a crucial factor for the success of energy access projects.

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3.3 Capacity development

Goals. The programme's sector capacity development activities are aimed at improving personnel skills at all levels and strengthening concerned institutions. Capacity-building is a programme component and makes up 6 percent of the programme's budget.

[16] ADB, 2009; AEPC, 2009.

[17] With valid claims, 80 percent of the insured amount would be repaid. The annual premium would be paid either in cash outright by the owner or borrowed from GOAs.

Training programmes. To date, 77 training programmes have been organized, with more than 1,500 participants (including 108 women). These have addressed a range of topics, including:

- conducting feasibility surveys;
- installation, repair and maintenance of IWMs;
- end-use diversification;
- electricity operation;
- quality assurance; and
- managerial training, including association management, report and proposal writing and project management.[18]

Capacity development activities targeting GOAs are described in more detail in Box 3.

Box 3: Developing capacities of GOAs

Established at a district level as business membership organizations, GOAs provide crucial linkage between DDCs and mill owners. Their functions include:

- information dissemination regarding IWMs and other business-related issues;
- capacity-building activities for business undertakings;
- conflict resolution in disputes related to water use (primarily at the village level);
- jointly with the government District Education Office, conducting informal education programmes for their members; and
- representing members at forums and meetings held at different district offices, including those of NGOs.

Against this background, the programme extends its support for developing GOA capacities in association management; business development; strategic planning; accounting and other skills necessary to run local enterprises. It also supports GOA evolution into private sector businesses and service centres for IWMs.

Currently, four of the 16 GOAs have developed into service centres, and a number have also grown into locally recognized organizations in the RE sector. For example, a GOA in Kavre District promotes RETs (including IWMs) and manages a revolving fund for the promotion of LS IWMs. It has also established a sister organization, Himchuli, a private entity pre-qualified by AEPC as an IWM electrification installer.

'*Ghatta* house management'. IWM owners are also being encouraged to run IWMs as micro-enterprises to serve the local community. In line with this, the concept of '*ghatta* house management' was introduced, referring to the provision of quality services to make IWM-related businesses more profitable. Specific areas include training of water millers in developing cottage industries (*lokta*, *chiura*, saw-milling, etc.), and promotion and marketing of goods produced.

Overall, the skills training has had a positive impact on the sector as a whole. For example, most mill owners are capable of running their IWM and solving minor technical problems.

3.4 Productive use of energy

SS IWM installation, a mixed experience. SS IWMs reduce the time required to grind grain by 50 percent. This allows the mill owner to serve more customers in a day, thereby increasing overall income and grain production. Saved time can also be directed to other income-generating activities. However, SS IWMs have had limited impact on new employment generation and on meeting rural energy needs.

LS IWM has the advantage of diversification. LS IWM, on the other hand, provides additional services needed in local areas. Each additional end use generates income and employment opportunities for IWM owners and operators.

[18] CRT/N, 2009b.

The programme has initiated the following strategies to promote LS IWM installation and take-up of additional end uses:

- adopting a target of 15 percent of total installations as LS IWM;
- continued research and piloting of new end uses, with 13 different types of end uses currently in practice;
- establishing demonstration sites to highlight the impacts of electricity, hulling, etc. for potential buyers;
- organizing exchange visits for GOA members;
- publishing promotional material such as catalogues and booklets explaining business-planning schemes, and disseminating in-depth knowledge regarding technology, costs, availability and cost-benefit analyses;
- training in LS IWM operation and income-generating activities; and
- facilitating credit support to encourage MFIs to invest in IWM or to provide a revolving fund for LS IWM promotion.

As a result of these strategies, the percentage of LS IWM of the total IWM installed has increased from 9 percent to 13 percent over 2006-2009.[19]

3.5 Involving local stakeholders

The IWM programme promotes local ownership and links with governments at all levels.

Any concerns raised by GOAs are brought up in VDC and DDC meeting, which incorporate reported problems and their solutions in their annual and other periodic plans. CRT/N staff encourage DDC offices to incorporate IWMs into their district-energy perspective plans. DDCs from Jumla, Dolakha, Sindhuli, Makawanpur and Dhading have allocated budgetary support to the IWM owners (particularly for LS IWM and electrification) and it is expected that DDC interest will contribute to IWM sustainability in future. DDCs have also registered GOAs at the local level, establishing a form of legal identity.

4. Impacts

The IWM programme has benefitted thousands of rural communities in Nepal, providing efficient agro-processing services and access to energy for areas not connected to grid electrification. The programme's accomplishments include:

- 6,349 (827 LS) IWMs installed and services such as grinding provided to around 330,148 rural households, benefiting approximately 1,980,888 people;
- 16 IWMs with electrification option installed and around 850 households (5,100 people) directly benefitting from lighting services;
- 16 GOAs formed and 15 registered (with four also assuming the role of service centres);
- capacity of 16 service centres (either local NGOs or GOAs) and 17 private manufacturers of IWM kits strengthened; and
- more than 850 people directly employed in the IWM sector as experts, manufacturers, suppliers and technicians.[20]

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An improved water mill offers diversified range of services.

IWM owners mostly society's poorest and most marginalized. Studies have revealed that as many as 75 percent of IWM owners are from poor and vulnerable groups, including ethnic and marginalized groups.[21]

[19] CRT/N, 2009b.

[20] CRT/N, 2011.

[21] CRT/N, 2006; CRT/N, 2009a.

Areas and levels of impact. Table 1 presents a gender-analysis matrix of IWM impacts on women, children, men and households. The programme's contribution to Nepal's achievement of its Millennium Development Goals (MDGs) is described further below.

Table 1: Gender analysis matrix for the IWM programme

	Labour	Time	Resources	Health
Women	**IWM user** Reduced effort in carrying heavy loads for long distances for agro-processing, since such services are locally unavailable. **IWM owner** Skills enhancement in operation and maintenance of IWM and its end uses, office management and accounting. Better working conditions through provision of lighting.	**IWM user** Time saved in agro-processing activities. Comfortable working environment at night due to improved lighting.	**IWM owner** Access to income-generating activities through adoption of end uses. Income level increased as more quantities of grain can be processed quickly due to milling efficiency increments. Micro-enterprise promotion. Access to means of communication (radio).	**IWM user** Reduced health risk from carrying heavy loads for long distances.
Children	**IWM user** Reduced effort in carrying heavy loads for long distances for agro-processing (particularly girls). **IWM user and owner** Students can study at night due to improved lighting.	**IWM user and owner** Less time spent on agro-processing, increasing time available for study.	**IWM owner and user** Improvement in education level. Access to means of communication (radio).	**IWM user** Reduced health risk from carrying heavy loads for long distances.
Men	**IWM owner and user** Technical skills enhancement (construction, repair and maintenance, GOA management), leading to increased employability.	**IWM owner** Micro-enterprise activities undertaken during time saved.	**IWM owner** Increased income from various end use applications in IWM and micro-enterprises. **IWM owner and user** Access to information through radio and increased reading time enabled by improved lighting.	
Household	Saved labour utilized for other household and income-generating activities.	Time saved utilized for other household and income-generating activities and family.	Increased possibilities for income generation from end use applications. Reduced expenditure on food processing in IWM, compared to other options such as diesel and electrical mill.	Reduced health risk from carrying heavy loads for long distances.

4.1 Impacts on income and livelihood (MDG 1)

Employment and income-generating opportunities. IWMs provide communities with more efficient milling systems, employment and income-generating opportunities. Each LS IWM system creates at least one job (two jobs when power generation is included). As of December 2009, the programme has created 6,558 jobs (all among the poor in rural areas), while another 130 people have been employed in service provision.[22] On average, the income of a mill owner rises from EUR 108 to EUR 461 per year after IWM installation, a fourfold increase.[23]

Increased labour productivity. Increased efficiency of IWMs improves labour productivity. The quantity of maize flour ground increased, on average, from 4.4 to 11.20 *pathi*[24] per hour, and from 2.0 to 19.9 *pathi* per hour for wheat.[25] This improved performance has increased the availability of food in communities.

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Less drudgery: freeing women from back-breaking chores of grinding and hulling.

Impacts of IWM installation on income and productivity are further illustrated in an example below (Box 4).

Box 4: Improved water mill displaces diesel mill

Mr. Bhim Bahadur Bhattarai operated a diesel mill in the Sindhupalchok District for five years, having invested NPR 165,000 in the business. Frequent breakdowns and the high price of diesel, however, forced him to sell the unit for just NPR 60,000.

In 2007, he learned about the IWM programme from the district service centre. Seeing its comparative advantage, Mr. Bhattarai installed an IWM by investing NPR 295,000 in establishing a *chiura* mill, oil-expeller and grinder. His own investment of NPR 167,000 was supplemented by a loan of NPR 110,000 from the Agricultural Development Bank of Nepal and a subsidy of NPR 18,000 from the IWM programme.

Mr. Bhattarai charges a per kg fee of NPR 1 for grinding, NPR 3.25 for expelling mustard and NPR 1.75 for making *chiura*. These rates are about half of what he used to charge in the diesel mill. His IWM serves 35 households in Thampaldhap and Bhotenamlang VDCs, while his *chiura* beater and oil expeller also serve the residents of seven peripheral VDCs that do not have these facilities. His profit figures are provided in a table below.

Income activity	Income generated (in NPR)	Activity expenditure	Annual expenditure (in NPR)	Total profit (in NPR)
Chiura mill	41,000	Mill operator	37,700	
Oil expeller	55,000	Maintenance	8,800	
Grinding	38,000	Loan interest	12,100	
		Depreciation	18,900	
TOTAL	134,000		77,500	56,500

'With the diesel mill,' Mr. Bhattarai says, 'I could hardly save NPR 3,000 a month, whereas I am now saving NPR 5,000 a month.'

Source: CRT/N, 2008.

[22] CRT/N, 2009b.

[23] AEPC, 2009.

[24] 1 *pathi* = 3.5 kg.

[25] CRT/N, 2009a.

4.2 Achieving universal primary education (MDG 2)

Better lighting and more time for studies. IWMs reduce children's time spent on labour-intensive agro-processing activities, allowing for more time to be spent on education. It is estimated that the installed IWMs have saved children 185,983 days per year.[26] In addition, the children in the 850 households that have received electricity from 16 IWM electrification projects benefit from electric lighting which increases the number of hours available for study.

4.3 Impacts on women's empowerment (MDG 3)

Less drudgery. With TWMs, women use inefficient traditional technologies such as the *dhiki* and *janto* (stone tools for beating and grinding grains). IWMs reduce processing time by more than half and, more importantly, women are freed from the back-breaking chores of grinding and hulling.

More time to devote to other ends. Labour and time saved by IWMs can be devoted to productive purposes such as farming, weaving, caring for children and participation in community affairs. The IWM programme also encourages women to participate in various project activities.

Changing perceptions of the roles and status of women. IWMs bring about changes in gender relations in rural Nepal. Thirty-three of the women trained under the programme now operate as successful entrepreneurs, and IWM technology is changing the social belief that agro-processing and kitchen-based activities are mainly the responsibility of women. The percentage of men using IWMs has been on the rise: whereas only 4.3 percent of males were involved in operating *dhikis* and *jantos*, this percentage increased to 30 percent with IWMs.[27]

Impacts of IWM installation on women's empowerment are further illustrated in an example below (Box 5).

Box 5: Women's economic empowerment through IWMs

Mrs. Parvati Paudel, a successful 44-year-old mill owner from Ghyang Sukathor (Dolakha District), owns and operates a water mill as a grinding and hulling business near Ladke Khola (a river).

Mrs. Paudel has installed an IWM by investing NPR 218,215 to establish a rice huller, a *chiura* mill and a grinder. Her personal investment of NPR 67,215 was supplemented with a subsidy of NPR 20,000 through the programme and two loans – NPR 31,000 from a local cooperative (at 12 percent interest) and NPR 100,000 from local money lenders (at 33 percent interest). As the owner, she earns an annual income of NPR 128,000 from different end uses, while her annual expenses are NPR 87,687 (including interest, salaries, and repair and maintenance costs). Net annual income, ensuring a payback period of three and half years, amounts to NPR 40,605.

The IWM has brought a number of socio-economic benefits to both Mrs. Paudel and mill users. The mill's services are used by 300 households (1,800 people) in five neighbouring VDCs, and the rice huller has benefited more than 90 households. Mrs. Paudel used her enhanced income to purchase land, and now earns an additional annual income of NPR 16,000 from banana and pineapple farming, and goat rearing.

This example clearly shows that women are able to operate IWM systems successfully and incorporate other income-earning activities for time saved by using the technology.

Source: CRT/N, 2008

Improving nutritional intake among women and children. Under the Micronutrient Initiative (www.micronutrient.org), iron, folic acid and vitamin A are added to grains during IWM agro-processing in order to reduce anaemia, particularly among women and children. Operating in the remote VDCs in Lalitpur District, the initiative is currently serving more than 2,000 households.[28]

[26] Average time saved by women and children is two hours per milling, with an average 52 millings per year. The 2008-2009 user survey showed that 13 percent of IWM users are children. Considering the increased efficiency represented by 6,349 IWMs, children gained an estimated 185,983 days of the total 1,305,356 days of time saved (AEPC, 2008).

[27] AEPC, 2009.

[28] Micronutrient, 2009.

4.4 Ensuring environmental sustainability (MDG 7)

Reduced greenhouse gas (GHG) emissions. Programme contributions to reducing GHG emissions can be calculated on the basis of fuel savings in existing diesel mills that provide agro-processing services and the replacement of kerosene in lighting appliances after IWM electrification. IWM power generation for SS, LS and electrification is 1.65 kW, 2 kW and 2 kW, respectively (compared to 0.5 kW for TWM). Number of operating hours was taken from the CRT/N internal database.[29] The emission factor for diesel was taken as 1.4 kg CO_2 per kWh. Using these figures, emission reductions from SS, LS and electrification are 4.4, 6.2 and 6.8 kg CO_2 per year, respectively.[30] Using this methodology, the IWM programme can offset an estimated 92,813 tonnes of CO_2 per year from the IWMs already installed.

A Kathmandu University study indicated that about 75 diesel mills have been replaced by IWMs. The main reasons for the replacement are the high cost of diesel; difficulties with transport from market; high maintenance costs; high tariffs to the customer; and degradation in product taste.[31]

Possibility of obtaining carbon credits. GHG emission reductions enabled by the programme may qualify for registration to receive carbon credits under CDM. The programme has completed a Project Idea Note and is developing a Project Design Document as per CDM procedures.

4.5 Promoting global partnerships (MDG 8)

The IWM programme has been visited by teams from the Islamic Republic of Afghanistan, the Republic of India and the Islamic Republic of Pakistan. The Nepal team has also participated in a study visit to the Indian Institute of Technology (Roorkee) and the Himalayan Environment Studies and Conservation Organization to learn about the Indian programme. CRT/N now plans to develop a regional IWM Knowledge Centre in Nepal, to undertake a review of existing IWM practices in the Kingdom of Bhutan, India, Pakistan and Afghanistan, and to launch technology demonstrations and pilots in collaboration with local organizations.

5. Programme expansion potential and sustainability issues

The programme has expanded beyond the initial four pilot districts, to 19 districts. The subsidy delivery mechanism is in place, and the GoN has indicated in its Three Year Interim Plan (TYIP 2008-2010) its intention to extend the programme to a target of 4,000 IWMs in 40 districts.

The next phase of the IWM programme is planned for extension to 2015. A proposal has been prepared by AEPC and CRT/N, setting a target of 416,000 households and 8,000 IWMs (including 1,600 LS installations and 320 IWM electrification systems). Resource mobilization from DDCs and VDCs, which are showing an interest in IWMs, is expected to co-fund the expansion. It is also expected that an additional 330,310 tonnes of CO2 emissions will be offset through IWMs in the next phase, making CDM funds a possible option and thus reducing dependency on donors and government funds.

Community acceptance vs. challenges to sustainability. The IWM technology has been well accepted by rural communities, and there is a strong demand for more IWMs. However, the following issues threaten programme sustainability:

- **High costs of electrification slowing uptake.** While the agro-processing systems have received a favourable response, the uptake of electrification systems has been slow, primarily because of high costs. Due to the limited resources available in this phase of the programme, this problem has not been addressed so far. The current average annual rate of expansion is 1,200 IWMs, which is expected to increase significantly in the next phase.
- **Funding and organizational constraints slowing expansion, particularly into highest-potential areas.** So far, the programme has focused mainly on the more accessible central, mid- and far-western regions. Limited funding has made it difficult to move into new districts, particularly into remote areas in high mountains with a higher hydro potential and a higher incidence of poverty. Remote districts also lack financing, due to the high cost of credit transfers and the physical risks of damage to the IWM systems.

[29] CRT/N, 2009b.

[30] Emissions displaced = the power requirement x hours of operation per year x the emission factor for diesel generator systems.

[31] Kathmandu University, 2009.

Local ownership and management remains a challenge. Pursuing a market-based approach, the programme has encouraged local ownership and management of the programme. However, a fully viable market for IWMs does not yet exist. Reliance on donor funding continues, and government instability means that future commitments are uncertain.

Future role of GOAs. It is envisaged that GOAs will be the main vehicles for IWM technology dissemination in the future. A number of GOAs have started providing IWM-related services not only to their members but to the community at large. Many have also started to diversify their services into other RETs and financing. Indications are that the RE sector can be sustained in future, albeit with considerable investment from donors and/or the GoN.

6. Lessons learned and good practices in expanding energy services for the poor

6.1 Locally appropriate technology focusing on productive uses

The suitability of technology has been important to the success of the IWM programme. TWMs represent a simple and well-known technology in rural areas. IWMs are an intermediate technology that increases the efficiency of TWMs and is relatively easy to manage, operate and maintain. IWMs can also provide a variety of cost-effective energy services for agro-processing, micro-enterprises and electrification. The programme has worked hard to promote awareness of the technology, demonstrating its efficiency and positive impact on livelihoods among rural households.

Through improved energy services, IWM technology contributes to micro-enterprise development and generation of incomes and employment opportunities in rural communities. At the same time, reducing the time needed for agro-processing tasks has lessened drudgery among women and children. The programme continues to enhance the entrepreneurial skills of IWM owners through its various capacity-development activities. Short IWM construction times, meanwhile, enable entrepreneurs to commence energy services provision (and hence income generation) quickly.

6.2 Linkage with local associations for sustainability

The programme's capacity development activities have uncovered an important lesson: sustainability targets must be incorporated into the programme early. A plan for encouraging income-generating activities among local stakeholders should be included from the outset, limiting dependence on external funding and support, thereby increasing local ownership and programme sustainability.

Aiming to increase the sustainability of the sector, the IWM programme has provided training to local service providers (service centres, GOAs and manufacturers). Support is also provided to other local partners, including the DDCs.

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Technician at work: installation, technical supervision and provision of quality after-sales services is much needed in rural and remote locations.

6.3 Increasing the upta ke of LS IWM for greater programme sustaina bility

The LS system is relatively expensive, but offers multiple benefits. When limited funds are available, RET programmes should focus on maximizing end user income and benefits. Consequently, the next phase plans to focus on promoting LS IWMs; in hindsight, this should have been done from the programme outset.

6.4 Market growth slow, private sector involvement lacking

The IWM experience shows that a successful market-based approach to RET dissemination requires the following factors to be in place:

- technology affordability;
- clear boundaries of programme responsibility and ownership;
- access to financial services for potential buyers; and
- external donor funding.

The market for IWMs in Nepal is not yet fully developed. Despite the short payback period, mill owner motivation has been lacking due to slim profit margins for services provided. In addition, IWM is relatively new compared to other RETs.

Consequently, the next phase of the programme will focus on encouraging more owner participation via new mechanisms such as provision of profit incentives. Further external funding would help to ensure that the social goals of the programme are still delivered.

6.5 Government commitment

The GoN has internalized the programme (including targets) in TYIP 2008-2010. The GoN commitment has been instrumental in attracting donor funding and in streamlining IWMs with other technologies promoted by AEPC. This has also encouraged the sharing of knowledge and lessons among programmes, improving efficiency of RET dissemination in general.

7. Conclusions

The IWM technology has demonstrated positive impacts on rural communities by promoting micro-enterprises, generating rural incomes and employment opportunities, and reducing drudgery for women. The IWM programme is currently being implemented in 19 districts around Nepal, with further potential in another 34 districts.

At this juncture, though the GoN has accorded the IWM programme a high priority, its own financial contribution has been limited, and programme sustainability depends on continuing donor cooperation and coordination. The GoN needs to extend ongoing support and increase its commitment to overseeing the programme through AEPC. It should also acknowledge and publicize the economic and social benefits of IWMs to increase awareness of the programme.

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