JOURNAL LA LIFESCI

VOL. 03, ISSUE 03 (133-145), 2022
DOI: 10.37899/journallalifesci.v3i3.787

Prospect of Protected Agricultural Structure and its Constraints for Utilizing in Nepal

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Article Info

Article history:
Received 2 February 2023
Received in revised form 16 March 2023
Accepted 14 April 2023

Keywords:
Agriculture
Protected Agriculture Structures
Sustainable Agricultural Development
Greenhouse
Plastic Tunnel

Abstract

Protected agricultural structures have been adopted by commercial farmers throughout the world including Nepal to cope with climate change and its adverse effects on agriculture. Technology based production system is important for sustainable agricultural development. It could be the tool for low-income countries like Nepal where agriculture is the priority of income generation for the rural people. A field study was conducted in 2021 and 2022 to understand the prospects of protected agriculture structures adaptation by farmers and agricultural entrepreneur in Nepal. The study was traversed with both physical observation and the user's interviews. The opportunities and the constraints have been critically analysed based on these field study along with the review of different policy documents and success stories published. This study found that the protected cultivation practice has been rapidly increased with increasing number of protected structures like plastic house or tunnel framed with bamboo or GI pipe, Agri-net house, naturally ventilated poly house and semi or hi-tech green house. In contrary, the import of horticulture products has also been increased more than 200% in last 10 years. This study finds the gap mismatching between technology enhancement, production and import of horticulture crops.

Introduction

A protected agriculture structure is quasi-permanent agriculture structure, covered with a transparent or translucent material, ranging from simple homemade designs to sophisticated pre-fabricated structures, wherein the environment could be modified suitable for the propagation or growing of plants (Jensen, 2002 & Singh et. al., 2015). Most of the agriculture researchers agree that the sustainable development and agricultural growth is only posible with the technologies-based production practices in the low-income generating countries like Nepal where agriculture is the source of income generation for the rural peoples (Diwakar et. al., 2021).

Nepal is one of the top ten fastest urbanizing countries in the world and will remain on this position with projected annual urbanization rate of 1.9% for the period of 2014-2050 (Bakrania S., 2015). This indicates, Nepal has been under the process of rapid urbanization and will create a high demand for agricultural commodities in the markets. It has found that Nepal imports around 70% of the total vegetable trade (CASA, 2020) and spent Rs 20.74 billion just for importing fruits & cashew nuts every year (Kumar R., 2020). With globalization of markets, shrinking land and climate change, the protected agriculture practice of high value crops has emerged as the single most important technology for ensuring food security. Nepals National

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Adaptation Programme of Action (NAPA) report concluded that Nepal is most vulnerable to climate change (MoE, 2010) and the increase is more pronounced in the Middle Hills and the High Himalayas (Xu et al., 2009). Paudel M.N. (2019) also mentioned that climate change altered the agricultural cropping system in all part of Terai, Hills and Mountainous region of Nepal. It is thus important to address the climate change risk to the farmers in the policies for the adaptation to climate change regelence agriculture technogies (Sujakhu et al., 2016).

In South Asia, Nepal government has emphasized technology-let interventions as strategies for the growth and development of farmers, the majority of whom are smallholders (MOAD, 2015). Government of Nepal has given priority on agricultural technology dissemination strategically, with lunching a Prime-Minister Agricultural Modernization Project (PMAMP). The project had introduced many agriculture infrastructure and machineries to enhance the poor Nepalese farmers by creating sustainable economic opportunities oriented towards agro-industrialization (Shrestha R., 2022). The tunnel technology in Nepal seems to be introduced in 1996 at Regional Agriculture Research Station, Lumle (Kafle and Shrestha, 2017). Such kind of tunnel structure built with bamboos or galvanized iron (GI) pipe framework structured designed to withstand the local wind.

The structure generally covered on the Top (roof) or entire side of the structure by transparent silpaulin plastic of 45 to 90 GSM (MOALD, 2016). In recent years, climate change risk has been acknowledged by the government of Nepal and emphasised the promotion of climate-smart agriculture technologies. In this context poly house technology has been widely promoted technology to the smallholder vegetable farmers which has cultivated in large farm land area (Atreya et.al., 2019). PMAMP has constructed 10 no. of high-tch greenhouse and 86 semi high-tech greenhouse in last few years (Poudel RR., 2020).

The first-time establishment investment for low cost structure to medium size natural ventilated structures ranges from NRs 20,000 to 20,00,000 and widely adopted by small and medium size farmers whereas forced ventilated with well facilitation of irrigation, shading, cooling, fogger etc system in the structure has been used by commercial farmers and cooperative farmers where the investments ranges upto NRs 1,50,00,000 (WOCAT, 2013) and most of them had subsidized by Government. Atreya et. al (2019) had reported that the Kathmandu alone covered 250 ha cultivalble area with tunnel farming in 2015-2016.

They further reported that total estimated area under protected horticulture in Nepal is about 702.86 ha, out of which 695.16 ha (98.9%) are under vegetable and 7.7 ha (1.1%) under flower production till 2019. Likewise tunnel technology has widely constructed with the supports received from various national and international development organizations. This shows, that the number of poly-house technology has been substantially increased in last decade (Mukul and Byg, 2020 and Panthi et.al., 2016).

In this way, it is now important to understand that what are the reason behind it that even there is immense expansion of poly-house technology the import of vegetables and fruits has not in the decreasing trend. It is also need to find the gap of reporting, whether or not those technology has been proven beneficial for farmers and were they continuing the cultivation under such poly-house technology. This study mainly concentrated on adoption of protected agriculture structures and the constraints in utilizing the structures. This helps the researchers to identifying the problems in the adoption of protected agriculture structures and support policy makers to manage the technology dissemination process. The impacts of tunnel technology were analysed based on the crop production under it and net annual profit received from the poly-house.

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Methods

Study Site

The study area was selected from various ago-ecological zones of Nepal based on the information received from the district agriculture offices (Krishi Gyan Kendra) where, government had subsidised the protected agriculture structure for installation and operations. The random sample of farmers where selected for the questionnaire from the large number of protected agriculture structure user farmers in the particular region of Chitwan, Gorkha, Kaski, Lamjung and Tanahu district. The list of the site from where the study were conducted are; Dikhur, Pokhari; Hemja, Pokhara; sundarbazar, Lamjung; Khaharey Bandipur; Aabukhaireni Baradia; Bharatpur, Prembasti; Bharatpur, Chitwan; Madi-4, Chitwan; Abukhaireni, Chitwan; Kantipur Eakartit basti. as shown in the fig.1 pointing the exact location of protected structure where questionnaire was completed with the user's farmers.

Figure 1. Location of study area showing the exact location of protected agriculture structure observed

Data Collection

A field study was conducted for the data collection where, a questionnaire has been prepared to know the perception of farmers in cultivating under the protected agriculture (PA) structure. The physical observation of the structure was carried out to understand the real problem facing by the farmers in using the structure and hence the structure dimensions were measured to identify the design aspects of the structure. The detail of the data collected has been explained result and discussion section with their critical analysis.

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Analysis

The socioeconomic data were analysed determining the cost benefit ratio and described the social aspects based on the perception of farmers while cultivating under the PA structure. Whereas, the physical measurement taken from the PA structure were analysed to determine the its strength against the local wind and climate condition also the suitability of the structure in maintaining the micro-climate inside the PA structure were discussed based on the cropping pattern followed by the farmers.

The protected agricultural structures were found subsidised from the government which has been categorization in two groups; (1) Poly house (Greenhouse) and; (2) Net house/ Screen house

Hi-tech structures, semi hi-tech structure and low-cost tunnel structure are categorized under plastic house. Center for Agricultural Infrastructure Development and Mechanization Promotion, Hariharbhawan, Lalitpur has specified the norms for subsidising the such PA structure with above categorize. The field data has been analysed and the structures are then classified based on the specification as described below in Table 1 for hi-tech structure which includes Fan and pad greenhouse/ poly-house type structure; Table 2 for semi hi-tech structure that includes naturally ventilated poly-house; Table 3 for low-cost plastic tunnel; and Table 4 describes the net-house/ screen-house

Table 1. Hi-tech Protected Agriculture Structure (Greenhouse)

S.N.	Major Components	Detail Description
1	Structure Framework:	Hot Dip Galvanized (minimum 120 GSM) Iron tubular structure
1.1	Columns	- ϕ 76 mm, thickness of 2 mm and Wt. of 3.75 kg/m - Ridge ht. of 5 to 6.5 m and Gutter ht. of 3 to 4.5 m
1.2	Bottom Chord	- ϕ 60 mm, thickness of 2 mm and Wt. of 2.85 kg/m
1.3	Purlins/Curtain/Arc	- ϕ 42 mm, thickness of 2 mm and Wt. of 2.10 kg/m
1.4	Bracing	- ϕ 32 mm, thickness of 2 mm and Wt. of 1.60 kg/m
1.5	Foundation	- Depth 75-100 cm; columns are fitted over ground ‘inserts’ & bolted to insert pipe of ϕ 60 mm, 2 mm thick & 120 cm long - Wall of 0.5 m high (0.3 m below GL & 0.2 m above GL)
2	Covering Material (Cladding)	- Material: HDPE, Min. 200 GSM, UV stabilized, Diffusion/Clear light transmission (Wt. 1 kg/5.4 sq. meter)
3	Top shading material (Manual or motorized operation)	i. <u>Shade Net:</u> HDPE; Min. 100 microns thick; Sade factor: 50-70%; UV stabilized ii. <u>Thermal screen/ Acuminate:</u> HDPE Min. 100 micron thick including 25-micron aluminium coating; shade factor Max. 50% UV stabilized
4	Side shading material (Manual or Auto operation)	i. <u>Shade Net:</u> HDPE; Min. 100 microns thick; Sade factor: min. 35%; UV stabilized ii. <u>Insect proof net:</u> HDPE Min. 75 micron thick 40 mesh or more, UV stabilized
5	Electrical fittings	Wiring as required for connecting light, fan, motor etc.
6	Climate Control (Fan and Pad) System	i. Air circulating fan/ air mixing fans: Min. 24 inch ii. Exhaust fan: 4 nos. of Min. 24 inch (1 quartered gas vol^n/min)

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		iii. Cooling pads: L = (3-5)*n iv. Cellulose cooling pads: 1.8 m ht. with 100 mm/150 mm thickness covering the area properly
7	Fogging system	- 4-way @ 1-1.5 m apart, anti-leak fogger 28 iph flow rate - Produce fogging particle size of 80-100 micron
8	Irrigation system	- Drip irrigation of 16 mm lateral, with pump, filter, valves etc.
9	Others	- Fixtures (Brackets, cleats, clamps, nut& bolt, washers, self-tapping, drilling screw etc); Gutter; Curtain; Door; Bottom Apron; GI profile/ Poly fixing; spring insert; PVC pipe etc - Temperature and humidity sensor, panel board with volt meter, relay switch, MCB etc.

Table 2. Semi Hi-tech Structure (Naturally Ventilated Poly-house)

S.N.	Major Components	Detail Description
1	- Structure Framework (Columns, Bottom chord, Purlins/Curtain/ Arc, Bracing, Foundation); - covering material (Cladding); - Top shading material (Manual or Auto operation); - Side shading material (Manual or motorized operation); - Air Circulating Fan/ Air Mixing Fans - Exhaust Fan - Others: Fixtures (Brackets, cleats, clamps, nut& bolt, washers, self-tapping, drilling screw etc); Gutter; Curtain; Door; GI profile/ Poly fixing; spring insert etc	Same as Hi-tech Greenhouse system
* No other components available as mentioned in Hi-tech structure		

Table 3. Low Cost Plastic Tunnel

S.N.	Major Components	Detail Description
1	Structure:	Matured Bamboo (Size: 5 m x 12 m): total quantity = 200 m
1.1	Columns	- 7 nos. of 4 m long @ 2 m distance at the centre (ht. 3.5m) - 14 no of 3m long@ 2m distance at both gutter side (ht. 2.5m)
1.2	Rafter	- 7 nos. of 6 m long each at each column
1.3	Purlins	- 3 nos. of 12 m long (two at gutter/ side post & one at ridge) - 25 nos. of 5 m long (one bamboo tear to give 4 purlins)
2	Covering Material (Cladding)	- 200 microns UV stabilized plastic/ Tarpaulin plastic 120 GSM (78 sqm) on the top only
2.1	Open Shed	- 78 sqm (Plastic/Tarpaulin only used on roof)
2.2	Tunnel	- 200 sqm (Plastic/ Tarpaulin covered from all side and top)
3	Others	- Rope (1 Kg); Iron nail (1 Kg); Binding GI wire (6 Kg); Waste Mobile/Tar (2 Lit.) etc.

Table 4. Net house/ Screen house

S.N.	Major Components	Detail Description
1	Structure:	Hot Dip Galvanized (minimum 120 GSM) Iron tubular structure

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1.1	Columns	- ϕ 60 mm, thickness of 2 mm and Wt. of 2.8 kg/m - Centre ht. 4 m (if dome type side ht. 2.5 m) otherwise 4 m flat structure
1.2	3-way; 4-way and 5-way pipe coupler	- ϕ 48 mm, thickness of 2 mm and Wt. of 2.30 kg/m
1.3	Purlins/Curtain/Arc	- ϕ 42 mm, thickness of 2 mm and Wt. of 2.10 kg/m
1.4	Bracing	- ϕ 32 mm, thickness of 2 mm and Wt. of 1.60 kg/m
1.5	Foundation	- Depth 75-100 cm; columns are fitted over ground 'inserts' & bolted to insert pipe of ϕ 60 mm, 2 mm thick & 120 cm long - Wall of 0.5 m high (0.3 m below GL & 0.2 m above GL)
2	Covering Material (Cladding)	- Material: HDPE, Min. 200 GSM, UV stabilized, Diffusion/Clear light transmission (Wt. 1 kg/5.4 sq. meter)
3	Shading Net	Shade Net: HDPE; Min. 100 microns thick; Sade factor: 35-75%; UV stabilized; Colour: white/green/black
4	Others	- Nut bolts; Gable; GI profile; Spring insert; Door; Anti-room

Results and Discussion

Protected Agriculture Structure in Nepal

In the study several model of protected agriculture structures has been observed. However, during the field observation only few of the constructed structures were found as hi-tech protected agriculture structure. The result showed that most of the structure was either low cost structure (less than 5 lakhs) used by small farmers or first-time establishment investment of more than 10 lakhs were preferred by commercial farmers involved in agri-business. Different type of structure that has been studied during the field observation is shown in fig 2 to fig 5 which construction features are found as described below:

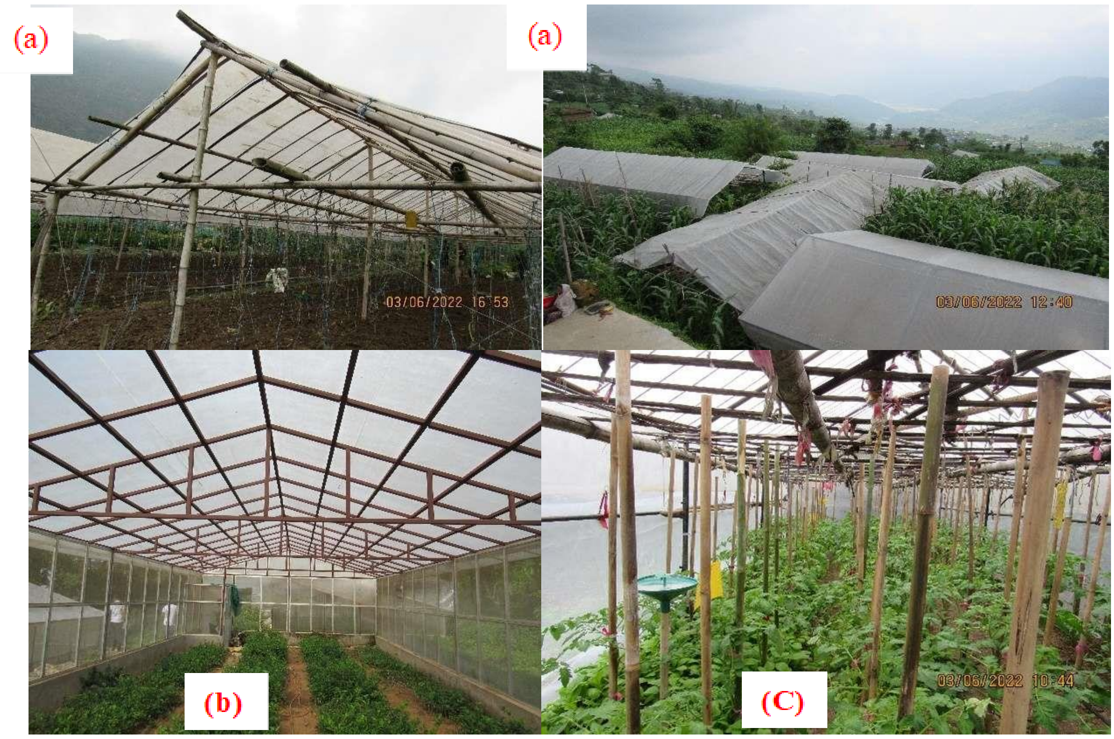

Figure 2. Low cost plastic (a) Bamboo open shed (b) GI framed tunnel (c) Bamboo tun

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The Low cos plastic house (LCPH): So, called plastic tunnel constructed with bamboo framed or GI structure. plastic house/ tunnel tie with Nylon or straw rope or iron nail or GI wire etc. is shown in fig.2. The structure either covered from entire side with tarpaulin plastic sheet or with insect net whereas the top of the structure has found covered with tarpaulin plastic except in the low-cost screen house or low-cost net house.

The semi Hi-tech poly-house (SHPH): So, called semi hi-tech greenhouse or naturally ventilated poly-house or simply poly-house, Mini hi-tech plastic house etc. is shown in fig.3. As described in table 2, SHPH found constructed with GI framing covered with HDPE cladding and on all the side, openable with manual or motorized rolling mechanism to facilitate the cross natural ventilation on the length side.

Figue 3. Semi Hi-tech poly-house (a) Naturally ventilated double span (b) Naturally ventilated multi-span

The top ventilation provided throughout the length on the ridge of the structure for each span and all the side and top ventilation has fixed insect net fitted. In the interior of structure air circulating or air mixing fan hanging on the gutter height just above the shade net and exhaust fan on the top of the wall section has found fitted in the structure.

High tech-greenhouse (HGH); which includes exhaust fan, cooling pad, fogger system, drip irrigation system etc. (fig. 4) as an additional component of semi-hi-tech poly house to control climate inside the greenhouse. The greenhouse with such control system is one of the advance greenhouse technologies available in Nepalese market. Only limited advance farmer had this type of greenhouse. Because of its high initial investment and sophistic climate management system, farmers are not motivated to adopt this model. The operation of fan and cooling pad system require technical skill where, the knowledge of humidity and temperature control inside the greenhouse is very critical and need to be monitored frequently if the system is not automatic. Since the covering materials mostly used in such kind of greenhouse was found using HDPE (Min. 200 GSM, UV stabilized, Diffusion/Clear light transmission of unit weight of 1 kg/5.4 sq. meter) where, it is found very difficult to control the temperature and humidity

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inside the greenhouse because such covering material is not sufficient to control heat transmission through the material. Thus, it is very difficult to maintain the temperature and humidity inside the greenhouse. Because of such sophisticated mechanism fan and cooling pad type of greenhouse, so called Hi-tech greenhouse, has not found adapted by Nepalese farmers.

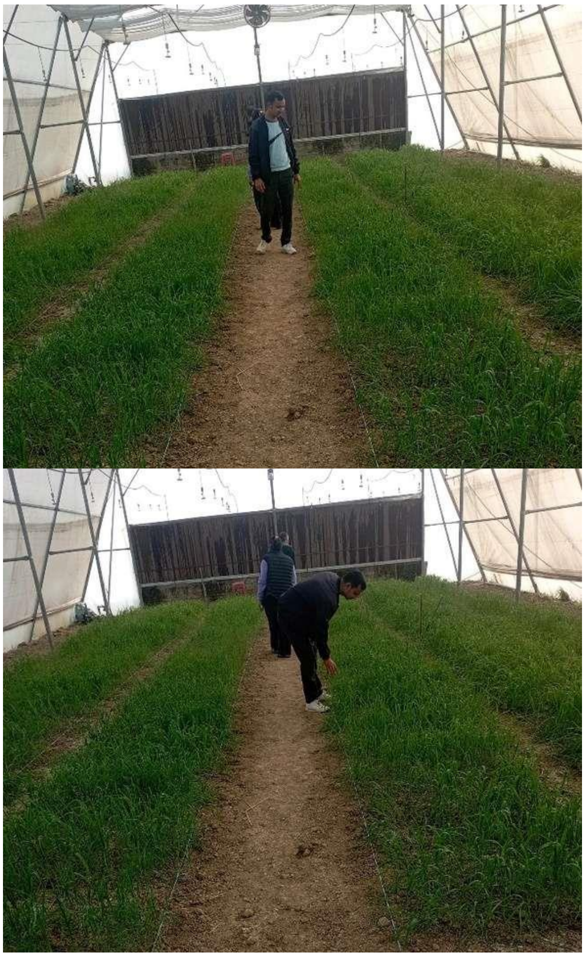

Figure 4. Hi-tech Greenhouse facilitated with cooling pad, exhaust fan & Foggier system

The frame structure of net house (NH) and screen house (fig. 5) has found constitute of either bamboo or of black iron pipe as a low-cost structure whereas GI pipe with hockey outward in commercial hitech structure. This type of Net has found constructed with flat roof or Dome or inverted V-shape, whereas in some of the Screen house the roof has made either Dome or inverted V-shape. The difference in net house and screen house has been identified with the top cover. In net house the top and all the sides are found covered with insect net of 40 mesh whereas in screen house the top has found covered with tarpaulin plastic sheet of 100 to 200 micron and the all the side wall has covered with insect net of 40 mesh

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Figure 5. (a) Net House (b) Screen house with its all features installed in farmers field

Status of Protected Agriculture Structures

The field study shows that only 11% of the structure justify the criteria of hi-tech protected agriculture structure based on the specification established by the government as shown in the table 1. whereas only 21% of the total structure in the study fulfil the specification of semi hi-tech protected agriculture as specified in table 2. Most of the structure were found low cost either constructed as plastic tunnel or plastic open shed or screen house or net house (Fig.6). The farmers constructed plastic tunnel or open shed and even net house are of bamboo framing or black iron square pipe with simple dome shape or inverted V-shaped roofing. Whereas, most of the subsidised protected agriculture structure were found naturally ventilated greenhouse. About 84% of farmers in the survey had received 50% to 75% subsidy of total one-time installation cost, from the Government. Only, less than 11% of farmers has constructed low cost bamboo or black iron trust plastic house with their own cost. Even for the low cost of plastic tunnel or screen house the farmers had found supports form the local government.

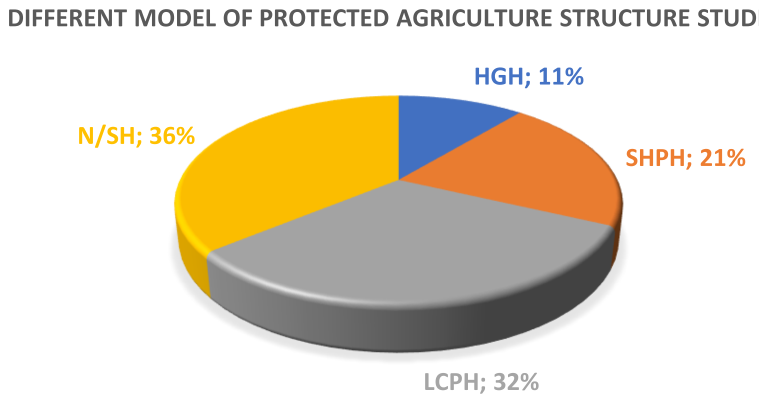

Figure 6. Different type of protected agriculture structure found in the field study

During the study, on the quarry to know the farmers perception on the adaptation of protected agriculture structure, it has been confirmed that the farmers are not willing to accepted this technology without receiving any kind of economic supports either form the government or other agencies. Although these farmers received subsidy for one-time construction, the structures had not found in proper working conditions (Fig. 7). The maintenance and management of highly invested structure are not done as per required. Only low-cost structures are under use, which has less repair and maintenance cost and seems to be benefited with such

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kind of protected agriculture technology.

Figure 7. Poor management and damaged protected structures constructed with high investment in addation to government subsidy

It has been observed that about 70% of highly invested structure constructed with receiving subsidy or with the funding of support organization were, found failure whereas, low cost structure constructed by farmers own investment were found almost (90%) successful. It has been noted that mostly, the structures' claddings are found damaged by wind and hailstones. It has also been complained by the users that even the structure had facilited with the components like shade net, cooling pad, foggers etc. for controlling the temperature and humidity inside the greenhouse/ plastic house, it has not found working perfectly. Also, the frame has not designed as per requirement of crop and local climatic condition. It has thus need to be modify the structure according to the need of farmers of different investing capacity favorable to the local climate.

Scope of Cultivation under Protected Agriculture Structure

Wide range of cultivation practices has been found practiced by protected agriculture structure user farmers (Fig. 8). Most of them, about 74% of farmers of total study site had found interested in cultivating vegetable such as Tomato, Mixed leafy green vegetable, Carrot, Potato, Coriander, Beans, Onion, Lettuce, Capsicum, Cucumber etc rather than fruits or citrus crop and some of they had established nursery in commercial scale (5% of total study site). Few farmers, only 21% among of study site had planted Lemon and Orange tree in the screen house and gaining satisfactory income.

Figure 8. Cultivation practices in protected agriculture structures

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As explained earlier, Nepal is not sufficiency in producing quality fruit and vegetables so there is lots of opportunity to create agri-business in horticulture sector. Adhikari and Pokhrel (2020) has mentioned that vegetable as a sub-sector prioritized as third most important sub-sector in agriculture of Nepal. Thapa and Dhimal (2017) has also mentioned that there is tremendous scope for the commercial horticultural crops production to enter into the international market. In this context protected agriculture structure could most necessary agriculture infrastructure for the growers to compete with the international agriculture entrepreneur and can fulfil the demand agriculture commodity in Nepalese and international markets. Also, the both the productivity and the quality of vegetable can be assured from the protected agriculture practices under the structure like naturally ventilated poly-house, screen house etc. rather than open field cultivation where the agriculture input resources can be utilized efficiently. Pattnaik and Mohanty (2021). On the other hand, many researchers had agreed that cultivation under protected agriculture structure is one and only one solution the cope with the alarming climate change effects (Mukherjee et al., 2016).

Development Strategies for Protected Agricultural Structures

As explained in the section 3.2 the repair and maintenance of hi-tech and semi hi-tech structure are the major reason for increasing un-utilization percentage of structure, which demotivating the farmers in investing for this technology advancement. Thus, to motivate the farmers some kind of training is required to them so that they could not be dependent on the technician from the manufacturing company. Also, the technical knowledge about the cropping system under the protected agriculture structure is required to manage proper cropping calendar and its management. Some initiation and approach have been made by the government to train young and the entrepreneur farmers to skilled them with the proper crop management practices (MOAD, 2015). The Prime Minister Agriculture Modernization Project (PMAMP), Nepal has regularly organizing several skill development training programs throughout the country. Likewise, Nepal Agricultural Research Council (NARC) annually organizing residential training as “A Farmers with Scientists” with the aim to orient young and entrepreneur framers to learn and practice with appropriate crop management practices. But because of low investing capacity of those farmers they are not capable to invest in establishing such expensive protected agriculture structures and hence unable to use their skill they gained from different agriculture training opportunities. For this, government has to develop practical working mechanism of agriculture infrastructure development loan on minimal interest rate so that such skilled farmers could invest such loan in establishing their agriculture enterprises, hire agriculture machine, tools and implements. This is the way forward, which definitely motivate the skill, trained young farmers to engage in agriculture and contribute the agriculture sector.

Conclusion

The study concluded that the poly-house technology is not in accordance of demand driven rather it has proven as supply driven. Thus, a suitable standards of protected agriculture structures need to be established base on the agroecological zone of Nepal. The structure in large scale is need to be promote with agriculture entrepreneur modality, to reduce the cost of establishment of protected agriculture structure, minimize cost of production and improve the utilization of input resources. The farmers cultivating under the protected agriculture structure should be skilled before using such poly-house technology, for the repair and maintenance of structures on damage and need to be trained with the crop management practices to be a successful agriculture entrepreneur. The government should have to develop one-time loan modality for the skilled and trained young farmers to establish such demanding useful poly-

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house technology as motivation skim to ensure the quality and productivity of agriculture commodity even in adverse climatic condition.

Acknowledgement

We thank to Government of Nepal: Nepal Agriculture Research Council for allocating the budget for conducting the field study. The farmers participating in completing the questionnaire during the field study are the special contributor of this finding which will guide Nepal Government in planning and developing the strategy for poly-house technology to enhance agriculture sector.

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ISSN 2721-1304 (Print), ISSN 2721-1207 (online)
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