Passive solar architecture for mountain agriculture

Photo: GERES

A solar greenhouse in Leh, Ladakh.

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In the higher and more remote parts of the Hindu Kush and Himalayan mountain ranges, winter temperatures fall below -30 °C, rainfall is low and natural resources are limited. Still, more than 150 million people make a living under these conditions. Farmers primarily rely on sheep, goats, cattle and yak and agriculture is limited to cereal production on very small landholdings.

The Ladakh region is located between 2700 to 4500 m altitude in the Western Indian Himalayas, close to the Tibetan/Chinese and Pakistan border. During the short summer period, Ladakhi communities concentrate on subsistence agriculture and collection of fuelwood in order to survive during the long and harsh winter. In the winter, snowfalls block the high passes, roads are closed and the people rely almost entirely on their own resources. All activities, even domestic, are very limited due to the cold. The market price of fresh products increases by two to three times and only the upper class modern families can afford the rare fruits or vegetables available on the market – imported by aeroplane from more fertile areas.

Since the early 1980s GERES (*Renewable Energy and Environment Group*) has tried to improve conditions by increasing use of the main natural resource that this region has in abundance, especially in winter: sunshine. Passive solar architecture can be used for warming houses, schools, dispensaries and handicraft centres as well as for developing off-season agricultural activities such as production in greenhouses and poultry farming. A particular challenge has been to develop a greenhouse for agricultural production to increase access to winter vegetables. The greenhouse has to be adapted to high altitudes, high snowfall and very low temperatures.

The first greenhouses were designed for maximum technical effectiveness and intended for the middle class. Although technically very efficient, these greenhouses had a number of problems, in particular the cost of construction and the long payback period.

Appropriate technology

In 1998, GERES entered into a partnership with *Ladakh Environment and Health Organization* (LEHO) and the University of Cashmere at Stakna, near to Leh, to develop a solar greenhouse better adapted to the economic, social and climatic conditions of the region and enable poor farmers to generate additional income, especially during the inactive winter period.

The resulting 50 m^2 solar greenhouse is south oriented and the east, west and north walls are constructed with sun-dried bricks. The walls are insulated with straw and support a tilted roof on the north side. The greenhouse is covered by Indian manufactured, U.V resistant polythene sheet. Overheating is controlled by natural ventilation. Because the walls retain the heat they receive during the day and release it slowly during the night, the vegetables do not freeze, despite outside temperatures below -20 °C.

In these greenhouses, farmers can grow vegetables all year round: from exotic vegetables in summer to leaf and root vegetables such as spinach, coriander, and carrot in the winter. In autumn, the greenhouses extend the season of fruits and vegetables – for example, tomato can be grown up to the end of November. In spring, the greenhouses can be used as a nursery to grow seedlings.

To promote the new solar greenhouse, a large demonstration greenhouse was built in Leh. Initially it was planned to build five demonstration greenhouses, but news of the efficiency of the new greenhouses spread quickly and many requests were received. The high demand meant that more than a hundred greenhouses were built within three years, with less than 30 percent subsidy. The subsidy consisted mainly of material contributions, such as plastic covers or wooden ventilators which are not available on the market but which are required for the proper running of the greenhouse. This material was provided at the end of the construction, after checking the quality of the basic construction.

To ensure initial success, farmers were selected based on their experience in vegetable growing, as well as social criteria such as size of land holding (small) and availability of other income sources (none). In this way, the project ensured that the selected farmers were motivated to obtain maximum benefit from the greenhouse and that the project would contribute to its social objectives. Practical technical criteria such as shading and water availability were also taken into consideration.

Scaling up

During the second and third year of the project, the marginal farmers, together with local masons and carpenters involved in the construction, suggested many practical improvements to further adapt the greenhouses to their skills and constraints and to improve the durability of the design. Their input was crucial in reducing the investment cost, simplifying construction and ensuring that the design was appropriate for the resources available in the high mountain areas. The masons and the carpenters associated with the project were specifically trained to become "service providers". The goal was to create a network, and to guarantee the presence of local specialists on a larger scale.

Since the local population adapted and improved the greenhouses, they have the capacity for further adaptation and development and local agriculture has therefore started to diversify further. High-value cash crops such as vegetables are now being added in autumn, winter and spring to the traditional summer cereal crop.

Impacts

The fast diffusion of the improved solar greenhouses led GERES to evaluate its work in Ladakh. The evaluation aimed at a better understanding of the effects of the improved greenhouses on different levels: on the family way of life and economy, on the Ladakhi society and on the vegetable market in Ladakh. In addition, the evaluation was seen as an important step for ensuring sustainability and for considering the replication of the programme in other areas of the Himalayas, such as Mustang (Nepal) and Tibet.

The evaluation was carried out in three areas: Leh and its closest villages (Central Ladakh), downstream from Leh along the Indus river (Sham, at least 30 km from the city) and in Chang Tang (high valleys in remote areas, near the Chinese border). It was found that most of the families had decided to build a greenhouse for two purposes: for own consumption of vegetables and for sale. Generally, the productivity of the greenhouse depended on the motivation of the family that used it. The most productive greenhouses were run by farmers who mainly sell their products at the local markets. For them, the greenhouse is their only source of cash income during the six months of winter and spring. In addition, their activity benefits many families, because they make products available at the markets during winter season. An improved greenhouse can generate up to 80 percent of the income of a small farmer, and these farmers represent the major target group for the extended greenhouse programme.

Women are often in charge of managing and selling the vegetables. The evaluation showed that often women themselves manage the income generated. Sometimes, it is the first time that they manage finances. The income is often invested in education for the children or inputs for further agricultural production such as fruit trees or fencing, rather than in consumer goods.

Economic reality

In Central Ladakh and Sham the greenhouses are mostly used to produce vegetables. The working time required is around two hours per day for weeding, watering and harvesting. Selling the products during winter is the most profitable activity: It is possible to earn US$50.00 per month for less than 2 hours work per day, at a time when no other agricultural activities are possible and average income for a full-time job is less than US$40.00 per month. In these two areas, public transport exists between the villages and the market, and farmers are able to market the produce themselves.

The majority of the families with greenhouses in Central Ladakh and Sham did not buy vegetables during the winter: Thanks to their greenhouse, these families could reduce their food budget in addition to earning extra income. Another saving comes from producing their own seedlings.

In Chang Tang, the greenhouses are often attached to the house and used partly as a room during the winter, to wash, for crafts such as carpet making, or even as a cattle shed. In spring, the greenhouse is mainly used to produce seedlings. The different uses can be explained by the lack of a market to sell the products and by the extreme coldness (-35 °C). In this area, around 10 tons of fuelwood is required per year for heating the house during the winter – this corresponds to at least two months of work for women and children. The main impacts of the greenhouses in this area are the reduction of the fuelwood consumption (by 65 percent) and the improvement of the indoor climate, which is less smoky.

The way forward

The experience in Ladakh has shown that passive solar architecture can be successfully applied for agricultural uses. The improvements made by the farmers themselves contributed strongly to this success story. Less expensive and just as effective, the greenhouses became well adapted for large-scale adoption. We learnt from this experience that technical improvement is essential but not sufficient. A technology has a future only if it is integrated, locally adapted, easy to build, cheap and profitable in the medium term.

Photo: GERES

Growing vegetables in a solar greenhouse in Leh, Ladakh.

In 2005, GERES will begin a new rural development project in Ladakh. This project includes the training of six local NGOs to implement the activities, because the success of the activities cannot be guaranteed without the strong involvement of local actors through the whole process. ■

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