‘GREENHOUSE CROP PRODUCTION IN LADAKH TO SUPPORT DEMAND OF FRUITS AND VEGETABLES FOR ARMED FORCES LOCALLY’

Dissertation submitted to the Panjab University, Chandigarh for the award of degree of **Executive Masters in Public Administration and Public Policy**, in partial fulfilment of the requirement for the Advanced Professional Programme in Public Administration (2023-24)

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NEW DELHI

CERTIFICATE

I have the pleasure to certify that Brigadier S T A Rizvi, VSM has pursued his research work and prepared the present dissertation titled 'Feasibility Of Greenhouse Crop Production In Ladakh to Support Requirements of Vegetables And Fruits of Armed Forces Locally' under my guidance and supervision. The dissertation is the result of his own research and to the best of my knowledge, no part of it has earlier comprised any monograph, dissertation or book. This is being submitted to the Indian Institute of Public Administration (IIPA), New Delhi for Executive Masters in Public Administration and Public Policy (EMPA & PP), in partial fulfilment of the requirement for the Advanced Professional Programme in Public Administration (APPPA) of the IIPA, New Delhi.

I recommend that the dissertation of Brigadier S T A Rizvi, VSM is worthy of consideration for the award of Executive Masters in Public Administration and Public Policy (EMPA & PP).

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ABSTRACT

Ladakh owing to its terrain and climatic conditions has traditionally not been self-sustaining in terms of production of fruits and vegetables. Extreme cold conditions during winter months, lack of oxygen and arid terrain has compounded the issue. Resultantly, locals suffer from various food deficiencies and attendant ailments and unique phenomenon like hidden hunger etc. The region has a massive deployment of armed forces which has increased recently owing to prevailing security concerns.

Ladakh's geography and climate are characterized by extremely high altitudes, low oxygen levels, and a cold desert environment. With an average altitude of over 3,000 meters (10,000 feet) above sea level, the region experiences prolonged winters, where temperatures can plummet to well below freezing point. Such harsh climatic conditions have posed a challenge to traditional agriculture, making it difficult to grow crops for a substantial part of the year. It has a short growing season, typically spanning from late May to early September, when temperatures are relatively mild. During this period, farmers have traditionally relied on the snowmelt from the surrounding mountains to irrigate their fields. However, as global climate change continues to affect precipitation patterns, the region has witnessed erratic and insufficient rainfall, further exacerbating the water scarcity issue.

For centuries, Ladakh's inhabitants have practiced a form of traditional agriculture known as "Zara" or "Zabo." This unique farming method involves cultivating barley, wheat, and some vegetables in small plots of arable land using a network of complex irrigation channels known as "kuls" to distribute water from the glacial melt waters. While Zara has been a testament to the resilience of Ladakhi farmers, it has limitations due to the short growing season and the dependence on unpredictable water sources. The traditional crops cultivated through Zara are primarily suited for the region's harsh climate. Barley, in particular, has been a staple crop, as it can withstand extreme cold and short growing periods. However, the limited variety of crops grown through traditional methods has resulted in food insecurity, as Ladakh remains heavily dependent on imports for many essential food items.

Recognizing the need for agricultural innovation and diversification, Ladakh has embarked on a journey to harness the potential of greenhouse crop production. Greenhouses, or "Polyhouses" as they are commonly known in the region, provide a controlled environment that

mitigates the adverse effects of Ladakh's extreme weather conditions. These structures are designed to trap heat and provide protection from frost, allowing farmers to extend the growing season and cultivate a wider range of crops. The adoption of greenhouses in Ladakh represents a significant departure from traditional farming practices. While there have been initial challenges related to knowledge transfer and technology acquisition, the introduction of greenhouse farming techniques has been met with enthusiasm and success. The shift towards greenhouse crop production has opened up new possibilities for Ladakh's agriculture sector, with the potential to address both food security and economic sustainability.

This study examines the feasibility of greenhouse production of fruits and vegetables (F &V) to locally support the demand of armed forces. For the purpose, questionnaires have been designed for various stakeholders namely armed forces, Agriculture Department of Ladakh, Defence Institute of High Altitude Research and local greenhouse farmers. The process of procurement of F & V by the armed forces, the present local contribution in the requirements of armed forces and suggested steps to augment local greenhouse production of fruits and vegetables to meet the requirements of armed forces have been analysed. The key recommendations include introduction of dedicated programmes to encourage proliferation of greenhouse farming amongst the farmers, armed forces should procurement of maximum possible fruits and vegetables locally by the armed forces, facilitation of farmers in marketing of greenhouse products and in formation of cooperative societies.

CHAPTER-1 : INTRODUCTION

1.1 BACKGROUND

Ladakh, an arid region characterized by its high-altitude desert landscape, has a rich history of agriculture shaped by the challenges posed by its harsh climatic conditions. Ladakh, situated in the northernmost part of India, faces extreme climatic conditions, including low temperatures, high altitudes, and short growing seasons. These challenges have historically limited the range of crops that can be cultivated and have shaped the adaptive strategies of local farmers. For centuries, Ladakhi farmers relied on traditional agricultural practices to cope with the limitations of their environment. Terraced farming on the slopes of the Himalayas, with a focus on hardy, cold-resistant crops, was the norm. However, the short growing season and unpredictable weather patterns posed significant constraints. The need for alternative methods to overcome the limitations of traditional farming practices led to the introduction of greenhouse technology in Ladakh. In the mid-20th century, the concept of controlled environment agriculture (CEA) gained attention, and initial experiments were conducted to adapt greenhouse structures to Ladakh's unique climatic conditions. Early attempts to implement greenhouses faced challenges such as insulation, temperature regulation, and energy sources. Innovations in greenhouse design, incorporating passive solar heating and thermal mass, were crucial in adapting these structures to the extreme cold of Ladakh.

With technological advancements, Ladakh has witnessed the emergence of climate-adapted greenhouses designed specifically for its high-altitude environment. These structures incorporated locally sourced materials and passive heating techniques, ensuring resilience in the face of sub-zero temperatures. To address the limited arable land and promote efficient water use, hydroponic and aeroponic systems were introduced. This marked a significant shift from soil-based cultivation, allowing for year-round production and improved nutrient management. The adoption of greenhouse technology in Ladakh has resulted in increased crop yields and expanded crop diversity. Farmers can now cultivate a wider range of vegetables, fruits, and flowers, contributing to food security and economic diversity.

Greenhouse technologies, particularly hydroponics, have played a role in efficient water management. Precise control over irrigation and nutrient delivery has minimized water wastage, addressing Ladakh's perpetual challenge of water scarcity. The introduction of greenhouse crop production has brought about a socio-economic transformation in Ladakh. Increased agricultural productivity has led to improved livelihoods, and the emergence of new employment opportunities in greenhouse management, marketing, and distribution.

The historical perspective of greenhouse crop production in Ladakh reflects a journey from traditional farming practices to the adoption of innovative technologies. Greenhouse cultivation has not only addressed the challenges posed by Ladakh's harsh environment but has also ushered in a new era of agricultural sustainability and socio-economic development. As Ladakh continues to navigate its agricultural future, the integration of traditional wisdom with modern innovations will play a pivotal role in shaping a resilient and prosperous agricultural landscape.

1.2 STATEMENT OF THE PROBLEM

The present system of supply chain management pertaining to fresh rations i.e. vegetables and fruits to cater for armed forces mostly rely on procurements from hinterland markets of Chandigarh, Srinagar, Jammu etc. Bulk of these are then transported by air upto Leh and onwards through arduous and long lines of road transportation. A portion of these supplies are directly transported by air. Owing to weather conditions and difficult terrain, both these modes of transport are susceptible to recurrent and long interruptions resulting in repeated breakdowns in supply chains. This situation compels reliance on tinned key food supplies is not preferred by the troops, besides it being expensive due to high transportation costs. Lastly and most importantly, the commercial dividends of these procurements are attributed to the farmers/ businessmen from outside Ladakh. This militates against the Government policy of promotion of local commerce. Though certain cooperative societies are in place in Ladakh but they have failed in promotion of the local growers. The local weather conditions and associated issues viz. irrigation facilities, soil conditions, availability of real estate, low productivity etc. offer limited scope of mass commercial production of fruits and vegetables (F & V) both in terms of variety and quantity. These are further restricted to only certain months (April to September) and not round the year. Thus, to promote local growers and farmers and enable them to undertake production of F & V on commercial scales to meet the requirements of armed forces locally, certain viable alternatives are imperatively required to be identified. Green House crop production is one such alternative. With the efforts of Defence Institute of High Altitude Research (DIHAR) and local administration, this initiative has been set up in the region which has been recognised though PM’s award of excellence in 2021. This study aims to examine the feasibility of Green House crop production to meet the requirements of F & V of armed forces deployed in Ladakh locally. A successful implementation of this initiative will not only ensure substantial savings to the state exchequer and uninterrupted supply chain but also boost the income levels of the local growers.

1.3 OBJECTIVES OF THE RESEARCH

These are as follows:-

(a) To study the existing fresh ration management system in Ladakh to cater to the needs of armed forces.

(b) To examine the feasibility of Green House crop production in Ladakh to meet the requirements of fruits and vegetables for armed forces deployed there locally.

1.4 RESEARCH STRATEGY AND DESIGN

A mixed research design is envisaged to be adopted in order to obtain a holistic analysis of the issue at hand viz. to examine the feasibility of greenhouse crop production in Ladakh to support requirements of armed forces locally. Details are as follows:-

(a) **Quantitative Approach**. Quantitative data have been collected to assess the feasibility and impact of greenhouse crop production in Ladakh by conducting surveys over a selected representative sample of local growers.

(b) **Qualitative Approach**. Qualitative data have been collected to capture the experiences, perspectives, and narratives of officials of Defence Institute of High Altitude Research and Brigadier ASC of 14 Corps who is entrusted with the responsibility of procurement of F & V in the region.

(c) **Data Analysis**. The quantitative data have been statistically analyzed, identifying common themes and patterns across the responses.

1.5 RATIONALE OR JUSTIFICATION

The rationale for conducting research on the Study 'Greenhouse Crop Production In Ladakh to Support Demand of Fruits and Vegetables for Armed Forces Locally' is derived from several factors and imperatives, as elucidated in succeeding paragraphs:-

(a) **Optimisation of Supply Chain for Armed Forces**. The present system of supply chain management pertaining to fresh rations i.e. fruits and vegetables to cater for armed forces mostly rely on procurements from hinterland markets of Chandigarh, Srinagar, Jammu etc. Bulk of these are then transported by road upto Leh and onwards through arduous and long lines of road transportation. A portion of these supplies (approximately 30%) are directly transported by air. Owing to weather conditions and difficult terrain, both these modes of transport are susceptible to recurrent and long interruptions, resulting in repeated breakdowns in supply chains. Local procurements of F & V may smoothen supplies to Armed Forces.

(b) **Cost Optimization**. The present supply chain involves large scale use of air transportation complemented with road transport through long and arduous road network. This increases the cost of procurements which is avoidable. By resorting to local procurements of F & V for the armed forces, considerable savings, both in terms of time and cost, can be made.

(c) **Boost to Local Economy**. The commercial profits on account of procurements of vegetables and fruits for the armed forces deployed in Ladakh flow mostly to the farmers/businessmen from hinterland. Though certain cooperative societies are in place in Ladakh, they do not seem to have augmented margins of the local growers. Adoption of Green House crop production on a mass, commercial scale is likely to facilitate local procurements by the armed forces for most of their consumption demand. This is envisaged to substantially boost the income levels of the concerned farmers and result in a fillip to the local economy.

(d) **Technology Infusion**. Defence Institute of High Altitude Research (DIHAR) has made some efforts in the sphere of Green House crop production and is based at Leh. Proliferation of technology devised by DIHAR and it's mass usage is expected to multiply the local production of fruits and vegetables manifold and facilitate meeting the requirements of armed forces locally.

(e) **Adoption of Best Practices**. Green House Crop production in Ladakh has been recognised by way of PM award of excellence in the category of innovation in 2021. Thus, it would be prudent to optimally leverage this initiative to the maximum towards commercial production of fruits and vegetables on a mass scale by encouraging local farmers.

1.6 RESEARCH QUESTIONS

Based upon above, research questions are as follows:-

(a) What is the present system of supplies of vegetables and fruits to support armed forces deployed in Ladakh?

(b) What is the present contribution of local resources in supplies of vegetables and fruits to armed forces deployed in Ladakh?

(c) What steps can be taken by the Government in boosting greenhouse crop production in Ladakh?

1.7 DATA SOURCES

For the purposes of research, primary data collected in form replies to questionnaires circulated to various stakeholders i.e existing greenhouse farmers, army authorities dealing with rations management in Ladakh, Chief Agriculture Officer of Ladakh and General Manager of Defence Institute of High Altitude Research (DIHAR) have been utilised. Sampling frame of greenhouse farming is approximately 500. 10 percent sample i.e 50 such farmers have been selected for collection of primary data.

1.8 RESEARCH METHODS AND DATA SOURCES

The methods applied in this research is a combination of exploratory, analytical and comparative. The study has been based on unclassified documents and official statements of all stakeholders. Sample surveys of relevant stakeholders in form of specific questionnaires has been obtained and analysed through relevant statistical tools. Academic literature including articles, journals and previous research work on the subject available with the IIPA library including those by individual researchers and various research agencies have been utilised as secondary data. Information from government policy documents, Reports of Krishi Vigyan Kendras (KVKs), ASSOCHAM and available information on the subject on the internet have been exploited.

1.9 CHAPTERISATION SCHEME

Chapterisation scheme is as under :-

(a) **Chapter 1 : Introduction**. This chapter delves on the background and context of the research bringing out the present supply chain for meeting the requirements of vegetables and fruits of the armed forces deployed in Ladakh, its shortcomings and vulnerabilities.

(b) **Chapter 2 : Review of Literature**. Review of literature focusses on Green House crop production in Ladakh, recent initiatives by DIHAR in this direction and details of citation leading to PM award for innovation to Ladakh in 2021 for encouraging Green House crop production.

(c) **Chapter 3 : Greenhouse Technology For Agriculture In Ladakh**. This chapter dwells on the various technologies of greenhouses adopted in Ladakh describing in detail various types of greenhouses and recent initiatives in this regard.

(d) **Chapter 4 : Logistics To Armed Forces Deployed In Ladakh And Importance Of Greenhouses**. This chapter describes in detail the present system of procurement of fruits and vegetables by the armed forces for the troops deployed in Ladakh and bring out the problems/voids alongwith the advantages of local procurement of these products.

(e) **Chapter 5: Findings And Analysis**. This chapter comprises of the findings/ results of the research with specific details related to development of a comprehensive framework, strategies for encouraging Green House crop production in Ladakh including recommended Government initiatives, assistance from DIHAR in terms of technology transfer, role of cooperative societies and recommended procurement procedure by the armed forces.

(f) **Chapter 6: Conclusion**. This chapter contains the summary of key findings and recommendations, implications of the research for policy and reforms as also highlight the essence of the need to undertake this research and why it was ‘worth the doing’. Scope for future research/study will also be listed out in the Chapter related to the subject.

CHAPTER-2 : REVIEW OF LITERATURE

2.1 INTRODUCTION

Relevant literature on the subject have been identified and reviewed. This chapter delves into an extensive literature review conducted for the dissertation. This review aims to provide a thorough understanding of the existing body of knowledge surrounding the research topic. Through a considered examination of academic journals, books, and other relevant sources, the literature review synthesizes the key findings, theoretical underpinnings and methodological approaches employed in previous studies. This in-depth exploration of the literature serves to establish the context for the present research, identify gaps in knowledge, and pave the way for a meaningful contribution to the area of research.

2.2 DETAILS OF STUDIES/REPORTS/JOURNALS

The following literatures in terms of books, articles and research papers have been reviewed:-

(a) **Aseeya Wahid et al (2022)**[1] in their thesis observes that the Ladakh region has a variety of agricultural practices adapted to the climate, such as greenhouses and poly houses, which greatly facilitate vegetable cultivation throughout the year. The study carried out in districts Kargil and Leh comes out with status of different such protected cultivation through survey of farm families from a selected village in Kargil and Leh with different land holding sizes. The study through a detailed survey observes that the cultivation of vegetables like sweet pepper, cucumber, brinjal, and chilies in summer under polyhouses is picking up. The production of vegetables had considerably increased inside the polyhouses compared to the outside cultivation. It delves into methods of protected cultivation adopted in the region and brings out the significance of greenhouse technology for sustainable development in the hilly region. The technology is helping people have green vegetables in the off-season, which was impossible without the help of government and non-government departments; also stating that it should be possible for poor farmers to adopt these technologies with financial assistance, such as low-interest loans. Research methodology adopted is quantitative exploratory. Research gap: Feasibility of supply of vegetables and fruits produced through greenhouse cultivation to augment the supply to armed forces locally has not been discussed.

[1] Wahid, A., Ali, A., Dixit, J., & Shukla, R. M. (2022). Prospect of protected cultivation under cold arid region of Ladakh, India: Status and future prospect. Published.

(b) **Gyan P MIshra et Al (2010)**[2] in their thesis state that The Defence Institute of High Altitude Research (DIHAR), one of the DRDO laboratories, is providing adequate support and technological help to set various types of green houses, both for the Army Units deployed in the far-flung areas and for the local farmers in the Ladakh. As per their thesis, the basic recommended quantity of vegetables for Indian soldier per head per day is 140 gm potato, 60 gm onion, and 170 gm fresh vegetables. To maintain the regular supply of fresh vegetables to our troops at our frontiers like Siachen, Kargil, Battalic, Drass in Ladakh sector of Jammu & Kashmir and along China/Tibet border is not an easy task since the region remains landlocked for over seven months in a year due to heavy snowfall which closes the road passes from November to May every year. Air-lifting of the fresh vegetables results involves heavy expenditure, which will not be affordable by the people. DIHAR has established about 65 greenhouses in various army units for production of fruits and vegetables. Army requires huge quantity of fresh vegetables to feed their troops deployed in this region and spends a substantial amount to import the vegetables from other parts of the country. Including army and floating population, vegetables are required for a population of about 3.0 lakh in the region. If it is calculated based on the ration scale provided to the Army, then total of 37,200 metric ton/year vegetables are required. Out of this quantity approximately 17,705 metric ton/year vegetables are produced locally and remaining quantity is either imported from other places of the country or the people replace it by other food ingredient in absence of availability of vegetable. The thesis further discusses various technologies used in different greenhouses and efforts made by DIHAR in establishment of about 65 greenhouses. Research gap : : Feasibility of supply of vegetables and fruits produced through greenhouse cultivation to augment the supply to armed forces [i]through an established supply chain locally has not been discussed.

(c) **Aqleema Banoo et Al (2022)**[3] in their thesis observe that implementation of protected cultivation offer huge scope and it supports small-scale farmers of cold arid region of Ladakh. The study delves into practices of protective cultivation adopted as a cropping technique wherein the micro climate surrounding the plant is controlled, as per the requirement of the plant species grown, during their period of growth and has an ability to produce variety of fresh vegetables even in harsh winter. It studies different

[2] Protected Cultivation for Food and Nutritional Security at Ladakh Gyan P. Mishra*, Narendra Singh, Hitesh Kumar, and Shashi Bala Singh

[3] Banoo, A., Hussain, S., Khan, F. S., Rasool, S., Dar, R. D., & Rasool, R. S. (2022). A review on economic aspect of protected cultivation in Ladakh. Published.

protected cultivation techniques and among these, greenhouse/polyhouses are extremely useful for round-the-year vegetable cultivation in the Ladakh region. It observes that though implementation of these protected cultivation technologies has the potential to improve the livelihood security of the farmers, there is lack of awareness amongst them which is limiting adoption of these technologies. The study exhorts that the farmers should think of adopting polyhouses instead of working in the open fields. Research methodology adopted is qualitative descriptive. Research gap: Feasibility of supply of vegetables and fruits produced through greenhouse cultivation to augment the supply ro armed forces locally has not been discussed.

(d) **M S Kanwar et al (2013)[4]** Ladakh region is a high altitude cold arid desert with special agro-climatic features. The region is one of the driest and coldest inhabited places on the earth. Due to harsh climatic features, short growing season is unable to offer sufficient food particularly vegetables. To supplement, fresh vegetables have to be imported by truck in summer or flown in by air during winter. The unavailability and high cost means that local people rarely eat fresh vegetables during the winter spell of the year, but instead rely on dried leafy vegetables and only stored root crops and cabbages. Specialized agricultural practices need to be developed and demonstrated for food and nutritional security of the inhabitants of the region. Protected cultivation is a well-defined sustainable technology for off season food production and thereby an important component in attaining nutritional security. It offers scope for the cultivation of plants under adverse conditions. Various naturally ventilated zero energy polyhouses have been tried and tested for the region. Despite the sub-zero temperatures, the cloudless skies in Ladakh guaranty over 300 sunny days per year which is the highest in the world. Therefore, there is plenty of sunshine for crops to grow even in winter, provided that they can be prevented from freezing. Various agencies are engaged in the research and development of protected cultivation of vegetables particularly during freezing winters to augment fresh food supply to the inhabitants. The present circumstances and priorities in the region need to be expanded for furthering the technologies to achieve self-sufficiency. Evaluation of farm friendly cultivation technology for the production of high value vegetable crops during summer and sustaining the vegetable production system in the region during the freezing winters can be well achieved by protected cultivation technology. Research gap: Feasibility of supply of vegetables and fruits produced through greenhouse cultivation to augment the supply to Armed Forces locally has not been discussed.

[4] Protected Vegetable Cultivation Technology for Cold Arid Agro-ecosystem of Ladakh , M.S. Kanwar_, M. Saleem Mir_, Anwar Hussain_

(e) **Sindhu V and Ranjit Chatterjee (2020)**[5] in their study discuss the different aspects of off-season vegetable cultivation to make the production system economically viable and remunerative. The authors examine the use of different protected structures for off-season vegetable production. This include growing of summer vegetables in winter months, growing winter vegetables in summer months and winter vegetables in rainy seasons. It also discusses various challenges faced by the farmers in off-season vegetable production under protected structures also citing the lack of awareness among farmers about the possibilities of protected vegetable production which is impeding cultivation on a large scale. Research methodology adopted is mixed approach. Research gap: Feasibility of supply of vegetables and fruits produced through greenhouse cultivation to augment the supply to armed forces locally has not been discussed.

(f) **M S Raghuvanshi et al (2019)**[6] in their paper discuss that Ladakh which has a short agricultural season of 6-7 months in the lap of Himalayas. It's production was high and enough to feed the entire population with traditional techniques to suit the local climatic conditions along with strong social structure to support the agricultural system. Today it faces many climatic challenges in more ways than one such as receding glacial snow, unusual rainfall, floods, changing weather patterns resulting infiltration of new pests and consequently and significantly changed the lifestyle of high altitude cold arid Ladakh. But an approach to resource utilization is patterned in present scenario diminishing the traditional identity with increasingly changing infrastructures due to climate change. Greenhouses with climate controlled devices are very few in the country. On the other hand, Ladakh, being cold, arid, high altitude region of India has a very harsh climate and a short agriculture season. Attempts are being made to popularize solar greenhouses with polyethylene covers in Leh. In early sixties, DIHAR (previously Field Research Laboratory) of DRDO at Leh attempted solar greenhouse vegetable production research and made an outstanding contribution to the extent that at present every household possesses a polyhouse these days in Leh valley. Greenhouse cultivation has been evolved with the objective to create favourable microclimates, which favours the vegetable production. During survey, it was recorded that during harsh winter and declining landholdings, there is an urgent need to encourage farmers by providing timely subsidy for taking up protected agriculture technology in a big way, demand greater attention towards protected agriculture. In addition to this, micro irrigation system has been found best for

[5] Sindhu, V., & Chatterjee, R. (2020). Off-Season vegetable cultivation under protected structures : a promising technology for doubling farmer's income. *Int. Arch. App. Sci. Techno*, *11*, 208-214. Published.

[6] Ladakh Traditional Farming: An Approach to Resource Utilization under Changing Climate M.S. Raghuvanshi, Ngawang Dorjay2 , R.K. Singh , B.L. Manjunatha.

watering plants in a greenhouse. Research gap: Feasibility of supply of vegetables and fruits produced through greenhouse cultivation to augment the supply to armed forces locally has not been discussed.

(g) **Angmo et al (2019)**[7] in their paper brings out that almost every household in Ladakh owns a greenhouse and these need to have improvises designs in order to make it economically viable and technologically feasible to cultivate different crops particularly during winter periods. Various types of passive solar greenhouses are their components are discussed in detail including pros and cons of each of these structures. The study covers varying temperature, humidity conditions, light intensity etc inside the greenhouses and the marketable yield and production of vegetables under such varying parameters. A door-to-door survey by the authors found that the passive solar greenhouses are used by farmers in winter and spring seasons but they remain unused in summer months. They observe existence of a vast scope to improve designs of greenhouse so that the constraints to grow crops can be overcome. Research methodology adopted is mixed approach. Research gap: Feasibility of supply of vegetables and fruits produced through greenhouse cultivation to augment the supply to Armed Forces locally has not been discussed.

(h) **Negi et al (2013)**[8] in their study convincingly argue protected cultivation as the only appropriate technology to cultivate vegetables in high-altitude regions like trans Himalayan regions. The study is carried out in high altitude Garhwal Himalaya region. In the study experiments are undertaken on efficiency of protected cultivation for brinjal, beans, cabbage, capsicum, cauliflower, coriander, peas and tomato, further comparing the yield to farmers under different conditions at high and low altitude regions. The study also demonstrates how capacity building of cultivators in off-season and protected vegetable cultivation would provide a sustainable livelihood alternative for locals in the region. Research methodology adopted is qualitative exploratory. Research gap: Feasibility of supply of vegetables and fruits produced through greenhouse cultivation to augment the supply to armed forces locally has not been discussed.

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[7] Angmo, P., Dolma, T., Namgail, D., Tamchos, T., Norbu, T., Chaurasia, O. P., & Stobdan, T. (2019). Passive solar greenhouse for round the year vegetable cultivation in trans-Himalayan Ladakh region, India. *Def Life Sci J*, *4*(2), 103-16. Published.

[8] Negi, V. S., Maikhuri, R. K., Rawat, L. S., & Parshwan, D. (2013). Protected cultivation as an option of livelihood in mountain region of central Himalaya, India. *International Journal of Sustainable Development & World Ecology*, *20*(5), 416-425. Published.

(i) **Ummyiah et al (2017)**[9] in their paper discuss the great potential of protected cultivation techniques of vegetables in offering quality, productivity and favourable prices in the market for cultivators thus increasing their income in off-seasons. In the study, the authors observes various pros and cons of greenhouse, however, the lack of awareness about the greenhouse technology and illiteracy are cited as major impediments for the technology not getting the necessary adoption. The study provides certain suggestions to overcome these shortcomings, how to push for technology adoption in the region and harvest its full potential. The study recommends considerations in site selection for greenhouse cultivation further highlighting how crop productivity is influenced by different components of crop micro-climate around it. The study brings out significance of raising healthy nursery for successful growing of crops and healthy harvesting of greenhouses' full potential with specific reference to common vegetables namely tomato, sweet pepper and cucumber. Research methodology adopted is mixed approach. Research gap: Feasibility of supply of vegetables and fruits produced through greenhouse cultivation to augment the supply ro armed forces locally has not been discussed.

(j) **Dame Jiliane (2018)**[10] in his article brings out the prospect of vegetable production in cold arid region of Ladakh. It outlines achievements in the vegetable production scenario in the region wherein it has progressed from need driven to market driven as against what was prevailing before 1990s and where the Defence Institute of High Altitude Research (DIHAR), Leh has played a very significant role in terms of technology perfection in cultivation, quality and standardisation of seeds/vegetables. The paper suggests measures for making the region self-reliant in agriculture with feasible strategies that could be adopted to improve financial capacities of people in the region. Greenhouse technology adoption and enhancing winter vegetable production in this cold region is one such measure cited in the paper. Research methodology adopted is qualitative and exploratory. Research gap: Feasibility of supply of vegetables and fruits produced through greenhouse cultivation to augment the supply to armed forces locally has not been discussed.

[9] Ummyiah, H. M., Wani, K. P., Khan, S. H., & Magray, M. M. (2017). Protected cultivation of vegetable crops under temperate conditions. *Journal of Pharmacognosy and Photochemistry*, *6*(5), 1629-1634. Published.

[10] Dame, J. (2018). Food security and translocal livelihoods in high mountains: Evidence from Ladakh, India. Mountain Research and Development, 38(4), 310-322. Published.

2.3 **CONCLUSION**

Review of literature from the above sources clearly brings out that research gap exists regarding Feasibility of supply of vegetables and fruits produced through greenhouse cultivation to augment the supply to armed forces locally has not been discussed. Therefore, the study is duly justified to examine these important issues.

CHAPTER-3 : GREENHOUSE TECHNOLOGY FOR AGRICULTURE IN LADAKH

3.1 Ladakh, often referred to as the "Roof of the World," is a region of incredible natural beauty and stark contrasts. Nestled high in the Himalayas, this cold desert region in Northern India boasts breathtaking landscapes, including towering peaks, serene lakes, and vast expanses of arid terrain. However, the challenging climatic conditions in Ladakh have long posed formidable obstacles to agriculture, making it difficult for the local population to sustain themselves through traditional farming practices. In recent years, the adoption of greenhouse crop production has emerged as a game-changer, offering a ray of hope for Ladakh's agricultural future and enabling the cultivation of a wide range of crops throughout the year.

3.2 LADAKH'S UNIQUE CLIMATIC CHALLENGES

Ladakh's geography and climate are truly distinctive, characterized by extremely high altitudes, low oxygen levels, and a cold desert environment. With an average altitude of over 3,000 meters (10,000 feet) above sea level, the region experiences prolonged winters, where temperatures can plummet to well below freezing. These harsh climatic conditions have posed a significant barrier to traditional agriculture, making it challenging to grow crops for a substantial part of the year. Ladakh has a short growing season, typically spanning from late May to early September, when temperatures are relatively mild. During this period, farmers have traditionally relied on the snowmelt from the surrounding mountains to irrigate their fields. However, as global climate change continues to affect precipitation patterns, the region has witnessed erratic and insufficient rainfall, further exacerbating the water scarcity issue.

3.3 TRADITIONAL AGRICULTURE IN LADAKH

For centuries, Ladakh's inhabitants have practiced a form of traditional agriculture known as "Zara" or "Zabo." This unique farming method involves cultivating barley, wheat, and some vegetables in small plots of arable land using a network of complex irrigation channels known as "kuls" to distribute water from the glacial melt waters. While Zara has been a testament to the resilience of Ladakhi farmers, it has limitations due to the short growing season and the dependence on unpredictable water sources. The traditional crops cultivated through Zara are primarily suited for the region's harsh climate. Barley, in particular, has been a staple crop, as it can withstand extreme cold and short growing periods. However, the limited variety of crops grown through traditional methods has resulted in food insecurity, as Ladakh remains heavily dependent on imports for many essential food items.

3.4 THE RISE OF GREENHOUSE CROP PRODUCTION

Recognizing the need for agricultural innovation and diversification, Ladakh has embarked on a journey to harness the potential of greenhouse crop production. Greenhouses, or "polyhouses" as they are commonly known in the region, provide a controlled environment that mitigates the adverse effects of Ladakh's extreme weather conditions. These structures are designed to trap heat and provide protection from frost, allowing farmers to extend the growing season and cultivate a wider range of crops. The adoption of greenhouses in Ladakh represents a significant departure from traditional farming practices. While there were initial challenges related to knowledge transfer and technology acquisition, the introduction of greenhouse farming techniques has been met with enthusiasm and success. The shift towards greenhouse crop production has opened up new possibilities for Ladakh's agriculture sector, with the potential to address both food security and economic sustainability.

3.5 CHALLENGES FOR AGRICULTURE IN LADAKH

The land based economy of Ladakh is in a beleaguered state today. There are more and more employment opportunity open to the locals in the form of the army, tourism, and varied jobs. With this, their need to depend on the land based economy is diminishing. However, due to several factors, this euphoria is proving to be a short-lived. The current economic boom that Ladakh is experiencing cannot be considered sustainable. As a result, most Ladakhis nowadays sport an attitude of disregard towards the land-based economy which could cost them dearly. There is an immediate attention required to lift the land-based economy out of the muddle it finds itself and make the region more self-reliant than it used to be.

Ladakh currently faces massive challenges related to agriculture. These involve increasing affluent population, shrinking agricultural land, rural-urban migration, shrinking agro-biodiversity, increased dependency on imported food, scarcity during winter, seasonal availability of fruits and vegetables, hidden hunger, post-harvest losses, poor market access, threatened traditional farming cultures and climate change. These multitude challenges are not only multidimensional but also require coordinated and targeted approach that can contribute to attain sustainable development in agriculture. They are discussed as follows :-

(a) **Increasing Affluence**. Majority of people in Ladakh live in rural areas. However, the region is going through a rapid population growth and also a decline in per capita farm sizes. The population of Ladakh has increased from 1,05,292 in 1971 to 2,74,289 in 2011.

In that the rise in urban population has gone up from 7.5 percent in 1971 to 22.6 percent in 2011. Moreover, the lifestyles in villages are also undergoing a fundamental change from rural roots to urban civilization. In addition, to the sizeable strength of army in the region, it's floating population is increasing swiftly. There has been significant increase in the number of tourists visiting Ladakh between 1991 and 2022. Therefore, the ability of small and marginal farmers to feed themselves and their families has been impacted by the effect of population growth on agriculture. To meet the growing requirements of farm produce for the local populace and the floating population in this delicate mountainous area is a formidable challenge.

(b) **Rural-Urban Migration**. Rural-urban migration is a global phenomenon. With no helping hands in old age this aspect is taking painful proportions in the region. Small agricultural lands are often neglected due to migration also largely affecting the rural lifestyle and thus the unique culture of Ladakh. The rural population in Ladakh which was 92.5 percent in 1971, has come down to 77.4 percent in 2011. This trend needs to be discontinued from the way it is progressing. Subsistence farming is not providing the necessary conditions and opportunities sought by young people. Agriculture needs to become economically feasible as well as socially attractive. Other reason for giving up farming and urban migration is the shrinking and fragmented agricultural land holdings in rural area. Also education, improved social services, and job opportunities in urban area is an attraction. The growing trend of agricultural land abandonment has become a grave threat to farming systems for the region.

(c) **Shrinking Agricultural Land**. There is an increase in agricultural land at the aggregate level; however, that land availability to do farming by individual households has declined in a considerable manner. The major decline in land holding is ascribed to land fragmentation due to increased population as also to new trend of nuclear families by way of the breaking up of joint family systems. Ladakh has witnessed a increase in population by about 2.6 times between 1971 and 2011. This has resulted in small and marginal holdings of less than 2 hectares of agricultural land account coming down to 79.8 percent in Leh district and 94.7 percent in Kargil district. Small land holdings is thus becoming non-viable for farming and livelihood. Farmers do not have adequate agricultural land to grow substantial crops to meet the requirement of food and income for their family in order to have a sustainable living.

(d) **Seasonal Availability Of Vegetables And Fruits**. The crop growing season is restricted due to climatic condition of the region in Ladakh. It is from May to September in open-field conditions. Vegetables are harvested from June to September. Crops such as potatoes, onions, cabbage, etc.are produced from later part of August to September. Fruits yields are between July to October. The region sees excess of fruits and vegetables during the period, in contrast to an acute scarcity of fresh produce in winter (Stobdan et al.,2018). During winter, passive solar greenhouse cultivation is the only source of locally produced fresh leafy vegetables. Crops such as potatoes, radishes, carrots, cabbage, onion, and turnip are stored in underground pits and root cellars for their consumption in winter months (Ali et al., 2012).

(e) **Food Dependency**. Ladakh is becoming excessively dependent on the outside world for essential needs. It has become a net food importer of cereals, fruits, vegetables, pulses and cooking oil. Leh's dependency on vegetable import is approximately 67 % and on fruits is around 85%. Self-sufficiency of food is a key issue for the region. Filling the demand and supply gap in respect of fresh farm produce is difficult. Limited quantity of fresh vegetables is brought in during the winters from Chandigarh or Delhi by air. As much as Rs 110 per kg is shelved for air freight. Fresh vegetables are hence 2.7 times costlier in Ladakh compared to big city of Delhi (Angmo et al, 2019). Meeting the increasing demand for fresh farm produce at a reasonable price in the region is a formidable challenge.

(f) **Hidden Hunger**. Survey results conducted in 2008 of 200 households on the assessment of the extent of malnutrition and related health problems have established that only 19.4% of the people of the Ladakh are well nourished. The study also brings out that 35% of people suffer from malnutrition-related diseases. Anemia, nigh blindness, scurcy, beri beri, and rickets are the most common diseases. A high prevalence of deficiency diseases is attributed to the low consumption of fruits, vegetables, milk and milk products (Dar and Rather, 2014). A significantly high percentage (36.6%) of lactating women in the region are malnourished as against 19.3% in Jammu and 10% in Kashmir. Similarly, 45.5% of Ladakhi women had lower calorific intakes as against 41.3% of women in Jammu and 12.7% of Kashmiri women. A significant number of the women (36.6%) showed clinical signs of nutritional deficiency in Ladakh (Khan and Khan, 2012). Therefore, there is an imperativeness to grow more nutritious food locally and make it accessible and affordable.

(g) **Rising Cases Of Cancer**. The region has an increasing trend of cancers and cancer related deaths. A hospital-based study in Kargil district for 10-year period from 2009-2019 found 31.5 cases per lakh population per year. The incidences of cancer are higher in males (69.4%) than in females (30.6%). The pattern of this disease in the region is unlike from rest of India, which could be because of the topography, unique food habits, peculiar culture and lifestyles. Stomach cancer is the most commonly seen in as high as 42.1% of patients. This is followed by lung, lever, esophagus cancers etc. The patients are mostly of 60-74 age group (47.3%), followed by 45-59 (26.1%), 75-89 (14.2%) and 30-44 years (5.4%) (Hussain et al, 2019). Many studies have shown connection between a higher intake of certain type of food and cancer risk. Main association has been seen between fruits consumption and cancer occurrences in Ladakh. Cancer is highest (58.8%) in patients taking less than one fruit serving per week, 24.6% in those taking one to four fruit servings per week and only 16.7% in those taking more than four per week (Hussain et al., 2019). Therefore, identifying the causes of the increasing number of cancer cases and growing food that could be associated with a lower risk of the disease is a major challenge.

(h) **Poor Market Access**. The farmers in Ladakh are faced by certain biggest problems causing direct bearing on their prosperity. These are inadequate marketing skills and lack of wider market access. Most fruits and vegetable crops reach the harvesting stage in August and September. The perishability of fresh fruits and vegetables makes farmers worried of possible losses, which may occur during marketing. This turn them away from venturing into horticulture crops. Inadequacies in storage also result in limited crop production.

(i) **Shrinking Agro-Biodiversity**. The agricultural biodiversity is richly embedded in traditional agricultural systems. So, people in Ladakh traditionally depend entirely on wild harvest collection for their requirements of vegetables. But, extensive trends towards change in food habits and increased shift towards cash crops has led to shrinkage in agro-biodiversity. Farmers with a market oriented farming system cultivate fewer crops and allocate less area to mixed crops than traditional farming. Many conventional farming lands have been rendered permanently fallow and unplanted.

(j) **Limited Availability Of Organic Manure**. Ladakh is a cold desert with meagre area of just 141 km^2 under forest cover. This fact makes availability of organic matter for farming a key challenge. There is also a decreasing trend in number of livestock populations in the region.

(k) **Accessibility During Winter**. The Ladakh region remains cut-off for over five months a year due to heavy snowfall. It has hugely suffered from inaccessibility during winter months, which restricts the period for the supply of critical inputs.

(l) **Post-Harvest Losses**. Approximately 40-60 % of the apricot produced in the region is wasted due to lack of cold-chain infrastructure for storing fresh fruit, hygienic processing and developing value-added products (Stobdan et al., 2020). The region sees a profusion of fruits and vegetables from August to September, which results in post-harvest losses. There is a need for an integrated value chain system which is market-oriented and sustainable.

(m) **Risk Management And Resilience**. Farmers in the region are exposed to risks from various quarters. Seasonal variability is one of them, due to which certain years may not be favourable to fetch a good harvest. The weather affects the yield and quality of the produce. Insect pests and diseases can devastate crops. In general, the incidence of insect pests and diseases in the cold arid region is low. Euproctis similis is not a regular insect pest of the fruit crop in Ladakh, however, it emerged as a main pest of apricot during 2013-16 in the region's major apricot growing belts, inflicting a substantial economic loss on the growers (Stobden et al, 2019). Cereals in the region are affected by the major disease of loose smut and vegetables gets affected by significant insect pests like cutworm, onion maggot, aphid and cabbage butterfly.

(m) **Threatened Traditional Farming Culture**. Agricultural land has a major influence on social and cultural relevance in the region, in addition to economic and environmental factors. Ladakh farming system has evolved from nutritional needs and ecological adaptation. In that agriculture and horticulture have shaped Ladakh's unique natural landscape. The trend of cash crops and monoculture began decades ago in and around Kargil town, however, it is yet to extend to distant villages of Ladakh. The traditional close ties between agriculture and cultural development are still seen and felt in the region. The traditional farming culture is, however, declining slowly. It may face a grave threat of extinction if appropriate and immediate actions are not taken.

(n) **Climate Change**. Climate change is a global phenomenon and Ladakh is no exception. The region is now feeling the impact of increasing temperatures. Studies suggest that the maximum temperature for peak summer months showed a rise of nearly 0.5^{o}C between 1973 and 2008, and the minimum temperature by almost 1^{o}C for all winter

months (Angmo and Helniger, 2009). A study was conducted by Tsering Stobdan in 2016 through a structured questionnaire and interview of farmers in order to gauge people's perception of climate change in Ladakh. In startling finding, all respondents stated that they had witnessed climate change in Ladakh, while 74% of them felt that the extent of climate change was extreme. Factors perceived as main indicators of climate change in the region are decrease in snowfall, receding glaciers, change in rainfall pattern and increase in temperature. Over 60% of the respondents believed climate change severely affected their lives. Urbanisation and an increasing number of motor vehicles are perceived as the main cause of climate change in Ladakh.

3.6 GREENHOUSE TECHNOLOGY IN LADAKH

Greenhouse technology has played a significant role to revolutionize agriculture in Ladakh, a region known for its harsh winters and short growing seasons. By extending the cultivation period, greenhouse farming has enabled Ladakhi farmers to grow a wider variety of crops, increase their yields, and enhance their livelihoods. Number of greenhouse technologies have been adapted and developed to suit the unique climatic conditions of Ladakh. These include:-

(a) **Passive Solar Greenhouse**. This is the most common type of greenhouse in Ladakh, utilizing natural sunlight to heat the interior. The south-facing transparent walls allow sunlight to enter, while the thick mud walls and earthen floor provide insulation and retain heat.

Fig 3.1 Passive Solar Greenhouse

(b) **Trench Greenhouse**. This type of greenhouse is partially sunk into the ground, taking advantage of the earth's natural insulation. The sunken design helps maintain a stable temperature inside the greenhouse, even during extreme weather conditions. The average service period of a greenhouse is 10 years. The walls, wooden frame and wooden roof need major repair in intervals to keep the greenhouse functional. Majority of the farmers (over 91%) do not use greenhouse during summer months. Due to removal of polyethylene sheet during summer, there is no additional benefit from the structure as compared to open field conditions.

Fig. 3. 2 A trench greenhouse in Leh

(c) **Polytrench Greenhouse**. This is a hybrid of the passive solar and trench greenhouses, combining the benefits of both designs. The polytrench greenhouse features a transparent polythene cover over the trench structure, enhancing heat retention and sunlight penetration.

Fig. 3. 3 A trench greenhouse in Leh

(d) **Polycarbonate Greenhouse**. These greenhouses utilize polycarbonate sheets as the covering material, providing excellent insulation and durability. Polycarbonate greenhouses are often equipped with ventilation systems to regulate temperature and humidity.

(e) **FRP Greenhouse**. Fiber-reinforced plastic (FRP) is another popular material for greenhouse construction in Ladakh. FRP greenhouses offer high strength, light weight, and resistance to extreme weather conditions.

Fig 3.4 FRP Greenhouse

(f) **Polynet Greenhouse**. Polynet greenhouses are constructed using a lightweight netting material, providing a semi-enclosed environment for crops. Polynet greenhouses are particularly suitable for shade-loving crops and allow for natural air circulation.

Fig 3.5 Polynet Greenhouse

3.7 ADVANTAGES OF GREENHOUSE FARMING IN LADAKH

Greenhouse farming offers numerous advantages for agriculture in Ladakh's cold arid regions as enumerated below:-

(a) **Extended Cultivation Period**. Greenhouses extend the growing season beyond the short outdoor growing period, allowing farmers to cultivate crops throughout the year.

(b) **Crop Diversification**. Greenhouses enable farmers to grow a wider variety of crops, including vegetables, fruits, and flowers, which were previously not possible due to the harsh climate.

(c) **Increased Yields**. Greenhouses provide a controlled environment, protecting crops from pests, diseases, and extreme weather conditions, leading to higher yields and improved quality.

(d) **Water Conservation.** Greenhouses minimize water evaporation and allow for efficient water usage through drip irrigation systems.

(e) **Year-Round Income**. Greenhouse farming provides farmers with a consistent source of income throughout the year, improving their economic stability.

(f) **Food Security**. Increased local production of vegetables and fruits enhances food security in Ladakh, reducing reliance on imported food items.

(g) **Employment Generation**. Greenhouse farming creates employment opportunities in rural areas, contributing to the overall economic development of Ladakh.

(h) **Reduced Environmental Impact**. Greenhouse farming reduces the need for chemical pesticides and fertilizers, promoting sustainable agricultural practices.

CHAPTER 4 : LOGISTICS TO ARMED FORCES DEPLOYED IN LADAKH AND IMPORTANCE OF GREENHOUSES

4.1 Ladakh holds immense strategic significance for India due to its geographical location and geopolitical considerations. It shares international borders with China and Pakistan. The Line of Actual Control (LAC) with China and the Line of Control (LoC) with Pakistan are crucial areas for India's defence. Recent border tensions with China in the Galwan Valley and other areas have underscored the importance of Ladakh in securing India's northern frontier. Ladakh serves as a buffer zone, providing strategic depth to the Indian mainland. Control over Ladakh ensures that any potential threat is detected and addressed before it reaches the heart of the country. It provides a gateway for India to connect with Central Asian countries. The region's geographical location makes it a potential hub for trade and energy corridors, enhancing India's strategic and economic interests in the Central Asian region.

4.2 Owing to it’s geopolitical and strategic importance, Ladakh has constantly been targeted by both our adversaries viz, China and Pakistan since our independence. Thus, to maintain the territorial integrity of our country, strong presence of armed forces in the region has become inescapable. To counter any attempts of misadventure by the adversaries, India has ensured strong presence of armed forces in the region comprising of approximately 60000 troops.

4.3 The deployment of the Indian Armed Forces in Ladakh is a critical aspect of India's national security strategy, particularly in the context of ongoing border tensions and geopolitical considerations. The deployment involves a combination of the Indian Army, Indian Air Force, and other paramilitary forces. Ladakh witnesses a substantial deployment of the Indian Army, given its strategic importance along the Line of Actual Control (LAC) with China and the Line of Control (LoC) with Pakistan. Various infantry divisions, mountain divisions, and specialized units are stationed in Ladakh to ensure territorial integrity and respond effectively to any security challenges. Ladakh's challenging terrain, characterized by high altitudes and extreme weather conditions, demands specialized training and equipment. The Indian Army has developed mountain warfare expertise to operate effectively in these harsh conditions. The deployment is strategically spread across key locations in Ladakh, including the Siachen Glacier, which is the highest battlefield in the world. These locations are chosen to maintain a strong defensive posture and to counter any potential threats. Apart from the Indian Army, paramilitary forces like the Indo-Tibetan Border Police (ITBP) and the Border Security Force (BSF) play a crucial role in securing the borders. These forces complement the military's efforts in maintaining vigilance and responding to any security challenges.

4.4 Logistics and supply chain management are crucial components in supporting the Indian Armed Forces deployed in Ladakh, given the challenging terrain, extreme weather conditions, and the strategic importance of the region. Ensuring a steady and efficient flow of resources is essential for sustaining military operations and maintaining the readiness of forces. Articulated, uninterrupted and seamless supply of rations to the troops deployed in Ladakh is one of the most important facets of logistics. These rations can be broadly classified into two groups viz. dry supplies and fresh supplies. Dry supplies comprise of basic foodgrains, edible oils, sugar, salt etc which can be stocked over long periods to cater for interruptions. On the other hand, fresh supplies comprise of perishables mainly fresh vegetables, fruits and non-veg items. They require to be continuously supplied and replenished because of their limited shelf life. The issue is further compounded by limited availability of fresh vegetables and fruits locally. Therefore, bulk of the requirements of fresh supplies including fruits and vegetables are met through procurements from hinterland locations in Punjab, Himachal Pradesh and Kashmir Valley. These are then transported by road/air to Ladakh. Both these modes of transportation substantially add to the cost of procurement. Besides, both are also prone to frequent interruptions owing to unfavourable weather conditions specially during winter months and road interruptions due to landslides, heavy snowfall etc. To cater for such anticipated interruptions, armed forces have to cater for tinned supplies which can be stocked and consumed for long periods. These, despite being exorbitantly priced are least preferred by the troops.

4.5 Road communication to Ladakh is crucial for the strategic and logistical requirements of the region, given its remote location and challenging terrain. Access to Ladakh is primarily facilitated through road networks connecting it with major cities like Srinagar, Chandigarh, and regions in Himachal Pradesh. A brief overview of the road communication networks to Ladakh from these three location are as follows :-

(a) **Srinagar to Ladakh**

- The Srinagar-Leh Highway (National Highway 1D) is the primary road link connecting Ladakh with Srinagar, the summer capital of the union territory of Jammu and Kashmir.

- The highway traverses through mountainous terrain, including high-altitude passes like Zoji La. This road is vital for both civilian and military traffic to and from Ladakh.

- The Srinagar-Leh Highway is open for a limited period during the year, typically from late spring to early autumn, as heavy snowfall makes it impassable during winter. It's essential for the road infrastructure to withstand harsh weather conditions.

(b) **Chandigarh to Ladakh**

- Ladakh is connected to Chandigarh and other parts of North India through the Manali-Leh Highway (National Highway 3 and 3A).
- The Manali-Leh Highway is known for its picturesque yet challenging route, passing through high mountain passes such as Rohtang Pass and Baralacha La. This route is crucial for maintaining the connectivity of Ladakh during the summer months.
- Similar to the Srinagar-Leh Highway, the Manali-Leh Highway faces closure during winter due to heavy snowfall, making it imperative for the effective management of the road during the operational season.

(c) **Himachal Pradesh to Ladakh**

- Himachal Pradesh provides another crucial route to Ladakh through the towns of Manali and Keylong, connecting with the Manali-Leh Highway.
- The journey involves crossing challenging passes, and the road infrastructure must be well-maintained to ensure the smooth movement of traffic, including military convoys and civilian vehicles.
- The road network through Himachal Pradesh contributes to the overall connectivity of Ladakh, offering an alternative route to and from the region.

4.6 Certain key considerations in the assessment of road connectivity to Ladakh which is the lifeline for supply of fresh rations to the troops deployed in Ladakh are as follows :-

(a) **Seasonal Constraints:** Both the Srinagar-Leh Highway and the Manali-Leh Highway face seasonal closures due to heavy snowfall, particularly during winter. Ensuring the roads are clear and safe for travel during the operational season is crucial.

(b) **Infrastructure Development:** Continuous efforts are made to upgrade and maintain the road infrastructure, including widening roads, constructing tunnels, and building bridges. This is essential for improving accessibility and reducing travel time.

(c) **Military Convoy Management:** The roads to Ladakh are strategically significant for the movement of military convoys. Effective coordination and management are critical to ensuring the security and efficiency of military operations.

4.7 From the above discussion, it is evident that road connectivity from hinterland i.e from the areas of procurement of fresh rations viz. fruits and vegetables to Ladakh is prone to lot of interruptions and not available for long periods of winter months. Thus, the other alternative is delivery through air. This despite being prohibitive in terms of cost is the only viable option. However, this mode also does not guarantee uninterrupted delivery of fresh rations owing to disruptions in sorties because of adverse weather conditions. The Indian Air Force (IAF) plays a pivotal role in providing airlift capabilities, air resupply missions, and facilitating the rapid movement of troops, equipment, and supplies to and from Ladakh. An overview of logistics through air support is as follows :-

(a) **Airlift Capabilities**

- The IAF operates various transport aircraft, including the C-130J Super Hercules, C-17 Globemaster III, and Antonov An-32, which are capable of airlifting troops, heavy equipment, and supplies.
- Airlift operations are essential for the rapid deployment of forces to Ladakh and the movement of critical supplies, especially during emergencies or when road access is limited.

(b) **Airstrips in Ladakh**

- Ladakh is equipped with several airstrips, including those in Leh and Thoise, which facilitate both military and civilian air traffic.
- These airstrips serve as key bases for air operations, allowing transport aircraft to land, unload or load cargo, and take off, contributing to the logistics chain.

(c) **Air Resupply Missions**

- Air resupply missions involve dropping essential supplies, including food, ammunition, medical provisions, and equipment, to remote or inaccessible areas. This capability is particularly crucial in the mountainous and challenging terrain of Ladakh.
- Precision airdrop techniques are employed to ensure that the supplies reach the intended locations accurately.

(d) **Weather Challenges**

- Ladakh's weather conditions, especially during winter, can be severe. The IAF employs specialized equipment and training to operate in these conditions, ensuring that air support is available even in challenging weather.

4.8 Apparently, the prevailing system of supply of fresh rations to the armed forced deployed in Ladakh is largely dependent on procurement from areas outside the union territory and subsequent transportation by road/air. Both these modes of transportation substantially add up to the costs and even then they do not guarantee uninterrupted supplies as has been discussed above. Thus, local availability and procurement of fresh rations viz. fruits and vegetables to the maximum possible extent is an extremely desirable option. This will not only cut costs substantially on account of transportation but also ensure uninterrupted and continuous supply of fresh rations. It will also cut down the requirements of stocking of tinned rations done to cater for interruptions which are also not liked by the troops and provide a fillip to the local economy. Recent efforts by the Government of UT of Ladakh which has been awarded by PM's award of excellence in 2021 is a fantastic option providing win win situation to all stakeholders. Proliferation of greenhouse technology to maximum farmers in Ladkh to increase it's footprints, evolving a system like cooperatives and formalising its supply to armed forces would be a magnificent step in this direction.

CHAPTER 5 : FINDINGS AND ANALYSIS

5.1 In order to elicit a holistic analysis of the subject matter of investigation i.e. “Feasibility of Green House Crop Production in Ladakh to Supplement the Requirements of Vegetables and Fruits of Armed Forces Locally,” tailormade questionnaires have been prepared for various stakeholders viz Brigadier ASC of 14 Corps who is responsible to procure vegetables and fruits for the Army deployed in Ladakh, competent authority of DIHAR (Defence Institute of High Altitude Research) and local farmers involved in Greenhouse production. For the sake of convenience, farmers based in and around Leh have been taken as Universe for this survey and questionnaires were sent to all of them. 46 responses have been received from them apart from the response from Brigadier ASC, Chief Agriculture Officer of Ladakh General Manager of DIHAR. The questionnaires prepared for Brigadier ASC, Chief Agriculture Officer, General Manager DIHAR and local farmers involved in Greenhouse crop production are attached as Annexures ‘A’, ‘B’, ‘C’ and ‘D’ respectively.

5.2 Based on questionnaires canvassed to them, important findings are as follows :-

(a) The local procurement of fruits and vegetables to meet the requirements of Armed forces is less than 25%. Balance requirements are met through procurements from outside the union territory viz. Chandigarh, Srinagar, Jammu, Himachal Pradesh etc which are then transported to Ladakh by road/ air.

(b) The procurement of vegetables and fruits through various modes of transportation leads to extra expenditure to the state which is more than 30% of the procurement cost of these products.

(c) All varieties of fruits and vegetables required by the armed forces are presently locally grown in Ladakh in greenhouses.

(d) It emerges that local procurement of fruits and vegetables is desirable and would be more economical.

(e) The present system of local procurement of a portion of fruits and vegetables is working well with an uninterrupted supply chain.

(f) The quality of fruits and vegetables procured locally through the produce of greenhouses are comparable to the products procured and transported from outside the Union Territory and they meet the defence specifications.

(g) It has been found that the present procurement process can cater for additional supplies through local greenhouse production without any changes.

(h) The annual requirement of vegetables and fruits for the armed forces have been estimated at 37,200 metric tons and 50,300 metric tons respectively.

(i) More than 2000 greenhouses have been established and the Government plans to construct additional 6457 greenhouses in next five years.

(j) The introduction of greenhouse crop production has resulted in extended cropping season with three cycles of crops including a wide variety of fruits and vegetables.

(k) Due to adoption of greenhouse technology, there has been a substantial improvement in crop production in Ladakh including increased varieties, harvest in peak winters, increase in productivity, income level of farmers, reduction in hidden hunger etc.

(l) The average annual profit to a farmer from a single greenhouse has been found to be in the range between Rs 40,000 to Rs 50,000.

(m) The Government of Ladakh is providing approximately 75% subsidy to Greenhouse farmers for construction of new greenhouses. It also provides good quality seeds and assistance in composting.

(n) It is a challenging for the Government of Ladakh to meet the increasing demand of subsidies/ loans by the farmers for establishment of greenhouses.

(o) The approximate annual yield from each greenhouse on an average is 2000 Kg.

(p) The farmers as of now are getting assistance from the Government in terms of subsidy and technical assistance for establishment and development of greenhouses.

(q) The Government may consider more initiatives like interest free long term loans, more subsidies, some organized mechanism of procurement of the products through Government bodies to further develop and encourage greenhouse production of fruits and vegetables in Ladakh.

(r) Ladakh has the potential to cater for 100% requirement of fruits and vegetables of the armed forces locally if greenhouse crop production is adequately promoted.

(s) All varieties of fruits and vegetables required by the armed forces are locally grown in the greenhouses in Ladakh.

(t) The present potential of greenhouse crop production in Ladakh can be enhanced by more than 100%.

(u) The local farmers would be keen in adopting and expanding greenhouse production of fruits and vegetables in case they get assured demand from the armed forces.

(v) The Agriculture Department in Ladakh is providing technical support to the interested farmers and also arranging subsidies. However, they are not supporting farmers in marketing their produce and opening stores.

(w) The Cooperative department of Ladakh is also not adequately enabling the marketing of greenhouse products viz fruits and vegetables.

5.3 **Response of Greenhouse Farmers**. A total of 23 questions were posed to 50 greenhouse farmers in and around Leh. Based on responses thus received. The relevant findings are as follows:-

(a) Types of greenhouse.

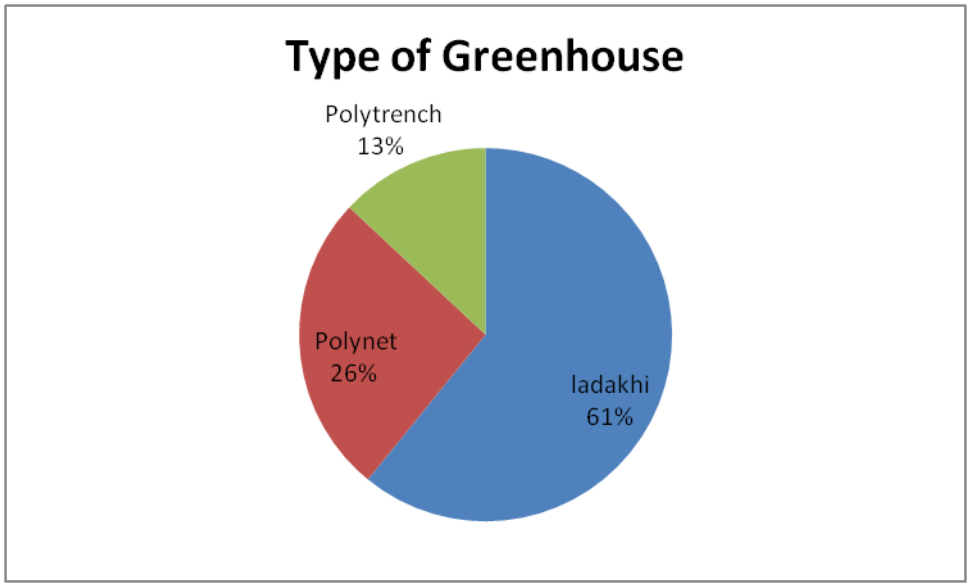

Fig 5.1

(b) Year of establishment of first greenhouse of the respondents.

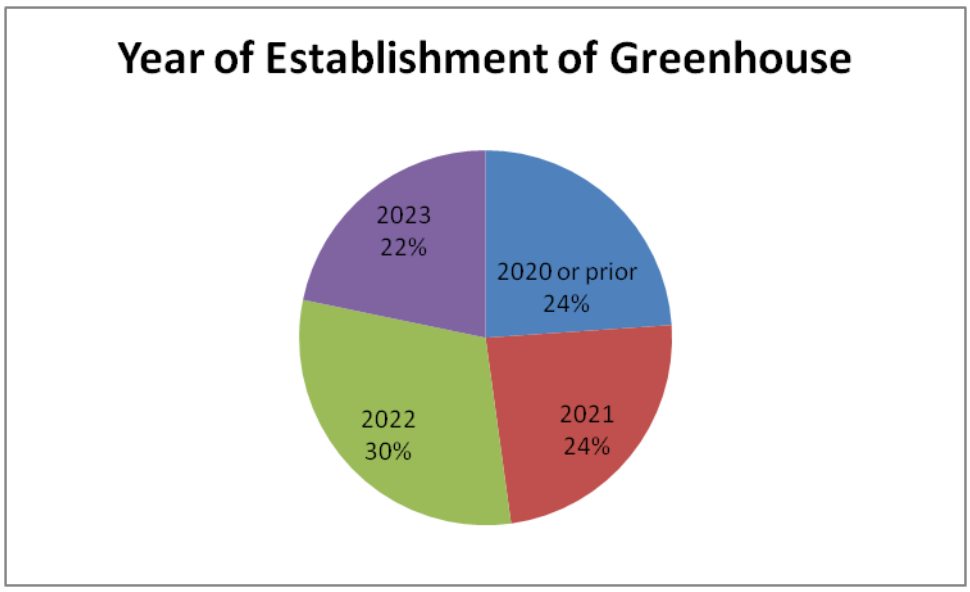

Fig 5.2

(c) Reasons for adopting greenhouse technology.

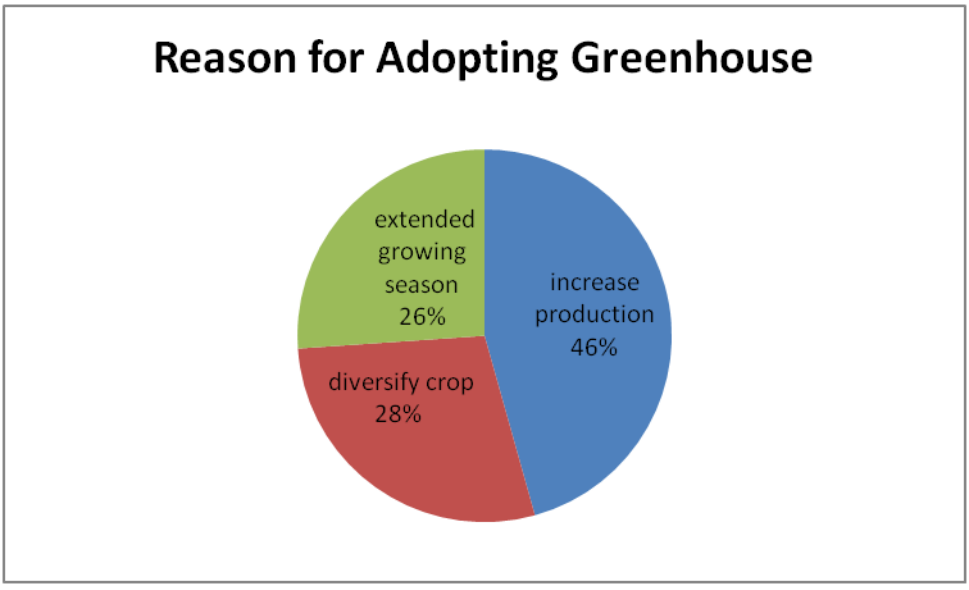

Fig 5.3

(d) Change in area of cultivation under greenhouse overtime.

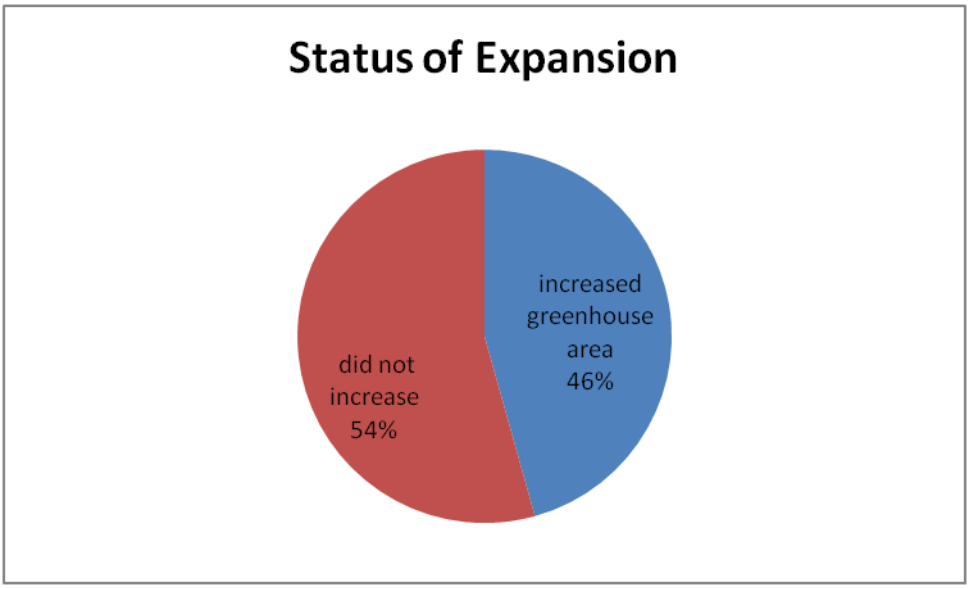

Fig 5.4

(e) Extent of increase in area under greenhouse farming.

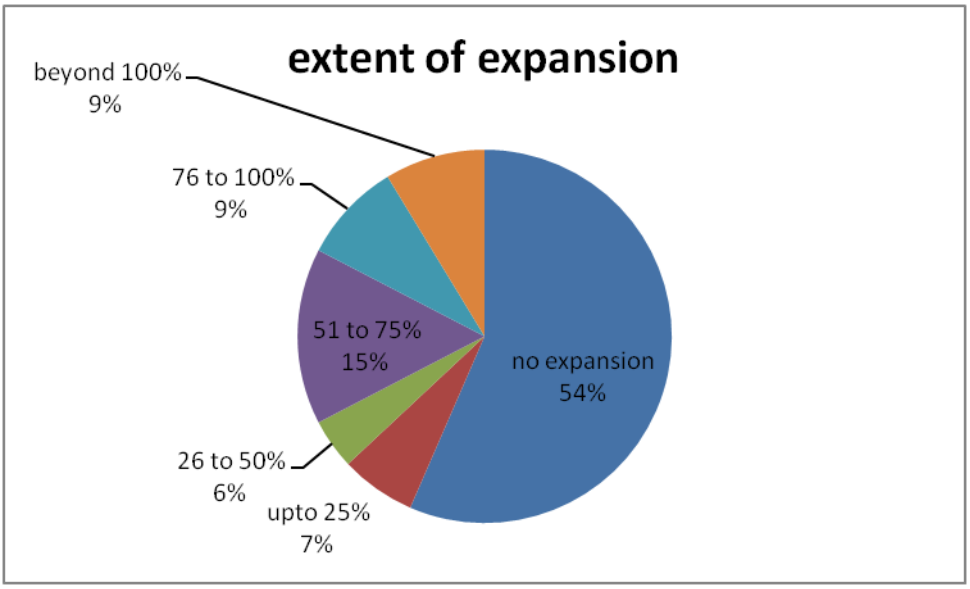

Fig 5.5

(f) Supply of greenhouse products to the Armed Forces.

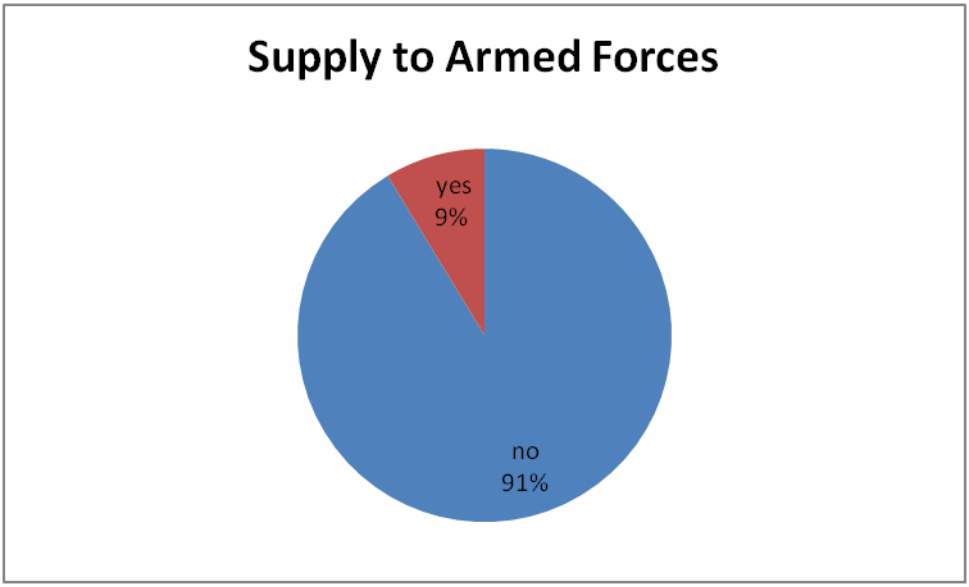

Fig 5.6

(g) All supplies to armed forces are through cooperative societies.

(h) Possibility of increase in number of greenhouses on increase in demand from the Armed forces.

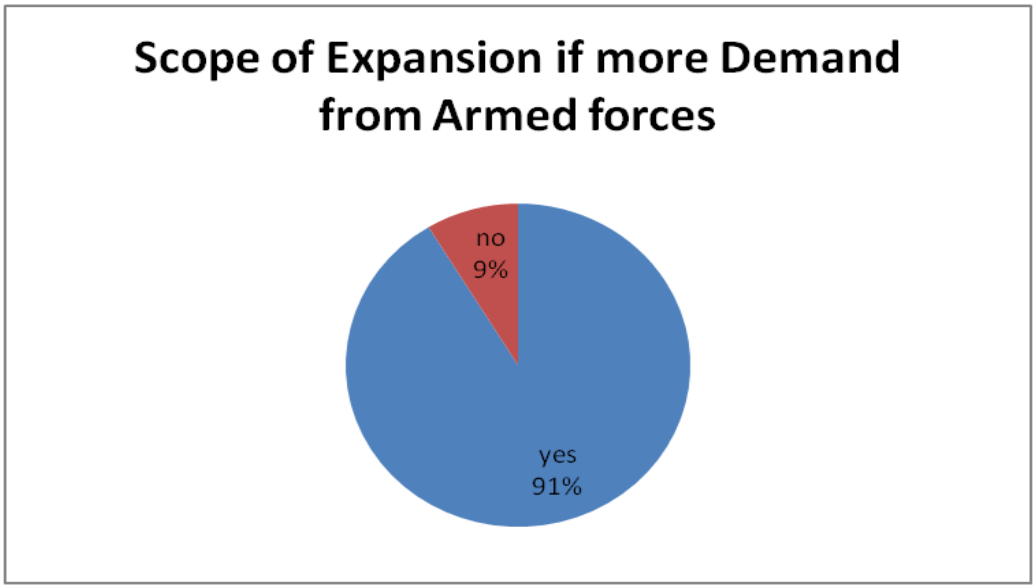

Fig 5.7

(i) Possibility of diversification of crops produced in terms of more varieties of fruits and vegetables to meet the demand of the Armed Forces.

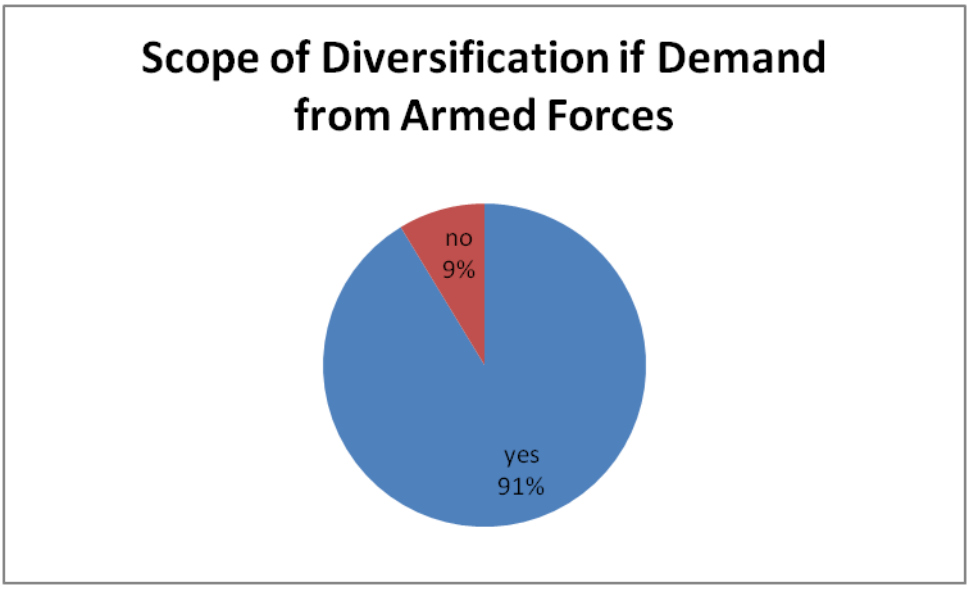

Fig 5.8

(j) Possibility of more farmers adopting greenhouse technology if more demand is furnished by the Armed Forces?

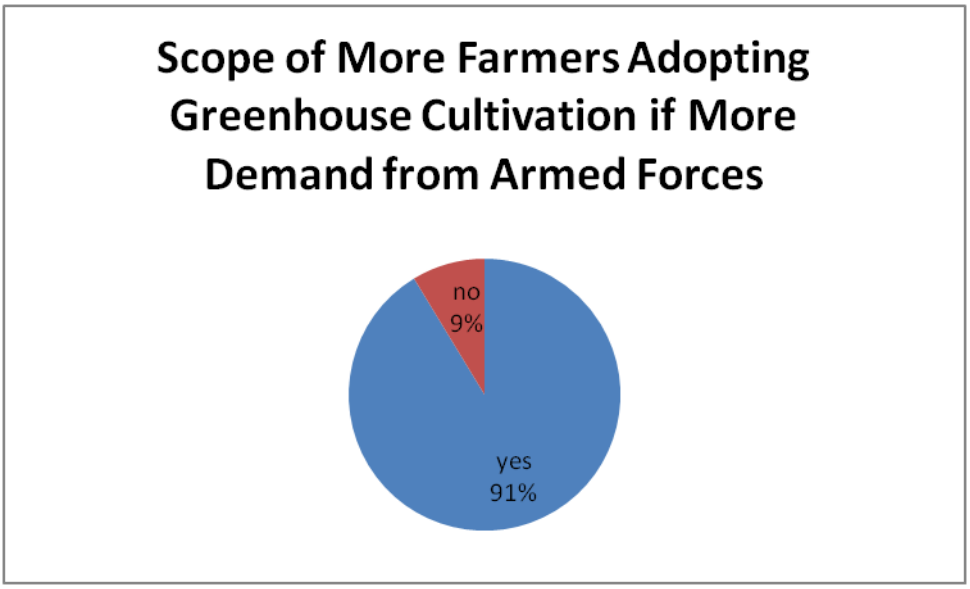

Fig 5.9

(k) Percentage of requirement of the Armed Forces i.e approximately 50,300 metric tons of fruits and 37, 300 metric tons of vegetables that can be met through greenhouse production locally.

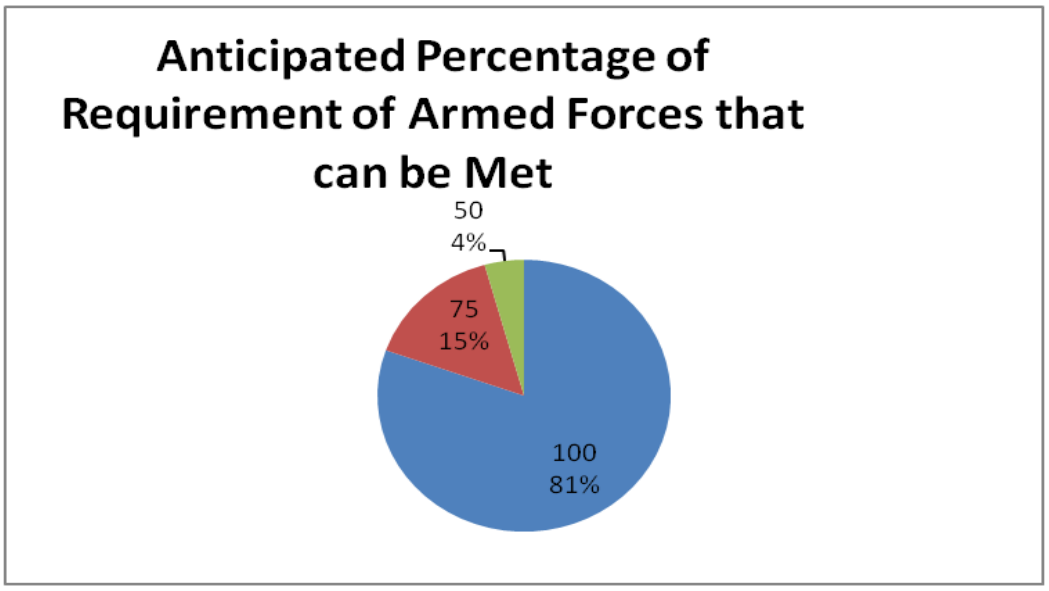

Fig 5.10

(l) Assistance received from the Government in establishment of greenhouses.

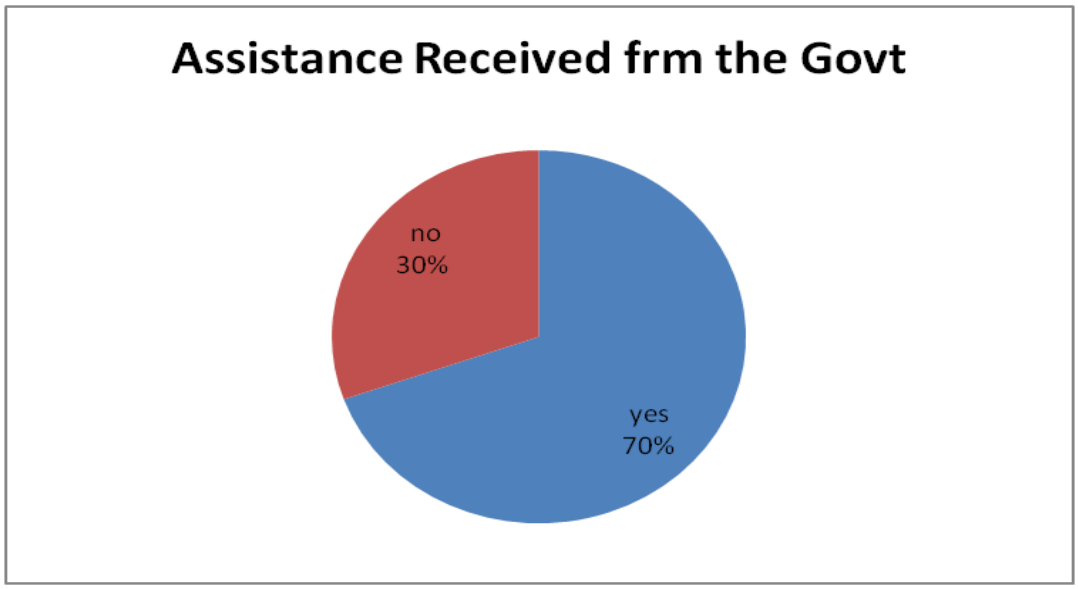

Fig 5.11

(m) Type of assistance received from the Government.

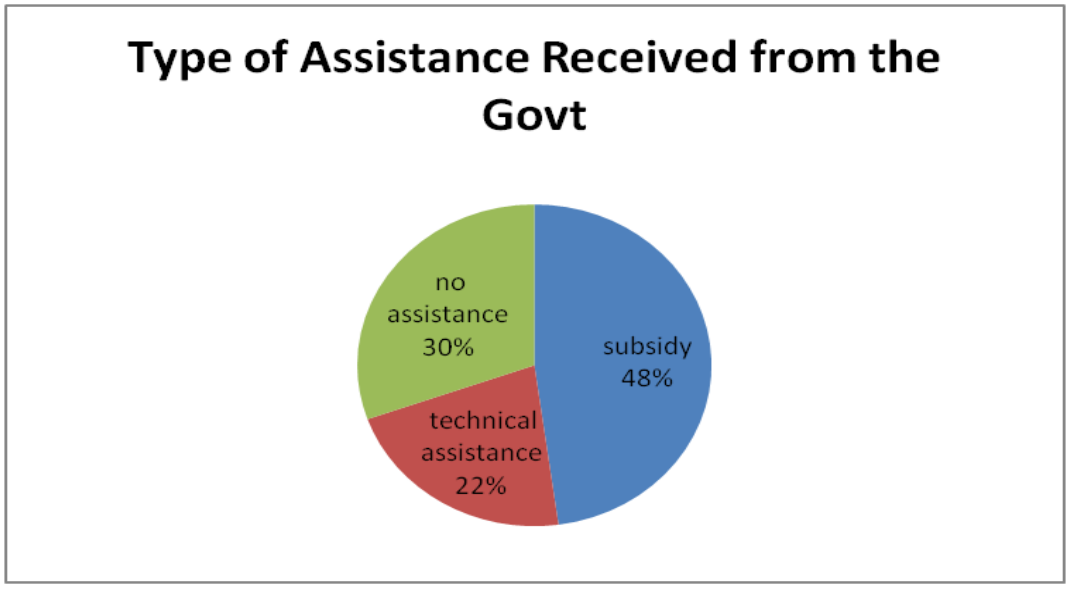

Fig 5.12

(n) Extent to which the assistance from the Government was helpful.

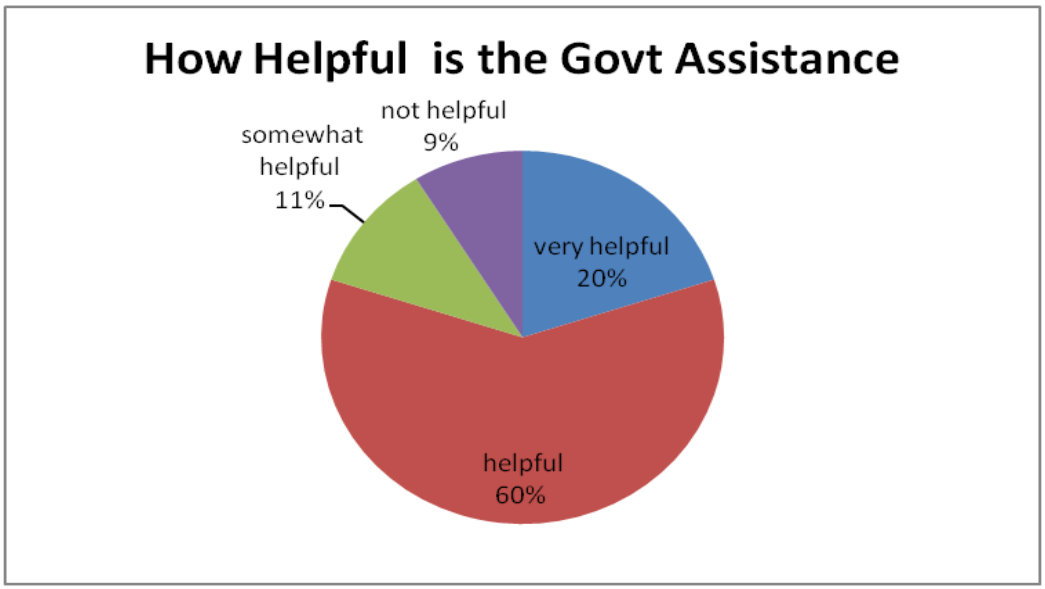

Fig 5.13

(o) Most required support from the govt to expand the greenhouse production of fruits and vegetables in Ladakh.

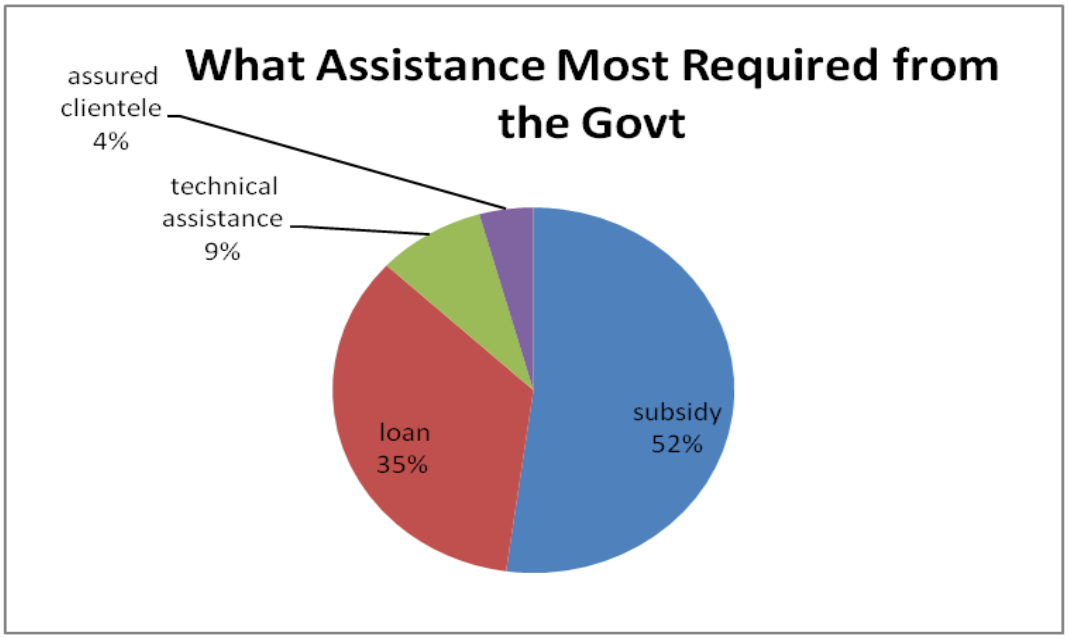

Fig 5.14

(p) Change in income on adopting greenhouse technology.

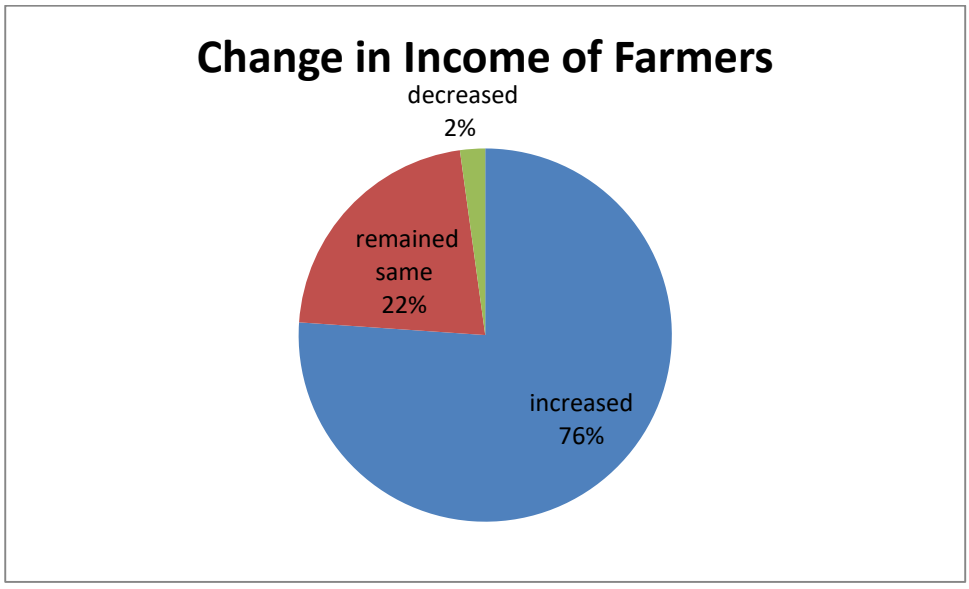

Fig 5.15

(q) Employment generation and food sustainability on adoption of greenhouse technology.

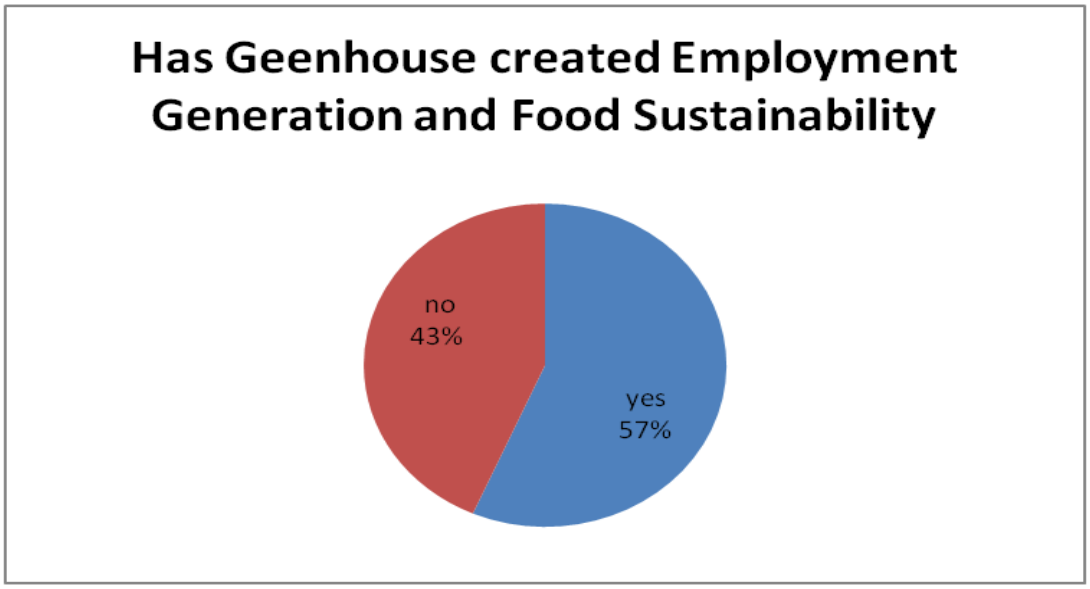

Fig 5.16

(r) Increase in income on adoption of greenhouse technology.

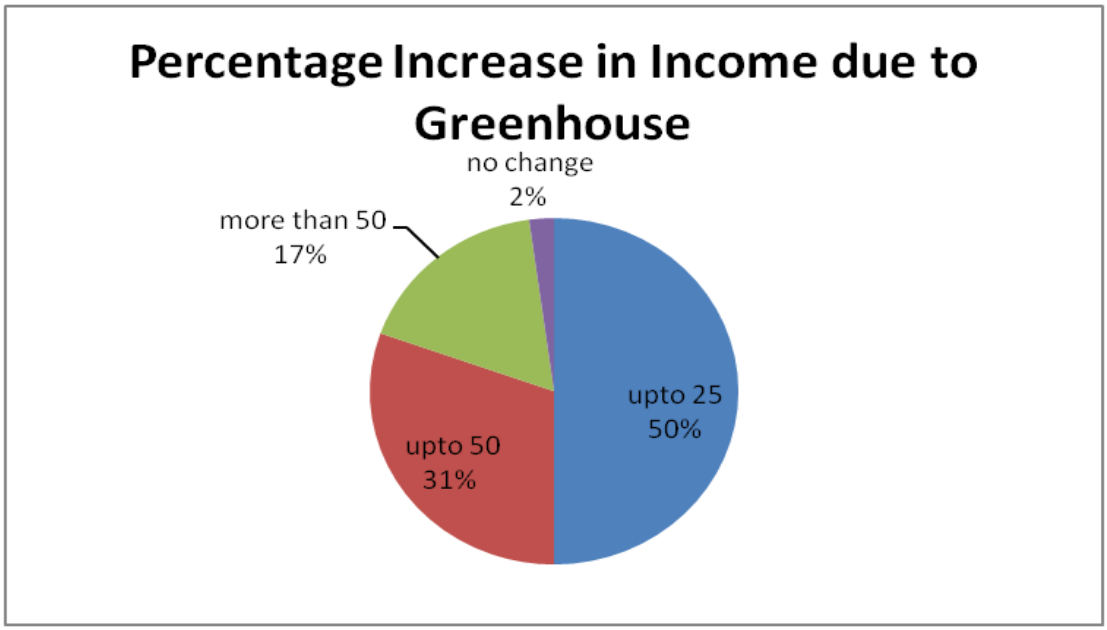

Fig 5.17

(s) Possibility of collectively supplying fruits and vegetables by the farmers to meet the requirements of Armed Forces.

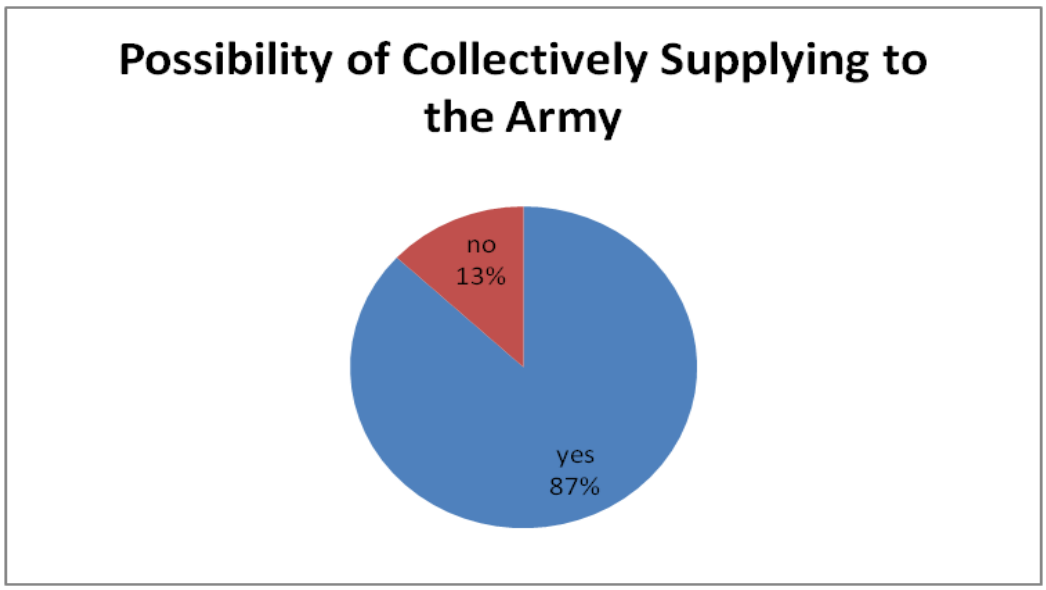

Fig 5.18

(t) Possibility of expansion of greenhouse production of fruits and vegetables to meet the increased demand from the Armed Forces.

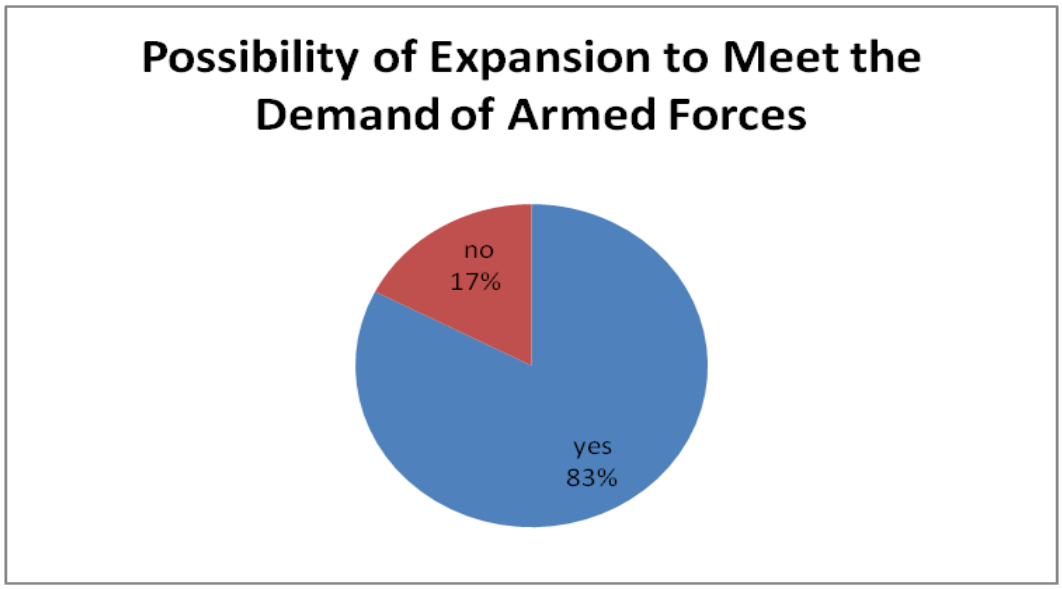

Fig 5.19

(u) Support from the Agriculture Department in marketing produce of farmers and opening stores.

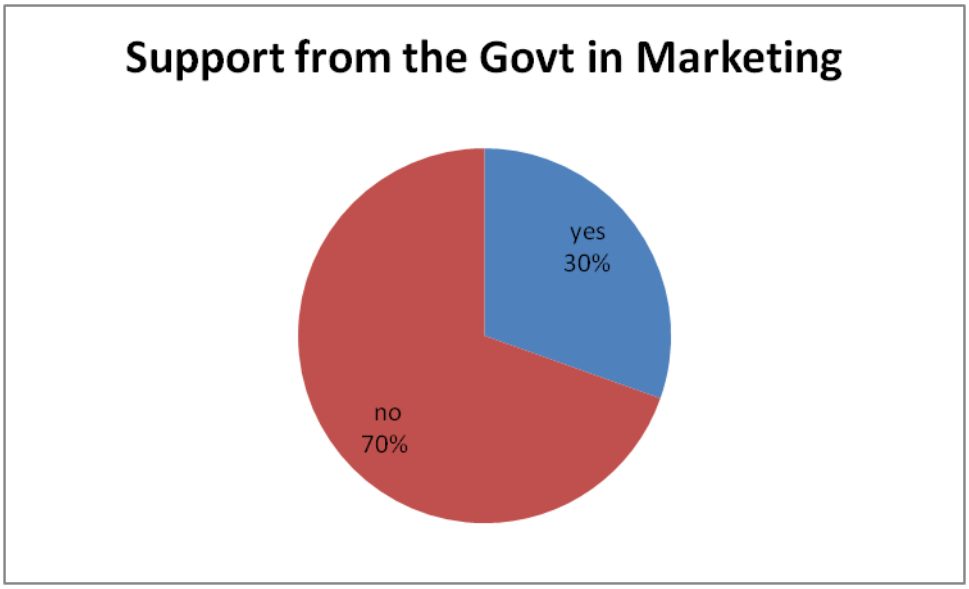

Fig 5.20

(v) Support from the Cooperative Department of UT in supply of the vegetables?

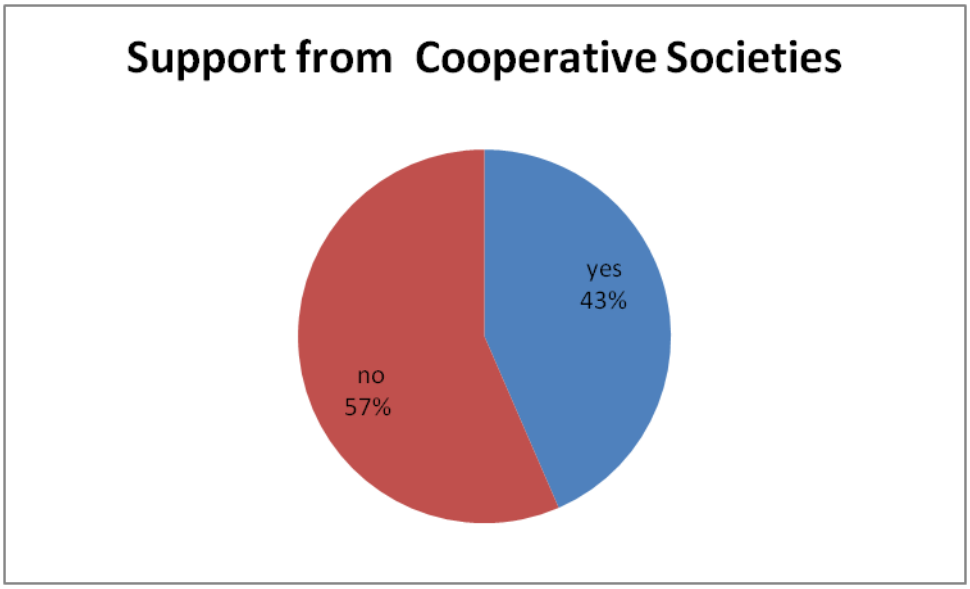

Fig 5.21

5.4 **Analysis of Responses**. The questionnaire to various respondents were elicited to seek responses to the research questions identified viz. (a) What is the present system of supplies of vegetables and fruits to support armed forces deployed in Ladakh? (b) What is the present contribution of local resources in supplies of vegetables and fruits to armed forces deployed in Ladakh? (c) What steps can be taken by the govt in boosting greenhouse crop production in Ladakh? The respondents have been carefully selected to address all stakeholders and the sample size of the farmers has been ensured to be truly representative of the universe. Broadly, the responses received from the three categories of respondents are in unison with no noteworthy conflicts. Clear cut answers have emerged to these research questions based upon which informed conclusions can be drawn. The detailed analysis of the responses is as follows:-

(a) The present system of procurement of fruits and vegetables for armed forces deployed in Ladakh is through a combination of procurements from hinterland i.e Chandigarh, Srinagar and Himachal Pradesh and local procurements. In this, the percentage of local procurements as asserted by Brigadier ASC 14 Corps is less than 25%.

(b) As per Brigadier ASC, the procurement of fruits and vegetables from outside the Union Territory leads to extra expenditure to the state to the tune of more than 30% of the actual procurement cost. Thus, the option of local procurement of fruits and vegetables is desirable and more economical.

(c) As per Brigadier ASC, Chief Agriculture Officer and General Manager of DIHAR, all varieties of fruits and vegetables required by the armed forces are locally grown in greenhouses in Ladakh.

(d) As per Brigadier ASC, the supply chain for the small portion of fruits and vegetables locally procured for the armed forces have functioned well and uninterrupted.

(e) Brigadier ASC 14 Corps has further stated that, the quality of fruits and vegetables locally procured meet the defence specifications and are comparable to that of fruits and vegetables procured from outside the Union Territory.

(f) As per Brigadier ASC, no changes would be required in the present procurement process to accept larger supplies of fruits and vegetables locally.

(g) As per Brigadier ASC, Chief Agriculture Officer and General Manager DIHAR, the greenhouses in Ladakh are mainly a combination of ladakhi, polynet and polytrench greenhouses.

(h) As per respondent farmers, 24% of the greenhouses are of vintage of 2020 or earlier, 24% of 2021 vintage, 30 % of 2022 vintage and 22% of 2023 vintage. This implies that there has been steady rate of establishment of greenhouses in Ladakh.

(i) As per respondent farmers, increased production is the most important reason for adopting greenhouse technology.

(j) Only 46% of the respondent farmers have increased their area of cultivation under greenhouse since establishment of their respective first greenhouse. Amongst these 46%, the increase upto 50% has been witnessed by 13% of the farmers. This implies that more efforts/incentives are required to encourage proliferation of greenhouse technology.

(k) 91% of the respondent farmers have stated that they do not supply to the armed forces. Balance 9% undertake supply to the armed forces through the cooperative societies which have entered into contract with the armed forces. This implies that there is a wide scope for local procurement of vegetables and fruits for the armed forces and thus reduce import from locations outside the Union Territory. This will prove to be a more economical option with a much more reliable supply chain. It will also add to the income levels of the local farmers and thus boost the economy of the area.

(l) Similarly, 91% of the respondent farmers have stated that they can increase the number of greenhouses established by them as also diversify their production of vegetables and fruits as per requirements of the armed forces incase they get more demand from the armed forces. Further, they have also stated that more farmers will adopt greenhouse production of vegetables and fruits if they get more demand from the armed forces. This indicates their alacrity to enter into business dealings with the armed forces.

(m) An overwhelming 81% of the respondent farmers have stated that they can meet 100% of the demand of vegetables and fruits of the armed forces locally through greenhouse production. This is also supported by the plans of expansion given by Chief Agriculture Officer. This is a very encouraging assertion, as if this option fructifies, it will not only cut down expenditure on the procurement but also cut down cumbersome and fragile supply chain.

(n) As regards assistance received from the Government for establishment of greenhouses, 70% have replied in the affirmative. Out of these 70%, 48% have stated that they received Government subsidies and 22% have stated that they received technical assistance. 80 % of the respondents have stated that the assistance they received was very helpful/helpful. The issue of 75% subsidy has also been highlighted by Chief Agriculture Officer but meeting the increasing demand of subsidy has also been listed out as a challenge by him. This implies that though Government assistance is forthcoming, there is a greater scope of efforts by the Government extend assistance in various forms including subsidy, loan and technical assistance particular in view of the alacrity shown by the farmers in expanding greenhouse crop production and the scope of local market available in terms of armed forces as a major buyer.

(o) An impressive 76% of the respondent farmers have stated that their incomes have increased on account of greenhouse farming, with 50% amongst these stating that the income rose by 25% or less. Further, 57% have agreed that it has led to employment generation. The increase in income has also been highlighted by Chief Agriculture Officer. Evidently, if the Government works more on marketing techniques to ensure greater consumption by large clients like armed forces, the income levels and employment opportunities can be further boosted. This has also been seconded by the views of General Manager DIHAR also.

(p) 87% of the respondents have stated that they will be able to collectively supply to the armed forces but 57% amongst them have stated that the Cooperative Department of the Union territory has not provided them with adequate support in supply of their products. Similarly, 70% have stated that the Agriculture Department of the Union Territory is not adequately supporting and guiding them in marketing their products. Chief Agriculture Officer, when asked about the initiatives taken by the Government in promoting greenhouse production has only referred to measures undertaken in promoting production but not brought out any steps taken by the govt in promoting marketing of the products. Even General Manager DIHAR has expressed the need for greater efforts by the govt in ensuring a sustainable and efficient marketing mechanism for sale of the greenhouse products. This reiterates the need for a more well organized, proactive and robust machinery by the state govt to ensure marketing of the greenhouse products.

CHAPTER 6 : CONCLUSION AND RECOMMENDATIONS

6.1 CONCLUSION

A smooth supply chain and assured market for these products will lead to enhanced income levels for the farmers and hence further catalyse the proliferation of greenhouse technology in Ladakh.

There is a massive deployment of armed forces in the Union Territory. The fresh rations comprising of fruits and vegetables for these troops are procured mostly from outside Ladakh i.e from Chandigarh, Srinagar and Leh. This is primarily because of non-availability of fruits and vegetables locally in adequate quantities throughout the year owing to severe winter conditions and inadequate yields. This arrangement of procurement of fruits and vegetables from outside is not an optimal option as the products are procured at the locations mentioned above and then transported either by road or by air. Both these modes of transportation exorbitantly add to the procurement costs of fruits and vegetables for the armed forces which is avoidable. Further, transportation of products over such large distances is prone to breakdowns owing to situations such as road closures, bad weather conditions and other similar contingencies. To cater for such contingencies, the armed forces have to cater for tinned fruits and vegetables. These are procured in requisite quantities and stocked for long periods to be issued to troops when there is breakdown in supply chain of fresh fruits and vegetables. These tinned rations despite being very costly are not relished by the troops.

Thus, the optimum solution would be to have an arrangement in place wherein the entire requirement of fruits and vegetables for the armed forces could be procured locally in Ladakh throughout the year. The recent initiatives of the Government of Union Territory of Ladakh towards encouragement of greenhouse crop production, if optimally exploited, can create a win win situation for both the farmers and the armed forces. While it can ensure round the year uninterrupted local availability of fresh fruits and vegetables for the armed forces at most economical rates, it can provide a fillip to the local economy by having in place assured clientele for the greenhouse farmers in form of a massive consumer viz. the armed forces.

The impetus of this study has been to examine the present system procurement system of fruits and vegetables by the armed forces, feasibility and extent of local procurement of fruits and vegetables by the armed forces and suggest measures to ensure adequate greenhouse production of fruits and vegetables locally in Ladakh.

It has emerged that the percentage of local procurement of fruits and vegetables as of now is less than 25% and the balance is procured from outside. This is due to limited yield available locally. However, the armed forces would be too eager to procure maximum possible local produce as it would be more economical and prone to minimum interruptions. The procedures for procurement of fruits and vegetables by the armed forces also would not require any major changes to facilitate maximum local procurements.

The local farmers have commenced exploiting the option of greenhouse farming and appear eager to imbibe this technology. They acknowledge that assistance from the state mainly in terms of subsidies is forthcoming but expect more. They also acknowledge that there has been an increase in their income levels on adoption of greenhouse technology. They also expect the Government to facilitate marketing of their products and in this direction armed forces can be a major consumer. They overwhelmingly appear willing to supply to the armed forces and also expand their greenhouse farming in case they get assured demand from the armed forces.

Thus, it emerges that a chunk of demand of fruits and vegetables for the armed forces can be met locally through greenhouse crop production which would be a win win situation for all.

6.2 **RECOMMENDATIONS** Following recommendations are made based upon this study:-

(a) The Government of Ladakh need to introduce dedicated programmes to encourage proliferation of greenhouse farming amongst the farmers. This may include incentives like subsidies, soft loans and technical assistance. Assistance may be sought from DIHAR as regards technicalities of the programme.

(b) The armed forces should procure maximum possible fruits and vegetables locally and procure them from outside only to cater for the shortfall.

(c) The Government of Ladakh should facilitate marketing of the greenhouse products through entering into contracts with various organisations like Army, Border Roads, paramilitary forces etc.

(d) The farmers should be facilitated by the Government to form cooperative societies so as to market their products in bulk.

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i

Annexure A

QUESTIONNAIRE TO BRIGADIER ASC (RESPONSIBLE FOR PROCUREMENT OF VEGETABLES AND FRUITS FOR LADKH) ON FEASIBILITY OF GREEN HOUSE CROP PRODUCTION IN LADAKH TO SUPPLEMENT THE REQUIREMENTS OF VEGETABLES AND FRUITS OF ARMED FORCES LOCALLY

(The study seeks to evaluate feasibility of greenhouse crop production in Ladakh to support requirements of vegetables and fruits of armed forces locally in the backdrop of recent initiatives in Ladakh for which the Department of Agriculture, UT Ladakh was awarded the Prime Minister's Award for Excellence in Public Administration in 2021 under Category : Innovation State).

Introduction. Thank you for participating in this survey! Your responses will assist in understanding the feasibility of greenhouse production of fruits and vegetables in Ladakh to supplement the requirements of Armed Forces

Part 1: Background Information

1. Name : (Optional)

2. Arm/Service

3. Rank

4. Appointment

Part 2: Local Greenhouse Production and Supply to Armed Forces

1. The requirements of vegetables and fruits of armed forces is met through local procurements and procurements from outside the state. In this the percentage of local procurement is:-

   (a) 0 to 25%

   (b) 25 to 50%

   (c) 50 to 75%

   (d) 75 to 100%

2. The procurement from outside Ladakh is through a combination of air and road transport. This leads to extra expenditure due to transportation vis-a –vis local procurement :-

(a) Strongly Agree

(b) Agree

(c) Disagree

(d) Neutral

3. The anticipated extra expenditure to the state on account of procurement from outside vis-à-vis local procurement from Ladakh may be :-

(a) 0 to 10%

(b) 10 to 20%

(c) 20 to 30%

(d) More than 30 %

4. The varieties of fruits and vegetables required for supply to armed forces are all locally produced in green houses :-

(a) Strongly Agree

(b) Agree

(c) Disagree

(d) Neutral

5. The option of local procurement of fruits and vegetables to meet the requirements of armed forces is desirable :-

(a) Strongly Agree

(b) Agree

(c) Disgree

(d) Neutral

6. The option of local procurement of fruits and vegetables to meet the requirements of armed forces would be more economical :-

(a) Strongly Agree

(b) Agree

(c) Disagree

(d) Neutral

7. The present system of meeting a portion of requirements of fruits and vegetables locally through local farmers is working well and the supply chain is uninterrupted :-

(a) Strongly Agree

(b) Agree

(c) Disagree

(d) Neutral

8. The quality of fruits and vegetables procured locally in Ladakh produced in Green Houses meets the defence specifications and are comparable to the products transported from outside the Union Territory :-

(a) Strongly Agree

(b) Agree

(c) Disagree

(d) Neutral

9. The present procurement process can cater for additional supplies through local greenhouse production without any changes :-

(a) Strongly Agree

(b) Agree

(c) Disagree

(d) Neutral

11. In my opinion, the local procurement of greenhouse production of fruits and vegetables will give a fillip to the local economy and enhance the income levels of greenhouse farmers of Ladakh :-

(a) Strongly Agree

(b) Agree

(c) Disagree

(d) Neutral

12. Briefly explain the process of procurement of fruits and vegetables for armed forces deployed in Ladakh.

13. Please list out the quantum of vegetables and fruits required annually for the Armed Forces giving out distribution as per varieties.

Part 3: Additional Comments (Please share any additional thoughts or comments you have about greenhouse technology adoption in Ladakh and its impact on your well-being)

Thank you for your participation!

Annexure B

QUESTIONNAIRE TO CHIEF AGRICULTURE OFFICER OF UNION TERRITORY OF LADAKH ON FEASIBILITY OF GREEN HOUSE CROP PRODUCTION IN LADAKH TO SUPPLEMENT THE REQUIREMENTS OF VEGETABLES AND FRUITS OF ARMED FORCES LOCALLY

(The study seeks to evaluate feasibility of greenhouse crop production in ladakh to support requirements of vegetables and fruits of armed forces locally in the backdrop of recent initiatives in Ladakh for which the Department of Agriculture, UT Ladakh was awarded the Prime Minister's Award for Excellence in Public Administration in 2021 under Category : Innovation State).

Introduction. Thank you for participating in this survey! Your responses will assist in understanding the feasibility of greenhouse production of fruits and vegetables in Ladakh to supplement the requirements of Armed Forces

Part 1: Background Information

1. Name : (Optional)

2. Village/Town :

3. Age :

4. Gender :

Part 2: Local Greenhouse Production and Supply to Armed Forces

1. What is the extent of adoption of greenhouse technology by the farmers of Ladakh?

2. Has the period of crop cultivation witnessed an increase due to adoption of greenhouse technology? Please elaborate.

3. What are the improvements that the greenhouse technology aoption brought in farming and farmers of Ladakh?

4. What is the average annual income and profit from each greenhouse in Ladakh?

5. What are the support/incentives provided by the govt of Ladakh in promoting greenhouse crop production?

6. What are the challenges/constraints in promoting greenhouse technology in Ladakh?

Annexure C

QUESTIONNAIRE TO DIHAR ON FEASIBILITY OF GREENHOUSE CROP PRODUCTION IN LADAKH TO SUPPLEMENT THE REQUIREMENTS OF VEGETABLES AND FRUITS OF ARMED FORCES LOCALLY

(The study seeks to evaluate. feasibilty of greenhouse crop production in ladakh to support requirements of vegetables and fruits of armed forces locally in the backdrop of recent initiatives in Ladakh for which the Department of Agriculture, UT Ladakh was awarded the Prime Minister's Award for Excellence in Public Administration in 2021 under Category : Innovation State).

Introduction. Thank you for participating in this survey! Your responses will assist in understanding the feasibility of greenhouse production of fruits and vegetables in Ladakh to supplement the requirements of Armed Forces

Part 1: Background Information

1. Name : (Optional)

2. Appointment :

3. Age :

4. Length of Service :

5. Main source of income: (Choose one or multiple)

6. Service Experience in Ladakh

Part 2: Greenhouse Technology Adoption

1. For how many years have you been associated with greenhouse crop production in Ladakh?

2. How many greenhouses are there approximately in Ladakh as per your information?

3. What would be the approximate yield of fruits and vegetables annually from the greenhouses in Ladakh?

4. Are the farmers getting adequate assistance from the govt in establishment and development of greenhouses?

5. What type of additional support/assistance from the govt is required to further develop greenhouse production of fruits and vegetables in Ladakh?

6. The average annual consumption of fruits and vegetables by the Armed Forces in Ladakh are approximately 50, 300 metric tons and 37 300 metric tons respectively. How much percentage of this can be met by Greenhouse production locally if the said production is promoted?

(a) 100% (b) 75% (c) 50% (d) 25% (e) less than 25%

7. The varieties of fruits and vegetables required by the Armed Forces are diverse. Can all the varieties of fruits and vegetables usually consumed in hinterland grow in greenhouses in Ladakh?

8. The present potential of greenhouse production can be enhanced by proper support from the govt by :-

(a) by 25-50% (b) by 50-75% (c) by 75-100% (d) 100% and above

9. In your opinion, would the local farmers be keen in adopting and expanding greenhouse production of fruits and vegetables in case they get assured demand from the Armed Forces?

(a) Yes (b) No

10. Is the Agriculture Department supporting and guiding the farmers adequately in marketing their produce and opening stores?

(a) Yes (b) No

11. Is the Cooperative Department of UT enabling the supply of the vegetables outside Leh?

(a) Yes (b) No

Part 4: Additional Comments (Please share any additional thoughts or comments you have about greenhouse technology adoption in Ladakh and its impact on your well-being)

Annexure D

QUESTIONNAIRE TO GREENHOUSE FARMERS ON FEASIBILITY OF GREEN HOUSE CROP PRODUCTION IN LADAKH TO SUPPLEMENT THE REQUIREMENTS OF VEGETABLES AND FRUITS OF ARMED FORCES LOCALLY

(The study seeks to evaluate feasibility of greenhouse crop production in ladakh to support requirements of vegetables and fruits of armed forces locally in the backdrop of recent initiatives in Ladakh for which the Department of Agriculture, UT Ladakh was awarded the Prime Minister's Award for Excellence in Public Administration in 2021 under Category : Innovation State).

Introduction. Thank you for participating in this survey! Your responses will assist in understanding the feasibility of greenhouse production of fruits and vegetables in Ladakh to supplement the requirements of Armed Forces

Part 1: Background Information

1. Name : (Optional)

2. Village/Town :

3. Age :

4. Gender:

Part 2: Local Greenhouse Production and Supply to Armed Forces

1. What type of greenhouse do you have?

   (a) Ladakhi Greenhouse (b) Trench Greenhouse
   (c) Polytrench Glasshouse (d) Polynet Greenhouse
   (e) If other, please specify

2. In which year did you establish your first greenhouse?

   (a) 2020 or prior (b) 2021 (c) 2022 (d) 2023

3. What was the most important reason for adopting greenhouse technology?

(a) Increase production (b) Diversify crops
(c) Extend growing season (d) If other reason, please specify

4. Have your increased your area of cultivation under greenhouse from your first greenhouse?

(a) Yes (b) No

5. Area under your greenhouse farming has increased by how much in last five years?

(a) by 25% or less (b) by 26-50% (c) by 51 to 100% (d) 101% and above

6. Do you supply your greenhouse products to the Armed Forces?

(a) Yes (b) No

7. If yes, is the supply through a cooperative, individually or through any other private arrangements?

(a) Cooperative society (b) Individually (c) Private arrangements

8. Can you increase the number of greenhouses and hence the production of fruits and vegetables if you get more demand from the Armed forces?

(a) Yes (b) No

9. Can you diversify the crops produced by you in terms of more varieties of fruits and vegetables as per requirements of the Armed Forces?

(a) Yes (b) No

10. In your opinion, will more farmers adopt greenhouse technology and produce fruits and vegetables if you get more demand from the Armed Forces?

(a) Yes (b) No

11. The annual requirement of Armed Forces is approximately 50,300 metric tons of fruits and 30,700 metric tons of vegetables. How much of this can be met through greenhouse production locally as per you?

(a) 100% (b) 75% (c) 50% (d) 25% (e) less than 25%

12. Have you received any assistance from the govt in establishment of greenhouses?

(a) Yes (b) No

13. If yes, what type of assistance did you receive?

(a) Financial grant (b) Technical training
(c) Materials support (d) Other

14. How helpful was the assistance you received?

(a) Helpful (b) Somewhat helpful
(c) Very helpful (d) Not helpful

15. Do you feel that govt support is required to expand the proliferation of greenhouses in Ladakh so as to enhance production of fruits and vegetables?

(a) Yes (b) No

16. Please specify most required support from the govt to expand the greenhouse production of fruits and vegetables in Ladakh?

(a) Subsidy (b) Loan (c) Technical assistance (d) Assured clientele

17. How has your income changed since adopting greenhouse technology?

(a) Increased
(b) Decreased
(c) Remained the same

18. Has the Greenhouse crop production created Employment generation and food sustainability?

(a) Yes (b) No

19. How much has your income increased since adoption of greenhouse technology?

(a) No change (b) by 25%
(c) by 50% (d) by more than 50%

20. Can you all collectively supply fruits and vegetables to meet the requirements of Armed Forces?

(a) Yes (b) No

21. Can you expand your Greenhouse production of fruits and vegetables to meet the increased demand from the Armed Forces?

(a) Yes (b) No

22. Is the Agriculture Department supporting and guiding the farmers adequately in marketing their produce and opening stores?

(a) Yes (b) No

23. Is the Cooperative Department of UT enabling the supply of the vegetables?

(a) Yes (b) No

Part 4: Additional Comments (Please share any additional thoughts or comments you have about greenhouse technology adoption in Ladakh and its impact on your well-being)

Thank you for your participation!