Researchers for Bio Heating Solutions
Բիոցեռուցման լուծումների հետազոտողներ

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PASSIVE SOLAR GREENHOUSE WITH DRIP IRRIGATION SYSTEM

Background

Within the context of climate change one of the most vulnerable sectors of the economy is the agriculture, making the high mountainous poor communities relying mainly on income from cattle breeding more vulnerable. Most of the mountainous communities of Armenia are specialized in cattle breeding and often do not have any serious economic alternatives to it. This means that in case of negative climate impacts on pastures and grasslands those communities may incur serious economic losses leading to migration. Adaptation alternative is considered important to create additional sources of income for such communities, thus diversifying their economic base, and reducing the vulnerability to climate change. One of such alternatives may be passive solar greenhouse (PSG).

The PSG project in Vayots Dzor region implemented by UNDP and Researchers for Bio Heating Solutions NGO in Armenia was a multi-component project that addressed climate adaptation and risk reduction through environmentally friendly approaches as renewable energy, energy saving, drip irrigation making less dependence from weather for agricultural/agribusiness development, as well as knowledge-transfer, organic crop cultivation and building technical skills, and marketable product development.

Taking into consideration the decision of the Government of Armenia to boost the greenhouse industries in rural areas, the passive solar greenhouse development plan might be accepted as a solution for high mountainous and sunny regions in Armenia. PSG might present an opportunity of new greenhouse model that with low operational costs in the long-run may enable the greenhouse industry in mountainous regions to flourish, and increase the food security of the country.

Introduction to Passive Solar Greenhouse and its benefits

There are number of efficient solar greenhouse designs that utilized in horticulture throughout the world. Weather conditions, difficulties with the insulation, requirements for additional heating during cold seasons require considering an option with improved efficiency and reliability of the solar greenhouse.

The PSG specific design increases solar heat collection and through applied materials and operational technologies increases the overall energy efficiency for same level of service.

The proposed design of PSG[1] uses a Chinese model. This structural model is specifically developed for application in high elevations, and has been tested and successfully adopted in mountainous regions of China, India, Japan, Nepal, Korea and Russia[2].

In 2013, the Researchers for Bio Heating Solutions (RBHS) NGO, for first time in Armenia has pioneered the PSG in Kut village, Gegharkunik region (2150 meters a.s.l.) to test the design as a potential model to resolve the construction and heating challenges of the

[1] Passive Solar Greenhouse: A potential model for Armenia, electronic publication 2014, www.rbhs.am
[2] Gao, Li-Hong, Mei Qu, Hua-Zhong Ren, Xiao-Lei Sui, Qing-Yun Chen, and Zhen-Xian Zhang. "Structure, Function, Application, and Ecological Benefit of a Single-slope, Energy-efficient Solar Greenhouse in China". Technology and Product Reports, June 1, 2010, 5.

greenhouse industry through incorporation of energy efficient and renewable energy technologies. The results have been very satisfying.

The PSG Technicalities

The proper orientation of the PSG to the sun - the longer axes positioned east-west and oriented toward true south, - is critical for maximizing solar exposure, collection of heat radiation, and thus ensuring the overall efficiency of the greenhouse. The construction materials used and design of the PSG in combination with its optimal positioning has a significant effect on decreasing energy losses and increasing energy preservation. The design's uniqueness is in the thermal protection features of the greenhouse. The thermal protection features of walls in the eastern, western and northern part of the greenhouse and the optimized exposure of these walls are essential for the collection, storage and retention of heat in the greenhouse. Heavy insulation, especially on the northern side of the greenhouse, ensures reduction of heat loss. The dense materials such as bricks, stones and cement, often used for the construction of the walls, are combined with low-density materials as straw placed in between the dense materials ensure insulation and appropriate thermal characteristics.

The proposed PSG walls are built with local materials such as straw bales and cement ensuring good thermal energy retention and an inflated double layer polyethylene cover ensures wind resistance, snow and hail protection and acts as insulation blanket from the outside air. Thus, the temperature stability in the PSG is guaranteed and positively affecting energy efficiency characteristics.

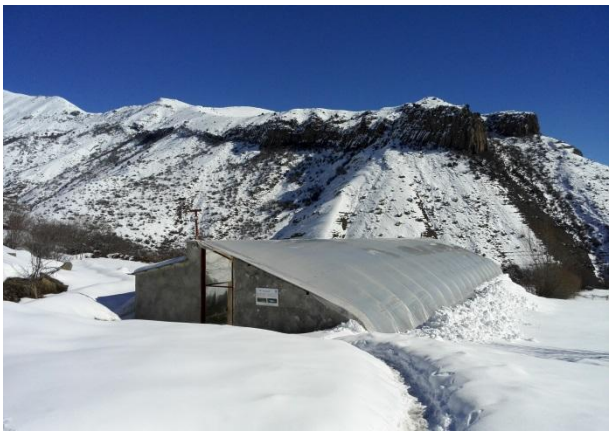
Picture 1. PSG in Kut village, Gegharkunik region. Picture taken during construction, 2013.

Picture 2. PSG in Kut village, Gegharkunik region. During winter, 2014.

In 2014, the "Mitigation of Climate Change Risks of Rural Communities through Improved Local Development Planning" UNDP-BCPR (Bureau for Crisis Prevention and Recovery) Project cooperated with RBHS NGO and initiated the construction of the passive solar greenhouse in Horbategh village of Vayots Dzor region. The construction design documents were improved based on lessons learned from the first installation in Kut community.

The PSG is equipped with drip irrigation system and with a passive refrigeration storage located behind its northern wall. The storage is intended for garnering the produce cultivated in the PSG as a pest-free, well-insulated, mold-free storage that can keep the produce fresh until planned delivery.

Picture 3. PSG in Horbategh village, Vayots Dzor region. Picture taken during construction, 2015.



Picture 4. PSG in Horbategh village, Vayots Dzor region. During winter, 2016.

The Passive Solar Greenhouse Horbategh

Fact Sheet	
Community	
Altitude	1850 m a.s.l.
Climate	Continental
Population	300 people
Income generation activities	Animal husbandry/ livestock
Passive Solar Greenhouse	
Land / Ownership	Communal
Type of structure	Energy Efficient Greenhouse
Main construction materials	Straw bales, cement and metal structure
Size of the greenhouse	262.5 sq./m
Dimensions	35.02 meters length, 7.5 meters width
Greenhouse cover	Inflated double layer polyethylene film
Passive Cooling	Doors and windows / eastern and western side of the PSG
Active cooling	5 fans, 6000 m3/h each
Watering	Water tank, 1500 liters, natural gravity/pressure watering
	Drip irrigation system
Weather data	Electronic data collection tools

The Passive Solar Greenhouse is intended for small-to-medium scale farming with specific focus on the most vulnerable communities in isolated, high elevation regions. The PSG model through employing technological advancements in the field of passive architecture - energy efficiency, renewable energy, and effectively utilizing the advantages of combining with agricultural production environment, presents the potential for expanding the greenhouse industry in mountainous areas creating the possibility of effective, efficient, and sustainable food production in marginalized, mountainous communities. Thus, the design of the greenhouses allows producing agricultural products without additional heating, even in the winter time, thus making possible the development of alternative sources of income in mountainous communities, where conventional greenhouse are not effective due to extremely high heating costs.

Financial Assessment and Risks

Although the expenses for PSG construction might seem to be high for most farmers and communities as compared with the conventional greenhouses, the benefits of PSG such as: low operational costs (no need for heating during long cold season) and year-round job security, makes it the priority for consideration for certain geographical locations.

According to rough calculations the energy consumption, being limited only to lighting, water pump, and ventilation thus, thanks to its better insulation and intake of solar energy, the operational costs related with PSG are much lower than those of conventional greenhouses, leading to the fact that the total lifecycle cost (construction and operation) of PSG (7-10 years) is lower compared to conventional greenhouses considering that PSG can operate during the winter season only with solar energy.

Picture 5. PSG in Kut village, Gegharkunik region. Cress, January 2014.

Picture 6. PSG in Horbategh village, Vayots Dzor region. Cress, parsley, coriander and dill, February 2016.

PSG Design and Bill of Quantity:

PSG can be easily replicated using local materials and human force. The blueprints with modifications and improvements for a 260 sq.m used in Horbategh village are provided to all interested parties for further replication opportunities by RBHS NGO and can be found on http://rbhs.am/wordpress/wp-content/uploads/2015/12/PSG_Final.pdf website.

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