Centralized Storage Facilities as a Strategic Development Tool for Agriculture: Evidence from Sabarkantha District, Gujarat

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ABSTRACT

This study analyzes the feasibility and strategy framework for the establishment of centralized storage facilities as a mechanism for agricultural advancement, Sample from Sabarkantha District, Gujarat, a significant producer of perishable agriculture products.

A cross-sectional quantitative survey was administered to 200 farmers and 68 Warehouse Owners across five talukas. The 25-item instrument demonstrated good reliability (Cronbach's α: Farmers=0.847, Warehouse Owner=0.812). Analysis employed descriptive statistics, Chi-Square tests, independent samples t-tests, One-Way ANOVA, Pearson correlation, and multiple linear regression.

Overall acceptance of centralized storage is remarkably high among farmers (M=4.68/5.00, SD=0.50) and Warehouse Owner (M=4.79/5.00, SD=0.41), with no significant variation across demographic or geographic segments (Chi-Square: all $p>0.05$; ANOVA: $F(3,196)=0.449$, $p=0.718$). Post-harvest losses are significantly higher among marginal farmers (M=4.12) compared to large farmers (M=3.08; $t(90)=5.591$, $p<0.001$, Cohen's $d=1.176$). Cold chain gap is the dominant predictor of strategic importance for Warehouse Owner ($\beta=0.482$, $p<0.001$), while income stability expectation is the strongest predictor of farmer acceptance ($\beta=0.235$, $p<0.001$). The regression models explain 67.6% (farmers) and 72.6% (Warehouse Owner) of variance in acceptance.

Recommended is a Cooperative-PPP hybrid model with 60% cold/cool storage capacity, tiered pricing for smallholders, e-NAM integration, and location at Himmatnagar. The study confirms a dual-pathway acceptance paradigm of agricultural infrastructure planning that may be replicated.

This study experimentally establishes demographic invariance of infrastructure adoption and identifies different motivating paths for farmers (economic aspiration) and Warehouse Owner (infrastructure shortage), adding to the agricultural infrastructure theory and policy.

Keywords: Centralized storage, post-harvest loss, cold chain, agricultural infrastructure, PPP model, Sabarkantha, Gujarat, farmer acceptance

1. INTRODUCTION

The scenario in India is what is generally experienced across the globe; a large production of food grains, fruits and vegetables and alarming losses after harvesting. Roughly ₹92,651 crores is estimated to be the value of the losses in the post-harvest phase annually, wherein perishable foods contribute to a disproportionate loss (CIPHET, 2020). Even after accounting for Gujarat's strong agricultural growth, it cannot be claimed that the state is spared of this infrastructure deficit.

Sabarkantha district in northern Gujarat is an interesting district to study. The district is one of the important producers of potato which accounts for significant contribution in making Gujarat as the third largest potato growing state of India, tomato, mangoes and wheat. The district, however, has no scientific management of the storage, which forces the farmers, including the small farmers, to sell their produce at the time of harvests at low prices.

This study investigates three significant research questions:
RQ1: What is the level of storage adequacy and post-harvest losses in Sabarkantha District?
RQ2: How do stakeholders accept centralized storage facilities and are there differences in acceptance by demographic and geographic segments?
RQ3: What predicts acceptance and what strategic framework should guide facility design?

2. LITERATURE REVIEW

2.1 Post-Harvest Loss and Storage Infrastructure

Post-harvest loss (PHL) represents both a food security challenge and an economic inefficiency. Kumar and Kalita (2017) estimate that India loses 4.6-15.9% of fruits and 5.2-18.3% of vegetables between harvest and consumption. The primary drivers include inadequate storage (40% of losses), poor handling (25%), and transportation gaps (15%) (NABCONS, 2021).

Storage architecture has been shown to considerably minimize PHL. Availability of cold storage reduced potato losses from 18 per cent to 6 per cent in Agra area (Birthal et al., 2019). However, India’s cold storage capacity is just 15% of the demand (NITI Aayog, 2022) and there exists a serious spatial mismatch between production zones and storage facilities.

2.2 Agricultural Infrastructure and Farmer Welfare

There are various ways in which storage facilities are connected to farmer welfare functions. One of the advantages of storage is the opportunity for temporal arbitrage. Farmers may delay and sell later in the off-season to obtain better pricing (Stephens & Barrett, 2011). Second, pledge finance will be enabled through the warehouse systems which will reduce demand for informal borrowing at outrageous rates (Coulter & Onumah, 2002). Third, at storage stations expenses per unit of logistics are minimized and price discrimination based on quality is conceivable (Reardon et al., 2019).

2.3 Cooperative and PPP Models in Agricultural Infrastructure

Governance model affects utilization and sustainability of storage facilities. Cooperative models benefit from farmer trust and local embeddedness, but tend to lack in managerial skills (Shah, 2016). Public-Private Partnership (PPP) models are technically efficient and market linked but can have farmer trust obstacles (Poulton & Macartney, 2012). Literature suggests that 'hybrid' systems (shared governance and private operational expertise) would be a better fit (Trebbin & Hassler, 2018).

2.4 Research Gap

The ex-ante adoption of centralized storage infrastructure across numerous stakeholder groups has been little explored using rigorous statistical modeling, but the extant literature addresses the estimation of PHL and storage technologies. This study fills the void by offering an in-depth and statistically validated demand assessment for Sabarkantha district.

3. METHODOLOGY

3.1 Research Design

A cross-sectional quantitative survey design was employed. Data collection utilized structured questionnaires administered through personal interviews in Gujarati.

3.2 Sample

Category	**Sample Size**	**Sampling Method**
Farmers	200	Stratified random (by taluka and land size)
Warehouse Owner/FPOs/Cooperatives/Processors	68	Purposive sampling
Total	**268**	

3.3 Instrument

Two parallel instruments (1-5) with 25 Likert scale questions were created: storage conditions and storage satisfaction, post-harvest losses, environmental issues, market behaviour, acceptance of the product, willingness to pay, institutional trust and benefits expected. The internal consistency of both instruments was good for the Farmers (α=0.847) and Warehouse Owner (α=0.812).

3.4 Statistical Analysis Protocol

Analysis proceeded in six sequential steps:

1. Descriptive statistics (means, SD, frequencies, skewness, kurtosis)
2. Chi-Square tests of association (demographic × acceptance)

3. Independent samples t-tests (group mean comparisons)
4. One-Way ANOVA with Tukey HSD post-hoc (multi-group comparisons)
5. Pearson correlation matrix (variable relationships)
6. Multiple linear regression (predictive modelling)

All analyses conducted at $\alpha=0.05$ using SPSS v26 and R v4.2.

4. RESULTS

4.1 Descriptive Profile

Farmers: 54% marginal/small (<2 Ha), 49% aged 36-50, 76% cultivate perishable crops (potato 36%, tomato 22%, mango 18%), 54% school-educated.

Warehouse Owner: 35.3% private Warehouse Owner, 22.1% FPOs, 26.5% cooperatives, 16.2% processors; 58.8% operate from rented premises; 26.5% handle potato as primary commodity.

4.2 Storage Deficit Assessment

Indicator	**Farmers**	**Warehouse Owner**
Storage Adequacy	M=1.87, SD=0.79	—
Capacity Utilization Gap	—	M=3.94, SD=0.82
Scientific Storage Adoption	M=1.82, SD=0.82	—
Cold Storage Experience	M=1.94, SD=0.81	—
Cold Chain Gap	—	M=4.12, SD=0.80

ANOVA confirmed no significant variation in storage inadequacy across talukas ($F(4,195)=0.093$, $p=0.985$, $\eta^2=0.002$).

4.3 Post-Harvest Loss by Land Size

Land Size	**Mean PHL**	**SD**
Marginal (<1 Ha)	4.12a	0.88
Small (1-2 Ha)	3.71ab	0.93

Land Size	Mean PHL	SD
Medium (2-4 Ha)	3.42bc	1.05
Large (>4 Ha)	3.08c	0.89

Different superscripts indicate significant differences (Tukey HSD, $p<0.05$)

One-Way ANOVA: $F(3,196)=10.201$, $p<0.001$, $\eta^2=0.135$ (Large effect). Marginal farmers experience significantly higher PHL than medium ($p<0.001$) and large ($p<0.001$) farmers.

4.4 Stakeholder Acceptance

Measure	M	SD	Skewness
Farmer Overall Acceptance	4.68	0.50	-1.12
Godown Owner Strategic Importance	4.79	0.41	-1.48

Chi-Square tests confirmed no significant association between acceptance and:

- Land Size ($\chi^2(6)=1.665$, $p=0.948$)
- Education ($\chi^2(4)=1.706$, $p=0.790$)
- Taluka ($\chi^2(8)=1.948$, $p=0.983$)
- Entity Type ($\chi^2(3)=0.343$, $p=0.952$)

4.5 Correlation Analysis

Top Farmer Correlates of Acceptance	r	Top Godown Owner Correlates of Strategic Imp.	r
Income Stability Expectation	0.672**	Cold Chain Gap	0.708**
Cooperative Trust	0.655**	Capacity Utilization Gap	0.685**
Employment Impact	0.645**	Location Preference	0.672**
Willingness to Pay	0.628**	Connectivity Priority	0.658**

Top Farmer Correlates of Acceptance	r	Top Godown Owner Correlates of Strategic Imp.	r
Post-Harvest Loss	0.612**	Value Addition Potential	0.645**

**p<0.01

Significant negative correlation: Storage Adequacy × Acceptance: r=-0.518, p<0.001.

4.6 Multiple Regression

Farmer Model (DV: Overall Acceptance)

- R^2=0.676, Adjusted R^2=0.662, F(8,191)=49.78, p<0.001
- Top predictors: Income Stability (β=0.235***), Cooperative Trust (β=0.228***), WTP (β=0.218***)

Godown Owner Model (DV: Strategic Importance)

- R^2=0.726, Adjusted R^2=0.699, F(6,61)=26.94, p<0.001
- Top predictors: Cold Chain Gap (β=0.482***), Capacity Gap (β=0.372***), Location (β=0.245***)

4.7 Key Comparative Findings

Dimension	Farmers	Warehouse Owner
Primary Driver	Economic (Income Stability)	Infrastructure (Cold Chain)
Motivation Type	Pull (Aspirational)	Push (Deficit-driven)
Governance Preference	Cooperative (M=4.42)	PPP (M=4.43)
Digital Readiness	Moderate (M=3.38)	High (M=4.35)
WTP	Tiered (3.65-4.15)	Uniform (4.43)

5. DISCUSSION

5.1 The Universal Demand Phenomenon

The most remarkable finding is that it is recognized almost universally across demographic and geographic groups. The non-significant Chi-Square and ANOVA results are interesting findings in themselves; they do indicate that centralized storage is perceived as a universal requirement and not the desire of certain groupings. This is contrasted to more conventional

patterns of agricultural technology adoption where land size, age and education are major factors in explaining and predicting adoption (Feder et al., 1985). Perhaps the magnitude of the infrastructure shortage may be explained in terms of Mean Storage Adequacy (M.S.A.). If the infrastructure shortage is large enough (M.S.A. = 1.87), then the demographic differences are no longer significant.

5.2 The Equity Imperative

Centralized storage is an equity intervention with much different PHL (Cohen's d=1.176) between the marginal farmers and non-marginal farmers. Marginal farmers (26%) are also equally important as their farming practices are not different from that of medium and high-income farmers but they are unable to make scientific storage in the field, unable to buy large volumes and due to financial vulnerability, they have to sell their products immediately after harvesting. A centralized facility with tiered pricing is a direct response to this structural unfairness.

5.3 Dual-Pathway Acceptance Model

The research presents a fresh theoretical contribution: the Dual-Pathway Acceptance Model. Farmers and warehouse owners have quite different reasons to adopt the same infrastructure

:

- **Farmers** follow an **Economic Aspiration Pathway**: they evaluate the facility based on expected outcomes (income stability, better prices, reduced losses). Their acceptance is *forward-looking and benefit-driven*.
- **Warehouse Owner** follow an **Infrastructure Deficit Pathway**: they evaluate the facility based on current constraints (cold chain gap, capacity shortage, logistics cost). Their acceptance is *present-focused and problem-driven*.

The discovery of this dual-pathway has substantial repercussions for stakeholder communication, facility design and policy drafting. Marketing to farmers should focus on economics. Warehouse Owner engagement should address specific needs in infrastructure.

5.4 The Primacy of Cold Chain

The cold chain gap is the most important predictor, establishing a Godown Owner regression model (β=0.482) 1.3× more important than the next predictor. The results from the Tukey HSD indicate that there is ample evidence for a cold chain prioritized design combined with 76% of farmers growing perishables and cold chain gap for the perishables being significantly higher than cold chain gap for the grains, as seen above.

5.5 Cooperative-PPP Hybrid: Statistical Convergence

The mean scores of the Cooperative Trust and PPP Readiness are almost equal, indicating a correlation. The Cooperative-PPP hybrid model, which could meet the farmers' trust criterion (cooperative governance) and the Warehouse Owner's efficiency criterion (private operational management), would be appropriate. This convergence is a rare statistical and valuable strategic opportunity.

6. RECOMMENDATIONS

6.1 Infrastructure Design

Specification	Recommendation	Statistical Basis
Total Capacity	5,000-10,000 MT (Phase 1)	41.2% of Warehouse Owner handle 1000-5000 MT
Cold/Cool Storage	60% of total capacity	Perishable crop dominance (76%); Cold Chain Gap β=0.482
Location	Himmatnagar, NH-8 corridor	Location M=4.72; Connectivity M=4.59; no taluka variation
Multi-modal	Rail siding + highway access	Connectivity β=0.242; Logistics Cost M=3.74

6.2 Governance Structure

Cooperative-FPO with private sector partner as technology, quality control, market linkage. Only government is responsible for land, and partial capital subsidy, and regulatory facilitation.

6.3 Pricing Model

Tiered structure: Marginal farmers (40% subsidy), Small (25%), Medium (10%), Large (market rate). Justified by significant WTP differential ($t=3.731$, $p<0.001$) and equity considerations.

6.4 Digital Integration

Phased approach: Phase 1 (e-NAM for Warehouse Owner, readiness=4.35), Phase 2 (farmer app with training component, readiness=3.38), Phase 3 (blockchain traceability for export).

6.5 Income Stabilization

Integrate warehouse receipt financing (Credit Need M=3.92), price information systems (Middleman Dependence M=3.82), and deferred sale facility (Forced Sale M=3.98).

7. CONCLUSION

The study provides substantial statistical proof of the need and widely adopted strategic intervention in Sabarkantha District which is storage facilities on central level. The combination of stakeholder demand, the magnitude of the storage gap, and the disproportion in the impacts of the storage shortfall on smallholders creates the viability and urgency for implementation.

The Dual-Pathway Acceptance Model is a hypothesis that can guide the intervention as well as the construction of future agricultural infrastructure in similar agro-climatic conditions. The conclusion that infrastructure acceptability works through multiple motivational pathways for different stakeholder groups has consequences beyond storage, but also extends to market yards, processing units and logistics centres.

The repo rt finishes with a clear call to action: The evidence calls for quick Detailed Project Report preparation, financial closure and construction. The 268 responders of Sabarkantha have spoken loud and clear – centralised storage is not only desirable, but it is a requirement.

8. LIMITATIONS AND FUTURE RESEARCH

Due to the cross-sectional design, causal inference is constrained. There may be a discrepancy between stated choice (acceptance) and revealed preference (real use). The sample is enough for the district, but may not be generalizable to other districts. Future research should include:

(1) Longitudinal study to measure actual use and effect of the model;

(2) Replication of the Dual-Pathway model within different districts;

(3) Contingent valuation studies for correct estimation of WTP; and

(4) Gender-disaggregated impacts.

REFERENCES

Birthal, P.S., et al. (2019). Cold storage infrastructure and potato marketing in India. *Agricultural Economics Research Review*, 32(1), 45-56.

CIPHET. (2020). *Annual Report 2019-20*. Central Institute of Post-Harvest Engineering and Technology, Ludhiana.

Coulter, J., & Onumah, G. (2002). The role of warehouse receipt systems in enhanced commodity marketing and rural livelihoods in Africa. *Journal of Rural Studies*, 18(3), 319-332.

Feder, G., Just, R.E., & Zilberman, D. (1985). Adoption of agricultural innovations in developing countries: A survey. *Economic Development and Cultural Change*, 33(2), 255-298.

Kumar, D., & Kalita, P. (2017). Reducing postharvest losses during storage of grain crops. *Foods*, 6(1), 8.

NABCONS. (2021). *Study on Post-Harvest Losses in India*. NABARD Consultancy Services, Mumbai.

NITI Aayog. (2022). *Cold Chain Infrastructure in India: Status and Recommendations*. Government of India.

Poulton, C., & Macartney, J. (2012). Can public-private partnerships leverage private investment in agricultural value chains in Africa? *World Development*, 40(1), 96-109.

Reardon, T., et al. (2019). Rapid transformation of food systems in developing regions. *Global Food Security*, 22, 13-21.

Shah, T. (2016). *Farmer Producer Companies: Fermenting New Wine for New Bottles*. Economic and Political Weekly, 51(8), 15-20.

Stephens, E.C., & Barrett, C.B. (2011). Incomplete credit markets and commodity marketing behavior. *Journal of Agricultural Economics*, 62(1), 1-24.

Trebbin, A., & Hassler, M. (2018). Farmers' producer companies in India: A new concept for collective action? *Environment and Planning A*, 44(2), 411-427.