WISIONS of sustainability

Factsheet Series:
Sustainability Solutions for Mountain People and Landscapes

Productive use of energy in mountainous regions in Nepal

Cold storage unit in Baiteshwor after construction.
(Photo: PEEDA, 2019)

Introduction

The term Productive Use of Energy (PUE) refers to energy use that creates value, for example in the form of increased productivity or income, employment creation, or reduced hardship[1]. While definitions of PUE differ, there are two main reasons why it is pursued: first, it is a means to achieve broader socio-economic goals and, second, it can improve the viability of energy access business models[2]. Powering PUE solutions using sustainable energy sources, such as electricity from decentralised solar, is cost-effective and brings added benefits, such as increased reliability of supply and reduced emissions.

This factsheet introduces the general concept of PUE solutions. It places particular emphasis on two types of PUE solutions, namely r**enewable energy irrigation pumps** and **cold storage**, which appears to be highly scalable and relevant for the agricultural sector in Nepal.

A commercial apple farm in Dolchalgad, Guthichaur Rural Municipality relies on diesel generators to pump water for irrigation. (Photo: Winrock, 2023)

The solution

Agriculture is the backbone of Nepal's economy and an integral part of its cultural identity. However, the country faces unique challenges in ensuring the productivity and sustainability of its agricultural practices. Its diverse topography and climatic conditions, erratic rainfall patterns due to climate change, and lack of reliable and affordable energy pose challenges to the production, harvesting, and processing or preservation of agricultural produce.

The agricultural sector in Nepal accounts for a third of the GDP. Most farmers in Nepal are smallholders relying on traditional rain-fed farming. Of the 2.6 million hectares of arable land, 69% is irrigable, but only 39% currently has irrigation. Many farmers depend on costly, environmentally harmful diesel pumps for groundwater irrigation due to limited electricity access. Agriculture, including irrigation, consumes 10.5% of the country's diesel. Despite 80% of the population working in agriculture, Nepal imports food, highlighting the need to boost productivity in the agricultural sector through the productive use of renewable energy.[3]

Irrigation and cold storage are two important technologies in the agricultural value chain in Nepal. Traditional irrigation methods that rely on gravity-fed canals and rain-fed agriculture often result in inefficient water use, which can lead to over-irrigation in some areas and under-irrigation in others. Post-harvest losses are estimated at around 25–30% of total production[4]. Much of this loss is due to inadequate storage facilities that do not maintain the required temperature and humidity levels. However, a reliable supply of fresh produce throughout the year - even during off-seasons or in adverse weather conditions - is essential for food security in Nepal. The utilisation of renewable energy sources has emerged as a promising solution to enhance agricultural productivity along the entire value chain, from production to harvesting, processing, cooling and preservation.

Renewable energy irrigation pumps

Renewable energy-powered irrigation systems, such as solar pumps, offer a dependable water supply that helps farmers cope with climate variability and ensures consistent access to water. These systems also enable water distribution to be controlled precisely, making resource use more efficient and boosting agricultural productivity. By customising irrigation schedules to meet the specific needs of their crops, farmers can significantly increase both yields and income. Renewable energy-powered pumping systems can utilise either solar energy or hydropower from mini and micro hydropower stations to generate electricity to pump water, especially in areas with flowing rivers and streams.

Renewable energy cold storage

Food waste and food loss are among the main causes for global greenhouse gas emissions. Global food waste and loss contribute significantly to greenhouse gas emissions, making them a major factor in climate change. Climate change exacerbates post-harvest food loss through higher temperatures, greater pest damage, and other factors. In Nepal, multiple studies have indicated that post-harvest loss of fruits and vegetables are estimated at between 20 and 30% and could even exceed more than 50% under adverse conditions. These unplanned losses result from disruptions to production or supply chains[5].

Cold storage facilities play a pivotal role in minimising post-harvest losses, extending the shelf life of perishable goods, and ensuring a steady supply of food, especially in remote and mountainous regions. Addressing Nepal's agricultural preservation challenges and advancing sustainability goals through renewable energy-powered cold storage requires a comprehensive and multi-faceted approach. There are two technology options:

- Solar-powered cold storage: By harnessing Nepal's abundant sunlight, solar-powered cold storage units can be developed and deployed. These systems can effectively maintain low temperatures, reducing post-harvest losses and ensuring the long-term quality of agricultural produce. As these systems are modular, they can be deployed to remote locations where the need for such technology is dire.
- Hydropower integration: In regions with access to water resources, integrating small-scale hydro-power systems to generate electricity can provide a consistent and reliable source of renewable energy for cold storage facilities.

To successfully implement renewable energy-powered technologies in agriculture, several key factors must be addressed. Capacity building is essential, including training farmers in best agricultural practices, the use and maintenance of renewable energy irrigation systems, and post-harvest storage techniques. In addition to this, equipping local technicians with the skills to install, maintain, and repair these systems ensures their long-term functionality.Policy and regulatory support are also crucial. Incentives, subsidies, and favourable financing options can encourage farmers to adopt these technologies, while clear regulations ensure their safe and efficient use. Integrating renewable energy systems into the grid can enhance energy resilience by feeding surplus energy back in.

Exploring energy storage solutions, such as battery technologies, enables excess renewable energy to be stored for later use, ensuring continuous operation during low generation periods. Community engagement and public awareness campaigns can further promote these technologies, with cooperative projects helping to reduce costs for farmers and encourage broader adoption.

Business and financing models

Various business and financing models can be considered to determine the most suitable approach to implementing solar irrigation and cold storage projects in Nepal's mountainous regions. **Public-private partnerships** (PPP) can leverage the strengths of both the public and private sectors to ensure sustainable outcomes. The Build-Own-Operate-Transfer (BOOT) model might also be an effective solution as it transfers the investment costs to the private sector, leading to sustainable operation. **BOOT (Build-Own-Operate-Transfer)** is a project financing model where a private entity builds, owns, and operates an infrastructure facility for a specified period before transferring ownership back to the public sector. Cooperatives allow farmers and local communities to collectively invest in and manage irrigation systems or cold storage options, sharing costs and benefits. Alternatively, **community-based ownership models** can empower local communities to take full control, ensuring that the projects are aligned with their specific needs and priorities. Active participation by the private sector can lead to the establishment of agriculture value chains and market linkages.

To support these initiatives, international cooperation and funding from organisations, development agencies, and governments can be crucial. Additionally, facilitating access to loans, grants, and other financial resources is essentialto enable farmers and entrepreneurs, particularly those in remote and underserved areas, to adopt and benefit from solar irrigation and cold storage technologies.

One of the primary economic challenges in implementing renewable energy-powered irrigation systems or cold storage facilities in Nepal is the initial capital investment. The cost varies significantly depending on the technology chosen (e.g., solar, hydropower) and the scale of the system. Solar-powered irrigation systems, for example, require solar panels, inverters, pumps, and other components to be purchased. The upfront cost can be substantial, especially for larger systems serving extensive agricultural areas. For hydropower-based systems, significant investments are needed in infrastructure, including water diversion structures, turbines, generators, and transmission lines. Furthermore, in areas with intermittent energy generation, for example during monsoon season, the need for energy storage solutions or backup systems, such as batteries or diesel generators, can increase the initial investment.

Operating costs for maintenance, labour, replacement and repair, as well as revenue generation, payback period and return on investment also need to be factored into business projections.

Socio-economic and sustainability impacts

The implementation of renewable energy-powered irrigation and cold storage systems in rural areas of Nepal can lead to improved living standards and enhanced economic opportunities. The systems create jobs in installation, maintenance, and operation, stimulating local economies. Increased agricultural productivity can contribute to poverty reduction, food security and increased income opportunities in rural communities. Sustainable cold storage in particular contributes to the preservation of natural resources by reducing post-harvest losses. By extending the shelf life of agricultural products, it reduces the need for additional water, land, and energy resources to produce replacement crops. It also helps reduce the amount of food waste that would otherwise end up in landfills, contributing to methane emissions. However, cold storage facilities are energy-intensive operations. Implementing energy-efficient equipment and practices at these facilities is essential to minimise the energy consumption and carbon footprint.

The adoption of renewable energy-powered technologies reduces greenhouse gas emissions associated with conventional diesel pumps and generators. Moreover, reduced fuel consumption decreases air and water pollution, benefiting both the environment and public health. In this case, a positive impact on the environment is also achieved when attention is paid to the energy efficiency of the systems. In addition to this, irrigation systems powered by renewable energy can optimise water use, reduce over-extraction from rivers and groundwater, and minimise water-related environmental degradation. Sustainable water management and preservation of water resources is crucial for Nepal given its vulnerability to climate change. Properly managed renewable energy-powered irrigation systems can also help maintain water quality by reducing contamination from fuel spills and engine exhaust systems, safeguarding aquatic ecosystems and drinking water sources.

Scaling-up potential

The government of Nepal has expressed a strong commitment to sustainable agriculture and renewable energy development. Various policies and incentives have been introduced to promote the adoption of renewable energy technologies, including solar and wind-powered irrigation systems. Aligning with these initiatives can help farmers to access financial support and technical expertise, making the transition to renewable energy-powered irrigation more accessible.

Case studies in Nepal

Solar-powered cold storage unit, Baiteshwor
Storage capacity: 5 metric tonnes

Cold storage unit in Baiteshwor after construction. (Photo: PEEDA, 2019)

The project, implemented by WISIONS and PEEDA in 2019, aimed to increase the income and improve the livelihoods of smallholder farmers in the rural community of Baiteshwor through the construction and demonstration of a solar-powered cold storage unit. Built with the help of a local solar company, the unit has a storage capacity of 5 tonnes, is equipped with 5 kW solar panels and has a 24-hour backup to maintain a minimum temperature of 2°C. It also served as a model to demonstrate feasibility and disseminate knowledge to other farmers and government institutions. The cold storage unit extends the shelf life of agricultural produce by several weeks, enabling smallholder farmers to sell their produce outside the harvest season, securing better prices and reducing post-harvest losses by more than 50%. The facility is managed by a trained operator selected by a management committee, which also co-ordinates the use and sale of products in bulk. The main impacts of the cold storage unit have been an increase in income for local farmers, reduction in food waste, incentive to increase agricultural production, and employment opportunities. In addition, an ongoing socio-technical exchange between 70 experts from civil society, the private sector, agriculture, renewable energy and government representatives contributed to sustainable cooperation and knowledge sharing.

Lessons learned

The following recommendations can be made:

Renewable energy-powered irrigation pumps:

- Establish comprehensive data collection and monitoring systems to track the performance and impact of renewable energy-powered irrigation systems on crop yields, water use, and energy savings.
- Engaging local communities throughout the project lifecycle is crucial for adoption and sustainability. Successful projects often involve local farmers in decision-making processes, ensuring that the systems meet their specific needs. Projects need robust systems for mainte- nance and repair. Training local technicians is crucial to ensure the long-term functionality of systems, especially in remote areas where access to replacement parts and skilled labour may be limited.
- Identifying suitable financing options is critical for the adoption of renewable energy systems. Flexible payment plans, subsidies, or low-inter- est loans can make technologies more accessi- ble to smallholder farmers.

Renewable energy-powered cold storage:

- Consider promoting PUE equipment that can be used during off-peak hours to increase consumption without reaching system capacity. Alternatively, increase the generation capacity, which is currently much lower than the actual installed capacity, to promote PUE equipment that can be used during peak and off-peak hours.
- Identify suitable locations for cold storage facilities, focusing on proximity to agricultural production areas. This reduces time and costs, minimising the risk of spoilage during transport.
- Ensure that cold storage facilities are appropriately sized to meet local demand and handle varying quantities of produce. Modular designs can accommodate expansion as needed.
- Implement remote monitoring systems that enable realtime tracking of temperature and energy consumption. This allows for proactive maintenance and optimisation of energy use.

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This factsheet is part of the series “Sustainability Solutions for Mountain People and Landscapes,” developed within the WISIONS Innovation Lab Nepal. The aim is to promote an integrated approach to strengthening the livelihoods of people living in mountain communities. Each factsheet provides information on specific sustainability solutions in the fields of energy and landscape management that have shown promising potential for improving the livelihoods of mountain people but have a low level of adoption in Nepal and other mountain regions. The information is tailored to the specific context of Nepal’s mountain landscapes and offers practical insights and guidance for scaling up the application of these solutions. Additionally, it presents an integrated approach that begins with an understanding of the opportunities and challenges faced by mountain communities, enabling the systematic deployment of synergies between solutions from the energy and landscape sectors.

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