Renewable Energy Resources for Improved, Sustainable Livelihood

A Case Study of a Holistic Community Development Project with a Remote and Poor Mountain Village in the Nepal Himalayas

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Abstract

Families in remote areas in the high altitude Nepal Himalayas are very poor. They depend upon scarce firewood for cooking, room heating and light, and with no pit latrines and polluted drinking water, their hygienic conditions are very poor. Due to the harsh climate and the short agriculturally productive season there is a permanent food shortage in the mountain district of Humla, Nepal. Ill health, high mortality of children, malnutrition, low education, low life expectancy and massive deforestation, are the consequence. A holistic grass-roots community development project initiated through The ISIS Foundation and Kathmandu University tries to address these issues. Through elementary lighting, an appropriate stove, a suitable pit latrine, clean drinking water, hot water for washing, a greenhouse and functional literacy classes, and in close partnership with the community, the project seeks to achieve appropriate and sustainable impacts. This paper describes the background, implementation process and the expected impacts of these integrated projects on sustainable community development.

Keywords: Renewable Energy, Holistic Community Development, Sustainability, Appropriate, Solar Photovoltaic, Pit Latrine, Stove, Drinking Water, Environment

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1. Introduction

Almost all of the identified 2 billion people without access to electricity (Mills, 2002), 1.1 billion without safe drinking water, 2.3 billion suffering from water-related diseases (with over 2 million children dying each year), 2.4 billion without adequate sanitation (TEAR, 2002) and 2.4 billion relying on traditional biomass for their daily energy services (IEA, 2002), live in developing countries. Four out of five live in rural areas (IEA, 2002). There is a close relationship between poverty and access to electricity (IEA, 2002), and poverty levels increase the more remotely communities live, while project costs increase. Lack of electricity and heavy reliance on traditional biomass are hallmarks of poverty in developing countries (IEA, 2002). 86% of Nepal's 27 million people (July 2005) live in rural areas[1], with half so remote that the nearest road, and indeed the national grid, is within 2-15 days walking distance. With a national average of 68.5 kWh/year electricity consumption per capita in the 2003-2004 fiscal year (Kathmandu Post, 2005), with a GDP/capita (Gross Domestic Product) of 1,100 -1,370 US$ (HDR, 2004)[2], with 42% of the people below the poverty line[3] and an HDI (Human Development Index) of 0.499 for Nepal and 0.244 for the Humla district (Jumla, 2002), Nepal belongs to the most needy of countries.

Families in the remote areas of Nepal use precious trees as firewood for cooking, room heating and light. These activities, especially indoor cooking on open fire places, have a direct chronic impact on the health and the extremely low life expectancy for women and the high death rate of children under 5 years of age (Warwick, 2004). Deforestation is widespread and the once picturesque, bio-diversity rich forests and valleys are stripped of their resources in unsustainable ways.

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[1] http://www.childwelfarescheme.org/about/nepal/facts.htm, http://www.nepal.com/culture/facts/population.html
[2] http://www.nepalinformation.com/, http://hdr.undp.org/reports/global/2004/pdf/hdr04_HDI.pdf, for 2002
[3] http://www.wooster.edu/ambassadors/nepalfacts.html

Drinking water is taken from dirty streams as both clean water springs and latrine use are rare. Nepal is poor in fossil fuel resources, but has rich renewable energy resources, including water (NEA, 2004), of which only 1.4% is currently utilized[4], sun, also minimally utilized (NASA, 2005, Zahnd, 2004)[5], and wind in some valleys.

2. Village and Community Needs Identification

Dhadhaphaya (Fig. 1), a remote and poverty-stricken mountain village in the north-western district of Humla Nepal, has 167 homes and 1,068 people. A holistic community development project began there in 2004, with the following needs identified for each household by the local people and the project team:

The 'Family of Four':

- *A solar PV system for lighting purpose only (with 1-watt white LED lights).*
- *A smokeless metal stove with hot water tank.*
- *A pit latrine.*
- *Clean drinking water from a community owned spring.*

Plus:

- *A high altitude solar water heated bathing center for women and men.*
- *Two greenhouses.*
- *Non-Formal-Education (NFE) classes for mothers and out-of-school children.*

3. Holistic Community Development Approach

Tapping into locally available renewable energy resources to provide the needed energy services in appropriate, affordable and culturally sensitive ways, in

[4] With total 609 MW (Kathmandu Post 23rd April 2005), though with 43'133 MW technical and economical feasible (*Theoretical Power Potential*, NEA (Nepal Electricity Authority), 2004), only 1.4% are utilised.
[5] Nepal has an average solar irradiation of 5.2 – 6.5 kWh/m^2 per day

conjunction with projects addressing health, food, hygiene and educational needs, results in synergetic benefits. The approach embraced in this collaborative effort between *The ISIS Foundation*, RIDS (Rural Integrated Development Services) and the local people, is that the combined outcome of a comprehensive community development project bears more sustainable benefits than the sum of each individual project. This is particularly true with respect to the four critical pieces of community development in remote Nepal: stoves, lights, latrines, and clean water. We believe in the synergistic effect of a project such as our 'Family of Four' (plus), and we have created project components that both stand alone *and,* especially in combination, energise villagers' faith in and enthusiasm for making the model work as a whole.

3.1. The "Software" Issues of a Project

The partners in this collaborative effort believe that people are the center of each project, and applied technologies serve and support them toward improved living conditions. This approach demands that the local context, language and culture have to be learned and understood in order to comprehend the unspoken and invisible "software" issues of the community. This demands time, compassion and dedication - crucial parts of a project, difficult to identify and judge and even more difficult to budget and "sell" to a donor agency.

3.2. Solar PV System

Every home in the remote and high altitude villages in Humla uses firewood in indoor open fireplaces for cooking, heating and light. Women and children are most likely to suffer from the enormous indoor smoke pollution (Warwick, 2002), causing respiratory diseases, asthma, blindness and heart disease (IEA, 2002). While the

US-EPA (Environment Protection Agency) PM_{10}[6] 24hrs average maximum value is not to exceed 150µg/m^3 more than 3 times a year, with an annual average not exceeding 50µg/m^3, open fire places create PM_{10} levels ≥ 20,000µg/m^3 (Warwick, 2002). Lighting is often the first use of electricity in a developing country, and people are willing to invest in home or village electrification once they understand the potential health improvements, the increased possible education for their children, and the possible financial savings (Mills, 2002) for their families.

In order to design a solar PV village system that will reliably light a house over an appropriate life span, the following issues are important to know and monitor:

- The solar irradiation (kWhm^{-2}day^{-1}) for the location of the solar PV system.
- The village's population, annual growth, its load distribution and growth pattern.
- The sustainability, ease of installation, and maintenance of components.
- Feasibility and reliability of locally developed and manufactured products.
- Trade-off between sustainability/cost vs. high-efficiency.
- Participation of all stakeholders in every project step.
- Culturally appropriate training, hand-over, operation and maintenance.
- The goal of minimal or no ecological impact during installation and operation.

With these points on the checklist, 15 clusters of 10 - 15 households were defined in Dhadhaphaya village. Each cluster has a central house, chosen by the community, on whose roof top a 75W_R PV module is mounted on a seasonally adjustable aluminum frame (Fig. 2). In that house, usually in the kitchen, is a 12V battery bank. This consists of 2 deep cycle, 12V solar batteries, each with 100 AH capacity. They are in a locally made wooden box, insulated with locally available silver birch tree bark and pine needles. Each household gets three 1-watt WLED (white light emitting

[6] PM_{10} are particular matters < 10 micrometer, and thus able to enter the respiratory system.

diode) lights (Fig. 3), connected to the cluster battery bank through armored underground cables. These 1-watt light, with 23 lumens/watt (consisting of 9 Nichia WLED diodes with a 50º light angle) have a life expectancy of 100,000 hours (Craine, 2002). They are developed and manufactured in Nepal by Pico Power Nepal[7]. They provide enough light to socialize, read, and carry out other daily tasks, thus eliminating the need for an open fire for lighting.

3.3. Smokeless Metal Stove for High Altitude

An open fireplace, and a home full of smoke is "normal" in Humla (Fig. 4). The daily firewood consumption is 30kg – 50kg (Zahnd, 1998), and the health of women and children is at great risk. Increasing deforestation results in a scarcity of local firewood, forcing women and children to spend 7 - 8 hours daily gathering fuel wood further afield (IEA, 2002; Haddix McKay and Zahnd, 2005) every second day. Women, the primary users and organizers of the household energy, place a high value on improved energy services such as light and an efficient cooking and heating stove.

Now, each household has an efficient smokeless (i.e. with a chimney flue) metal stove (Fig. 5), with a measured consumption of only half previous levels. The stove is designed for local eating preferences and space heating needs. The stove is also time efficient, as it allows women to cook their traditional meal (rice, lentils and a vegetable curry) all at one time. Additionally it provides hot water for drinking and washing in an attached 9 litre stainless steel tank. The stove ensures a smoke-free, cleaner, and safer home environment, where children are not longer at risk of falling into the open fire.

[7] Pico Power Nepal (PPN) can be contacted through Mr. Muni Raja Upadhaya, at: muniraj@wlink.com.np

3.4. Pit Latrine for a more Hygienic and private Environment

Usually defecating is done wherever a free and private place can be found. The lack of hygiene awareness, the shortage of land, and with no examples to be followed, the pit latrine has not yet become part of the accepted infrastructure for a household. Through posters and songs written in their own mother language and NFE classes, people are now seeing the need to build and use a pit latrine (Fig. 6).

The walking paths, the surrounding village fields, and the streams now remain clean, preventing diseases from being spread uncontrollably.

3.5. Clean Drinking Water from a Community owned Spring

The local river, contaminated by upstream villages, human waste, washing and disposal of dead animals, used to be the daily drinking water supply for Dhandhaphaya. Now, from the community owned spring high above the village, water is led down to the village through 90cm underground polyethylene pipes to seven cemented tap stands, providing clean and fresh drinking water (Fig. 7).

3.6. A High Altitude Solar Water Heater Bathing Center

The rivers in this high altitude have been found to be warmest from June – August, measured as 12℃ - 16℃. The rest of the year they are between 4℃ - 12℃. Thus water needed to be heated by wood fires, and the wood was already a huge burden for women to collect. Thus, a commonly owned high altitude solar water heater bathing center for women and men has been designed and is being built. The solar water heaters are designed and manufactured in Nepal, with freezing protection and hot water storage tanks.

The bathing center will allow up to 1,100 people to take a hot shower (calculated at 10 liters, 50℃ water per person) once every two weeks, addressing the pressing need to improve local hygiene. A "village bathing center committee" is responsible to keep track of and to maintain the infrastructure. A data monitoring system, recording the incoming solar irradiation, the intake water, the absorber, the hot water storage tank temperatures and the daily hot water consumption, will provide valuable feedback for future improvements of that prototype project.

3.7. Two greenhouses to grow vegetables for 8-10 months per year

With 199 days frost in a year (NASA, 2004), only 3-4 months[8] agricultural work is possible. Thus people suffer permanent food shortages with high levels of malnutrition, especially in children. A low-cost greenhouse prototype, constructed using local stones, wood beams and UV stabilised plastic from Kathmandu, was built at the High Altitude Research Station (HARS) in Simikot, Humla (Fig. 8). Already this has produced vegetables for 10 months in its first year. This is absolutely critical as our data show that an astonishing 67% of Upper Humli children under five are stunted, a sign of serious long term malnutrition (Haddix McKay and Zahnd, 2005).

3.8. Non-Formal-Education classes for mothers and out of school children

With a literacy rate for women as low as 4.8% in Humla (Jumla, 2002), booklets and brochures are not useful for awareness raising and education initially. Thus a new NFE programme for mothers and out-of-school children has been designed with topics that support the projects described above, including solar lighting, cooking stoves, safe drinking water, pit latrine usage, greenhousing and improved hygiene.

[8] District Development Plan, *Review of Development Status,* chapter 1, page 1, Humla, 2003

These themes are taught initially through songs and posters, and as students' literacy increases, novel and locally relevant reading materials are developed and used under the guidance of the NFE facilitator.

In this way the participants are immediately involved at a level appropriate to their background, leading them to discover the wonder of functional literacy, and to participate strongly in the classes and in the development of their own teaching materials.

5. Expected Impacts

If the hypothesis is correct, that a holistic project, in close partnership with the community, will have a more sustainable long-term impact than the individual projects, then planned yearly impact surveys should identify this. Beyond the quantitative changes currently (Haddix McKay and Zahnd 2005) being monitored in villagers' time usage, morbidity, and nutritional status, a range of qualitative impacts are being monitored, including:

- Overall improvement in hygienic conditions inside and around the homes.
- Decrease in the firewood consumption for cooking, heating and lighting purpose.
- Increase in women's literacy rate, with more girls joining the local school.
- Increase in sociality, now possible in community gatherings after dark
- Increased community based, community initiated development projects.
- Less breakdown times, improved use and maintenance of the new technologies.

6. Conclusion

No clean lights or stoves in homes, no latrines, no access to clean drinking water, barely enough food for 4-5 months of each year, with the rest of the year a daily struggle for survival, and minimal education for a chosen few; these have been the conditions in the Humla village of Dhadhaphaya until recently. In close partnership with the village elders and each household, the village's most urgent needs were defined, and now a holistic community project is being implemented with the community. Through NFE educational tools people have understood quickly that improved indoor lighting, a stove for cooking and heating, pit latrines, better hygiene, access to sufficient pure drinking water, and more nutritious food on their plates are not just desirable, but necessary for healthy growth and development of their whole families and community. Using locally available renewable energy resources with appropriate technologies, alongside health, nutrition, hygiene and education related projects, has enabled an impoverished mountain community, in partnership with a team of dedicated professionals, to develop their living conditions in sustainable and environmentally friendly ways. We continue to study the social and health impacts of these new technologies, and anticipate that future analyses will show that the 'Family of Four' (plus) will continue to deliver a range of truly life enhancing improvements.

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Pictures

Fig. 1: Dhadhaphaya Village in Humla Nepal


Fig. 2: Cluster Home with solar PV System


Fig. 3: 1-watt WLED Light


Fig. 4: In Humla homes: No light - No stove


Fig. 5: Smokeless Metal Stove


Fig. 6 : Pit Latrine and clean walking paths

 Fig. 7: Clean, pure spring water	 Fig. 8: First Greenhouse Prototype

Authors' Curriculum Vitae

ZAHND Alex has a mechanical engineering degree from Switzerland, and a Masters in Renewable Energy from Australia. His industrial experience ranges from development projects in extrusion technology for the food and plastic industry, to pharmaceutical production plants. He lived and worked from 1996 - 2000 in one of the remotest and poorest mountain communities in the Nepal Himalayas, in Jumla, as director of a holistic community development project. Since 2001 he has been a member of expatriate staff of Kathmandu University, mainly involved in applied research of renewable energy technologies, with implementation on a village scale in the remote mountain districts of Humla and Jumla. He is currently working on his PhD in rural village electrification systems for Himalayan villages.

Haddix McKay, Kimber is a cultural anthropologist who specializes in demography, health and human behavioral ecology. Dr. Haddix McKay has worked both full time and as a consulting anthropologist designing studies of health and treatment of illness in remote areas of Nepal and Uganda. She has lived and worked in Nepal frequently from 1994 to the present, and assisted in the design of locally appropriate development schemes aimed at improving health conditions, particularly in the use of sustainable energy technologies and in public health-related interventions such as latrine design, improved/smokeless cookstoves, lighting schemes, community based health training, and drama programmes with specific health-related messages.