Renewable energy options to strengthen climate resilience of mountain communities

A case study from Nepal

Raju Laudari[1], Bibek Raj Kandel[2] and Shankar Lal Baidya[3]

[1]Raju Laudari, Assistant Director, Alternative Energy Promotion Center, Nepal
E-mail: raju.laudari@aepc.gov.np
[2]Bibek Raj Kandel, Alternative Energy Promotion Center, Nepal
E-mail: bibek.kandel@aepc.gov.np
[3]Shankar Lal Baidya, Renewable Energy Expert, Nepal
E-mail: edspl@ntc.net.np

Abstract

Agriculture provides the major livelihood base of the majority of the people of *Dheye*, a mountainous village in Nepal. People of Dheye are considering or are already initiating to move down to Thangchung, a bank of Kaligandaki River as an attempt to move to more stable and less vulnerable areas with better off access to water sources amidst the acute depletion of water resources in Dheye in the face of climate change. It is also necessary to understand the limits of adaptive capacity of Thangchung considering that future climate scenarios that might again increase impacts that may further invite other stresses to the community. Energy and water systems are connected. Changes in climatic effects will likely to influence the energy demand. To ensure the sustained adaptive capacity of these villagers, they too would be required to engage in both the on-farm and off-farm enterprises and economic activities which often necessitate huge energy demand. The paper attempts to explore the sustained energy options at Thangchung in the light of strengthening the climate resilience of migrants of Dheye.

Introduction

Agriculture continues to provide the major livelihood base of Nepal. Various researches indicate that negative impacts of climate change in Nepal are expected to increase. Any changes in the local weather pattern resulting from any global climatic changes will have a direct impact on the agricultural practices thereby posing a serious threat to the economic and social well-being of people. Himalayan region is often considered to have received the sign of climate change impacts (IPCC, 2007). Climate change stresses in terms of water stress, particularly in dry season, in Dheye (about 4,000 msl), one of the mountainous villages in northern part of Nepal have become so profound that the resettlement of people of Dheye has been considered as an immediate next thing (Figure 1). Adaptation to climate change and variability necessitates the adjustment of a system to moderate the impacts of climate change, to take advantage of new opportunities, and to cope with the consequences (IPCC, 2001). The impacts have been so critical that a few of the households in Dheye have already left their ancestral homes to migrate to better places elsewhere in the backdrop of multitude of challenges, the major one being the depleting water sources and springs which have largely impacted the locals to irrigate their farmlands.

Socio-economic setting of Dheye and climate impacts

Dheye has a very low population of 225 comprising 24 numbers of households out of which 10 households have already migrated out the village. It lies in the trans-himlayan district of Mustang in Nepal adjoining Tibetan Plateau. The rising trend of people leaving the village for safer places elsewhere has threatened the demography and cultural heritage of Dheye at large. Agriculture land is quite limited and has a 33 hectare of agriculture land for 24 households. The population growth rate seems under the replacement level. Dheye village has a 2,332 livestock in total where 91% is occupied by the number of goat and about 5% is yak.

Mobility in and out of Dheye is only possible either on foot or on horses' back; hence, Dheye has minimal impacts from any external influences. Such unique and undisturbed local culture and practices is now at the threat of disappearance.

The impact of climate change is expected to create number of challenges in Dheye. The water shortage is especially critical in the dry seasons. Dheye is facing acute water shortage for last 6–7 years. Studies and researches reveal that the impact of climate change is expected to create number of challenges in Dheye. Critical issue in Dheye is primarily emerged from the shortage of water for agriculture. Ten numbers of households have already abandoned the village and even those staying there usually seek to adopt a range of adaptation strategies, as one being water conveyance system to farm the agriculture land from the water reservoir as seen from image taken from Google earth.

A study carried out by a team of Swiss researchers for Kam for Sud in 2012 after comparing two scenarios either to "move down" to somewhere closer to the river bank or "stay" in the villages suggests Thangchung as a safe haven to move down from Dheye. Those still living in Dheye have continually expressed for willingness to move out of Dheye because of rapidly decreasing water supply causing problems to villagers to manage agriculture, cattle feeding, and household requirement of water including even drinking water.

The people of Dheye see Thangchung not only as better location for water availability for farming but also as a new opportunity to increase their interaction with outsiders. They further intend to reap some of the advantages of having Thangchung

Figure 1: Dheye village under severe water stress, especially to irrigate the farmlands

(Credit: USAID/Brownyn Llewellyn)

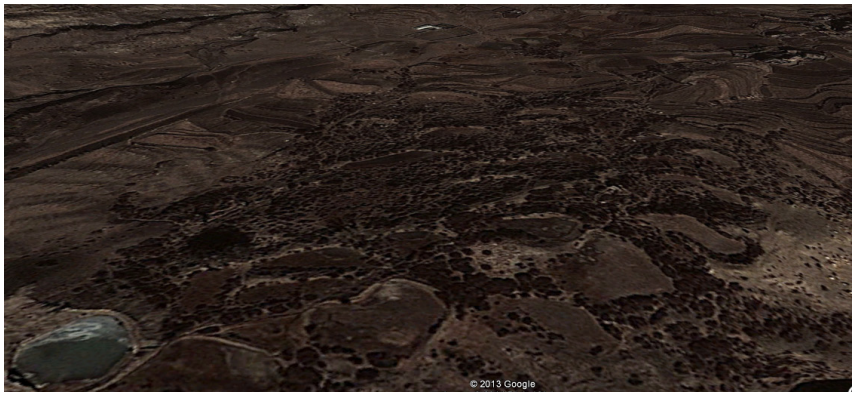

Figure 2: Water collection pond in Dheye

(Credit: Google Earth)

on a trekking route to Lo Manthang which is often visited by foreign tourists.

Preparing for resettlement and energy demand prospect of Thangchung

Thangchung needs to give all due consideration to alleviate the possible consequence of climate change over a foreseeable future including water stresses and other socio-economic stresses the Dheye community is currently facing. Upper Mustang has seen steady and robust growth of tourism despite prolonged period of insurgency and political instability periods. The Thangchung plateau where settlement plan is being developed is uninhabited at the moment and offers ideal location for settlement in terms of space and orientation. The proposed site Thangchung lies along the trekking route to Lo Manthang which is reported to have received around 3,340 tourists in 2013. Thangchung's geographic landscape is unique considering the fact that the Kaligandaki River is actually said to originate from the confluence of Dheye Chyang river with the main river. The point of confluence and the main river, as referred in the paper as Kaligandaki river holds every prospect to attract tourists provided it can offer some overnight stay facilities. The proposed apple orchard will add to its attractiveness. Another important factor is the fact that the settlement came into being primarily from movement of Dheye community due to the effect of climate change — this could be a factor to sell to future researchers and interested groups and individuals. The likely vibrancy of the local economy as spurred by the influx of tourists will give a rise to the energy demand.

Energy supply options at the moment in Dheye and surrounding areas are largely limited to animal dung. This is detrimental to ecology over time. Attempts could be made to replace mush of it by other more sustainable energy source — Solar PV, IWM, MHP. Compounded with that effort or in absence of that, appropriate energy saving technologies could be introduced and promoted to the fullest to at least mitigate the negative effects of use of animal dung. These might include extensive use of thermos (boil larger quantity at any one time and store) and pressure cookers.

The settlement area is too far away from any selling point of commercially available energy source such as hydro electric distribution grid or diesel depot in a town. It will be very costly to import petroleum fuel to meet their daily energy need. A study was carried out to design the energy aspect of resettlement plan of Thangchung. Currently, near Thangchung a liter of petrol costs about NPR 200 (Approx. 2 USD) and that can give about 3 kWh of energy. Taking 25% more for engine depreciation, operation, and maintenance, a kWh of energy would then cost NPR 80. Moreover, experience has shown that petroleum fuel that needs to be imported is not sustainable and supply reliability cannot be assured. Thangchung is going to provide a unique challenge in addressing the sustainable energy options when demand increases to cater to both household's energy need and serve visitors need.

Meeting energy demand to the new settlement area requires the assessment of potential energy resources. The demand for energy for cooking and heating households shall be of prime concern and more so especially during the harsh winter climate. Even though there is high potential for tapping solar energy for lighting that will be for lighting purpose. Attempt must be made to address partially if not fully other traditional sources of energy the villagers are using to meet needs other than lighting in order to go green and mitigate ecological imbalance if not replace completely. As the tourist arrival will increase and boost economy, energy demand would eventually increase too which is why they need a sustainable energy system.

Tourists travelling to such remote mountain would actually appreciate if they know the efforts placed for green energy and be willing to contribute by way of paying more for services they purchase at local level.

- Animal dung energy

As the per capita livestock of Dheye community is quite high, animal dung is a good source of energy for cooking and heating homes, thus cattle dung is the primary source of energy. Considering the total number of livestock of these Dheye community, overall energy potential from cattle dung assuming that per kg of cattle dung would produce 10.92 MJ/kg is estimated to be 13786.8 GJ assuming that 75% of dung is collected and available as energy. Energy potential from livestock is provided in Table 1.

The figure assumes 75% dung collection for energy, which is a crude and probably optimistic considering mobile nature of cattle and animals. It should be noted that the number of animals is declining over time, partly because pasture quality is declining, but also because of changing socio-economic conditions. This trend might continue and the rate of decline might accelerate.

Moreover, animal dung is primarily used up as fertilizer for the fields. Utilizing it to meet part of the household or commercial energy would be an unsustainable approach as it will compel villagers to resort to chemical fertilizers and jeopardize productivity of land over time. Any use of it is a compulsion for the villagers as the project area is almost devoid of alternatives. This should be discouraged and alternative means provided.

- Solar energy

The solar resource map (SWERA, 2006) of Nepal shows a 4.7 kWh/m2/day annual average global horizontal solar irradiance and a higher potential in the north western region (5–5.5 kWh/m2/day). A large number of households and institutions in Mustang already use an array of solar technologies including solar photovoltaic (PV) systems, solar cookers, solar driers, solar PV water pumping systems, solar thermal water heaters, etc., mostly as supported by Alternative Energy Promotion Center (AEPC), a government apex institute promoting renewable energy in Nepal. What is required in the days ahead is to promote individual solar home systems for lighting and provide solar thermal for cooking and drying to the households in Thanghchung and explore any potential for large-scale energy systems to support entrepreneurial activities.

In absence of other better electrification options, solar PV is the best option to provide lighting to the households (Table 2). Each house equipped with a 50 Wp system would suffice for lighting purpose. The Government of Nepal provides subsidy through AEPC for this.

Micro-hydro technology (MHP) has evolved from the very basic agro-processing turbine mill to well-built electrification schemes. Thousands of MHPs have been installed throughout the country to electrify off-grid rural communities. Many are successfully operating and managed. While some have performed poorly due to a multitude of reasons including poor or unfavorable site condition, improper site selection, inadequate training or high turnover of trained operator, lack of dedication on the part of owner (usually users committees that do not have adequate motivation make the MHP perform better), etc.

Cost of an MHP in the context of Upper Mustang may cost around NPR 600,000 per kW. But this would vary depending upon remoteness, walking distance from nearest track road, length of distribution lines needed to connect consumers, gradient of water way system, and economy of scale.

In the case of Thangchung, a MHP could easily be coupled to the water supply system because much of the basic structures would anyway be constructed and could be used by a MHP to generate power. There is sufficient gradient in the Dheye river (not the best yet) to gain about 90 m gross head from intake site to bottom of Thangchung plateau near the apple orchard at the left bank of the source stream. There is no shortage of water in Dheye river most of the time in a year. Considering energy requirement at Thangchung for the permanent population and the possible future influx of visitors into Thangchung, there seems no other better way than to install a MHP. An extra 30 l of water could generate about 15 kW from a MHP. This amount of power could electrify all households and even provide some power to cook, boil water, or provide energy for some space heating in winter.

Despite, attractiveness in MHP in general, there are other factors that can make it unsustainable. The geology in Upper Mustang is fragile; stream water carries a lot of silt and debris during wet

Table 1: Energy potential from number of livestock available at Dheye

Species	Numbers	Dung production per animal per year (kg)	Dung production MT	Energy production (GJ)
Yak	70	5,256	367.92	3,013.26
Horse and mules	40	4,380	175.2	1,434.89
Chayngra, mountain goats	2,000	456.25	912.5	7,473.38
Jhopa, bull — a cross breed of yak and ordinary cow	12	4,380	52.56	430.47
Lulu gai, cow — a cross breed of yak and ordinary cow	40	4,380	175.2	1,434.89
Total	**2,162**	**18,852.25**	**1,683.38**	**13,786.88**

season which is detrimental to water supply system. Frequent slides, change in river course, diminishing water flow due over time are other obstacles which could as well make the MHP less reliable.

However, as the out-front equity required by villagers is huge — so is the potential benefit — it looks more appropriate to support a feasibility study of a MHP at Thangchung immediately after the winter to assess marginal costs, benefits, integration with other RE sources such solar PVs and passive solar equipment. On the longer time horizon, a MHP would be more economical and environment-friendly to meet the energy need of Thangchung. This could provide energy for versatile household electrical appliances.

Besides MHP, improved cooking stoves (ICSs) could as well be considered for cooking and heating purpose and to create a smokeless environment in the kitchens. As many of the households will burn cow or goat dung in areas of Upper Mustang, the use of metallic stoves may not ensure the desired success in Thangchung too. Metallic stoves are also used for reasons of heat radiation in cold climatic zones. However, every household shall be provided with metallic stoves which will heavily reduce use of firewood and indoor air pollution. Other factors remaining the same, ICS as compared to open hearth stove can save 10–50% heat energy.

Table 2: Estimated solar PV cost for lighting (1 USD ~ 96 Nepalese Rupees)

Users	Typical system size	Approximated system cost (Rs)	Total system cost (Rs)
24 households	50 pW	35,000	840,000
2 guest houses/ motels	100 pW	52,000	104,000

Conclusion

Availability of sustained energy systems strengthens the resilience of Thangchung as it offers the opportunities to integrate possible livelihood options that often are energy intensive. The additional energy services thus strengthen the resilience of the new settlement to climate variability. Thangchung is going to provide a unique challenge in addressing the sustainable energy options when demand increases to cater to both the increasing household energy need and the need to serve visitors/tourists who will probably come to Thangchung for several reasons as discussed in the paper above. Thangchung, unlike Dheye, also provides ample opportunities even to lift water from Kaligandaki if required to meet any additional water demand unforeseen at this stage by applying appropriate energy option. Options of solar water lifting, as an add-on or replacement, can be implemented in future should the gravity fed water system currently designed for Thangchung becomes inadequate to cater the water need or does not serve the purpose for some reason. These additional or alternative energy, and thus water supply provisions, will likely make the villagers more resilient to water stresses caused by climatic variation at Thangchung. Besides, the demand for energy for cooking and heating households that will be more felt especially during the harsh winter climate have also been looked at. These energy needs shall be provided through range of energy options like ICSs or improved institutional solar cooking and alike. Thangchung on its way to become a new resettled village not only needs to ensure access to educational and improved health services but also needs to provide ample of opportunities to run and operate entrepreneurial services at Thangchung. Besides, the discussed possibilities of tourism entrepreneurships and these prospects to operate their services and businesses inherently become energy intensive. Integration and management of sustained energy options in Thangchung will continue to play a key role in building the resilience of what people of Dheye have hoped as their safe heaven.

References

✓ Developing a Climate Smart Re-settlement Plan for Thungchung, Upper Mustang (2014), WWF & EDS, Unpublished.

✓ District Climate and Energy Plan (2011), District Development Committee, Mustang.

✓ IPCC (2001), "Adaptation to climate change in the context of sustainable development and equity", in Climate Change 2001: Impacts, Adaptation and Vulnerability, Chapter 18, Cambridge: Cambridge University Press. Available at http://www.ipcc.ch/ipccreports/tar/wg2/pdf/wg2TARchap18.pdf

✓ IPCC (2007), "Climate Change Synthesis Report. Contribution of Working Group I to the Fourth Assessment Report," An Assessment of Intergovernmental Panel on Climate Change. Available at http://www.ipcc.ch/pdf/assessment-report/ar4/syr/ar4_syr.pdf

✓ Kandel, B.R. (2012), Renewable Energy Financing in the Changing Climate Context, Are Private Sector Financiers Ready for This New Investment Opportunity?, *Journal of Institute of Chartered Accountants of Nepal*, Vol. 14, No. 4, Kathmandu.

✓ Moving Down or Not: A Key Question for Samzong, Yara and Dheye, Three Villages in Upper Mustang, Mustang District, Part I Synthesis (2012), Kam for Sud.

✓ Moving Down or Not: A Key Question for Samzong, Yara and Dheye, Three Villages in Upper Mustang, Mustang District, Part IV Dheye (2012), Kam for Sud.

✓ National Planning Commission, Government of Nepal (2011), "Climate-Resilient Planning," Working document, Kathmandu.

✓ Ministry of Environment (2011), District Climate and Energy Plan (DCEP) Preparation Guideline (draft), Government of Nepal, Ministry of Environment, Alternative Energy Promotion Centre (AEPC), UKAID, SNV, Kathmandu.

UNDP/GEF (2008), "Solar Wind Energy Resource Assessment in Nepal (SWERA)," Prepared by Alternative Energy Promotion Center, Kathmandu, Nepal. Available at http://www.aepc.gov.np/docs/resource/subreport/20130818124528_Solar%20and%20Wind%20Energy%20Resource-Assessment%20in%20Nepal.pdf