

Final Report

Impact Assessment of Supporting Solar Cold Storage Systems, Nagaland (December 2022 – March 2024)

Study Duration: 1st October to 2025 - 07th December 2025

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List of Abbreviations

Abbreviation	Full Form
CSR	Corporate Social Responsibility
IDAN	Investment & Development Authority of Nagaland
OECD	Organisation for Economic Co-operation and Development -
DAC	Development Assistance Committee
OI	Outline India
SHG	Self-Help Group
FPO	Farmer Producer Organisation
IDI	In-depth Interview
SCSS	Solar Cold Storage System

A. Executive Summary

Axis Bank supported the implementation of the **Solar Cold Storage System Program** in partnership with the Investment & Development Authority of Nagaland (IDAN) under its Corporate Social Responsibility (CSR) mandate, to address persistent post-harvest losses, income instability, and limited cold-chain access faced by smallholder farmers in Nagaland. The program was implemented between **December 2022 and March 2024** across **16 locations**, introducing decentralised, solar-powered cold storage units designed to function effectively in remote, hilly, and electricity constrained contexts.

An independent impact assessment was undertaken following program completion to evaluate relevance, effectiveness, efficiency, impact, and sustainability. The assessment covered **four locations Kohima, Chümoukedima, Peren, and Mokokchung** and employed a mixed-methods approach comprising **60 structured quantitative surveys with farmer beneficiaries** and **10 qualitative in-depth interviews** with farmers, cold storage caretakers, and IDAN implementation staff.

Targeting and Relevance

The intervention successfully reached its intended beneficiaries. **73.3% of surveyed farmers cultivate one acre of land**, and agricultural production is dominated by perishable crops **vegetables (41%), spices (25%), and fruits (16%)** which are highly vulnerable to spoilage. Prior to the intervention, **54.2% of farmers reported losing between 26-50% of their produce**, and **6.3% reported losses exceeding 50%**, primarily due to the absence of local storage and the need to sell immediately after harvest.

Cultivation occurs year-round, with **41.7% of farmers cultivating in winter, 26.7% in summer, 18.3% in the monsoon**, and the remainder following mixed or crop-specific cycles. This continuous production of perishables confirms the sustained relevance of cold storage beyond a single season.

Effectiveness: Reduction in Losses and Improved Market Outcomes

The program delivered a **substantial reduction in post-harvest losses**. After accessing cold storage, **nearly 80% of farmers reported losses limited to 1-10%**, including **12.5% reporting losses below 2%** and a small proportion reporting **zero loss**. Farmers primarily used the facility for short-term storage (1-3 days), enabling them to preserve freshness, manage unsold produce between market days, and avoid distress selling.

Improved storage directly translated into **better price realisation and cost savings**. Farmers reported that by preventing spoilage and allowing delayed sales, they were able to sell produce at higher prices, often covering storage fees through even marginal

price improvements. Reduced wastage also resulted in **direct savings on input costs**, as produce that would otherwise have been discarded was successfully sold.

Efficiency and Capacity Utilisation

Operational performance was strong across locations. **91.7% of farmers reported never facing technical issues**, and cooling quality was rated as **good or excellent by over 95% of users**. Caretakers played a key role in ensuring smooth day-to-day operations, supporting users, and maintaining system reliability.

Cold storage capacity was **largely adequate across the program**. **81.3% of farmers reported that they were never unable to use the facility due to it being full**, while **16.7% experienced such constraints only sometimes**. Capacity constraints were **negligible** in **Kohima** (5 MT), **Chümoukedima** (15 MT), and **Peren** (15 MT), where **over 92% of farmers consistently found space available**. **Mokokchung**, operating with a **5 MT unit**, experienced relatively higher demand, with **40% of farmers reporting occasional or rare capacity constraints**, indicating strong utilisation rather than systemic inadequacy.

Affordability, Access, and Governance

Tariffs were widely perceived as affordable. **64.6% of farmers rated the storage fees as affordable or very affordable**, and only **2.1% considered them somewhat expensive**. Importantly, affordability did not emerge as a barrier to usage in any location. **33.3% of farmers reported not knowing the tariff**, a pattern driven almost entirely by **Mokokchung**, where storage costs are managed collectively by village institutions or caretakers. This community-managed model reduced individual-level tariff awareness but did **not affect access, affordability, or utilisation**.

Community-Level Benefits and Sustainability

Beyond individual farmers, the intervention generated **clear community-level benefits**. Farmers reported reduced overall wastage within villages, more stable market supply of fresh produce, and improved collective confidence in growing perishable crops. The presence of cold storage also reduced pressure to sell through middlemen, strengthening local market participation.

Acceptance of the intervention was high. **86.7% of farmers stated they would definitely recommend the facility**, and an additional **8.3% reported they would probably recommend it**. Regular use across seasons indicates that cold storage has become embedded in routine agricultural practices. While performance was strong overall, farmers and caretakers highlighted the need for **hybrid or backup power solutions** in cloud-prone areas and **context-specific capacity planning** in high demand locations to support long-term sustainability.

Overall CSR Assessment

The Solar Cold Storage System Program has delivered **measurable, outcome-oriented benefits** aligned with Axis Bank’s CSR objectives, including significant reduction in post-harvest losses, improved price realisation, cost savings for farmers, and enhanced community level resilience. With high utilisation, strong beneficiary satisfaction, affordable pricing, and minimal operational constraints, the intervention demonstrates a **scalable and replicable CSR model** for strengthening rural livelihoods in geographically challenging regions.

Key Data Points and Overall Metrics

High Performance
 Moderate Performance
 Low Performance

1. Relevance

Metric	Key Data Points	Rating
Perceived usefulness of storage	The cold storage facility was highly relevant to farmer needs, with over 80-90% of farmers reporting significantly improved freshness, reduced spoilage, and greater confidence in storing perishables. Pre-intervention losses were extremely high (54.2% losing 26-50% of produce), and post-storage losses dropped to 1-10% for nearly 80% of farmers, demonstrating clear usefulness.	
Alignment with farmer storage needs	Farmers primarily grow perishables (vegetables (41%), spices (25%), and fruits (16%)) all highly prone to spoilage. The storage unit directly addressed this need, with farmers reporting reduced distress selling and the ability to wait for better market prices. Usage aligned well with weekly market cycles and peak seasons such as festival periods.	
Accessibility & awareness	Awareness spread effectively, with 70% of farmers learning about the facility immediately after installation through village meetings and peer networks. While access was smooth in locations near main roads, terrain-related constraints in areas like Longkhum affected ease of use for some farmers.	






Suitability to geographic context	The solar-powered model fit Nagaland’s unreliable electricity conditions, and over 90% of farmers reported no technical issues. However, cloud-prone districts such as Kohima experienced reduced cooling efficiency, and poor roads limited transport for some farmers, giving it a moderately suitable profile.	
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2. Effectiveness

Metric	Key Data Points	Rating
Reduction in spoilage	The cold storage led to a substantial drop in post-harvest losses. Before the intervention, 54.2% of farmers lost 26-50% of their produce. After using the storage, spoilage fell sharply, with 52.1% reporting only 10% loss, 27.1% reporting 1-2%, and 4.2% reporting zero loss. This reflects strong effectiveness in preserving quality.	
Regular usage & behaviour change	Farmers incorporated cold storage into routine practice, using it to store produce overnight, hold unsold stock between market days, and avoid distress sales. Many reported feeling more confident in timing their sales, and a large majority expressed clear intent to continue using the facility in future seasons.	
Cooling performance & reliability	Storage performance was rated highly, with 83.3% describing cooling as good and 12.5% as excellent. Technical issues were minimal 91.7% never faced any problem and users appreciated timely support when required. Minor deviations were noted in cloud-heavy locations, but overall reliability remained strong.	
Capacity adequacy	While general operations were smooth, demand exceeded available capacity in some locations, especially during peak seasons. Around 23% of farmers recommended increasing unit size, and caretakers in busy sites reported occasional space shortages. This indicates moderate but not critical limitations.	
User experience & caretaker support	Farmers consistently described caretakers as supportive, approachable, and helpful in resolving queries. The caretaker played a key role in spreading	





awareness and ensuring smooth operation, contributing positively to user confidence and adoption.



3. Efficiency

Metric	Key Data Points	Rating
Operational performance & technical reliability	The system performed reliably across districts, with 91.7% of farmers reporting they never faced any technical issues, and only 8.4% experiencing occasional or frequent problems. Cooling quality was rated positively by the vast majority: 83.3% rated cooling as good , while 12.5% rated it excellent, indicating strong technical stability.	
Accessibility & logistics	Awareness of the facility rose rapidly after installation, with 70% of farmers learning about it post-installation . Accessibility varied widely: farmers in Longkhum reported difficult approach roads and often carried produce by hand, while users in Sovima and Jalukie reported smooth access with no transport challenges for most farmers .	
Capacity utilisation & peak-season pressure	Usage demand increased steadily, but 23% of farmers requested larger storage capacity due to space shortages in high-utilisation sites such as Meriema and Sovima. Although 39% reported no suggestions, many caretakers noted instances where the unit reached full capacity during peak harvests.	
Maintenance support & servicing efficiency	Maintenance support from Inficold was described as timely and effective. However, 14% of farmers recommended more frequent preventive maintenance, especially before peak seasons. District-wise reliability remained high, with 92.3% of users reporting no recurring issues .	
Energy reliability (solar performance)	Awareness of the solar-powered system was high at 88.3%, with universal awareness in Peren and Mokokchung. However, Kohima showed lower awareness (60%) and more frequent performance dips during extended cloudy spells, indicating the need for hybrid backup during monsoon and winter months.	




<p>Caretaker support & user interface</p>	<p>Caretakers played a central role in ensuring smooth operations, offering guidance on crop handling and assisting with storage. Although not quantified, qualitative findings consistently highlighted their responsiveness, contributing to streamlined user experiences across districts.</p>	
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4. Impact

Metric	Key Data Points	Rating
<p>Reduction in post-harvest losses</p>	<p>The cold storage intervention resulted in a significant reduction in post-harvest losses. Before the intervention, 54.2% of farmers experienced high losses of 26-50%, and 6.3% reported losses exceeding 50%. After using cold storage, 52.1% of farmers reduced losses to around 10%, while 29.2% reported losses of only 3-5% and 12.5% achieved minimal losses of 0-2%. Overall, losses shifted from widespread spoilage of 20-50% to largely 3-10%, demonstrating strong improvement in produce preservation.</p>	
<p>Ability to wait for better market prices</p>	<p>Farmers reported significantly improved flexibility in timing their sales. Many described using the facility to store unsold produce overnight or for several days, allowing them to avoid distress selling. While not captured numerically, qualitative evidence consistently highlights that farmers gained bargaining power and could access multiple markets when prices were favourable.</p>	
<p>Improvement in income and price realisation</p>	<p>Lower spoilage and better timing contributed to higher income stability. Farmers reported improved price realisation for vegetables, chillies, and fruits due to better quality retention. District-level patterns show similar positive trends, with users in all four districts citing income gain as a key benefit of the facility.</p>	
<p>Community-level benefits and shared use</p>	<p>A majority of farmers perceived community-wide gains: Peren (80%), Mokokchung (93.3%), Chümoukedima (66.7%), and Kohima (73.3%). The facility supported collective market stability, reduced village-level wastage, and ensured fresher produce availability across local markets.</p>	

<p>Employment effects</p>	<p>Perceptions of employment creation were limited. While 51.7% of farmers were unsure whether new opportunities were created, only 3.3% reported “many opportunities” and 25% reported “some opportunities.” Most visible roles were caretakers and informal support in loading and transport.</p>	
<p>Improved agricultural resilience and market participation</p>	<p>Farmers described higher confidence in growing perishables, reduced stress from potential spoilage, and a shift towards more structured decision-making around harvest and sale timing. These changes, while qualitative, indicate stronger adaptive capacity and enhanced participation in local markets.</p>	

5. Sustainability

Metric	Key Data Points	Rating
<p>Long-term intention to use the facility</p>	<p>Farmers expressed extremely strong intent to continue using the cold storage in future seasons. 86.7% said they would “definitely recommend” the facility to other farmers, while 8.3% said they would “probably recommend” it. Only 3.3% in Kohima and 1.7% in Peren expressed hesitation. This high endorsement reflects strong perceived usefulness and long-term relevance.</p>	
<p>Community ownership and collective responsibility</p>	<p>Village councils and caretakers played active roles in managing access and maintaining informal norms. While not quantified numerically, qualitative accounts show growing community anchoring across most districts. Some locations demonstrated stronger ownership than others, suggesting a maturing but uneven foundation for long-term community stewardship.</p>	
<p>Integration into regular agricultural practice</p>	<p>Farmers increasingly planned harvest volumes and market participation around the availability of cold storage. Many described storing unsold produce overnight to prepare for next-day markets or peak-demand events. The consistent use across multiple seasons indicates that the system has become embedded in routine agricultural decision-making.</p>	

<p>Environmental and technical sustainability of the solar system</p>	<p>Awareness of the solar-powered model was high at 88.3%, including 100% awareness in Peren and Mokokchung. However, Kohima showed lower awareness (60%) and more frequent cooling inconsistencies during prolonged cloudy spells. While reliability remained strong overall, district-level variation indicates the need for hybrid backup systems in certain geographies.</p>	
<p>Potential for scale-up and expansion</p>	<p>Rising utilisation and strong user satisfaction point to clear demand for expansion. 23% of farmers requested increased storage capacity, and qualitative findings highlight interest from neighbouring villages for similar units. With endorsement rates exceeding 90%, the model demonstrates strong potential for scale-up across Nagaland.</p>	

B. Introduction

Agriculture remains the backbone of rural livelihoods in Nagaland, with smallholder farmers depending heavily on perishable crops for income and sustenance. However, the region faces persistent post-harvest challenges, including limited access to cold storage, inadequate supply chain infrastructure, and distant or volatile markets. These constraints often force farmers into distress selling, resulting in significant wastage and reduced profitability, particularly for vegetables and other perishable produce. The challenges are further amplified in Nagaland’s hilly and geographically dispersed landscape, which makes conventional cold chain solutions both costly and difficult to implement.

To address these issues, Axis Bank, under its Corporate Social Responsibility (CSR) mandate, partnered with the Investment & Development Authority of Nagaland (IDAN) to implement the Solar Cold Storage System Program across Nagaland. The program was implemented in two phases - **Phase I between December 2022 and March 2023**, and **Phase II between April 2023 and March 2024** covering a total of **16 locations across the state**. The initiative aimed to reduce post-harvest losses, improve farmer incomes, and promote a decentralised, renewable-energy-based cold chain infrastructure suited to the state’s geographic and infrastructural context. The intervention targeted individual farmers, farmer groups, and self-help groups (SHGs), providing solar-powered cold storage units along with training and capacity-building support to ensure effective operation and maintenance. By extending the shelf life of produce and enabling better market access, the program sought to strengthen local agricultural value chains and enhance economic resilience for farming communities.

Recognising the need for evidence-based insights to guide future initiatives, Axis Bank commissioned an independent Impact Assessment following the completion of program implementation in March 2024. The assessment evaluates the effectiveness, adoption, and outcomes of the Solar Cold Storage System Program, with a focus on how farmers and communities have engaged with the storage units, the operational efficiency of the facilities, economic benefits such as increased income and reduced distress sales, and the effectiveness of training and support provided during both phases of implementation. Additionally, the study seeks to identify enabling factors and constraints influencing program performance, sustainability, and potential for replication in other regions.

Through this assessment, Axis Bank aims to generate actionable recommendations that can inform the design of similar initiatives, strengthen the sustainability of solar-powered cold storage solutions, and contribute to improved livelihoods and agricultural productivity across rural Nagaland.

C. Key Objectives

The assessment aims to generate evidence-based insights about the overall impact of the program. The specific objectives of the assessment include:

- **Assess the extent of adoption and utilization** of solar-powered cold storage units by individual farmers, farmer groups, and self-help groups (SHGs) across the implementation sites.
- **Evaluate the operational efficiency and usage patterns** of the cold storage units, including duration, frequency, and types of produce stored.
- **Impact of the program on post-harvest loss reduction**, particularly in terms of reduction in spoilage and wastage of perishable agricultural produce.
- **Examine the change in beneficiaries' income levels and market linkages** attributable to improved produce preservation and reduced dependency on distress sales.
- **Evaluate the effectiveness and reach of the training and capacity-building support** provided to farmers and stakeholders for the usage and maintenance of the units.
- **Document beneficiary perceptions and satisfaction** with the intervention, along with any unintended outcomes or challenges faced during implementation.
- **Identify enabling and limiting factors** that influenced the program's performance, sustainability, and potential for replication or scale-up in similar contexts.
- **Provide actionable recommendations** for enhancing the design, delivery, and long-term sustainability of cold storage infrastructure programs in rural and agrarian communities.

D. Methodology

1. Study Design

Outline India (hereafter OI) adopted a comprehensive **mixed-methods approach** to rigorously assess the outcomes and impacts of the Solar Cold Storage System Program. This approach combined quantitative and qualitative methodologies to capture both measurable results and contextual insights from beneficiaries and other stakeholders. OI adopted the **OECD-DAC framework**, which facilitated assessment across five key criteria: **relevance, effectiveness, efficiency, impact, and sustainability**. This framework **ensured** that the evaluation aligned with the program’s stated objectives while generating actionable insights for improving future interventions.

2. Study Location and Sampling

The Solar Cold Storage System Program was **implemented across 16 locations** in Nagaland. For this impact assessment, Outline India (OI) **focused on four key locations** that reflect diverse geographical and operational contexts:

- **Kohima** (Meriema) - **5 MT** Solar Cold Storage Unit
- **Mokokchung** (Longsa) - **5 MT** Solar Cold Storage Unit
- **Peren** (Tening/Jalukie cluster) - **15 MT** Solar Cold Storage Unit
- **Chümoukedima** (Sovima) - **15 MT** Solar Cold Storage Unit

Within each selected location, **two to three villages** situated near the solar cold storage units were included to ensure adequate representation of beneficiary experiences and usage patterns. In total, the study covered eight villages across the four locations.

A **purposive and stratified sampling approach** was adopted to identify respondents. Farmers were selected from the beneficiary lists provided by the IDAN team, ensuring that only those who had engaged with the solar cold storage units were included. From each location, **15 farmers were randomly selected, resulting in a total quantitative sample of 60 farmers**. The sample included **individual farmers, farmer groups, and self-help groups (SHGs)**, allowing for representation across different categories of program beneficiaries and capturing variations in usage, access, and outcomes.

The table below summarises the **quantitative and qualitative sample** across the stakeholder groups:

Type	Stakeholder	No. of locations (where Solar Cold Storage System is established)	No. of Surveys per location	Total
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Structured Quantitative Surveys	Farmer beneficiaries	4 (2 villages to be visited for each solar cold storage which are situated in close vicinity)	15	60
Total: Quantitative surveys				60
In-depth interviews	Farmer beneficiaries	4	1	4
	Solar Cold Storage System caretaker	4	1	4
	Program/ implementation team from IDAN	NA	NA	2
Total: Qualitative interviews				10

Note : - While data collection was ongoing, Wokha was replaced with Chümoukedima due to the non-availability of eligible respondents in Wokha. This change was discussed with and approved by Axis Bank and did not affect the overall study design or sample size.

3. Study Respondents

OI proposes to engage the following key stakeholders in this impact assessment across the sampled locations:

- **Farmer beneficiaries** who benefited from the Solar Cold Storage System program
- **Solar Cold Storage System caretaker** associated with the program and managing the Solar Cold Storage System in the selected location
- **Member of the Program/ implementation team** from the Investment & Development Authority of Nagaland (**IDAN**) associated with this program

4. Tool description

- I. **Quantitative Survey Tool-** The quantitative survey tool consisted of a structured, in-person questionnaire administered to farmer beneficiaries and designed to be completed in approximately 15 minutes. The survey captured a range of information on awareness and usage of the Solar Cold Storage System, types of produce stored, and the frequency and duration of storage. Farmers were also asked about changes in post-harvest losses, reductions in spoilage, and resulting income effects. Additional sections explored access to markets,

sales outcomes, satisfaction with the storage system, and the training received, along with suggestions for system improvement.

- II. **Qualitative in-depth interview (IDI) guide for farmer beneficiaries**, the tool focused on overall experience with the Solar Cold Storage System, usage patterns and the suitability of the system for different types of produce. It examined changes in their post-harvest management practices, perceived benefits such as reductions in crop losses and improvements in income, and operational challenges they encountered while using the system.
- III. **Qualitative IDI guide for Solar Cold Storage System caretakers**: The tool focused on operational and management aspects, including daily functioning, maintenance practices, user engagement, and the support provided to farmers. It also explored technical challenges, usage patterns, and perceived community benefits, along with recommendations for improving system operations.
- IV. **Qualitative IDI guide for the IDAN program and implementation team**: The tool explored implementation-level perspectives, including program design and rollout, training and capacity-building efforts, coordination processes, and operational challenges, along with mitigation strategies. It also captured perceptions of program outputs, outcomes, early impacts, and recommendations to improve delivery and sustainability.

Each interview was conducted in approximately 20 minutes.

E. Study Findings

This section presents the findings from the assessment of the Solar Cold Storage initiative implemented across four locations in Nagaland. The analysis is structured according to the OECD-DAC evaluation criteria to evaluate the program's performance across dimensions of **relevance, effectiveness, efficiency, impact, and sustainability**.

The study draws on evidence generated through **60 structured quantitative surveys** with farmer beneficiaries residing in villages situated near the solar cold storage units. To complement the quantitative assessment, **10 qualitative interviews** were conducted, comprising **4 farmer beneficiaries, 4 cold storage system caretakers, and 2 members of the IDAN program/implementation team**. Together, these data sources provide both the breadth and depth required to understand the operational functioning of the cold storage units, beneficiary experiences, and the emerging economic and behavioural outcomes of the intervention.

The analysis examines the extent to which the Solar Cold Storage Program has supported farmers in reducing post-harvest losses, improving produce shelf life, enhancing market timing, and stabilising income through better price realisation. It also explores awareness and usage patterns, caretaker roles, operational challenges,

and the broader influence of improved storage access on agricultural decision-making within the community.

The subsections that follow present the findings under each OECD-DAC criterion, offering a comprehensive understanding of program performance and the lived experiences of participating households.

I. Relevance

This section examines the relevance of the Solar Cold Storage initiative implemented under the IDAN Axis Bank partnership by assessing the extent to which the intervention corresponded with the agricultural and post-harvest needs of farmers across the four selected locations in Nagaland. The analysis draws on quantitative findings from 60 farmer surveys and qualitative insights from interviews with farmer beneficiaries, caretakers, and program personnel to determine whether the intervention’s design, placement, and operational model were appropriate for the target group.

This module evaluates the alignment of the cold storage services with farmers’ storage challenges, their contextual appropriateness, and the suitability of the technology for local agro-ecological and infrastructural conditions.

The analysis in this section is guided by the following key research questions:

Table: Key Research Questions and Indicators (Relevance)

Sl. No.	Research Question	Indicators
1	Was the program delivered to an appropriate target group?	Demographics, education, occupation, landholding, FPO/SHG membership
2	Did the intervention address farmers’ post-harvest storage needs?	Land size, harvest quantity, seasonal production, spoilage levels, storage use
3	How well did the program align with local agricultural value chains?	Crop types, perishability, market timing, distress selling, middlemen dependence
4	Was the initiative appropriate for the geographic and infrastructural context?	Terrain, distance to markets, electricity reliability, suitability of solar systems
5	How accessible were the cold storage units to community members?	Awareness channels, timing of awareness, proximity, ease of access

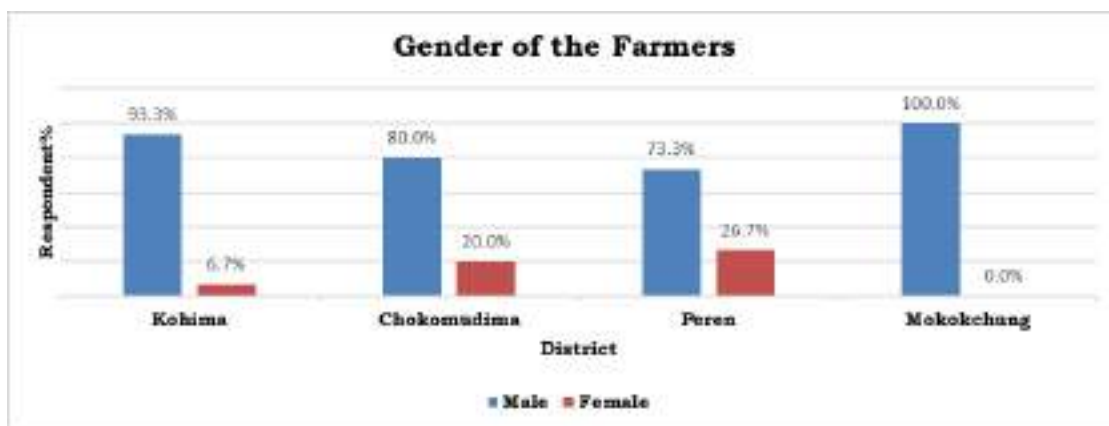
1.1 Profile and Appropriateness of the Target Group

The program reached a relevant and representative group of farmers across the four districts, with **25% of the sample from each location** (Kohima, Chokumodima, Peren, and Mokokchung)

District Name	Sample Covered	% of the sample Covered
Kohima	15	25
Chokomudima	15	25
Peren	15	25
Mokokchung	15	25
Grand Total	60	100

Across all four locations, the respondent **pool was predominantly male**, though the proportion varied by district. **Kohima (93.3%), Chokoma (80%), Peren (73.3%), and Mokokchung (100%)** were all overwhelmingly represented by male farmers, with **female participation ranging from 0% in Mokokchung to 26.7% in Peren**. This pattern aligns with local gender norms in agricultural work and market engagement, where men typically take on more mobility-intensive and market-facing roles, resulting in lower survey representation of women.

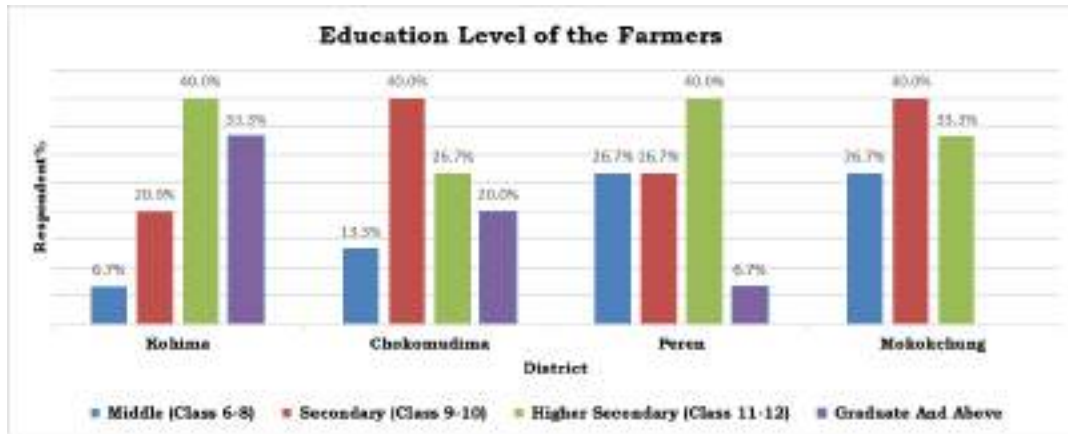
Fig 1



The education profile of farmers shows that most respondents across districts have completed **Secondary (31.7%)** or **Higher Secondary (35%)** education, indicating a moderately educated user base well-positioned to understand and adopt new technologies like cold storage. Kohima stands out with the highest share of **graduates (33.3%)**, reflecting its more urban and institutionally connected context. In contrast, Peren and Mokokchung have very few graduates, with most respondents concentrated

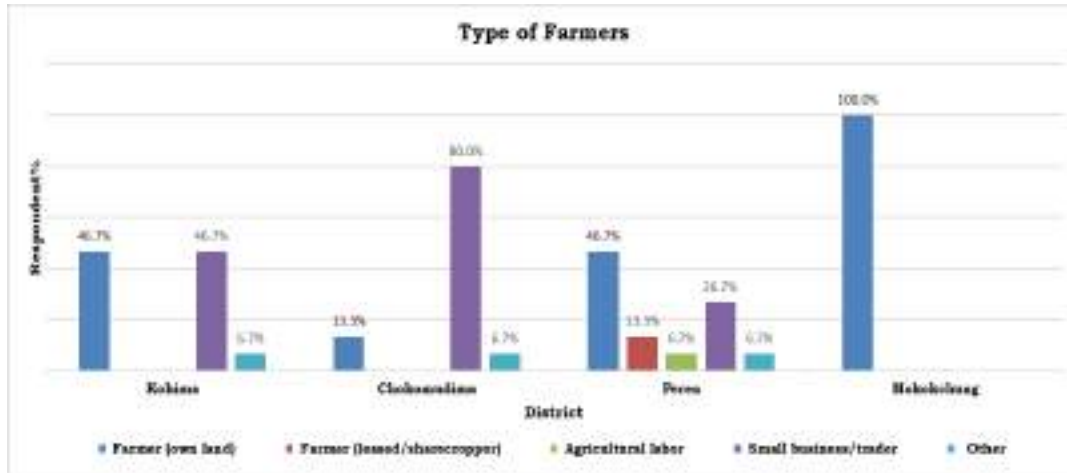
in Middle and Secondary levels, suggesting a more traditional rural educational profile. Despite these variations, all districts show a substantial proportion of farmers educated up to Class 10-12, supporting the suitability of practical, easy-to-understand training and communication methods across all locations.

Fig 2



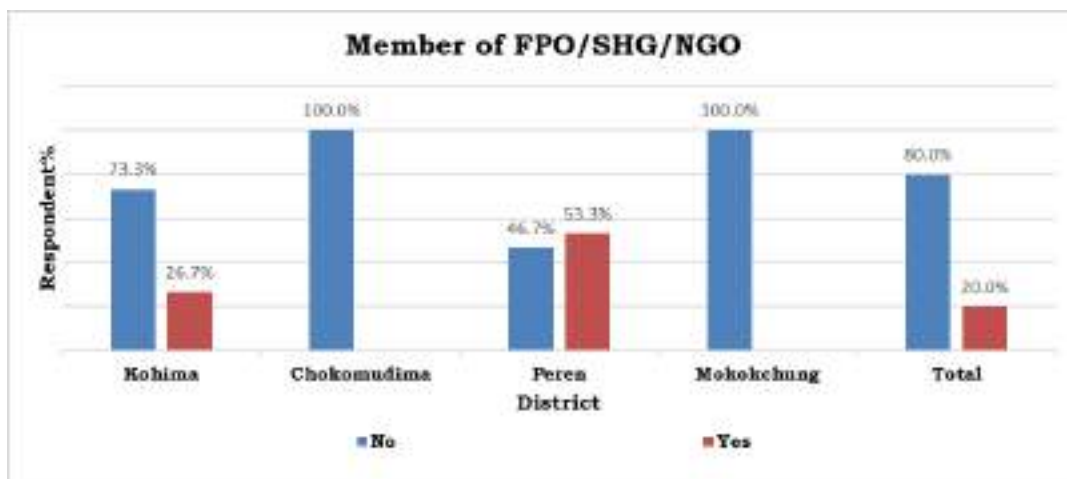
The occupational profile shows that just over half of all **respondents (51.7%) are farmers cultivating their own land**, confirming that the cold storage intervention is reaching its intended target group. This pattern is strongest in Mokokchung, where all respondents (100%) are own-land farmers, and in Kohima and Peren, where nearly half fall in the same category. Chümoukedima, however, has a different profile, with 80% engaged in small businesses or trading reflecting its more commercial, peri-urban character. Small business/trader activity is also notable in **Kohima (46.7%)** and **Peren (26.7%)**, suggesting that many respondents combine farming with market-based income. Very few respondents identified themselves as agricultural **labourers (1.7%)** or **sharecroppers (3.3%)**, indicating limited landlessness in the sample. Minor categories such as contractor, entrepreneur, or private job holders appear only sporadically.

Fig 3



Across districts, a large majority of farmers (80%) are not part of any FPO, SHG, or NGO, indicating that most operate independently rather than through organised collectives. Membership is highest in Peren, where over half of respondents (53.3%) belong to such groups, suggesting a stronger culture of community-based farming networks. In contrast, Chümoukedima and Mokokchung show no membership at all, and Kohima has only a small share (26.7%) associated with farmer groups. This pattern highlights that while organised platforms exist in some areas, most farmers rely on individual decision-making and direct market participation. It also reinforces the relevance of decentralised cold storage models, which do not depend on collective membership for access or usage.

Fig 4



Qualitative narratives reaffirm that the program successfully reached the intended target group, smallholder farmers cultivating highly perishable crops such as tomatoes, chillies, Naga King Chilly, oranges, and cabbages across Longkhum, Chungkhumo, Jalukie, and Sovima. These crops are highly vulnerable to spoilage, making short-term storage particularly valuable. Farmers also noted that their small

landholdings require frequent harvesting, increasing the relevance of a decentralised cold storage solution. As one farmer from Meriema market shared,

Most respondents were not part of any FPO or organised group, yet they reported being able to access the facility without barriers. A farmer from Sovima explained,

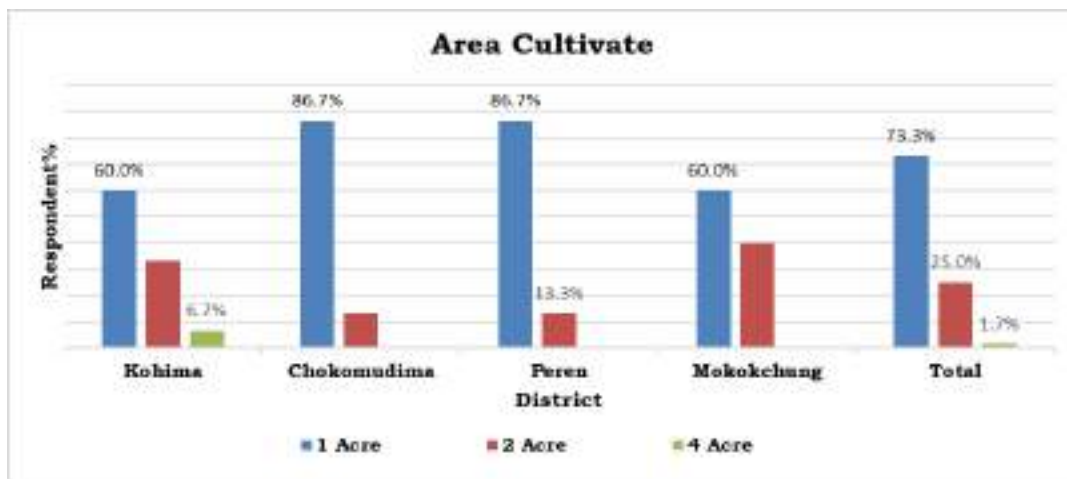
“Even though I am not part of any FPO, I can use it whenever I need.” - Farmer, Sovima village, Chümoukedima

This demonstrates that, these insights confirm that the community-level, solar-powered cold storage model effectively catered to individual smallholders, reinforcing the relevance and inclusiveness of the program’s targeting strategy.

1.2 Alignment With Post-Harvest Storage Needs

The data shows that most respondents are smallholder farmers, with 73.3% cultivating just 1 acre of land. This pattern is consistent across districts, particularly in Chümoukedima and Peren, where 86.7% of farmers operate on 1 acre. A smaller segment (25%) cultivates 2 acres, with slightly higher representation in Kohima (33.3%) and Mokokchung (40%), indicating pockets of moderately larger landholdings. Only one respondent (1.7%), from Kohima, reported cultivating 4 acres, showing that large holdings are rare. Overall, the dominance of small land sizes underscores the need for short-term, decentralised storage solutions tailored to frequent, small-volume harvests reinforcing the appropriateness of the solar cold storage intervention for this user base.

Fig 5



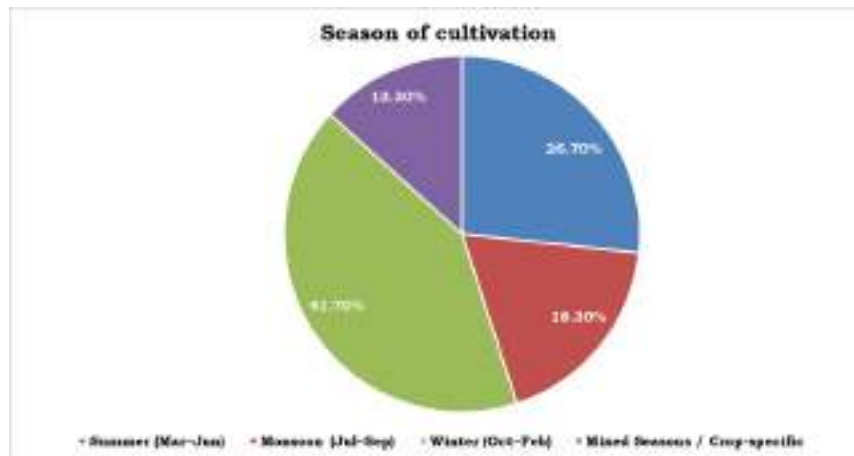
This pattern is clearly visible in the distribution of harvest quantities. A significant **38.3% of farmers harvest up to 500 kg** of produce, highlighting the predominance of low-volume production. Additionally, **11.7% each** fall within the **501-1000 kg**, **1001-3000 kg**, and **3001-5000 kg** categories, reinforcing the observation that even among slightly larger growers, output remains modest. The relatively even spread

across these mid-range categories indicates variability in crop type and seasonal yield, yet still aligns with the overall smallholder profile. Together, these trends illustrate that **cold storage is not merely supportive but essential**, enabling farmers to manage perishability, reduce spoilage, and strategically time market sales despite their limited scale of production.

On average, how much produce do you harvest annually?	Kohima	Chokomudima	Peren	Mokokchung	Total %
0-500 kg	46.0%	40.0%	47.0%	20.0%	38.3%
501-1000 kg	13.0%	13.0%	13.0%	7.0%	11.7%
1001-3000 kg	7.0%	7.0%	13.0%	20.0%	11.7%
3001-5000 kg	7.0%	7.0%	13.0%	20.0%	11.7%
5001+ kg	7.0%	0.0%	7.0%	7.0%	5.0%
Other (pieces, etc.)	20.0%	33.0%	7.0%	26.0%	21.7%

Seasonality patterns further reinforce this alignment. As shown in **Figure 6**, cultivation takes place across multiple seasons, with **41.7% of farmers reporting winter cultivation, 26.7% summer cultivation, 18.3% monsoon cultivation, and 13.3% indicating mixed or crop-specific seasonal patterns.** This year-round spread of cultivation highlights that perishable produce is generated in every season, making access to cold storage a consistently relevant and valuable resource rather than a seasonal or occasional support mechanism.

Fig 6



Seasonal differences in harvest volumes further reinforce this alignment. The analysis shows that **smaller harvest quantities are more common during the winter season**, with **75% of farmers harvesting up to 500 kg doing so in winter**, reflecting frequent, low-volume harvesting of perishable crops. In contrast, **higher harvest volumes are concentrated in the summer months**, when all harvests above 1000 kg are reported, indicating peak production periods and increased storage demand. At the same time, a substantial share of farmers across both seasons reported harvest quantities in pieces or non-weight measures, highlighting the small-scale and dispersed nature of agricultural production. Together, these patterns indicate that storage needs vary by season, underscoring the importance of flexible, decentralised cold storage systems that can support farmers throughout the year.

Distribution of Harvest Quantity by Season of Cultivation

Harvest Quantity (Grouped)	Summer (Mar–Jun)	Winter (Oct–Feb)	Total
0–500 kg	25.0%	75.0%	100%
501–1000 kg	57.1%	42.9%	100%
1001–3000 kg	100.0%	0.0%	100%
3001–5000 kg	100.0%	0.0%	100%
5001+ kg	100.0%	0.0%	100%
Other / pieces	47.4%	52.6%	100%

Qualitative insights clearly demonstrate that the cold storage intervention directly addressed farmers’ most pressing post-harvest challenges. Across all four locations, farmers described experiencing **significant spoilage and quality deterioration** before the facility was introduced, particularly during peak harvest periods when market saturation forced immediate sales. A farmer from Longkhum noted,

“Before the cold storage, a large portion of my produce would go to waste if I couldn’t sell it the same day.” - Farmer - Sovima Chümoukedima

“Depending on the number of produce I harvest, I decide how much to store.” - Farmer, Meriema market- Kohima

In Sovima, a farmer estimated losing “30 to 40 percent” of his harvest earlier due to the lack of storage and reported that losses had now decreased to roughly “8 percent.” Several respondents emphasised that the facility helped them manage unsold produce from weekly markets, with one Jalukie, Perern farmer explaining,

“If I can’t sell everything in the market, I store it overnight and use it the next day without loss in quality.” farmer- Jalukie, Perern

These narratives reflect the strong alignment between farmers’ storage needs rooted in small, frequent harvests and high spoilage risk and the intervention’s design as a short-term, village-level solution for preserving freshness, preventing wastage, and stabilising market participation.

1.3 Alignment With Local Agricultural Value Chains

The Solar Cold Storage initiative is well aligned with the structure and needs of the local agricultural value chain in Nagaland, where farming is dominated by smallholder households cultivating highly perishable crops. These perishables, particularly vegetables, spices, and fruits, require careful handling and short-term storage to retain freshness and market value. The intervention directly addresses long-standing gaps in the region’s post-harvest ecosystem, providing decentralised cooling solutions that reduce losses and allow farmers to optimise market timing.

Survey data indicates that **vegetables (41.23%)** make up the largest share of crops grown, followed by **spices such as king chilli, turmeric, and ginger (24.56%)**, **fruits (15.79%)**, and smaller shares of **rice/paddy (7.89%)** and **pulses/legumes (7.02%)**. Only **3.51%** of farmers reported cultivating other niche or specialty crops. This distribution underscores a strong dependence on produce that is extremely vulnerable to spoilage, making cold storage both relevant and necessary.

Farmers provided specific examples of what they grow and store, including tomatoes, cabbage, long beans, oranges, lemons, papayas, avocados, kiwi, persimmon, and even fresh flowers. Many of these crops experience rapid deterioration under warm and humid conditions typical of the region, reinforcing the importance of accessible cooling solutions.

Main Crops Cultivated and Their Relevance to Cold Storage:-

What are the main crops/produce you grow?	Share of Farmers (%)	Examples Mentioned by Farmers	Why Cold Storage Helps
Vegetables	41.23%	Tomatoes, cabbage, long beans	Extends shelf life; reduces heat damage; supports staggered selling

Spices	24.56%	King chilli, turmeric, ginger	Prevents shrinkage; preserves aroma and quality
Fruits	15.79%	Kiwi, persimmon, orange, lemon, papaya, avocado	Slows ripening; reduces bruising; maintains market grade
Rice/Paddy	7.89%	-	Reduces moisture exposure, helpful in monsoon months
Pulses/Legumes	7.02%	-	Protects from humidity and fungal damage
Other	3.51%	Fresh flowers, frozen foods	Preserves freshness; reduces wilting; supports higher-value market

These trends demonstrate that farmers often harvest in **small batches**, making traditional large-capacity storage unsuitable. The decentralised solar cold storage model, which accommodates small quantities and provides day-to-day storage flexibility, is therefore an excellent fit for these communities.

This alignment underscores why cold storage is not just useful but strategically positioned to meet the core needs of small-scale producers in Nagaland.

Qualitative evidence illustrates that the cold storage intervention is well aligned with the structure and constraints of Nagaland’s local agricultural value chains. Farmers across Longkhum, Chungkhamo, Jalukie, and Sovima described a long-standing dependence on **immediate post-harvest selling**, driven by the absence of storage and the highly perishable nature of their crops. This often resulted in distress sales during market gluts. As one farmer from Longkhum noted,

“When everyone harvests at the same time, the price falls. Earlier, we had no choice but to sell quickly.” - Farmer, Longkhum, Mokokchung

The availability of cold storage now enables farmers to **delay sales strategically**, wait for better prices, and stabilise income. Respondents also highlighted that storing produce for even **two to three days** makes a substantial difference in market opportunities. A farmer from Jalukie explained,

“If the price is low, we keep it for a day or two and sell when it improves. This was not possible before.” - Farmer, Jalukie, Perern

Several farmers further shared that having local storage reduces dependence on middlemen and supports more direct market engagement. This aligns with quantitative findings showing reduced distress selling and higher flexibility in choosing when to sell.

Overall, qualitative narratives confirm that the solar cold storage units fit seamlessly into local value chains by strengthening farmers’ ability to manage perishables, avoid rushed transactions, and secure better returns, thereby addressing a critical systemic bottleneck in Nagaland’s agricultural markets.

1.4 Responsiveness to Geographic & Infrastructural Conditions

The selected districts are characterised by hilly terrain, dispersed settlements, and inconsistent electricity supply, conditions that hinder traditional cold storage models. A solar-powered solution is therefore particularly relevant.

Farmers’ location-specific characteristics reinforce this need: Mokokchung had 100% male respondents, indicating strong male-led market engagement, while Peren and Kohima had more mixed gender participation. Across all districts, the geographic spread demands decentralised storage that does not rely on grid electricity, an alignment reflected in the program design.

Qualitative findings strongly reinforce that the solar-powered cold storage model is highly suited to Nagaland’s geographic and infrastructural realities. Farmers repeatedly described the challenges posed by **hilly terrain, dispersed settlements, and unreliable electricity**, all of which make conventional grid-dependent storage impractical. A farmer from Chungkhamo noted,

“Our electricity goes off very often. A normal cold storage would not work here.”- Farmer, Kohima

The decentralised location of units within or near villages was also appreciated, as it reduces transportation burdens and prevents spoilage during travel. Respondents emphasised that long distances to markets increase losses, making proximate storage particularly valuable. As shared by a farmer from Jalukie

“Earlier, by the time we reached the town market, some vegetables would already spoil. Now we can store them safely first.” - Farmer, Jalukie, Peren

Caretakers and village leaders further highlighted that the solar system ensures **continuous cooling even during outages**, improving reliability. In Sovima, a caretaker remarked,

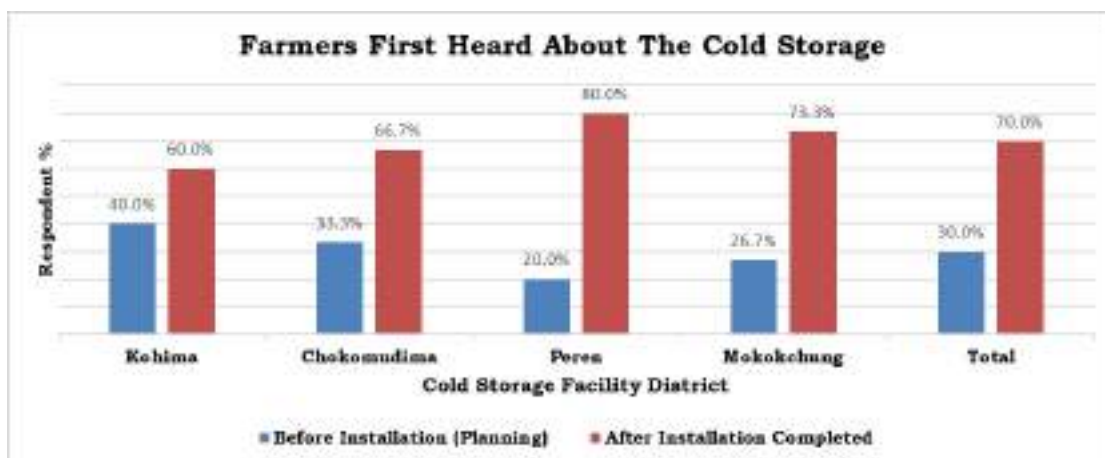
“Even when power fails, the solar keeps it running. That is why farmers trust this facility.” - Caretaker, Sovima, Chümoukedima

Taken together, these narratives confirm that the intervention is well-designed for Nagaland’s infrastructural constraints, offering a dependable, locally accessible solution that traditional cold storage cannot provide.

1.5 Accessibility and Awareness of the Facility

The majority of farmers across all districts learned about the cold storage facility **only after installation was completed**, with 70% reporting post-installation awareness. This pattern is consistent across locations, with especially high shares in Peren (80%) and Mokokchung (73.3%). Awareness during the installation phase was moderate (16.7%), with the highest incidence in Mokokchung (26.7%), suggesting some level of community visibility as the units were being set up. Only a small proportion (13.3%) learned about the facility during the planning stage, primarily in Kohima (33.3%), where local councils and community groups tend to engage earlier in infrastructure discussions. The relatively low planning-phase awareness in other districts indicates that early consultation was limited, but strong post-installation communication ensured that most farmers quickly became aware of the facility once it became operational. Overall, the data suggests that awareness spread effectively through community networks after installation, even if early-stage engagement varied by district.

Fig 7



Qualitative insights indicate that the cold storage facilities were **highly visible and easily accessible** to farmers across locations. In most villages, word-of-mouth through

community networks, particularly **village councils and fellow farmers** played a central role in spreading awareness. As one farmer from Longkhum shared,

“We heard about it in the village meeting, so everyone came to see how it works.” - Farmer - Longkhum, Mokokchung

Farmers also emphasised that the **proximity of the storage units** significantly reduced the burden of transporting produce long distances, especially for those living in remote hamlets. A farmer from Sovima explained,

“It is close to our fields, so we can store vegetables the same day we harvest.” - Farmer - Sovima, Chümoukedima

Caretakers echoed this view, noting that footfall increased rapidly once farmers realised the convenience. A caretaker from Chumukedima remarked,

“Initially only a few came, but once they saw how easy it was to use, more farmers started coming regularly.” - Caretaker, Chumukedima

These insights confirm that the facilities were not only well-publicised through trusted community channels but also strategically located to maximise accessibility, reinforcing their relevance and ease of adoption among smallholders.

II. Effectiveness

This section examines how effectively the Solar Cold Storage initiative improved post-harvest management practices, reduced spoilage, and enhanced farmers’ ability to make better marketing decisions. The analysis combines quantitative findings from 60 farmer surveys with qualitative insights from farmer interactions and caretaker interviews. Emphasis is placed on understanding how farmers used the facility, why they continued using it, and what changes the availability of cold storage brought to their daily decision-making and income-related strategies.

Prior to the intervention, farmers across the four districts commonly relied on makeshift storage methods, storing produce in shaded areas, temporary bamboo structures, or directly on household floors, options that offered limited protection from humidity, heat, and pests. The introduction of a systematic, temperature-controlled facility created an entirely new possibility for handling perishable produce, and the following sections explore how well the intervention fulfilled this purpose.

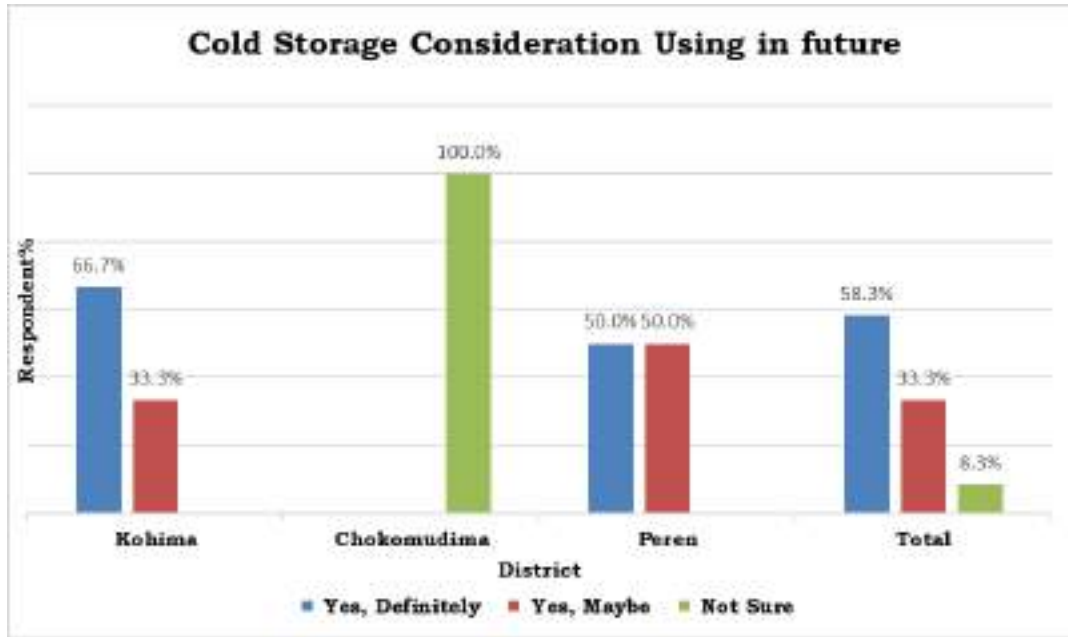
Table: Key Research Questions and Indicators (Effectiveness)

Sl. No.	Key Research Question	Indicators Used
1	Did farmers regularly use the cold storage facility?	Continued usage, frequency of use
2	Did the facility help reduce spoilage and improve produce management?	Storage duration, primary reason for use, seasonality
3	Was the facility technically reliable and well-maintained?	Cooling efficiency, quality ratings, technical issues
4	Were operating hours and capacity adequate?	Convenience of operating hours, capacity challenges
5	Was the tariff structure clear and affordable?	Tariff awareness, affordability perceptions
6	Did farmers receive adequate support from the caretaker/operator?	Caretaker behaviour and support ratings
7	Were results consistent across the four districts?	District-wise variations

2.1 Uptake and Integration into Routine Practice

Farmers expressed a strong willingness to use the cold storage facility in the future, with **over 90% indicating definite or potential interest**. Among the non-users surveyed, **58.3% stated they would “definitely” use the facility**, while another **33.3% said “maybe,”** indicating openness to adoption once they better understand the benefits or gain easier access. District-wise patterns show notable variation: Kohima farmers demonstrated the highest certainty, with **66.7% expressing definite willingness**, reflecting strong perceived relevance. In Peren, responses were evenly split between “definitely” and “maybe,” suggesting growing but cautious interest. Chümoukedima is the only location where the sole respondent reported being “not sure,” indicating the need for targeted awareness or demonstration activities. Overall, the findings suggest a positive adoption pipeline, where initial exposure and facility familiarity are likely to translate into increased usage over time.

Fig 8



Farmers repeatedly highlighted that cold storage helped them avoid the stress of “same-day selling.” Instead of rushing to market immediately after harvest, they could store produce for a few days and wait for better prices or better weather conditions.

Qualitative Findings from farmers and caretakers indicate that the cold storage has been increasingly integrated into farmers’ routine post-harvest practices. Many respondents shared that the facility is now used **whenever harvest volumes exceed immediate household needs** or when market prices are temporarily low. A farmer from Jalukie explained,

“Whenever the price drops, I store my chillies for a day or two instead of selling in a hurry.” - Farmer, Jalukie, Perern

Farmers also reported that they have gradually begun planning harvest and sales cycles around the availability of cold storage, particularly during peak seasons. In Mokokchung, one farmer shared

“After seeing the benefit once, we now use it every time we have more than we can sell.” - Farmer, Longkhum, Mokokchung

Caretakers further observed that usage has increased steadily as farmers became familiar with the system. A caretaker from Sovima highlighted this shift:

“At first they came only occasionally, but now most farmers store their produce whenever they harvest in bulk.” Caretaker - Sovima, Chümoukedima

Farmers engaged in both cultivation and small-scale trading expressed that the storage facility has now become a routine part of their income strategy. A trader-farmer from Chumukedima shared,

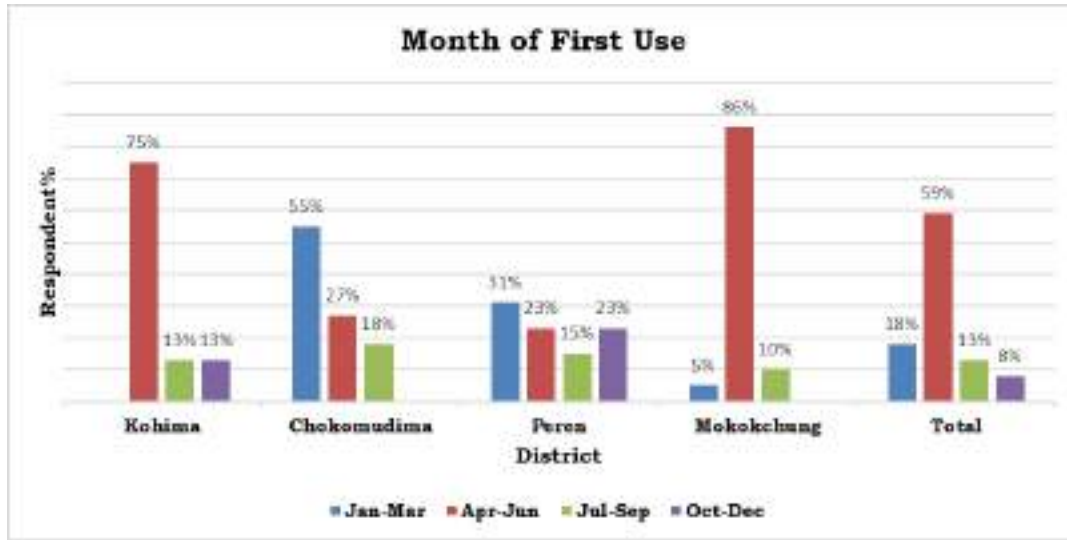
“It has become part of our regular practice... we store first and then decide when to sell.” - Farmer-trader, Chumukedima

These qualitative findings show that the cold storage is not being used sporadically but has become a **consistent and planned component of farmers’ post-harvest routines**, reinforcing the quantitative evidence on adoption and regular usage patterns.

2.2 Seasonal Timing and First Use

The seasonal distribution of cultivation shows that farming activity in Nagaland is heavily concentrated in the **summer months (April-June)**, with 36 farmers **60% of the sample** reporting production during this period. This aligns with the peak growing season for key vegetables and spices. Early-year cultivation (January-March) is moderate, with 11 farmers (18.3%), mainly concentrated in Chokomudima and Peren. Monsoon-season production (July-September), although risky due to humidity, is still practiced by 8 farmers across all districts, reflecting the need to grow perishables year-round. Post-monsoon and winter cultivation (October-December) accounts for 5 farmers, mainly from Kohima and Peren. The even spread across districts suggests that all regions engage in multi-seasonal agriculture, but **summer remains the dominant production window**. This pattern underscores the importance of cold storage throughout the year, particularly during summer and monsoon months when spoilage risk is highest.

Fig 9



Qualitative findings show that farmers first began using the cold storage during peak harvest periods when spoilage risks were highest, particularly in the **winter and summer vegetable seasons**. Many farmers explained that they were motivated to try the facility when they experienced frequent losses during these high-production months. A farmer from Meriema shared,

“I first used it during the winter harvest because the vegetables would spoil quickly at home.” - Farmer, Meriema market, Kohima

Seasonal fluctuations in market prices also influenced the timing of first use. Several farmers reported testing the storage when they encountered price drops during heavy supply periods. A grower from Jalukie shared,

“When the price of chilli fell suddenly, that’s when I tried the cold storage for the first time.” - Farmer, Jalukie

Caretakers confirmed that initial uptake typically coincided with months of **high-volume harvest**, after which farmers continued to return. As one caretaker explained,

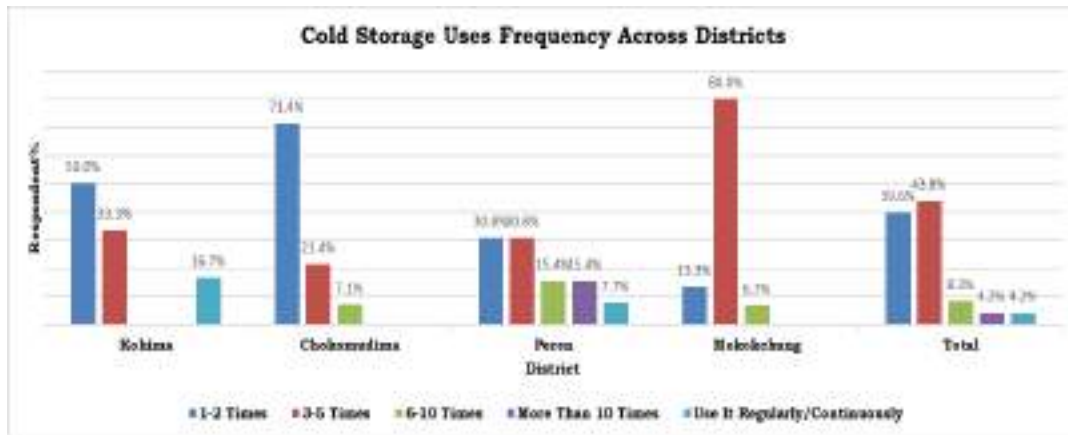
“Most farmers came for the first time during the big harvest season; once they saw the benefit, they kept coming back.” - Caretaker, Sovima, Chümoukedima

These insights indicate that first use was driven by **seasonal need**, particularly during periods of excess produce and heightened spoilage risk. Once farmers recognised the advantages during these peak seasons, storage use became a recurring practice throughout subsequent cycles.

2.3 Frequency of Use and Behavioural Change

The frequency of cold storage use shows strong integration into farmers’ routine post-harvest practices, with most users storing produce multiple times. Overall, **43.8% of farmers used the facility 3-5 times**, making this the most common usage range. This pattern is driven largely by Mokokchung, where **80%** of users fall into this category, reflecting consistent reliance on the facility. Meanwhile, **39.6% used the storage 1-2 times**, a pattern most visible in Chokomodima (71.4%) and Kohima (50%), suggesting emerging but less frequent usage, likely aligned with specific crop cycles or market needs. More intensive usage **6-10 times or more** is most notable in Peren, where **30.8% used the facility 6-10 times** and **15.4% more than 10 times**, indicating higher demand or larger production volumes. Only a small proportion (4.2%) used the facility continuously or as a default storage option. Overall, the data reflects meaningful adoption across districts, with particularly strong and repeated use in Mokokchung and Peren, signalling sustained relevance and operational trust in the cold storage system.

Fig 10



Qualitative findings indicate a clear shift in farmers’ post-harvest behaviour, with many integrating cold storage into their regular marketing routines. Farmers reported using the facility multiple times across a single harvest season, depending on crop volume and market conditions. A farmer from Longkhum described how storage has become a recurring part of his routine:

“Whenever I harvest in bulk, I keep some in the cold storage. I do this almost every week during the season.” - Farmer, Longkhum, Mokokchung

Several farmers also mentioned that the ability to store produce has encouraged them to avoid rushed selling and make more deliberate decisions about when and where to sell. A respondent from Jalukie highlighted this behavioural shift:

“Now I don’t sell everything immediately. I keep it for a day or two and wait for a better price.” - Farmer, Jalukie, Peren

Caretakers observed that repeat usage has increased steadily as farmers recognised the benefits. One caretaker from Sovima noted,

“They come back again and again. Once they used it and saw the result, they started storing more regularly.” - Caretaker, Sovima, Chümoukedima

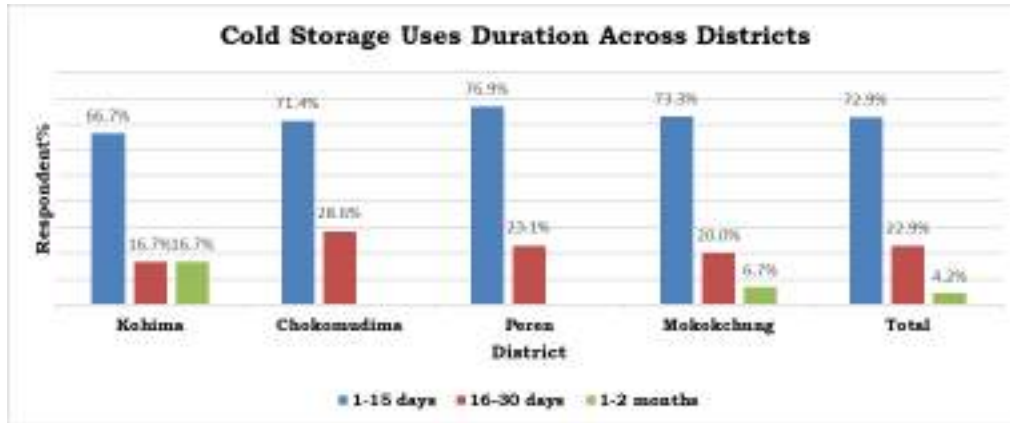
These behavioural changes, shifting from immediate sale to planned storage and pricing, demonstrate strong integration of the facility into routine practice. The facility is no longer viewed as a backup option but as a regular tool for managing perishables and optimising income.

2.4 Duration of Storage: Reducing Waste and Enhancing Market Timing

Storage duration patterns show that farmers primarily use the cold storage for **short-term preservation**, reflecting the perishability of their crops and weekly market cycles. Across districts, an overwhelming **72.9% of farmers stored produce for 1-15 days**, indicating that the cold storage functions largely as a short-term buffer to reduce immediate spoilage and align sales with market days. This pattern is consistent across all locations, with the highest proportions in Peren (76.9%) and Chokomudima (71.4%).

A smaller but notable share was 22.9% stored produce for **16-30 days**, particularly in Chokomudima and Peren. These medium-duration users are likely farmers storing semi-perishable crops such as ginger, Naga chilli, or tomatoes to target better price windows or avoid glut periods. Longer-term storage (1-2 months) was rare (**4.2%**), observed only in Kohima and Mokokchung, and usually linked to hardy crops like dry chillies or ginger. This suggests that while the intervention supports longer storage when needed, its primary value lies in enabling farmers to hold produce for short strategic intervals.

Fig 11



Qualitative findings show that farmers used the cold storage for **short, strategic durations, typically one to three days** to preserve freshness and avoid losses during peak harvest periods. These short storage windows were described as sufficient to prevent spoilage and allow farmers to time their sales more effectively. A farmer from Longkhum explained,

“Even keeping it for two days makes a difference. Before, it would spoil if we waited.” - *Farmer, Longkhum, Mokokchung*

Farmers noted that this brief holding period helped them avoid distress selling, especially when prices fluctuated sharply. As one respondent from Chumukedima shared,

“If the rate is too low that day, we keep it overnight and sell it the next morning.” - *Farmer, Chumukedima*

Caretakers also observed that most farmers used the facility frequently but for short durations, reflecting a practical adaptation to perishability and market cycles. A caretaker from Sovima described this pattern:

“They don’t store for very long, mostly one or two days, to keep it fresh until the right time to sell.” - *Caretaker, Sovima, Chümoukedima*

Overall, these insights confirm that short-term storage aligns well with farmers’ needs, enabling them to reduce waste, maintain quality, and make more informed timing decisions without disrupting their existing marketing routines.

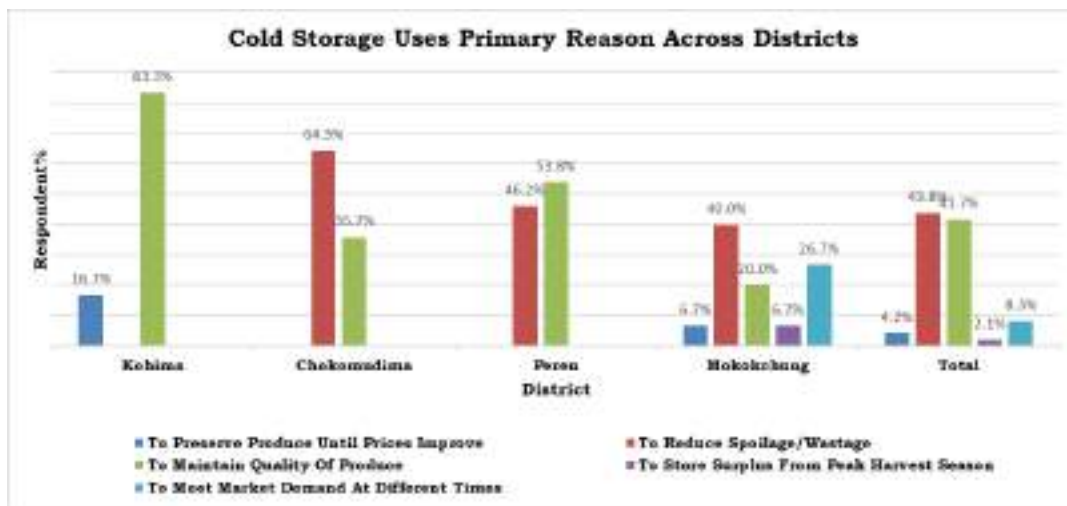
2.5 Why Farmers Use the Facility: Matching the Intervention to Actual Needs

The primary motivations for using the cold storage reveal that the intervention is closely aligned with farmers’ real post-harvest challenges. Overall, the two most common reasons were **reducing spoilage/wastage (43.8%)** and **maintaining the quality of produce (41.7%)**, showing that farmers rely on the facility primarily as a preservation tool to protect the value of their perishable crops.

District patterns show interesting differences. In **Kohima**, where farmers supply urban markets and face quality-sensitive buyers, **83.3%** used the facility mainly to maintain produce quality. In contrast, **Chokomudima** farmers were most concerned with spoilage, with **64.3%** identifying waste reduction as their primary reason, likely reflecting more humid conditions and limited home-storage options. **Peren** exhibited a balanced pattern, with 46.2% prioritising loss reduction and 53.8% prioritising quality maintenance. In **Mokokchung**, motivations were more diverse: while 40% aimed to reduce wastage and 20% focused on quality, **26.7%** used the storage to meet market demand at different times, showing stronger engagement with price cycles and weekly market strategies.

Very few farmers (4.2%) used the facility primarily to wait for improved prices, indicating that while price optimization is a valued secondary benefit, the immediate need remains safe short-term preservation. Only 2.1% used it to store peak-season surplus, suggesting that most farmers deal with small, frequent harvests rather than large seasonal gluts.

Fig 12



Qualitative findings show that farmers use the cold storage primarily because it directly addresses their most pressing post-harvest challenges, rapid spoilage, price fluctuations, and the need to maintain freshness during transportation. For many, the

facility provides a practical solution to problems they face **every harvest season**, making its use both intuitive and necessary. A farmer from Sovima explained,

“The vegetables spoil very fast here. That is why we use the cold storage, to keep them fresh until we can sell.” - *Farmer, Sovima, Chümoukedima*

Farmers also highlighted the advantage of being able to hold produce temporarily when market conditions are unfavourable. This was especially relevant for high-value perishables such as chillies and tomatoes. A respondent from Jalukie shared,

“Sometimes the price drops suddenly. Storing it for a day or two helps us avoid a loss.” - *Farmer, Jalukie, Peren*

Ease of access and proximity contributed greatly to adoption. Several farmers mentioned that they use the facility simply because it is nearby and fits smoothly into their existing routines. A farmer from Longkhum noted,

“It is close to the village, so we can bring our harvest directly without wasting time.” - *Farmer, Longkhum, Mokokchung*

Caretakers also observed that farmers use the facility because it solves real problems related to spoilage and transport delays. As one caretaker from Chumukedima explained,

“They come because they see the benefit immediately, less damage and better condition when they sell.” - *Caretaker, Chumukedima*

Together, these insights make it clear that farmers use the cold storage not because it is available, but because it **fits their actual needs**, aligns with local constraints, and offers immediate, practical value in protecting produce and improving sale outcomes

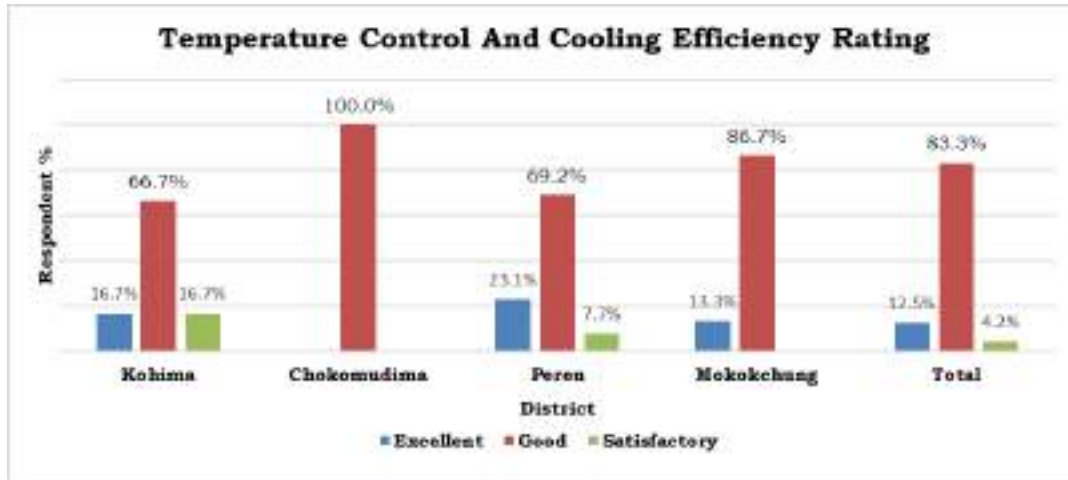
2.6 Facility Quality, Cooling Performance, and Technical Reliability

High satisfaction with quality and maintenance

Farmers across all districts expressed high satisfaction with the cold storage’s temperature control and cooling efficiency, with **83.3% rating it as good** and another **12.5% as excellent**, reflecting strong and consistent performance in preserving freshness and reducing spoilage. District-level feedback reinforces this pattern: in **Kohima**, most farmers (66.7%) found the cooling good and a smaller share (16.7%) rated it excellent, noting that even quality-sensitive produce remained fresh; **Chokomudima** reported the most uniform results, with **100% of farmers rating the cooling as good**, indicating stable performance and reliable temperature maintenance; in **Peren**, cooling was rated positively by all users, with **69.2% marking**

it as good and a high 23.1% as excellent, showing strong suitability for crops like Naga King Chilli; while in **Mokokchung**, a large majority (86.7%) rated the cooling good and 13.3% excellent, with farmers observing that delicate vegetables maintained firmness even after overnight storage. Only a very small share (4.2%) across districts reported the cooling as merely satisfactory, and none reported poor performance, underscoring the system’s strong technical reliability across diverse agro-ecological contexts.

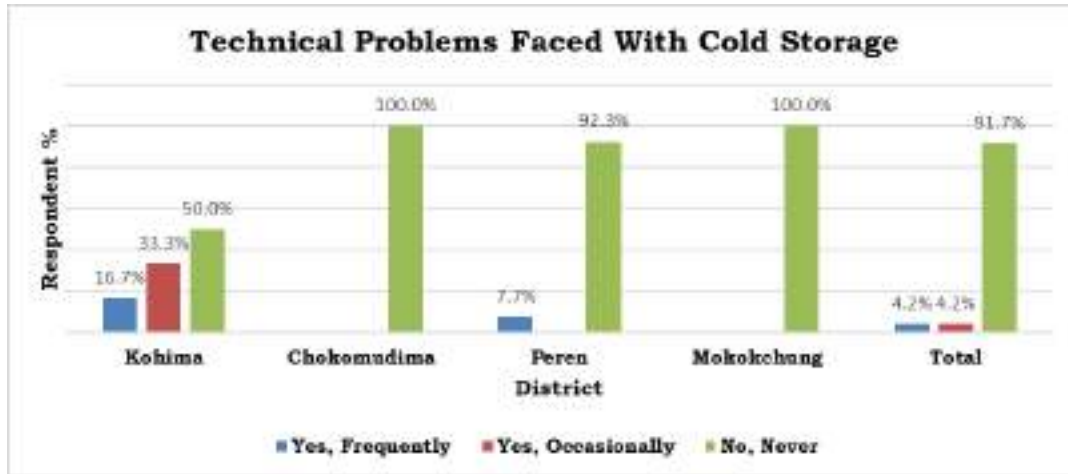
Fig 13



Technical issues are rare and resolved quickly

The solar cold storage facilities demonstrated very strong technical reliability, with **91.7% of farmers reporting they never faced any technical problems**. Only **4.2%** of users experienced issues occasionally, and another **4.2%** faced them frequently, showing that disruptions were rare and highly localised. District patterns further highlight this robustness: **Chokomudima** and **Mokokchung** reported flawless performance, with 100% of users stating they never encountered any issues. **Peren** also showed high stability, with **92.3%** reporting no problems and only one farmer noting frequent technical faults. **Kohima** was the only district with slightly higher reports of disruptions half of the users (50%) faced no issues, while **33.3%** experienced occasional problems and **16.7%** reported frequent ones. Overall, the data indicates that the cold storage units operate reliably across all locations, with only a few isolated cases of technical disturbances that do not undermine overall system performance.

Fig 14



Qualitative findings indicate that farmers consistently perceived the cold storage units as **high-quality, reliable, and effective** in maintaining the freshness of their produce. Across locations, respondents emphasised that the cooling performance met their expectations and that produce remained noticeably fresher compared to home storage. A farmer from Longkhum shared,

“The cooling is good. The vegetables stay fresh even after two days.” - *Farmer, Longkhum, Mokokchung*

Farmers also appreciated the **steady temperature and consistent operation**, noting that the solar-powered system functioned smoothly even during frequent power cuts, an important advantage in Nagaland’s hilly regions. A farmer from Jalukie remarked,

“Even when the electricity goes, the storage still works. That is why we trust it.” - *Farmer, Jalukie, Peren*

Caretakers confirmed that the system required minimal troubleshooting and that any technical issues were rare and quickly manageable. One caretaker from Sovima explained,

“There have been no big problems. The cooling runs well, and farmers are happy with how it keeps their produce.” - *Caretaker, Sovima, Chümoukedima*

Farmers further highlighted that the **cleanliness and organisation** of the facility gave them confidence in using it regularly. As a respondent from Meriema shared,

“The place is clean and well maintained. We feel safe keeping our vegetables there.” - *Farmer, Meriema market, Kohima*

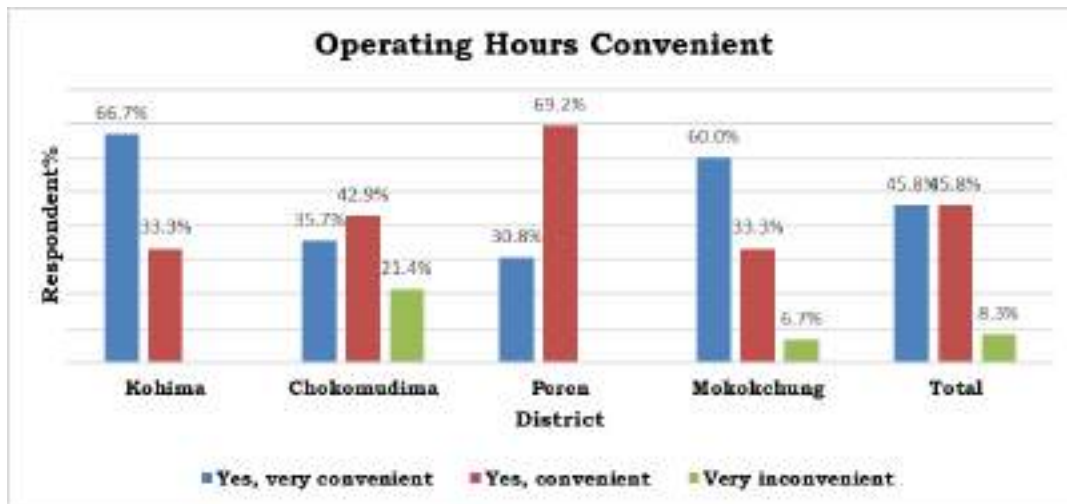
Overall, farmers’ experiences reflect high satisfaction with the cold storage facilities’ performance, reliability, and upkeep, reinforcing the intervention’s technical suitability for the local context.

2.7 Accessibility: Operating Hours and Capacity

Operating hours align with farmer routines

Overall, farmers found the operating hours of the cold storage facilities highly convenient, with **91.6% reporting that the timings were either convenient or very convenient**. Nearly half of all users (45.8%) described the hours as very convenient, while another 45.8% found them convenient, indicating that the facilities are well aligned with farmers’ daily harvesting and market routines. District-level patterns show some variation: **Kohima** and **Mokokchung** reported the highest satisfaction, with 66.7% and 60% respectively saying the hours were very convenient. In **Peren**, most users (69.2%) rated the hours as simply convenient rather than very convenient, suggesting satisfactory alignment with farming schedules. **Chokomudima** had more mixed feedback while 78.6% still found the hours convenient or very convenient, **21.4%** described them as very inconvenient, the highest among all districts, possibly due to timing mismatches with peak harvest or travel hours. Despite these pockets of inconvenience, the overwhelmingly positive feedback across regions indicates that the facilities’ operating hours largely support farmers’ workflow and market engagement.

Fig 15



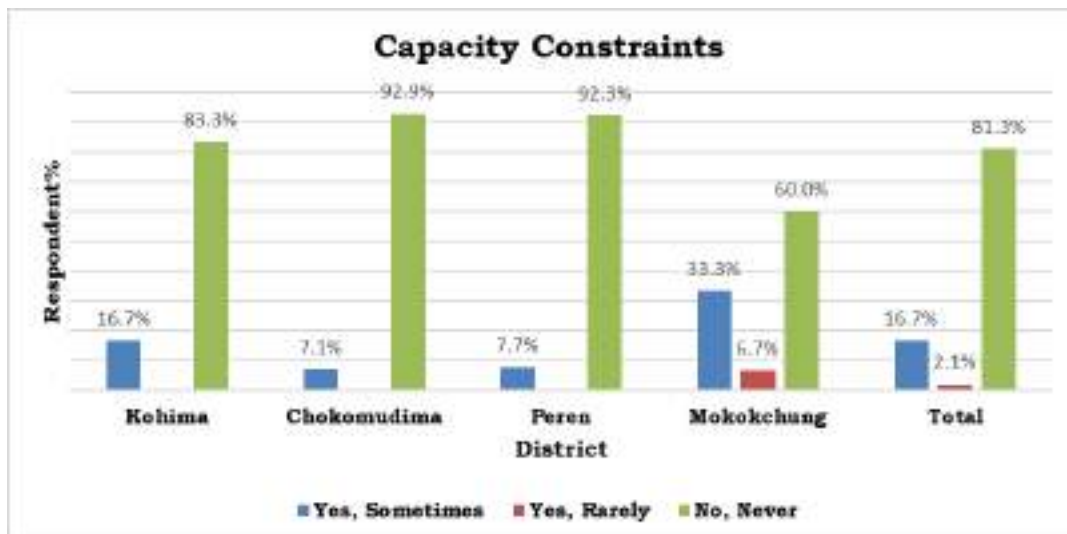
Capacity is generally adequate

Capacity-related challenges were relatively uncommon across districts, with **81.3% of farmers reporting that they were never unable to use the cold storage due to lack of space**. Only **16.7% experienced this issue sometimes**, and a very small share (**2.1%**) reported facing it rarely, indicating that overall capacity has been largely adequate relative to usage levels.

District-level patterns reflect how **unit capacity interacts with local demand**. In **Kohima (5 MT), Chümoukedima (15 MT), and Peren (15 MT)**, capacity constraints were minimal, with **over 92% of farmers consistently finding space available**. This suggests that, in these locations, the installed capacities are broadly aligned with harvesting volumes and usage patterns. In contrast, **Mokokchung**, which operates with a **smaller 5 MT unit**, emerged as the only district experiencing notable capacity pressure. Here, **33.3% of farmers reported being unable to use the facility sometimes**, and an additional **6.7% reported this occurring rarely**, pointing to higher user load and greater reliance on the facility particularly during peak harvest periods.

Overall, the findings indicate that while cold storage capacity is generally sufficient across locations, **smaller-capacity units in high-demand areas may face periodic strain**, highlighting the importance of context-specific capacity planning based on local production intensity and usage patterns.

Fig 16



Qualitative findings show that farmers found the cold storage facilities highly accessible in terms of **operating hours, proximity, and available space**, making it easy to integrate the service into their daily routines. Farmers appreciated that

caretakers were available throughout the day, allowing them to store produce immediately after harvest. A respondent from Chumukedima shared,

“Whenever we bring the vegetables, the caretaker is there to help, morning or afternoon.” - *Farmer, Chumukedima*

Many farmers emphasised that the location of the storage, within or near the village, reduced the time and cost of transporting produce. This was particularly helpful during peak harvest periods or when market trips were not feasible. As one farmer from Sovima explained,

“It is very close for us. We can go anytime without travelling far.” - *Farmer, Sovima, Chümoukedima*

Caretakers noted that the storage units had sufficient capacity to accommodate multiple farmers at once, even during heavy harvest months. A caretaker from Longkhum remarked,

“So far, there has been enough space for everyone. We have not had to turn anyone away.” - *Caretaker, Longkhum, Mokokchung*

Farmers also expressed that the flexible access and available storage space encouraged them to store produce more frequently, particularly when managing bulk harvests. As a respondent from Jalukie noted,

“There is enough room, so we don’t worry about whether our vegetables will fit.” - *Farmer, Jalukie, Peren*

Overall, the combination of convenient operating hours, close-to-home location, and adequate capacity significantly improved the accessibility of the facility, contributing to its consistent use across communities.

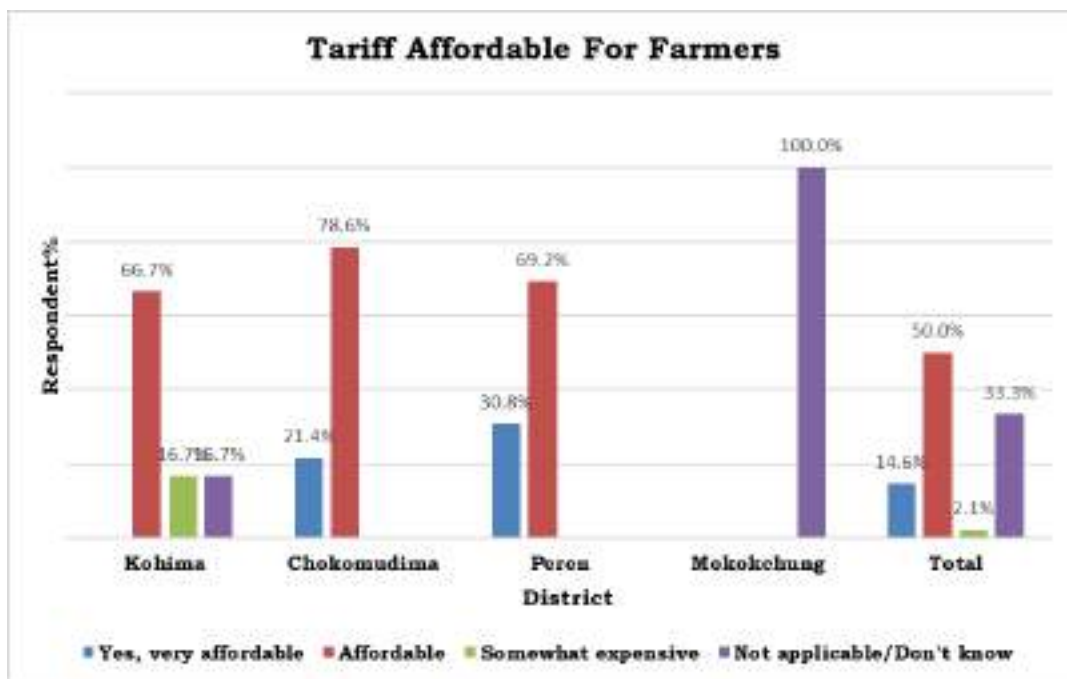
2.8 Awareness and Affordability of Tariffs

Farmers generally found the cold storage tariffs affordable, with **64.6% rating the fees as either “very affordable” or “affordable”**, indicating that cost is not a barrier to usage. Only **2.1%** of farmers considered the tariff somewhat expensive, showing minimal discomfort with pricing. However, **33.3%** selected “Not applicable/Don’t know,” driven almost entirely by **Mokokchung**, where all respondents reported that they were not directly handling fee payments often because the village community or caretaker manages charges collectively. District-level patterns reveal strong affordability perceptions in **Chokomudima** (100% rated the tariffs affordable or very affordable) and **Peren** (also 100% finding them affordable). **Kohima** showed moderate comfort, with **66.7%** finding the fees affordable and only one reporting them somewhat expensive. In contrast, **Mokokchung** had no respondents rating the tariffs as

affordable not due to dissatisfaction, but because **100% reported not knowing the tariff**, reflecting a community-sponsored or centrally managed payment approach. Overall, the data suggests that tariffs are well within farmers’ financial comfort zone, and in many locations, the cost is absorbed or simplified through collective village mechanisms, further enhancing accessibility

It is important to note that “Not applicable/Don’t know” responses do not reflect affordability concerns but rather governance arrangements in certain locations, particularly Mokokchung, where tariffs are managed collectively and farmers are not directly involved in payments.

Fig 17

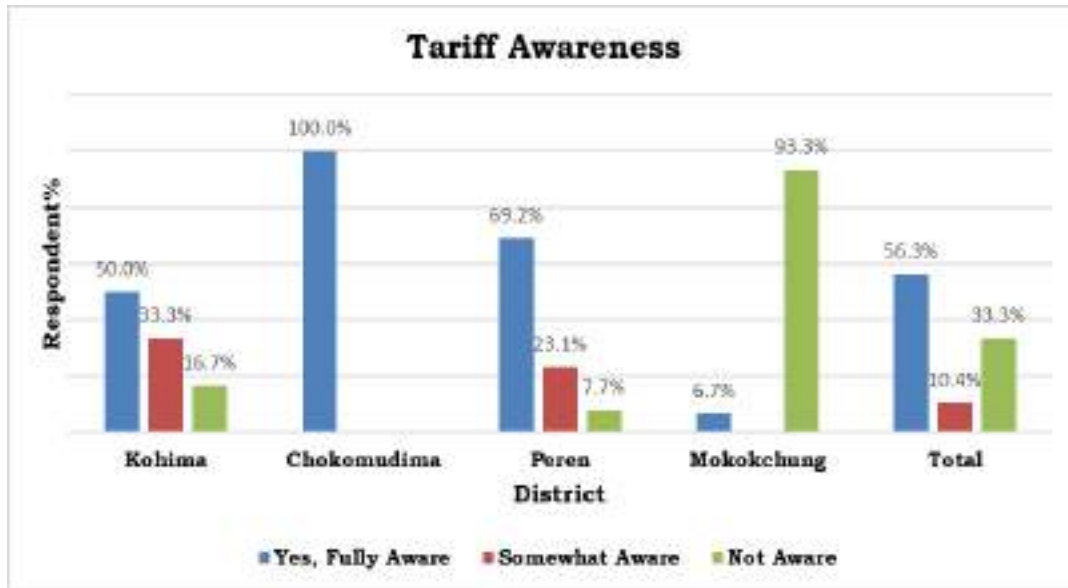


Tariff Awareness

Awareness of the tariff structure varied significantly across districts, with just over half the farmers (**56.3%**) reporting that they were fully aware of the fees associated with using the cold storage. An additional **10.4%** were somewhat aware, while a considerable **33.3%** stated they were not aware of the tariff structure at all. This lack of awareness was heavily concentrated in **Mokokchung**, where **93.3%** of users reported having no knowledge of the fees largely because the village council or community sponsors the facility, and farmers are not individually involved in payments. In contrast, awareness was extremely high in **Chokomudima**, where every respondent (100%) was fully aware of the tariff structure, reflecting clear communication and possibly more direct user-level payment. **Peren** also exhibited strong awareness, with **69.2%** fully aware and **23.1%** somewhat aware. **Kohima**

showed a mixed pattern: half of the users (50%) were fully aware, while 33.3% were only somewhat aware, and 16.7% had no knowledge of the tariff details. Overall, the findings suggest that while tariff transparency is strong in most districts, community-managed models especially in Mokokchung reduce individual-level tariff awareness without negatively affecting affordability, access, or utilisation of the facility.

Fig 18



Qualitative findings indicate that farmers were generally **well-informed about the storage charges** and viewed the tariffs as reasonable and affordable. Most respondents recalled hearing about the fee structure either during community meetings or directly from caretakers. A farmer from Meriema mentioned,

“We knew about the charges from the village meeting. It is not expensive for us.”
 - Farmer, Meriema market, Kohima

Farmers commonly noted that the tariff was justified by the reduction in spoilage and improved selling conditions. Several respondents shared that even a small increase in price after storage allowed them to comfortably cover the fee. A farmer from Jalukie explained,

“The amount we pay is small compared to what we earn by selling fresh vegetables later.” - Farmer, Jalukie

Caretakers confirmed that farmers rarely raised concerns about affordability, and many appreciated that the charges were consistent and predictable. One caretaker in Sovima remarked,

“They don’t complain about the fees. Most farmers say it is fair because the storage helps them save their harvest.” - *Caretaker, Sovima, Chumukedima*

Some farmers also highlighted that the cost was manageable because the facility allowed them to store small quantities without needing large investments. A farmer from Chumukedima shared,

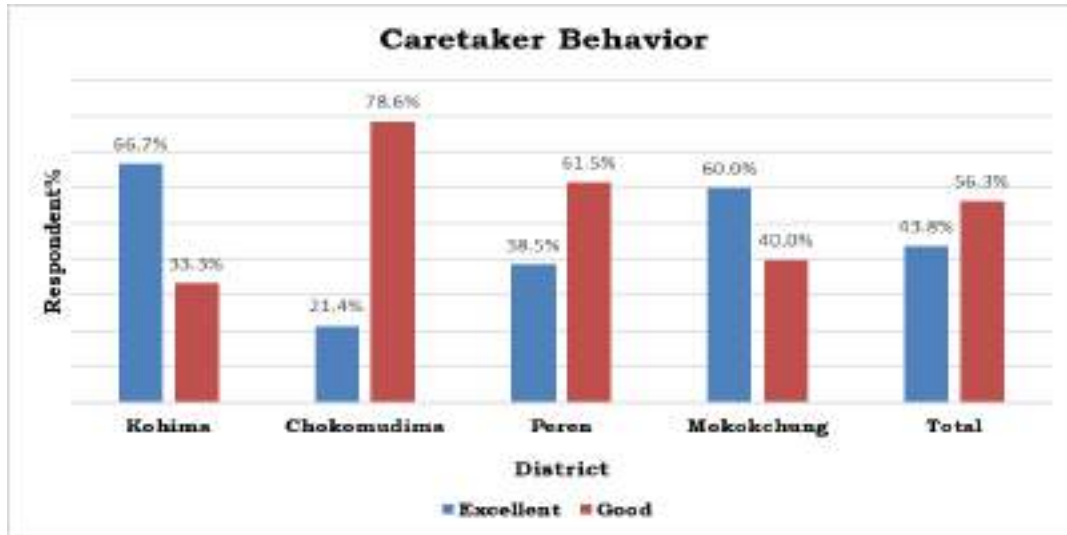
“Even if we bring just a little produce, the fee is still worth it. It prevents loss.”
- *Farmer, Chumukedima*

Overall, qualitative narratives show that awareness of tariffs was high, and affordability was not a barrier. Instead, farmers viewed the tariff as a **good value for money**, reflecting strong alignment between the storage cost and its perceived benefits.

2.9 Caretaker Support: A Key Driver of Positive Experience

Farmers across all districts expressed very high satisfaction with the behaviour and support provided by the cold storage caretakers, with **100% rating their experience as either “excellent” or “good.”** Nearly half the respondents (**43.8%**) rated caretaker support as excellent, while the remaining **56.3%** rated it as good, indicating consistently positive interactions and reliable assistance. District-level patterns reveal some variation: **Kohima** and **Mokokchung** reported the highest excellence ratings, with **66.7%** and **60%** respectively highlighting exceptional caretaker support, reflecting proactive engagement and hands-on assistance. In **Peren**, 38.5% rated the behaviour as excellent and 61.5% as good, while **Chokomudima** had the highest share of “good” ratings (78.6%) and 21.4% excellent, suggesting consistently supportive interactions even if fewer users rated them exceptional. Overall, the uniform positivity across all districts underscores the crucial role of caretakers in ensuring smooth facility operations, resolving issues quickly, and building user confidence in the cold storage system.

Fig 19



Qualitative findings highlight that **caretaker support played a central role** in shaping farmers’ positive experiences with the cold storage facilities. Farmers across locations consistently described caretakers as approachable, responsive, and proactive in assisting with loading, arranging, and monitoring produce. Their presence made the facility easy to use, especially for first-time users unfamiliar with cold storage systems. A farmer from Jalukie shared,

“The caretaker helps us arrange everything properly. Because of him, we feel comfortable using the storage.” - *Farmer, Jalukie*

Farmers also appreciated that caretakers explained basic procedures in a simple and friendly manner, ensuring confidence in how their produce was handled. A respondent from Longkhum noted,

“He guides us on how to keep the vegetables so they stay fresh. That guidance is very helpful.” - *Farmer, Longkhum, Mokokchung*

Caretakers themselves emphasized their role in maintaining cleanliness and ensuring smooth day-to-day functioning of the facility. One caretaker from Sovima mentioned,

“I try to keep the place clean and assist the farmers whenever they come. They trust the facility more because of this.” - *Caretaker, Sovima, Chumukedima*

Farmers further expressed that a supportive caretaker made storage more convenient, especially during peak harvest days when handling produce can be physically demanding. As a farmer from Chumukedima explained,

“When there is a lot to store, he helps us quickly. It saves us time.” - *Farmer, Chumukedima*

Overall, caretaker involvement significantly enhanced usability, trust, and satisfaction. Their active engagement ensured smooth operations and encouraged farmers to use the facility repeatedly, making caretaker support a **key driver of effective adoption and positive user experience**.

III. Efficiency

The efficiency of the solar-powered cold storage facilities was examined in terms of affordability, responsiveness to technical issues, reliability of the solar system, and user perceptions of how the system could be improved. Together, these dimensions indicate whether the intervention delivers good value for the resources invested and whether farmers experience it as smooth and hassle-free to use.

Table: Key Research Questions and Indicators (Efficiency)

Sl. No.	Research Question	Indicators
1	How quickly were technical problems resolved?	Speed of issue resolution, caretaker responsiveness, technician support
2	How reliable was the solar-powered system across districts?	Year-round reliability, location-wise performance, effect of cloudy/rainy conditions
3	Were users able to afford and regularly use the facility?	Affordability of fees, perceived value for money, consistency of use
4	How smooth and hassle-free was the user experience?	Ease of using the system, downtime, cooling performance, caretaker support
5	What improvements did users suggest for better operational efficiency?	Capacity expansion, preventive maintenance, transportation access, improved accessibility, need for additional training

3.1 Speed of Problem Resolution

Across all districts, farmers unanimously reported that any technical issues they encountered were resolved **quickly and efficiently**, with **100% of respondents** stating that problems were addressed without delays. This uniform finding consistent across **Kohima, Chümüokedima, Peren, and Mokokchung** indicates a highly responsive support system involving caretakers and technical teams. Even in districts

where occasional issues such as cooling fluctuations or minor faults were reported, users emphasised that resolutions were immediate, often handled directly by caretakers or through rapid intervention from Inficold technicians. The complete absence of unresolved or prolonged problems underscores the strong operational backbone of the cold storage system, contributing significantly to user confidence and the perceived reliability of the intervention.

If faced technical problems, how quickly were they resolved	Kohima	Chokomudima	Peren	Mokokchung
No Delay	100%	100%	100%	100%
Delay	0%	0%	0%	0%

Qualitative evidence indicates that farmers and caretakers experienced **quick and responsive problem resolution**, contributing to overall confidence in the cold storage system. Across locations, farmers shared that minor issues, such as temperature adjustments or clarification on storage procedures, were addressed promptly by the caretakers, often on the same day. A farmer from Meriema explained,

“If we have any issue, the caretaker responds immediately. We don’t have to wait.” - *Farmer, Meriema market, Kohima*

Caretakers themselves highlighted that they were able to resolve most operational concerns without delay, and only rarely required external technical support. A caretaker in Sovima mentioned,

“Small problems we handle right away. Only big technical issues are reported, but those also get solved quickly.” - *Caretaker, Sovima, Chümoukedima*

In cases where technical assistance was needed, farmers noted that response times remained efficient, ensuring minimal disruption. A farmer from Longkhum shared,

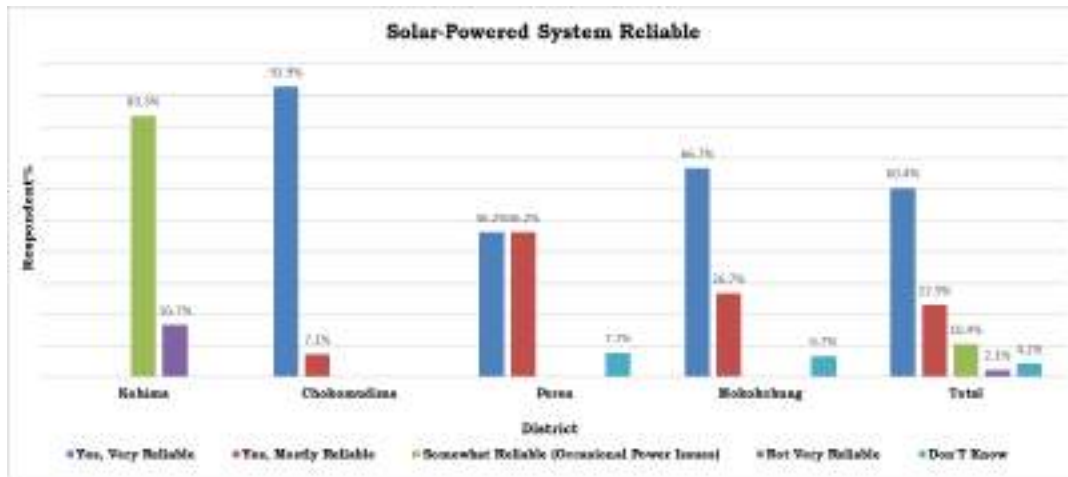
“Once the cooling was low, and they fixed it fast. It did not affect our vegetables.” - *Farmer, Longkhum, Mokokchung*

Overall, qualitative feedback shows that the system for addressing problems works smoothly and promptly. This timely resolution not only prevents spoilage but also strengthens farmers’ trust in the facility’s reliability , a crucial factor for sustaining long-term usage.

3.2 Reliability of the Solar-Powered System

Overall, farmers expressed strong confidence in the solar-powered cold storage system, with **60.4% rating it “very reliable”** and another **22.9% describing it as “mostly reliable.”** Together, more than **83%** of users reported high year-round reliability. However, district-level variations reveal important contextual differences. **Chümoukedima** demonstrated the strongest performance, with **92.9%** of farmers rating the solar system “very reliable,” reflecting consistent sunlight exposure and stable system functioning. **Mokokchung** also performed well, with **66.7%** rating it “very reliable” and **26.7%** “mostly reliable,” indicating dependable performance with only occasional variability. **Peren** showed a balanced pattern **46.2%** “very reliable” and **46.2%** “mostly reliable” suggesting steady functioning but perhaps more sensitivity to weather conditions. In contrast, **Kohima** stood out as an anomaly: **none** of the farmers rated the system “very” or “mostly” reliable. Instead, **83.3%** described it as “somewhat reliable,” and **16.7%** said “not very reliable,” reflecting Kohima’s heavy cloud cover, frequent monsoon conditions, and lower solar irradiation. A few farmers in Peren and Mokokchung also reported uncertainty (“don’t know”), indicating limited direct interaction with the technical aspects of the system. Overall, while the solar system is functioning reliably in most districts, Kohima’s climatic constraints underscore the need for hybrid power backup in specific locations.

Fig 20



Qualitative findings consistently show that farmers viewed the solar-powered cold storage system as highly reliable, particularly in areas where electricity supply is irregular. Respondents across multiple villages noted that the solar setup ensured uninterrupted cooling, even during frequent power cuts, which gave them confidence to store perishables without fear of spoilage. A farmer from Jalukie highlighted this benefit, stating,

“Our power goes off many times, but the storage keeps running because of the solar. That is why we trust it.” - Farmer, Jalukie, Peren

Caretakers also emphasised that the solar system operated smoothly with minimal disruption. They reported that the panels provided adequate power throughout the day and that the battery backup ensured consistent cooling at night. A caretaker from Chumukedima shared,

“The solar runs well every day. Even when there is no electricity, the cooling does not stop.” - Caretaker, Chumukedima

Farmers further expressed that the reliability of the system encouraged them to store produce more frequently, as they did not have to worry about failures or sudden shutdowns. A respondent from Longkhum noted,

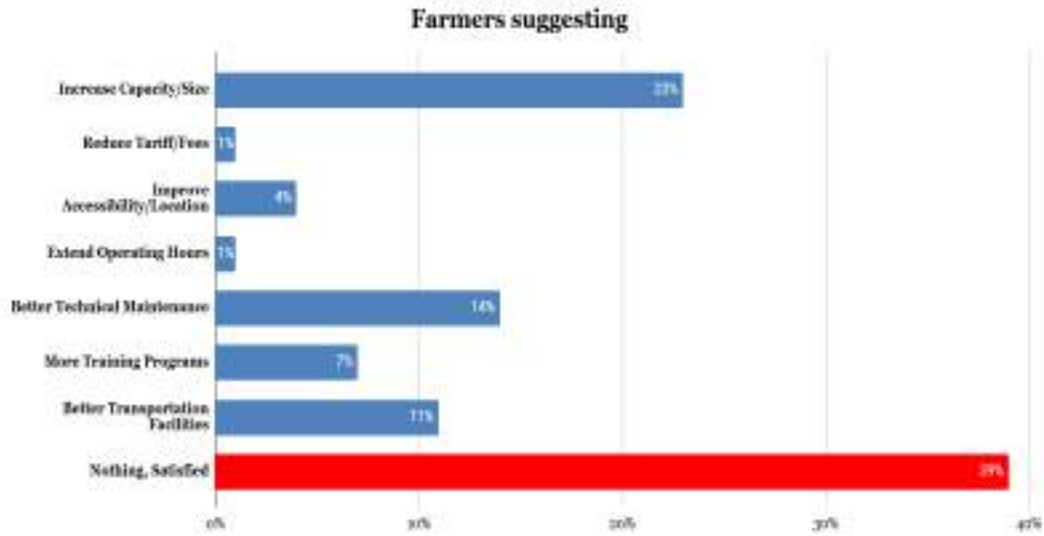
“Earlier, we were worried the cooling might stop, but now we know it is stable. That’s why we use it more often.” - Farmer, Longkhum, Mokokchung

Overall, the solar-powered system addressed a critical infrastructural challenge in the region and significantly improved farmers’ trust in the cold storage facility. Its reliability emerged as one of the strongest drivers of consistent usage across locations.

3.3 User Suggestions for Improving Operational Efficiency

Farmer suggestions for improving the cold storage facilities highlight both high satisfaction levels and a few targeted operational needs. The largest share of respondents (**39%**) reported no suggestions, indicating that they are fully satisfied with the current functioning of the facility. Among those who did suggest improvements, the most common recommendation was to **increase storage capacity (23%)**, reflecting rising demand during peak harvest seasons. Another **14%** called for **better technical maintenance**, pointing to the need for more preventive servicing and quicker routine check-ups. Suggestions also focused on strengthening the supporting ecosystem: **11%** requested **better transportation facilities**, and **4%** mentioned improving accessibility or location, especially in areas with difficult terrain. Farmers also expressed interest in **more training programs (7%)** to maximise safe storage and understand crop-specific requirements. Very few users felt tariffs needed reduction (**1%**) or that operating hours should be extended (**1%**). Overall, these suggestions reflect a system that is functioning well but would benefit from increased capacity, stronger peripheral infrastructure, and continued user training as demand expands.

Fig 21



While farmers expressed overall satisfaction with the cold storage facilities, qualitative feedback also highlighted **practical suggestions to further improve operational efficiency**. These recommendations were modest and focused on enhancing ease of use rather than indicating dissatisfaction.

Several farmers suggested extending operating hours during peak harvest periods, noting that flexibility would help them manage late-evening or early-morning harvests. A farmer from Jalukie shared,

“Sometimes we harvest late in the evening. If the storage stayed open a little longer, it would help us.” - *Farmer, Jalukie, Peren*

Some respondents expressed the need for clearer communication about storage capacity during high-demand days to avoid last-minute uncertainty. A farmer from Longkhum mentioned,

“If we know beforehand how much space is free, we can plan better.” - *Farmer, Longkhum, Mokokchung*

A few farmers recommended minor infrastructure additions, such as shelves or partitioning, to make the arrangement of different produce types more convenient. As one farmer from Meriema noted,

“If there were more racks inside, it would be easier to organise our vegetables.”
- *Farmer, Meriema market, Kohima*

Caretakers also suggested periodic refresher orientations for new users to maintain uniform handling practices. A caretaker from Sovima explained,

“A short orientation for new farmers will make the process smoother and reduce confusion.” - *Caretaker, Sovima, Chümoukedima*

Overall, these suggestions were constructive and indicate that users are engaged and invested in improving the facility’s operations. They also show that farmers perceive the system as valuable and worth optimising for long-term use.

IV. Impact

The impact of the solar-powered cold storage intervention was assessed by analysing how the facility influenced key dimensions of agricultural production, post-harvest management, income stability, market participation, and overall household well-being across the four study districts. This section draws on quantitative responses from 60 farmers and qualitative feedback from open-ended questions to build a comprehensive, evidence-based narrative of change. Together, these insights present a clear picture of how the cold storage facility has shaped farming outcomes, the extent of benefits realised by farmers, and the challenges that continue to affect the system’s long-term impact.

Table: Key Research Questions and Indicators (Impact)

Sl. No.	Research Question	Indicators
1	Did cold storage reduce post-harvest losses?	Loss levels before vs. after, shift in loss categories, spoilage reduction
2	Did farmers achieve better price realisation and improved market timing?	Ability to delay sales, reduction in distress selling, improved price outcomes
3	Did production and marketable surplus increase?	Change in production volume, surplus availability, crop diversification
4	Did agricultural income increase and were earnings reinvested?	Increase in income, reinvestment in seeds/tools/labour, improved productivity
5	Did household livelihoods improve?	Financial stability, ability to cover expenses, overall livelihood improvement

6	Did dependency on middlemen reduce?	Reduced forced selling, increased bargaining power, direct market access
7	Did the project generate community-level benefits?	Village-wide usage, collective spoilage reduction, market stability, local opportunities
8	What challenges still remain and what areas require strengthening?	Road connectivity, capacity limits, solar backup issues, temperature consistency, need for maintenance/training

4.1 Reduction in Post-Harvest Losses

Before cold storage, approximately % of produce is lost/wasted due to spoilage

Before the introduction of cold storage, farmers across all four districts experienced substantial post-harvest losses due to spoilage. More than half of the sample (**54.2%**) reported **high losses in the range of 26-50%**, indicating that significant portions of harvested produce were routinely lost before reaching the market. This pattern was particularly pronounced in **Chümoukedima (64.3%)**, **Mokokchung (66.7%)**, and **Peren (46.2%)**, reflecting the high perishability of vegetables, chillies, and fruits cultivated in these areas.

Moderate loss levels of **11-25%** were reported by **20.8% of farmers**, mainly in Kohima and Peren, suggesting slightly better handling conditions but still considerable spoilage. Low-loss outcomes (**0-10%**) were rare, reported by only **6.3% of farmers**, indicating that very few had access to any effective pre-cooling or temporary storage options. A small but concerning share (**6.3%**) experienced **very high losses exceeding 50%**, particularly during peak harvest or high-humidity periods. Overall, high spoilage was the norm rather than the exception, underscoring the urgent need for reliable cold storage infrastructure.

Loss Category	% Range	Kohima	Chokomudima	Peren	Mokokchung	Total
Before cold storage, approximately % of produce is lost/wasted due to spoilage						
Low loss	0-10%	16.7%	7.1%	7.7%	0.0%	6.3%
Moderate loss	11-25%	66.7%	14.3%	30.8%	0.0%	20.8%

High loss	26-50%	16.7%	64.3%	46.2%	66.7%	54.2%
Very high loss	>50%	0.0%	7.1%	7.7%	6.7%	6.3%

After using cold storage, approx % lost/wasted

Following the introduction of cold storage, post-harvest losses declined sharply across all districts, demonstrating the strong technical effectiveness of the intervention. To capture meaningful improvements at lower loss levels, **post-intervention loss categories are defined at narrower percentage ranges.**

After using cold storage, **52.1% of farmers reported losses of around 10%**, representing a substantial improvement from pre-intervention loss levels of **26-50%**. A further **29.2% experienced moderate losses of only 3-5%**, reflecting stable storage performance that prevented rapid deterioration of perishable produce. **Low-loss outcomes of 0-2% were achieved by 12.5% of farmers**, particularly in **Chümoukedima (7.1%)** and **Peren (15.4%)**, indicating that under optimal handling and storage conditions, spoilage can be almost eliminated.

Only **6.3% of farmers reported higher losses of around 20%**, with such cases limited to **Peren (7.7%)** and **Mokokchung (13.3%)**. These instances appear to be isolated and are likely linked to factors such as crop type, extended storage duration, or packaging practices rather than systemic issues with the cold storage facilities.

After using cold storage, approx % lost/wasted:-

Loss Category	Kohima	Chokomudima	Peren	Mokokchung	Total
After using cold storage, approx % lost/wasted					
Low loss (0-2%)	0.5	7.1%	15.4%	0.0%	12.5%
Moderate loss (3-5%)	50%	28.6%	38.5%	13.3%	29.2%
High loss (10%)	0.0%	64.3%	38.5%	73.3%	52.1%
Very high loss (20%)	0	0.0%	7.7%	13.3%	6.3%

Qualitative findings strongly indicate that the solar cold storage facilities have contributed to a **significant reduction in post-harvest losses**, particularly for highly perishable crops such as tomatoes, chillies, cabbage, and Naga King Chilly. Farmers repeatedly highlighted that before the introduction of cold storage, vegetables often spoiled within a day, especially during warm or humid periods, forcing them to sell

immediately at whatever price was available. A farmer from Jalukie described the earlier situation,

“Before, if we kept the vegetables at home even for one night, they would start rotting.” - *Farmer, Jalukie, Peren*

With access to cold storage, farmers reported noticeable improvements in quality retention and a reduction in wastage, even when harvest volumes were high. Many shared that storing produce for **one to two days** now keeps it fresh long enough to plan sales more effectively. A farmer from Longkhum explained,

“After keeping it in the cold storage, the vegetables do not get damaged. Even after two days, they look fresh.” - *Farmer, Longkhum, Mokokchung*

Caretakers further confirmed that farmers who previously suffered losses due to heat and transportation delays were now able to preserve surplus produce without worry. One caretaker noted,

“Earlier, they lost a lot on the way to the market. Now most of them store first and there is almost no spoilage.” - *Caretaker, Sovima, Chumukedima*

Farmers also expressed relief that their efforts in cultivation no longer went to waste, especially during peak harvests when prices dropped and excess produce risked damage. A respondent from Chumukedima shared,

“We used to throw away damaged vegetables before. Now we hardly waste anything.” - *Farmer, Chumukedima*

Overall, qualitative evidence confirms that the cold storage units have meaningfully reduced post-harvest losses, protecting farmers’ produce, labour, and investment. This reduction in wastage is one of the strongest and most immediate impacts of the intervention.

Here is a comparative analysis of the before and after loss :

A comparison of pre- and post-intervention wastage levels shows a **clear downward shift in spoilage severity** across the farming communities. The share of farmers experiencing **low losses nearly doubled**, increasing from **6.3% before cold storage to 12.5% after**, reflecting improved preservation and reduced rapid spoilage. Moderate loss levels also increased from **20.8% to 29.2%**, indicating that many farmers previously facing high losses shifted into lower, more manageable loss categories.

While the proportion of farmers classified under “high loss” appears numerically similar before and after the intervention (**54.2% before vs. 52.1% after**), it is critical to note that this category represents **very different levels of spoilage**. Before cold

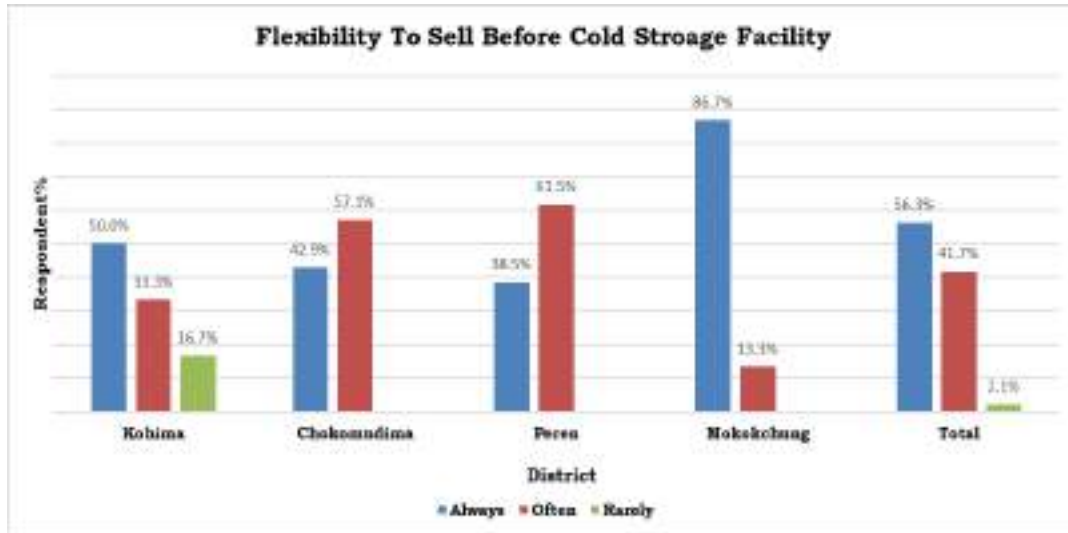
storage, high loss corresponded to **26-50% wastage**, whereas after cold storage it reflects losses of **around 10%**, representing a substantial reduction in absolute spoilage. The share of farmers reporting very high losses remained unchanged at **6.3%**, suggesting that a small subset continues to face challenges related to crop characteristics or handling practices rather than storage availability.

Loss Category	% Before	% After	Change
Low loss (0-10%)	6.30%	12.50%	▲ Improved
Moderate loss (11-25% before / 3-5% after)	20.80%	29.20%	▲ Improved
High loss (26-50% before / 10% after)	54.20%	52.10%	▼ Reduced slightly
Very high loss (>50%)	6.30%	6.30%	No change

4.2 Improved Price Realisation and Market Timing

Before the introduction of cold storage, farmers across all districts were overwhelmingly compelled to sell their produce immediately after harvest, with **56.3%** reporting they always had to sell right away and **41.7%** saying they often did so. This reflects the absence of any storage options and the highly perishable nature of vegetables and spices grown in these regions. **Mokokchung** showed the highest level of distress selling, with **86.7%** of farmers always selling immediately; only 13.3% sold immediately “often,” and none reported the ability to delay. **Chümoukedima** and **Peren** followed similar patterns, with **100%** of farmers in both districts forced to sell either “always” or “often,” indicating severe pre-intervention vulnerability. **Kohima** presented slightly more flexibility but remained constrained, with **50%** always and **33.3%** often selling immediately, and only one farmer (16.7%) rarely able to hold produce.

Fig 22



Qualitative findings clearly demonstrate that the cold storage facilities have enabled farmers to secure **better prices and improved market timing**, particularly during periods of oversupply. Before the intervention, farmers described being forced to sell immediately after harvest, often at low prices, due to the risk of spoilage. With access to cold storage, respondents reported greater flexibility to wait for favourable market conditions. A farmer from Jalukie shared,

“If the price is too low, we keep the produce for a day or two and sell when the rate improves.” - Farmer, Jalukie, Peren

Farmers emphasised that even short-term storage helps them avoid distress selling during market gluts. In hilly areas where transport to markets takes time, storing produce also prevents quality degradation during travel. A farmer from Longkhum explained,

“We don’t have to hurry anymore. By storing first, we can choose the right day to sell.” - Farmer, Longkhum, Mokokchung

Caretakers observed that improved timing has been particularly beneficial for high-value crops such as chillies and tomatoes, where even a small price increase can significantly improve margins. A caretaker from Sovima noted

“Farmers often wait one more day and get a better price. That difference makes the storage worthwhile for them.” - Caretaker, Sovima, Chumukedima

Farmers also reported that by avoiding rushed sales, they can target specific market days with higher footfall or better demand. A respondent from Chumukedima shared,

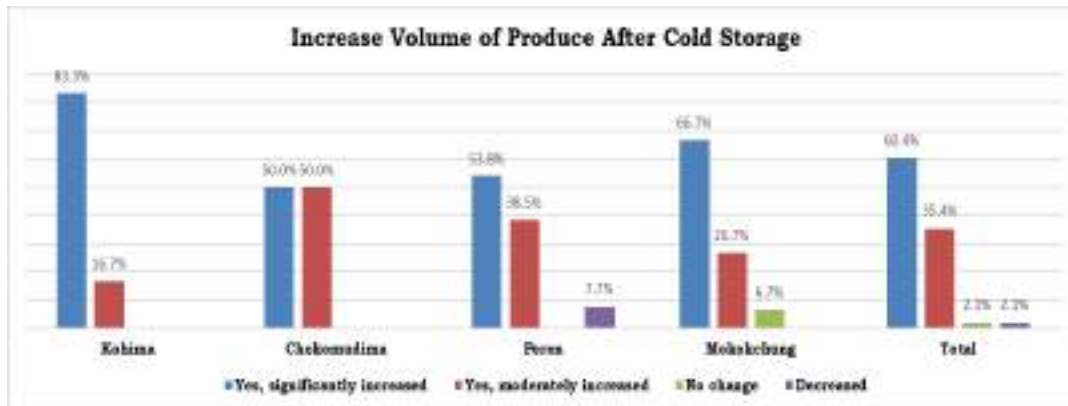
“We now sell on days when more buyers come. Earlier, we had no option but to sell whatever we could.” - Farmer, Chumukedima

Overall, qualitative narratives indicate that the cold storage facility has strengthened farmers’ ability to time their market entry more strategically, leading to **higher price realisation, reduced distress selling, and greater control over income.**

4.3 Increase in Marketable Surplus and Production Volume

Access to cold storage has led to a clear expansion in production across districts, with **60.4%** of farmers reporting a significant increase in the volume of produce they now grow and another **35.4%** reporting a moderate increase. This reflects a strong shift in farmer confidence driven by reduced spoilage and better price realisation. District-wise patterns show particularly strong gains in **Kohima**, where **83.3%** of farmers significantly increased production the highest among all districts. **Mokokchung** also showed substantial growth, with **66.7%** reporting significant increases, followed by **Peren (53.8%)** and **Chümoukedima (50%)**. Moderate increases were consistent across locations, ranging from **26.7%** in Mokokchung to **50%** in Chümoukedima. Only a very small share of farmers reported no change (2.1%) or a decrease (2.1%), both clustered in Peren and Mokokchung. Overall, the data indicates that cold storage not only reduced risks but also incentivised farmers to scale up production, diversify crops, and invest more confidently in agriculture.

Fig 23



Qualitative findings suggest that the availability of cold storage has encouraged farmers to **increase both their marketable surplus and overall production**, particularly for perishable crops that were earlier prone to spoilage. Farmers shared that the assurance of safe storage motivated them to harvest more confidently and, in some cases, expand the area cultivated for high-demand vegetables. A farmer from Jalukie described this shift,

“Now that we can store safely, we harvest more at one time because we know nothing will spoil.” - *Farmer, Jalukie, Peren*

For many respondents, the ability to store surplus for one or two days provided the confidence to increase production without fear of wastage. This was especially evident among farmers cultivating chillies, tomatoes, and cabbages. A farmer from Longkhum explained,

“Earlier we harvested less because we worried it would get damaged. With cold storage, we can produce more.” - *Farmer, Longkhum, Mokokchung*

Caretakers also observed this trend, noting that farmers who were initially hesitant to bring larger quantities now do so more frequently, indicating a behavioural shift towards higher production and planned marketing. One caretaker from Sovima remarked,

“Farmers bring more vegetables now compared to before. They say the storage gives them confidence to increase production.” - *Caretaker, Sovima, Chumukedima*

Some farmers also reported reduced household-level wastage, allowing more produce to be sold rather than consumed quickly or discarded. A farmer from Chumukedima noted,

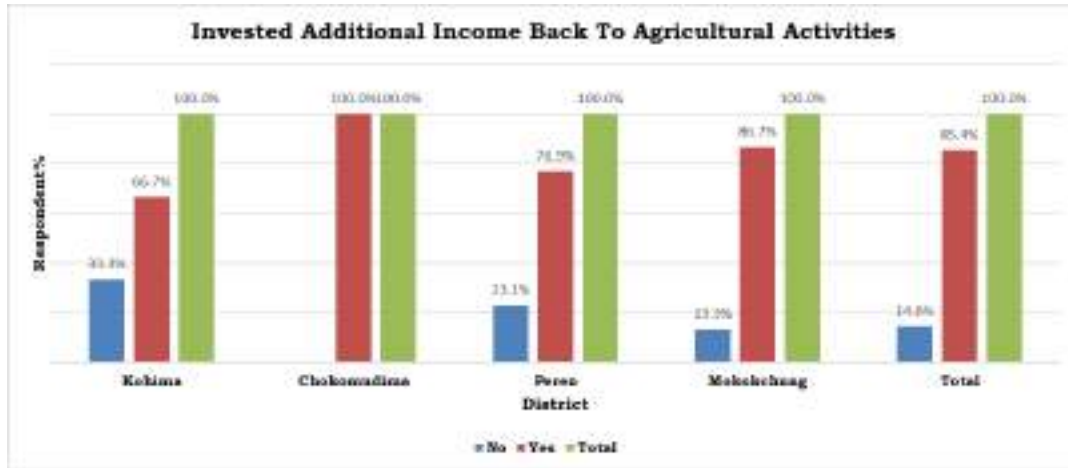
“Before we lost a lot at home itself. Now most of it can be sold, so our market quantity has increased.” - *Farmer, Chumukedima*

Overall, the cold storage facility has supported an increase in **marketable surplus and production volume**, enabling farmers to maximise the value of their crops and participate more confidently in local markets.

4.4 Increases in Agricultural Income and Reinvestment Patterns

A large majority of farmers reinvested the additional income earned through the use of cold storage back into their agricultural activities, with **85.4%** reporting that they had made such reinvestments. This demonstrates a strong positive cycle where improved storage reduces losses, increases income, and enables further productivity enhancement. District-wise trends show particularly high reinvestment behaviour in **Chümoukedima**, where **100%** of farmers reinvested, followed closely by **Mokokchung (86.7%)** and **Peren (76.9%)**. **Kohima**, while still showing a majority reinvesting (**66.7%**), had the highest proportion of farmers who did not reinvest (**33.3%**), possibly reflecting alternative livelihood priorities or smaller income gains. Overall, the consistently high reinvestment levels across districts indicate that farmers recognise the value of strengthening their production systems and are using increased earnings to purchase better inputs, tools, and labour further enhancing the long-term impact of the cold storage intervention.

Fig 24



Qualitative findings indicate that farmers experienced **meaningful increases in agricultural income** after using the cold storage facility, largely due to reduced spoilage, improved price realisation, and the ability to sell higher-quality produce. Respondents repeatedly emphasised that even small increases in price, combined with saved losses, translated into better earnings across the season. A farmer from Jalukie explained,

“By storing for a day or two, we earn more than before. Even a small increase in price makes a difference for us.” - *Farmer, Jalukie, Peren*

Many farmers shared that higher and more stable income allowed them to **reinvest in inputs**, such as better seeds, fertilisers, and small equipment. This reinvestment was especially common among vegetable growers who saw immediate financial benefits from improved market timing. A farmer from Longkhum noted,

“After getting better returns, I bought more seeds this season. I feel confident to grow more now.” - *Farmer, Longkhum, Mokokchung*

Caretakers also observed that farmers who regularly used the facility showed a noticeable improvement in their ability to manage cash flows and plan future cultivation cycles. As a caretaker from Sovima stated,

“They earn more now and some even said they are putting part of it back into farming. The storage has helped them plan better.” - *Caretaker, Sovima, Chumukedima*

For some farmers, improved income stability reduced their reliance on urgent, low-value sales and enhanced their ability to cover household expenses. A respondent from Chumukedima shared,

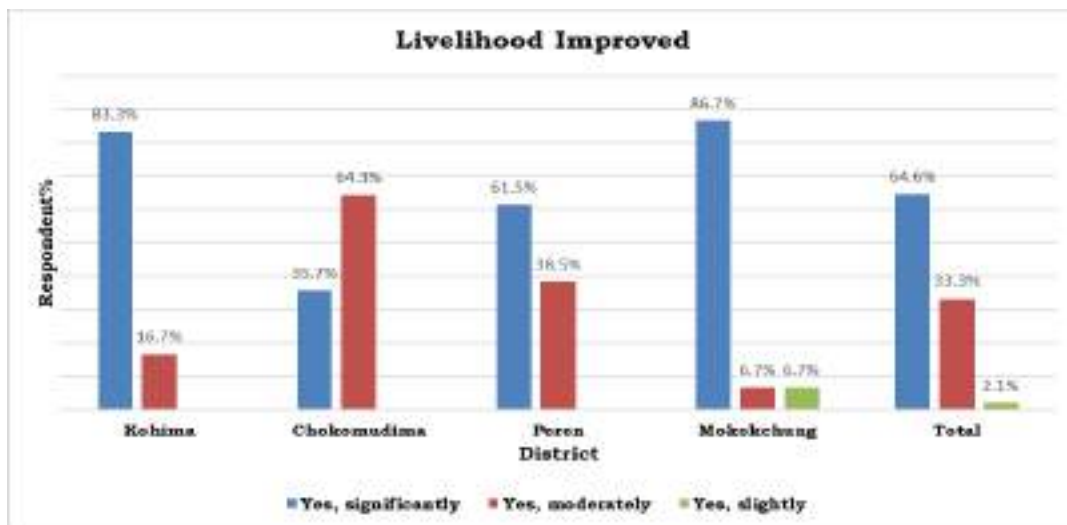
“Now we don’t have to sell in a hurry. We get a better price and can manage our home needs more comfortably.” - *Farmer, Chumukedima*

Overall, the cold storage facility contributed to **higher agricultural income, better financial planning, and greater reinvestment in farming**, reinforcing its long-term economic relevance for smallholder households.

4.5 Improvements in Household Livelihoods

The cold storage facility has had a strong positive impact on household financial stability, with **64.6% of farmers reporting significant improvements** and another **33.3% reporting moderate improvements**. Only **2.1%** experienced slight improvement, and no respondents reported worsening conditions. District-level patterns highlight especially strong gains in **Mokokchung**, where **86.7%** of farmers reported significant improvement reflecting the district’s high reliance on perishable crops and substantial reduction in spoilage after cold storage adoption. **Kohima** also showed strong outcomes, with **83.3%** reporting significant improvement. **Peren** displayed a balanced but positive pattern, with **61.5%** experiencing significant and **38.5%** moderate improvement. **Chumoukedima**, while still positive overall, showed a different distribution: **35.7%** significant improvement and a majority (**64.3%**) reporting moderate gains, suggesting steady but gradual financial uplift. Overall, these findings show that cold storage has played a crucial role in enhancing income stability, reducing losses, and improving the economic resilience of farming households across all districts.

Fig 25



Qualitative findings show that the cold storage intervention has contributed to **tangible improvements in household livelihoods**, particularly through reduced financial stress, better food availability, and more predictable earnings. Farmers described that the ability to store produce and avoid distress selling helped them stabilise weekly income, which in turn eased day-to-day household management. A farmer from Jalukie shared,

“Because we get a better price now, it has become easier to manage household expenses.” - *Farmer, Jalukie, Peren*

Some respondents highlighted that reduced spoilage allowed them to retain a portion of their harvest for home consumption without compromising market sales. This dual benefit improved dietary diversity and reduced the need to purchase vegetables from the market. A farmer from Longkhum noted,

“We keep some vegetables for our family and sell the rest later. Earlier, much of it would spoil.” - *Farmer, Longkhum, Mokokchung*

Caretakers also observed that improved earnings enabled families to meet essential needs more comfortably and reduced the pressure to borrow during low-price periods. As a caretaker from Sovima explained,

“Farmers tell us that with less loss and better selling, they manage their home needs without taking loans.” - *Caretaker, Sovima, Chumukedima*

In some cases, farmers mentioned being able to set aside small savings or invest in children’s education due to improved income stability. A respondent from Chumukedima shared,

“Now that our earnings are steadier, we can save a little and support our children better.” - *Farmer, Chumukedima*

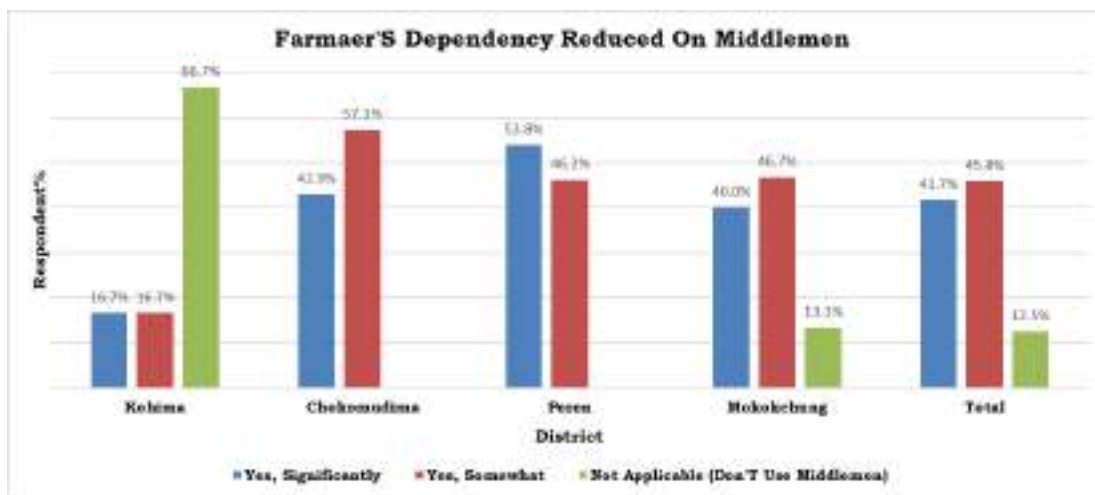
Overall, the cold storage intervention has strengthened household wellbeing by improving cash flow, reducing wastage-related losses, supporting food security, and enabling families to manage expenses with greater confidence and stability.

4.6 Reduction in Dependency on Middlemen

Cold storage has played a significant role in reducing farmers’ dependency on middlemen, with **41.7%** reporting a significant reduction and another **45.8%** noting a moderate reduction. This indicates that most farmers now have greater control over when and where to sell their produce, reducing the pressure to accept low prices offered by intermediaries. District-level patterns show the strongest reduction in **Peren**, where **53.8%** experienced significant decline in middlemen dependency,

followed closely by **Chümoukedima (42.9%)** and **Mokokchung (40%)**, suggesting that producers in these areas have gained improved bargaining power and flexibility through cold storage. **Kohima** presents a different picture, with **66.7%** of farmers marking “not applicable,” indicating that many already sold directly even before the intervention resulting in fewer middlemen in the local value chain. Among Kohima farmers who did previously rely on intermediaries, reductions were evenly split between significant and moderate (16.7% each). Overall, the data shows that cold storage has helped shift market dynamics in favour of farmers, enabling them to hold produce longer, avoid distress sales, and reduce reliance on middlemen across most districts.

Fig 26



Qualitative findings show that the cold storage facilities have contributed to a **notable reduction in farmers’ reliance on middlemen**, particularly during peak harvest periods when perishables typically lose value quickly. Before the intervention, farmers shared that they often had no choice but to sell immediately to local agents, sometimes at significantly lower prices, because their produce could not be stored safely. A farmer from Longkhum reflected on earlier practices,

“Earlier, we sold to middlemen because the vegetables would spoil if we waited. We didn’t have another option.” - *Farmer, Longkhum, Mokokchung*

With access to cold storage, farmers now have the flexibility to hold their produce temporarily and **approach buyers directly** when prices improve. This shift has reduced pressure to accept middlemen’s rates and strengthened farmers’ bargaining power. A farmer from Jalukie explained,

“Now we can store and wait. We don’t have to give it to agents quickly at whatever price they offer.” - *Farmer, Jalukie*

Caretakers observed that cold storage has encouraged more farmers to explore direct sales in nearby markets, especially when demand is higher. As one caretaker from Sovima noted,

“Farmers are selling more on their own now. They say the storage gives them time to find better buyers.” - *Caretaker, Sovima, Chumukedima*

In some villages, farmers reported that selling directly, either in local markets or through community networks, helped them retain a larger share of the final price. A respondent from Chumukedima shared,

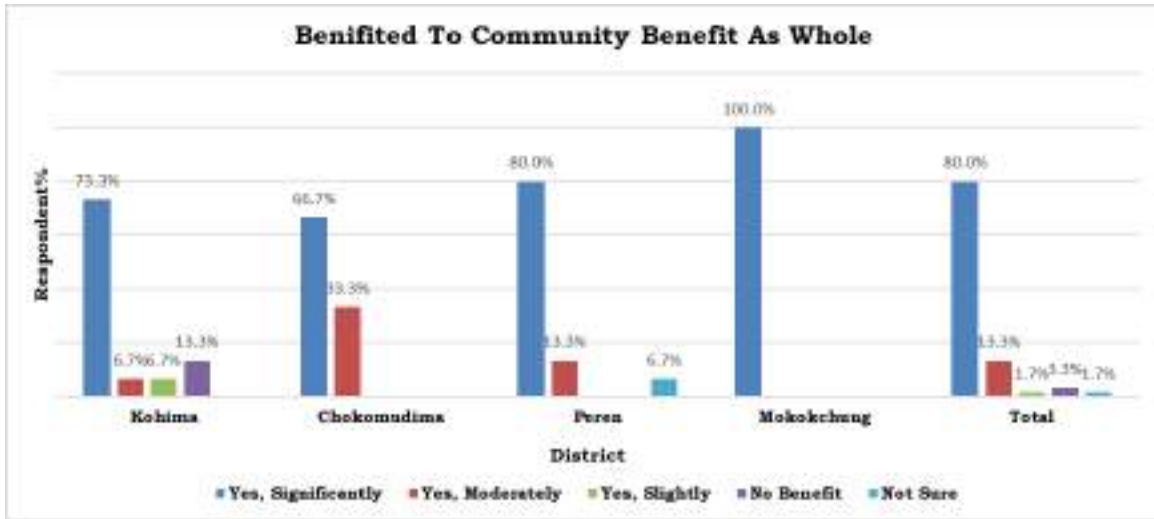
“We don’t depend on middlemen like before. Because we can store, we sell directly and earn more.” - *Farmer, Chumukedima*

Overall, the cold storage intervention has strengthened farmers’ control over when and to whom they sell, reducing dependency on intermediaries and enhancing their ability to negotiate better prices, ultimately improving market autonomy and income stability.

4.7 Improvements in Community-Level Benefits

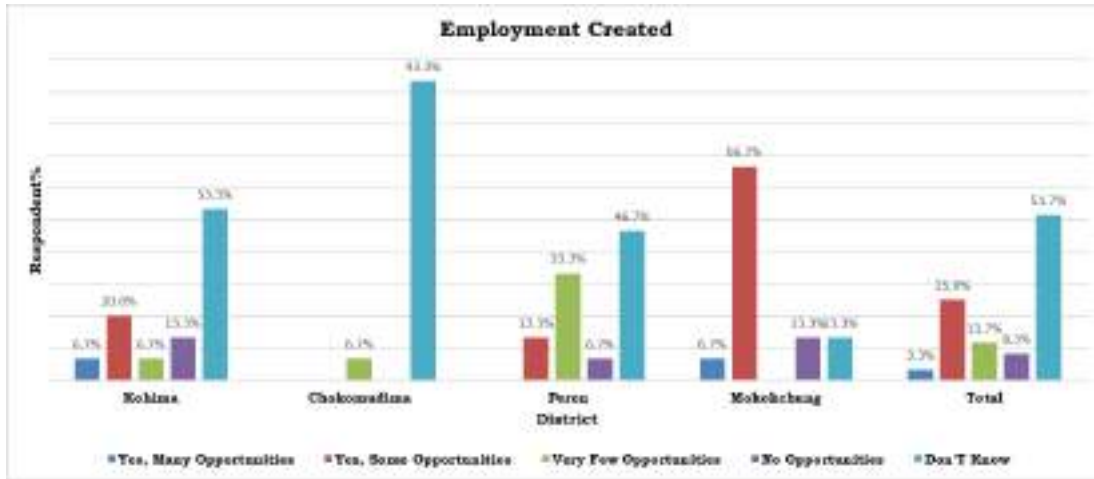
The cold storage project is widely viewed as a strong community asset, with **80% of respondents** stating that it has significantly benefited their community and another **13.3%** reporting moderate benefits. Perceptions were overwhelmingly positive across districts, especially in **Mokokchung**, where **100%** of farmers reported significant community benefits indicating strong collective reliance on the facility and noticeable improvement in storage practices, reduced spoilage, and enhanced market opportunities. **Peren** also reflected very high approval, with **80%** reporting significant benefits and **13.3%** moderate, showcasing broad community-level gains. In **Chümoukedima**, **66.7%** saw significant benefits and **33.3%** moderate, indicating positive but slightly more varied experiences. **Kohima**, while still largely positive, displayed the widest range of views: **73.3%** saw significant benefits, **6.7%** moderate, but **13.3%** felt there was no benefit and **6.7%** cited only slight benefits suggesting mixed utilisation patterns or variability in engagement with the facility. Only one farmer across all districts (1.7%) was unsure. Overall, the findings show that the cold storage project is broadly perceived as a **community-enhancing intervention**, improving post-harvest outcomes, supporting market stability, and strengthening the local agricultural ecosystem.

Fig 27



Perceptions of employment generation from the cold storage project vary widely across districts, with more than half of all respondents (**51.7%**) indicating they don't know whether new opportunities were created reflecting limited visibility or indirect involvement in employment aspects. Among those who did observe changes, **25%** reported that the facility created some opportunities, and **11.7%** noted very few opportunities, while only **3.3%** felt that many jobs were created. District-level patterns show the clearest employment impact in **Mokokchung**, where **66.7%** observed "some opportunities" and **6.7%** saw "many opportunities," likely linked to higher utilisation levels and greater operational activity around the facility. **Peren** reported modest gains, with **13.3%** noting some opportunities and **33.3%** reporting very few. In **Kohima**, employment perceptions were mixed: **20%** saw some opportunities, while **53.3%** did not know and **13.3%** felt there were none. **Chümoukedima** had the least reported employment impact, with **93.3%** of farmers unsure and only a small share (6.7%) perceiving very few opportunities. Overall, while the cold storage has created some local employment mostly in caretaker roles, loading/unloading, and transport the impact appears limited, uneven across districts, and not widely visible to most community members.

Fig 28



Qualitative findings highlight that the cold storage intervention has generated **broader community-level benefits**, extending beyond individual users to improve collective resilience, cooperation, and market participation. Farmers shared that the facility has encouraged greater interaction and coordination within villages, as they now discuss storage plans, market prices, and timing decisions together. A farmer from Longkhum expressed,

“We talk more with other farmers now, about when to store and when to sell. It helps all of us.” - *Farmer, Longkhum, Mokokchung*

In several villages, farmers mentioned that the cold storage has reduced tensions around oversupply and price crashes, fostering a more supportive environment during peak harvest seasons. A respondent from Jalukie noted,

“Because we are not forced to sell on the same day, there is less competition among farmers.” - *Farmer, Jalukie, Peren*

Caretakers also observed that the facility has strengthened community trust and collective problem-solving. Farmers now approach caretakers as a group to plan usage, especially during high-volume periods. A caretaker from Sovima shared,

“Sometimes they come together and plan how to use the space so everyone gets a chance. It has improved cooperation.” - *Caretaker, Sovima, Chumukedima*

Additionally, the cold storage has enhanced the village’s reputation within surrounding areas, attracting interest from neighbouring farmers and increasing footfall in local markets. A farmer from Chumukedima commented,

“People from nearby villages also come to see the storage. It has made our village better known.” - *Farmer, Chumukedima*

Overall, the intervention has fostered **collective benefits** by improving farmer cooperation, reducing local market stress, and strengthening the community’s economic identity. These wider gains reflect the intervention’s role in enhancing both social cohesion and local market systems.

4.8 Challenges and Areas Requiring Strengthening

Farmers reported a mix of operational, infrastructural, and seasonal challenges, though a large number also expressed satisfaction with the facility. A prominent concern across responses especially in **Mokokchung** was **poor road connectivity** to the cold storage, making transportation of produce difficult, particularly during the rainy season. Several farmers noted that **the facility is located far from the main road**, resulting in additional transport labour and costs. Capacity-related challenges also emerged, with users in Mokokchung indicating that **the storage size becomes insufficient during peak harvests**, limiting how much they can store at once. A few farmers from **Peren and Kohima** highlighted **temperature inconsistencies**, including occasional over-freezing or difficulty maintaining the right cooling level for certain crops. Power-related concerns such as **shortage of solar backup during cloudy or rainy days** were reported in Kohima, along with suggestions for an **electric backup** to complement solar operations. Some farmers also mentioned the absence of **storage racks**, making it harder to organise produce inside the chamber.

Despite these issues, a substantial number of respondents particularly in Chümoukedima and Kohima said they were **fully satisfied and faced no challenges**, with many indicating that the facility meets their needs “as of now” but may require **capacity expansion in the future** as usage increases. Overall, the challenges raised are practical and solvable, largely relating to **last-mile connectivity, seasonal power fluctuations, and growing demand**, while sentiments remain predominantly positive about the value and usefulness of cold storage.

Qualitative insights reveal that while farmers value the cold storage facilities highly, several recurring challenges continue to shape how effectively they can use them. The most frequently raised issue was **poor road access**, especially in hilly or muddy areas like Longkhum, where farmers described carrying heavy bags by hand because “vehicles cannot reach the storage during rains.” This not only makes usage physically demanding but also limits how much produce can be transported at one time. **Capacity constraints** also emerged in high-demand sites such as Meriema and Sovima. Caretakers noted that during peak seasons or major events, farmers sometimes had to wait their turn or store only part of their stock because “the unit cannot take everyone at once.” A smaller but important challenge involved **solar dependency in cloudy regions** like Kohima, where extended monsoon periods reduce

power availability. The Meriema caretaker explained that during such times “solar alone is not enough, and electric backup is needed for smooth functioning.” Some farmers also expressed concern about **temperature inconsistencies**, especially when different crops were stored together or when new users were unsure of ideal settings. While technical support from Inficold was generally prompt, caretakers felt that more preventive maintenance and refresher training would help avoid minor issues. Overall, these qualitative accounts highlight that although the facilities are functioning well, improvements in road connectivity, system capacity, hybrid power backup, crop-specific guidance, and proactive maintenance would significantly enhance long-term usability and impact.

V. Sustainability

The sustainability assessment examines the extent to which the solar-powered cold storage facility is positioned for continued use and long-term relevance within the communities it serves. This section explores farmer willingness to use and recommend the facility in future seasons, perceptions of the solar-powered system’s reliability, and the operational factors that contribute to or hinder sustained adoption. Insights from both quantitative responses and qualitative feedback help illustrate whether the benefits experienced by farmers are likely to continue over time and how the intervention fits into existing agricultural practices and local conditions.

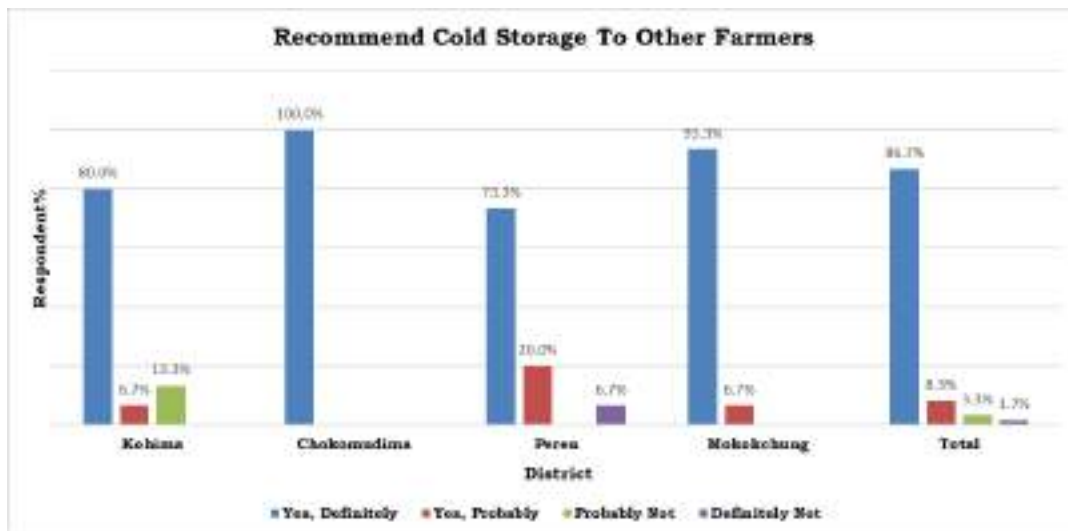
Table: Key Research Questions and Indicators (Sustainability)

Sl. No.	Key Research Question	Indicators Used
1	Are farmers willing to continue using the cold storage in the long term?	Intention to use in future seasons; perceived usefulness and relevance over time
2	Is there community ownership or collective responsibility for the facility?	Role of village councils; community involvement; informal norms for shared use
3	Is the intervention becoming embedded in regular agricultural practices?	Use of cold storage across harvest cycles; planning of harvest and sales around storage availability
4	Are environmental conditions favourable for sustaining a solar-powered system?	Solar reliability across seasons; geographic suitability for long-term solar operation
5	Does the initiative show potential for scale-up or replication?	Demand from neighbouring villages; farmer suggestions for expansion; interest in additional units

5.1 - Recommend Cold Storage to Other Farmer

Farmer endorsement of the cold storage facility is overwhelmingly positive, with **86.7%** stating they would definitely recommend it to other farmers and another **8.3%** saying they would probably recommend it. This high level of trust reflects strong user satisfaction with the facility’s performance, storage quality, and economic benefits. District-level trends are consistently favourable: **Chümoukedima** showed perfect endorsement, with 100% of farmers stating they would definitely recommend the facility. **Mokokchung** followed closely, with **93.3%** definite recommendations, while **Kohima (80%)** and **Peren (73.3%)** also reported strong positive intent. A very small proportion expressed hesitation **3.3%** in Kohima selected “probably not,” and only **1.7%** in Peren said “definitely not” likely due to individual challenges such as road access, storage distance, or crop-specific compatibility. Overall, the data indicates exceptionally high user confidence and strong community acceptance, suggesting that the cold storage model holds substantial potential for wider replication and scale-up.

Fig 29



Qualitative findings indicate strong willingness among farmers to recommend the cold storage facility to others, reflecting high satisfaction with its usefulness, accessibility, and impact on reducing losses. Farmers across all locations expressed confidence that the facility would benefit other smallholders facing similar post-harvest challenges. A farmer from Jalukie shared,

“I have already told other farmers to try it. It helps a lot when the harvest is big.” - Farmer, Jalukie, Peren

Many respondents noted that they actively encourage neighbours and relatives to use the facility, especially during seasons when spoilage risks are high. A farmer from Longkhum explained,

“I recommend it because the vegetables stay fresh. Others should also use it instead of keeping it at home.” - *Farmer, Longkhum, Mokokchung*

Caretakers confirmed that new users often visit after receiving recommendations from existing farmers, indicating strong word-of-mouth diffusion. One caretaker from Sovima remarked,

“Most new farmers come because someone in the village told them it works well.” - *Caretaker, Sovima, Chumukedima*

Some farmers also highlighted that the facility is especially helpful for those who cultivate perishables and may lack transport options, making it a valuable community asset. A respondent from Chumukedima shared,

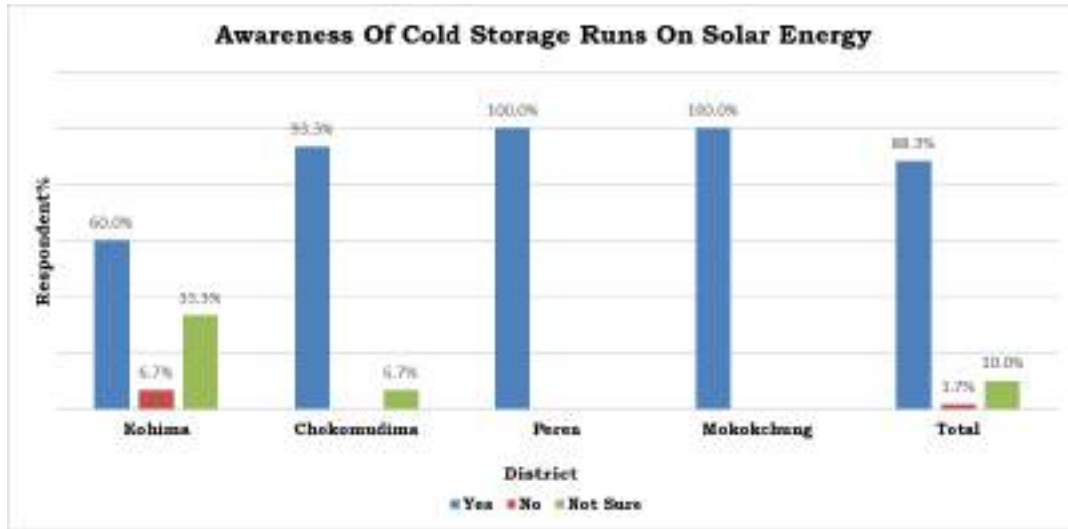
“Everyone who grows vegetables should use it. It reduces waste and gives better price.” - *Farmer, Chumukedima*

Overall, the strong willingness to recommend the facility underscores its perceived value, community acceptance, and potential for sustained and expanded use, contributing positively to its long-term sustainability.

5.2 - Cold Storage run on Solar Energy

Awareness that the cold storage facility operates on solar energy is very high across districts, with **88.3%** of farmers reporting that they are aware of the solar-powered system. This indicates strong visibility of the technology and effective communication during installation and use. Awareness is universal in **Peren** and **Mokokchung** (100%), reflecting clear understanding among users about how the facility functions. **Chümoukedima** also shows extremely high awareness at **93.3%**, with only one respondent unsure. **Kohima**, however, stands out with comparatively lower awareness: while **60%** knew the facility was solar-powered, a notable **33.3%** were “not sure,” and **6.7%** said they were unaware. This suggests a need for clearer communication or orientation sessions in Kohima, possibly related to limited direct interaction with the system due to weather constraints or differing engagement levels. Overall, the findings show that most farmers recognise the solar-based design of the facility, which is important for building user trust in reliability and sustainability.

Fig 30



Qualitative findings highlight that farmers view the **solar-powered design** of the cold storage system as a major advantage for long-term sustainability. In regions where electricity supply is inconsistent, the solar setup ensures uninterrupted cooling, reducing the risk of spoilage and strengthening farmers’ trust in the facility. A farmer from Jalukie emphasized this benefit,

“Even when the electricity goes off, the cold storage keeps running because of the solar. That makes it very reliable.” - Farmer, Jalukie, Peren

Farmers also noted that solar energy reduces operational disruptions and ensures that the facility remains functional throughout the year, regardless of weather or power fluctuations. A respondent from Longkhum shared,

“The solar system works every day. We don’t worry about power cuts anymore.” - Farmer, Longkhum, Mokokchung

Caretakers confirmed that the solar infrastructure requires minimal intervention and has been stable since installation. According to a caretaker from Sovima,

“The solar runs smoothly. There have been no major issues, and farmers feel confident using it.” - Caretaker, Sovima, Chumukedima

Farmers widely perceived the solar-powered model as cost-effective and environmentally suitable for their terrain. A farmer from Chumukedima stated,

“Solar is the best for our area. With our power problems, only this kind of system will work long-term.” - Farmer, Chumukedima

Overall, the solar-powered design enhances the **technical, financial, and operational sustainability** of the cold storage system, making it well-suited to Nagaland's geographic and infrastructural realities and ensuring consistent benefits for farmers in the long run.

Inputs of IDAN Staff Interviews

Interviews with IDAN's CSR and implementation teams reveal a highly structured, strategically aligned, and evolving approach to the Solar Cold Storage Program. As the state's facilitating agency, IDAN positions itself not merely as a conduit for CSR implementation but as an institution shaping the broader agricultural ecosystem through coordinated interventions. Their insights highlight strong operational discipline, adaptive learning between phases, and an explicit commitment to sustainability.

1. Strong Facilitation Role and Governance Structure

IDAN staff demonstrates a strong facilitation role and clear governance structure in the implementation of the Solar Cold Storage Program, positioning itself as the central coordinating agency rather than a direct implementer. Internally, responsibilities are well divided across planning, entrepreneurship, field supervision, and M&E teams, enabling smooth decision-making and operational efficiency. The senior leadership manages approvals and strategic planning, while the entrepreneurship division handles beneficiary mobilization and the field teams conduct on-ground verification, installation oversight, and continuous monitoring. This structured governance ensures accountability at each stage vendor negotiations, timeline adherence, site readiness, beneficiary agreements, and post-installation supervision allowing IDAN to maintain high implementation discipline and deliver complex projects effectively across multiple districts.

2. Clear Objectives Focused on Value Chain Strengthening

IDAN staff articulated clear and well-aligned objectives that positioned the Solar Cold Storage Program as a strategic intervention to strengthen Nagaland's agricultural value chain. Rather than treating the units as standalone assets, the program is designed to reduce post-harvest losses, improve farmers' bargaining power, and facilitate smoother market access by enabling farmers to store produce temporarily and avoid distress sales. The cold storages are viewed as one essential component within a broader ecosystem that IDAN is building linking production clusters, entrepreneurs, and market hubs. This systems-oriented approach emphasizes long-term value chain development, where improved storage, combined with future logistical linkages, can enhance income stability and create more resilient market pathways for farmers across the state.

3. Evolution Between Phase I and Phase II Demonstrates Institutional Learning

The transition from Phase I to Phase II clearly demonstrates IDAN’s strong capacity for institutional learning and adaptive implementation. Challenges encountered in the first phase such as unsuitable site locations, logistical delays, and reliance on intermediaries were systematically addressed in Phase II through more rigorous processes and refined strategies. IDAN introduced physical site verification to ensure that units were placed closer to farming clusters, improved logistical planning to avoid simultaneous dispatch bottlenecks, and streamlined partnerships by reducing intermediary layers. These adjustments resulted in faster installations, better utilization, and smoother coordination with the technical vendor. Overall, the evolution between phases reflects IDAN’s ability to critically assess on-ground realities, incorporate lessons into planning, and enhance program effectiveness through continuous improvement.

4. Entrepreneur-Based Sustainability Model

The staff interviews highlight that the entrepreneur-based sustainability model is a central pillar of IDAN’s implementation strategy, designed to ensure that the cold storage units remain functional and viable beyond the CSR funding period. Instead of distributing the units as one-time donations, IDAN deliberately positioned local entrepreneurs as operators responsible for generating modest revenue through nominal tariffs and managing routine upkeep. Training on bookkeeping, enterprise management, and transparent usage norms reinforced this expectation from the outset. Staff acknowledged that some beneficiaries initially struggled with this shift, often expecting IDAN to handle even minor issues, indicating the need for continuous mentoring. However, the model has succeeded in cultivating ownership in several locations, where operators proactively maintain the units, manage records, and ensure steady use. This approach reflects IDAN’s broader commitment to sustainability, reducing dependency on external support and encouraging operators to treat the cold storage units as small, locally anchored enterprises rather than grant-based assets.

5. Strong Monitoring Systems, with Preference for Physical Verification

Staff interviews underscore that IDAN maintains a strong and proactive monitoring system, with a clear preference for **physical verification over paper-based reporting**. The team conducts frequent field visits, including unannounced inspections, to assess utilization, cleanliness, and operational conditions of the cold storage units. They emphasized that documentary evidence or photographs can be easily fabricated, making on-ground observation the most reliable method for assessing performance. This hands-on monitoring approach allows IDAN to identify issues early, support operators directly, and maintain accountability among beneficiaries. Regular interactions with operators during site visits also serve as informal mentoring opportunities, reinforcing usage norms, troubleshooting practices, and

entrepreneurship expectations. Overall, the monitoring system reflects a high level of institutional commitment and significantly contributes to the consistent functionality and reliability of the cold storage units across districts.

6. Utilization Patterns and Variability

Staff interviews reveal notable variability in the utilization patterns of the cold storage units across districts, shaped largely by local agricultural production, market frequency, and the level of operator engagement. Approximately 40% of the units particularly those in districts like Mon, Longleng, Tuensang, and parts of Kohima are performing exceptionally well, with frequent or even daily usage during peak seasons. These locations benefit from higher product volumes, multiple market days, and strong operator ownership. In contrast, about 60% of units experience moderate or seasonal utilization, influenced by fluctuations in crop availability, limited farmer awareness, or sites that are relatively distant from farming clusters. While all units remain functional, the mixed usage patterns underscore the importance of strategic site selection, demand-side strengthening, and sustained support to ensure that the entrepreneurial model translates into consistent and long-term uptake across all locations.

7. Early Outcomes: Reduced Spoilage and Increased Farmer Confidence

Staff interviews indicate that the program has already generated clear and meaningful early outcomes, most notably in reducing post-harvest spoilage and improving farmers' confidence in storing and marketing their produce. In districts where utilization is high, farmers are now able to keep vegetables and fruits for two to three days, allowing them to avoid distress sales and wait for better market prices, an important shift from earlier practices where perishables often had to be sold immediately or discarded. Operators and district administrations have observed visible reductions in wastage during peak seasons, especially for crops like Naga king chilli and tomatoes. These positive experiences have strengthened farmer trust in the technology and increased the perceived value of the cold storage units within communities. The growing number of requests from MLAs, district officials, and local groups for additional units further reinforces that the intervention is viewed as beneficial, practical, and worth expanding. Overall, these early outcomes suggest that the project is beginning to influence farmer behaviour, post-harvest management practices, and local market dynamics in a positive way.

8. Persistent Logistical and Operational Challenges

Staff interviews highlight several persistent logistical and operational challenges that affected implementation across both phases of the program. Nagaland's difficult terrain and unpredictable weather conditions created delays in equipment transportation, especially to remote districts where roads are narrow, steep, or prone

to landslides. In some locations, IDAN had to undertake land leveling or filling before installation, a process that added time and coordination requirements. Simultaneous deliveries during Phase I also strained vendor capacity, resulting in scheduling conflicts and delayed commissioning. Additionally, the single-temperature cold storage design led to crop damage in at least one site when incompatible produce types were stored together, pointing to technical limitations in handling diverse commodities. On the operational side, some beneficiaries initially relied on IDAN to manage minor maintenance issues, indicating incomplete adaptation to the entrepreneurship model. While Phase II improvements reduced several of these challenges, the interviews reveal that logistical complexities, terrain-related constraints, and operator expectations continue to shape the program’s overall efficiency and outcomes.

9. High Motivation and Personal Commitment

Staff interviews reflect a high level of motivation, personal commitment, and professional pride among IDAN team members involved in the Solar Cold Storage Program. Many described the project as one of the most meaningful and large-scale CSR initiatives undertaken since the activation of the CSR division in 2022. Their enthusiasm is evident in their willingness to travel extensively across districts, conduct frequent field visits, and engage directly with beneficiaries to troubleshoot issues and encourage utilization. Several staff members highlighted the satisfaction they felt when farmers reported reduced spoilage or improved earnings, noting that these outcomes validated the challenges faced during implementation. They also appreciated the collaborative nature of the project, which required coordination with district administrations, technical partners, and local entrepreneurs. Overall, the interviews show a deeply invested team that views the project not just as a professional responsibility, but as an opportunity to contribute tangibly to farmer livelihoods and strengthen Nagaland’s agricultural ecosystem.

Conclusion

The assessment of the Solar Cold Storage initiative in Nagaland shows a clear and consistent message: the intervention is working, and it is reaching the right farmers. Across Kohima, Chümoukedima, Peren, and Mokokchung, farmers repeatedly shared that this is the first time they have had a practical, reliable way to manage perishable produce after harvest. For communities that cultivate on small and fragmented plots, often harvesting in small but frequent cycles, a decentralised, village-level cold storage facility fits naturally into their daily agricultural routine.

The quantitative evidence reinforces this. A large share of farmers (73.3%) cultivate 1 acre of land, and many grow vegetables across multiple seasons, patterns that naturally create repeated peaks of perishable produce. Without storage, farmers previously had little option but to sell immediately, often at lower or distress prices. With the cold storage now available, this pattern has changed for many households.

Across locations, farmers described using the facility regularly, sometimes multiple times a week during peak seasons, mainly to preserve freshness and avoid spoilage. Even a short storage duration of 1 - 2 days was enough to help them time their market visits better or wait out sudden price drops. For crops like tomatoes, chillies, cabbage, and Naga King Chilly, this short buffer made a significant difference. The reduction in post-harvest losses was one of the strongest and most frequently mentioned benefits.

The intervention performed well operationally too. The solar-powered system was widely appreciated, especially in areas where electricity cuts are common. Farmers and caretakers both expressed confidence that cooling remained stable even during outages, which strengthened trust in the system. Caretaker support emerged as another strong pillar, farmers consistently said that caretakers made the process easy, guided them when needed, and maintained the units well.

These improvements translated into meaningful economic gains. Farmers reported earning slightly better prices, selling more of their produce instead of losing it, and being able to manage household needs more comfortably. Some even spoke about reinvesting their improved earnings into better seeds and inputs, reflecting a positive cycle of productivity.

Importantly, the benefits extended beyond individuals. In several villages, farmers said the cold storage reduced pressure during harvest gluts and encouraged more cooperation and planning among community members. Many also mentioned that they actively recommend the facility to neighbours, showing strong acceptance and trust in the model.

Taken together, the findings suggest that the Solar Cold Storage initiative is not only technically appropriate, but also socially relevant and economically meaningful for the communities it serves. It reduces waste, enables better price realisation, and gives farmers greater control over post-harvest decisions. Farmers see value in it, use it regularly, and advocate it to others.

Overall, the intervention stands out as a grounded, practical, and sustainable solution, one that fits well into Nagaland's agricultural realities and contributes positively to farm-level resilience and household livelihoods.

Recommendation

Based on the findings of the impact assessment and insights from multiple stakeholders including farmers, caretakers, and IDAN implementation staff the following recommendations aim to strengthen the long-term sustainability, effectiveness, and scalability of the Solar Cold Storage Program in Nagaland:

1. Enhance Technical Design for Multi-Crop Compatibility

The current cold storage units operate on a single-temperature system, which limits their effectiveness when farmers store crops with differing temperature and humidity requirements. Several respondents including farmers, caretakers, and IDAN staff reported instances where storing mixed produce led to quality deterioration, such as in Phek where one crop spoiled because the temperature settings favored another. To address this, the program should transition toward **multi-crop compatible storage designs** that provide greater flexibility and reduce risk of spoilage.

This enhancement can include:

- **Multi-chamber cold rooms** with independently controlled temperature zones, allowing farmers to store vegetables, fruits, and spices simultaneously without compromising quality.
- **Humidity control systems**, especially important for leafy greens, fruits, and spices that require specific moisture conditions to prevent wilting or shrinkage.
- **Pre-cooling units** to remove field heat before produce enters storage. Many crops, particularly Naga King chilli, tomatoes, and cabbages, degrade quickly when transferred directly from field heat into cold rooms. Pre-cooling will improve storage efficiency and extend shelf life.
- **Crop-specific temperature presets**, enabling caretakers and operators to store diverse commodities safely through simple pre-programmed settings rather than manual adjustments.
- **Modular expansion options**, where small chambers can be added based on community needs and cropping patterns.

2. Strengthen Last-Mile Logistics and Market Linkages

While the cold storage units have significantly reduced spoilage and improved short-term preservation, farmers across districts continue to face major logistical barriers in transporting produce to larger, more profitable markets such as Dimapur, Kohima, and other commercial hubs. Interviews with IDAN staff reveal that cold storage is only one part of the broader agricultural value chain; without reliable transport and aggregation systems, farmers cannot fully realize the benefits of improved storage. Several high-performing locations are already requesting additional units, but their impact will remain limited unless last-mile connectivity is strengthened.

To address this gap, the program should incorporate a **structured logistics and market linkage strategy** that includes:

- **Village-to-market transport solutions**, such as linking cold storage operators with local transporters, SHGs, or farmer groups who can run shared vehicles (e.g., pick-up vans) on fixed schedules or demand-based routes.

- **Aggregation centres or mini-hubs** in strategically located market towns (e.g., Dimapur, Kohima, Mokokchung), where produce from multiple villages can be collected and bulk-transported to urban or wholesale markets.
- **Partnerships with FPOs, cooperatives, or private aggregators**, enabling farmers to tap into larger procurement networks for vegetables, fruits, and spices.
- **Digital market information systems** (e.g., WhatsApp groups, local price dashboards) so farmers can decide when to sell based on real-time price trends across markets.
- **Linkages with institutional buyers**, including food processors, hospitality sectors, and retailers, which can provide stable demand and reduce farmers' dependence on fluctuating bazaar prices.
- **Seasonal mobility planning**, ensuring transport availability during peak harvest periods when demand for cold storage and market access is highest.

3. Expand Capacity in High-Demand Locations

Utilization patterns across districts show that while some cold storage units are used moderately or seasonally, several locations experience consistently high demand often exceeding the available storage space. In areas such as Mokokchung, Meriema (Kohima), and Sovima, farmers reported instances where the cold room was temporarily full, preventing them from storing produce during peak harvest periods. Caretakers in these high-performing sites also noted increased footfall around festival seasons (e.g., Hornbill Festival) and during peak cultivation months. This pattern indicates not only strong acceptance of the technology but also a clear need for expanded capacity to ensure equitable and reliable access for all farmers.

To address this growing demand, the program should consider the following strategies:

- **Installing larger-capacity units** in sites that demonstrate repeated high utilization and consistent storage demand across seasons.
- **Adding secondary or modular units** near existing high-demand sites, allowing the system to scale incrementally without requiring large upfront installations.
- **Creating cluster-based storage models**, where multiple nearby villages share expanded cold rooms or additional units, reducing the risk of congestion during peak periods.
- **Integrating capacity planning with cropping calendars**, ensuring that expansions align with high-production crops such as Naga King chilli, tomatoes, cabbage, and ginger, which drive seasonal surges in storage requirements.

4. Introduce Hybrid Backup Power in Cloud-Prone Regions

While the solar-powered cold storage system has performed reliably in most districts, farmers and caretakers in cloud-prone and high-altitude areas particularly Kohima (Meriema) reported reduced cooling efficiency during extended periods of cloudy weather or heavy rainfall. In such conditions, solar panels generate insufficient power, causing the internal temperature of the cold room to rise and occasionally reducing the system’s ability to maintain produce quality. Although these issues did not result in major spoilage, they present a recurring seasonal challenge that could undermine user confidence and restrict utilization during monsoon months.

To ensure uninterrupted performance across all regions, especially those with limited sunlight exposure, the program should integrate **hybrid backup power solutions** into the existing infrastructure. This can include:

- **Solar-electric hybrid systems**, where grid electricity automatically supports cooling during low-sunlight periods, ensuring stable temperatures year-round.
- **Battery capacity enhancements** for districts with frequent cloud cover, enabling longer backup duration and reducing reliance on immediate solar input.
- **Small-scale inverters or generator backup** for remote locations with no reliable grid access, ensuring emergency continuity without compromising affordability.
- **Weather-responsive automation**, where the system automatically switches to backup modes when solar input drops below critical thresholds, preventing temperature fluctuations that can harm sensitive crops.
- **Prioritised installation in high-risk districts**, based on historical precipitation patterns, solar irradiance data, and user-reported performance (e.g., Kohima, parts of Peren).

5. Continue and Expand Capacity Building for Operators and Farmers

Training has been a critical component of the program’s success, equipping operators with basic technical knowledge and familiarizing farmers with usage norms. However, interviews indicate that both groups would benefit from **more comprehensive and continuous capacity-building support** to ensure consistent, safe, and optimal operation of the cold storage units. Some operators still rely on IDAN or the vendor for minor issues, and farmers expressed interest in better understanding crop-specific storage requirements and improved post-harvest handling techniques.

To strengthen operational sustainability and enhance utilization, the program should implement an expanded, multi-tiered training approach that includes:

- **Refresher training for operators**, focusing on technical troubleshooting, energy management, cleanliness protocols, and accurate record-keeping. This

will reinforce the entrepreneurial model and reduce dependency on IDAN for small maintenance tasks.

- **Crop-specific storage guidance for farmers**, including information on temperature settings, compatible crop categories, pre-cooling practices, and packaging methods to improve shelf life and minimize spoilage risks.
- **Business and bookkeeping modules** for operators, enabling them to manage tariffs, maintain transparent registers, and operate the facility as a community micro-enterprise.
- **Seasonal training cycles**, delivered before peak harvest periods to ensure both operators and farmers are prepared for increased usage and storage demand.
- **Demonstration-based learning**, such as field demonstrations, farmer-to-farmer exchanges, and caretaker-led sessions, which were shown to be highly effective in building trust and confidence.
- **Digital or printed SOPs and quick-reference guides**, featuring simple instructions and crop-specific recommendations that operators and farmers can easily refer to.
- **Training support for new users**, ensuring that first-time farmers understand how to prepare produce, pack materials properly, and store safely.

6. Improve Accessibility Through Site Planning and Infrastructure Support

Although many cold storage units are strategically located near markets or main roads, several sites particularly in hilly and remote villages face accessibility challenges that limit frequent use. Farmers in areas like Longkhum reported difficulty transporting produce due to steep terrain and poorly maintained approach roads, sometimes having to carry vegetables by hand or delay storage during adverse weather. Such barriers reduce overall utilization and prevent farmers from fully benefiting from the facility, especially during peak harvest periods when timely storage is critical.

To ensure equitable and convenient access for all farmers, future planning and ongoing program support should include:

- **Rigorous pre-installation site verification**, incorporating assessments of terrain, road connectivity, walking distance for farmers, proximity to cultivation areas, and feasibility of vehicle access. This was a successful strategy in Phase II and should be institutionalized for all future installations.
- **Minor infrastructure improvements**, such as leveling the ground, improving footpaths, installing ramps, or constructing small approach roads, particularly in villages where terrain prevents easy movement of produce. These low-cost enhancements can significantly improve usability.
- **Community-led micro-infrastructure initiatives**, where village councils or local committees collaborate in maintaining access routes, cleaning surroundings, and ensuring that pathways remain usable during monsoons.

- **Strategic placement of units within farming clusters**, reducing travel time for farmers and ensuring that storage is situated at points of highest daily footfall rather than only administrative or residential centers.
- **Coordination with district administration** to secure permissions or technical assistance for minor civil works when necessary, especially in regions where land preparation or leveling was identified as a challenge during the interviews.
- **Consideration of alternate siting models**, such as shared locations for multiple villages, placement near community aggregation points, or integration with existing community infrastructure (e.g., market sheds).

7. Strengthen Data Recording and Monitoring Mechanisms

IDAN's strong emphasis on physical verification and surprise site visits has been central to ensuring accountability and consistent performance across cold storage locations. However, the monitoring system currently relies heavily on manual observations and paper-based registers, which vary in quality and completeness across operators. While this approach has worked well so far, scaling the program or adding additional units will require more systematic, standardized, and digitized monitoring mechanisms to ensure timely decision-making, identify early signs of underutilization, and support continuous improvement.

To enhance the robustness and efficiency of monitoring, the program should adopt the following measures:

- **Standardized data recording formats** for all operators, including daily logs on volume stored, types of produce, duration of storage, tariff records, and maintenance activities. A uniform template will ensure comparability and reduce inconsistencies across sites.
- **Digital usage tracking**, such as simple mobile-based apps or WhatsApp reporting formats that caretakers can update regularly. Even low-tech solutions like photographing logbooks or sending geo-tagged storage photos can support real-time monitoring without heavy infrastructure.
- **Monthly performance dashboards** maintained by IDAN, summarizing key indicators such as utilization rates, recurring technical issues, revenue patterns, and seasonal trends. This can help identify high-performing sites, locations requiring support, and opportunities for expansion.
- **Early warning indicators** built into the monitoring system, such as sudden drops in utilization, frequent repair requests, or prolonged periods of zero storage activity. These flags can trigger targeted support visits or refresher training.
- **Periodic operator review meetings**, conducted quarterly or bi-annually, where operators share experiences, common challenges, and best practices. This peer-learning platform can also help reinforce accurate reporting habits.

- **Integration of AMC (Annual Maintenance Contract) tracking**, ensuring that vendor visits, technical issues, and repair timelines are logged systematically and monitored for timely resolution.
- **Geo-tagged photo documentation** during major events installation, repairs, seasonal usage peaks to create a visual record of the facility's condition and functioning over time.

8. Support the Entrepreneurship Model With Clear Communication of Roles

The program's sustainability depends heavily on the entrepreneurship model, where operators manage the cold storage units as small enterprises rather than viewing them as donated assets. While many operators have embraced this role, interviews revealed that some beneficiaries initially expected IDAN or the vendor to handle even minor repairs or operational decisions. This indicates that the entrepreneurship model, though well-designed, requires ongoing reinforcement through clearer communication, structured orientation, and continuous engagement to ensure operators fully internalize their responsibilities.

To strengthen this model and ensure long-term ownership, the program should implement the following measures:

- **Clear and repeated communication of operator roles and responsibilities** during onboarding, training, and follow-up visits, ensuring that expectations around minor maintenance, cleanliness, tariff collection, and user management are consistently understood.
- **A simple Operator Responsibility Guide**, outlining what tasks operators should handle independently, what issues fall under AMC support, and when to contact IDAN. This guide can be printed, laminated, and placed inside each cold room.
- **Transparent discussions on revenue and cost management**, helping operators understand how small tariff collections contribute to routine maintenance, upkeep, and sustainability. This will reinforce the idea that the unit is a functional enterprise rather than a free resource.
- **Structured grievance and support channels**, such as dedicated helplines or WhatsApp groups, to help operators resolve concerns quickly without becoming overly dependent on IDAN for routine issues.
- **Periodic refresher sessions** to revisit entrepreneurial expectations, address skill gaps, and clarify responsibilities based on evolving challenges observed in the field.
- **Recognition and incentive mechanisms**, such as public acknowledgment of high-performing operators or small performance-based rewards, to motivate consistent ownership and operational excellence.

9. Promote Community Awareness and Behaviour Change for Wider Adoption

Although many farmers who use the cold storage units report clear benefits such as reduced spoilage, improved price realization, and better market timing there remains a segment of the farming community that is either unaware of the facility, uncertain about how it works, or hesitant to change long-standing selling practices. Some non-users noted they had “no need yet,” while others cited lack of information, concerns about tariffs, or misconceptions about which crops can be stored. These attitudes indicate that while the technology is effective, adoption depends heavily on **sustained awareness-building and behaviour change efforts** within the community.

To expand reach and ensure that cold storage becomes a widely accepted post-harvest practice, the program should invest in structured and ongoing community engagement initiatives that include:

- **Village-level awareness campaigns**, led jointly by operators, caretakers, and IDAN field staff, explaining the purpose of the facility, costs, benefits, and how farmers can access it.
- **Demonstration-based learning**, where real examples of stored crops, improved shelf-life, and successful earnings are showcased is an approach already noted by operators to be highly motivating for new users.
- **Farmer-to-farmer experience sharing**, enabling early adopters to share their positive outcomes with peers, which can be more persuasive than formal training alone.
- **Simple communication materials** such as posters, leaflets, or WhatsApp messages summarizing which crops can be stored, ideal storage durations, and expected benefits.
- **Seasonal reminders during peak harvest months**, encouraging farmers to use the facility when the risk of spoilage and market volatility is highest.
- **Engagement with local institutions** (village councils, SHGs, church groups, FPOs) to build trust and encourage collective participation.
- **Clarifying tariff structures**, which some non-users perceive as a barrier; sharing transparent information can ease concerns and encourage trial.

10. Plan for Strategic Scale-Up Based on District Demand

Demand for additional cold storage units has grown significantly across multiple districts, driven by strong performance in several high-use locations and positive feedback from farmers and district administrations. IDAN staff reported numerous formal and informal requests from MLAs, district officials, NGOs, and local entrepreneurs, particularly in areas where storage has directly reduced spoilage and improved income. This presents a clear opportunity for scale-up but expansion should be **strategic, data-driven, and aligned with district-specific agricultural potential** to ensure efficient use of resources.

To maximize impact and maintain program quality, the scale-up strategy should include:

- **Prioritizing high-performing districts** such as Mon, Longleng, Tuensang, and specific sites in Kohima and Mokokchung, where utilization consistently exceeds expectations and additional capacity is already in demand.
- **Using utilization data and crop production patterns** to identify the next tier of expansion districts, ensuring that new units match local cropping cycles (e.g., Naga King chilli, tomatoes, cabbages, ginger, fruits).
- **Cluster-based expansion**, where multiple villages or farming clusters are supported through a network of interconnected storage points, aggregation centers, and transport linkages, creating a more integrated cold-chain ecosystem.
- **Adopting flexible deployment models**, such as modular units or mobile cold storage solutions, in areas where population density or farming volumes fluctuate seasonally.
- **Ensuring readiness of operators and community demand** by assessing leadership interest, existing entrepreneurial capacity, and the willingness of farmers to pay nominal tariffs.
- **Strengthening vendor partnerships and AMC coverage** to ensure that technical support can scale proportionately with an increasing number of units.
- **Building district-level coordination mechanisms** so that expansion aligns with agricultural priorities, local governance capacity, and market access opportunities.

Annexure I: Field Photographs from Project Sites

















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