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Research Article

Assessment of Cold Storage Infrastructure in India: A Production–Capacity Gap Analysis (2015–2024)

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Abstract

India is the second largest producer of fruits and vegetables in the world. However, the post-harvest loss amounts to approximately ₹ 92,651 crores annually, including ₹16,644 crore from fruits and ₹14,842 crore from vegetables, causing significant economic burden to the country. This loss is persistent due to the perishability nature of the fruits and vegetables. Therefore, the F&V should be stored in a cold storage to enhance its shelf life and mitigate the losses. The present study attempts to examine the growth of both the cold storage and production of F&V in the country, its relationship and the gap persistent. It is found that production of F&V is growing relatively faster than the cold storage capacity. There is a gap of approximately 50 percent in the cold storage space in comparison to its required storage space, moreover the upward trend signifies a growing gap over the years. This is also supported by a downward trend of the coverage ratio. The correlation and regression analysis reveals a strong and positive relationship between the production of F&V and the cold storage capacity. Therefore, considering the persistent growing gap, there is a requirement of proper policy focusing in the growth and strengthening of the cold storage sector to mitigate the post-harvest loss.

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KEYWORDS: Cold storage, fruits and vegetables, storage gap, coverage ratio, correlation and regression.

1. INTRODUCTION

Agriculture plays an important role in the economy of the country and act as primary source of livelihood of the people. As per the Periodic Labour Force Survey (PLFS) (National Statistics Office, 2025) about 46.1 percent of the total workforce of the country are engaged in Agriculture and allied sector. India is the second largest producer of fruits and vegetables in the world (FAO, 2023). However, according to (Press Information Bureau, 2023) post-harvest loss in India amounts to approximately ₹ 92,651 crores annually, including ₹16,644 crore from fruits and ₹14,842 crore from vegetables. This loss poses a significant economic burden to a developing country like India.

The F&V are highly perishable in nature and prone to early spoilage. Therefore, due to this perishable nature, it requires a proper cold storage infrastructure for storing (Sivaraman, 2016). Due to lack of cold storage infrastructure, a substantial proportion of F&V is lost every year. Post-harvest loss of the fruits and vegetables not only causes a huge loss to the economy of the country; however, it also affects the farmer's income and also results in loss of the scarce resources like, water, land, fertilizers etc (Negi & Anand, 2015). Despite the growth of the cold storage infrastructure, the postharvest loss is still prominent in the country (Chakraborty, 2020).

Therefore, this present study attempts to assess the cold storage infrastructure in the country, examine its gap; and the relation between production of F&V and storage facility. This assessment would help to understand the gap persistent in the cold storage and the production of F&V, which may assist in the policy formation for the cold storage sector, to mitigate the loss.

2. REVIEW OF LITERATURE

The fruits and vegetables are perishable in nature, and are prone to early spoilage, and therefore to enhance the shelf life of the F&V, it should be stored at a cold storage facility (Sivaraman, 2016). From the previous study, it is evident that, the postharvest loss is a serious problem in India. Out of various factors; lack of cold storage infrastructure act as one of the major factors contributing to that loss (Paul, Ezekiel, & Pandey, 2016), (Arivazhagan, Geetha, & Parthasarathy, 2012).

The study states that around 30 percent of F&V are wasted annually due to inadequate cold storage capacity, poor cold storage infrastructure and proper transportation facilities (Maheshwar & Chanakya, 2006). Moreover, (Rajan & Sahni, 2023) estimated 30-40 percent loss in F&V is due to several factors including cold storage infrastructure. It is also estimated that around 92 million tonnes of agriculture produce are lost in post-harvest stage in India (Cardoen, Pant, Sharma, Joshi, & Diels, 2015). (Chakraborty, 2020) elaborated that despite the growth of the cold storage, it is still not inadequate while compared to its requirements. Therefore (Cardoen, Pant, Sharma, Joshi, & Diels, 2015) the need of more cold storage infrastructure to mitigate the loss.

The lack of cold storage infrastructure or inefficient supply chain has resulted in the poor price realisation of the farmers at one end, and exorbitant prices paid by the consumers at the other end (Negi & Anand, 2015). Moreover, it is reported that, farmers could not sell 34 percent of fruits and 44.6 percent of vegetables in the market (Committee on Doubling on farmer's Income, 2017). The poor post-harvest infrastructure not cause the wastage of fruits and vegetables, but also results in the availability of food (Kader, 2005). (Hossain & Bepary, 2015) has opined that mitigation of the post-harvest loss is a key to secure future global food security.

From existing literature, it is evident that, cold storage infrastructure plays an important role in the agriculture sector. It ensures the enhancement of shelf life of the fruits and vegetables, helps in mitigation of post-harvest loss, address the low farmers income and ensures global food security. Considering this importance of the cold storage, this study has been undertaken to make an attempt to assess the cold storage infrastructure in India and examine the gap between storage capacity and production of fruits and vegetables.

Since several studies have reported that, a post-harvest loss of F&V in India is in a range of 30 to 40 percent, primarily due to inadequate cold storage infrastructure. This loss indicates that, substantial proportion of the highly perishable F&V does not get a space in the cold storage. Therefore, to mitigate such losses, cold storage facility has to be provided for a significant share of total production. Based on the conservative interpretation of the existing literature, it is assumed that 25 percent of the total production of fruits and vegetables has to be accommodated in the cold storage facilities to prevent spoilage and reduce wastage.

2.1 OBJECTIVES

1. To analyse the growth trends in cold storage capacity and production of fruits and vegetables in India during 2015–2024.
2. To assess the adequacy of cold storage infrastructure in India by examining the gap between storage capacity and production of fruits and vegetables.
3. To examine the relationship between cold storage capacity and production of fruits and vegetables in India.

3. METHODOLOGY

The present study is descriptive and analytical in nature, and is based on the secondary data. The study covers the period from 2015 to 2024. The study has used various analytical tools, including trend analysis, gap analysis, coverage ratio, correlation and regression to fulfil the stated objectives. The results are presented using tables and graphs for better visualisation. The scope of the study is limited to the analysis of cold storage capacity and production of fruits and vegetables, and is dependent on the accuracy of the available data.

HYPOTHESIS OF THE STUDY

H_0 (Null Hypothesis): There is no significant relationship between cold storage capacity and the production of fruits and vegetables in India.

H_1 (Alternative Hypothesis): There is a significant relationship between cold storage capacity and the production of fruits and vegetables in India.

4. Data Analysis and Interpretation:

4.1 Trend analysis of Cold storage capacity and Production of fruits and vegetables.

Table 4.1.1: Growth of Cold storage Capacity and Production of fruits and vegetables.

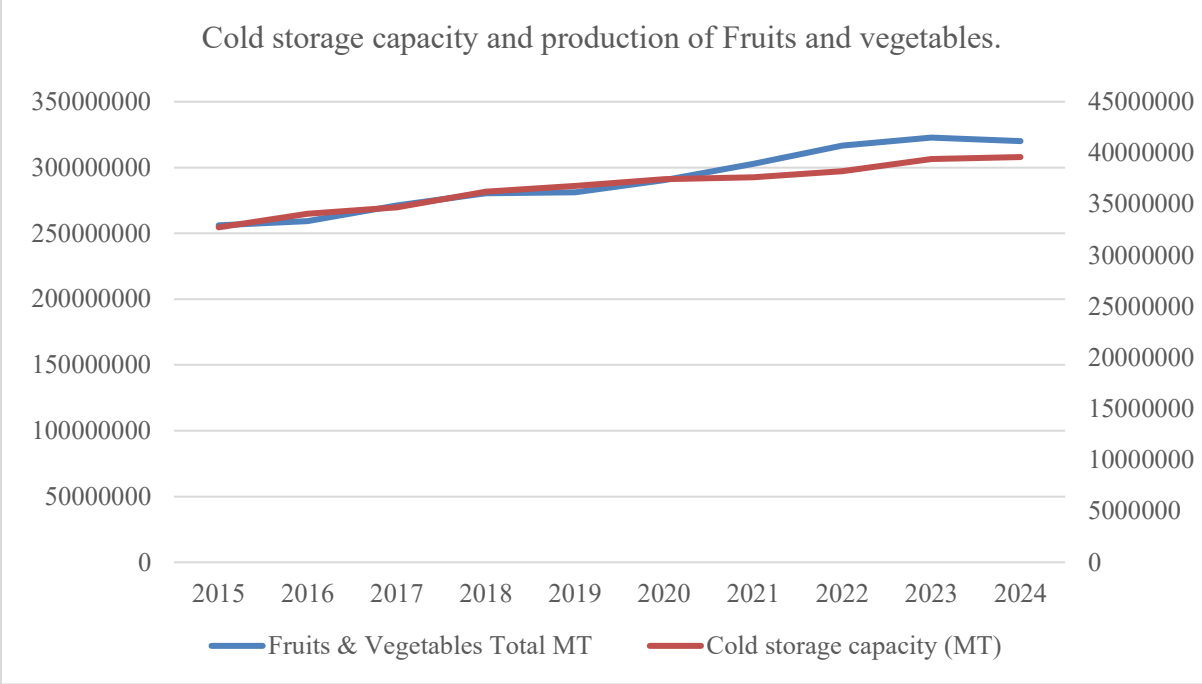
Year	Fruits & Vegetables		Cold storage capacity	
	Production (MT)	YOY growth (%)	Capacity (MT)	YOY growth (%)
2015	256080000	-	32729271	-
2016	259247000	1.24	34050359	4.04
2017	271090000	4.57	34673886	1.83
2018	280487790	3.47	36209480	4.43
2019	281137000	0.23	36770637	1.55
2020	290364000	3.28	37425097	1.78
2021	302926000	4.33	37634076	0.56
2022	316650000	4.53	38224006	1.57
2023	322755890	1.93	39417231	3.12
2024	320185870	-0.80	39596277	0.45

Source: Compiled and analysed from (Department of Agriculture & Farmers Welfare, 2024).

Table 4.1.2: Growth (CAGR) of Cold storages and production of fruits and vegetables.

Growth	Fruits & Vegetables production	Cold storage capacity
CAGR (2015-2024)	2.51%	2.14%

Source: Author's compilation.



Source: Author's compilation.

Figure 4.1.1: Trend of Fruits & Vegetables Production and Cold Storage Capacity (2015–2024)

Table 4.1.1 exhibits a steadily increasing trend in the production of fruits and vegetables, rising from 256.08 million tonnes in 2015 to 320.19 million tonnes in 2024. Similarly, cold storage capacity has also increased from 32.73 million tonnes to 39.60 million tonnes during the same period, indicating a gradual expansion of storage infrastructure.

However, Table 4.1.2 shows that the compound annual growth rate (CAGR) of fruits and vegetables production (2.51 percent) is relatively higher than that of cold storage capacity (2.14 per cent). Further, Figure 4.1.1 illustrates the persistent gap during the study period, reflecting a potential imbalance between the production of fruits and vegetables and cold storage infrastructure. In can be concluded that, although cold storage infrastructure is expanding, it is not keeping pace with the increasing production of fruits and vegetables.

4.2 Gap analysis between the Storage Capacity and the production of fruits and vegetables.

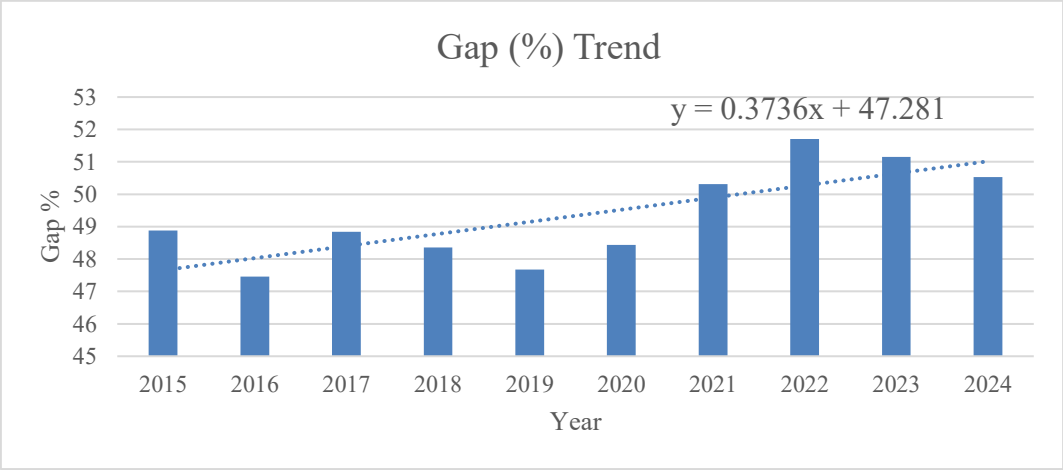
Chart 4.2.1: Gap between storage capacity and production of fruits and vegetables.

Year	Production (MT)	Required storage capacity	Actual storage capacity	Gap (MT)	Gap (%)
2015	256080000	64020000	32729271	31290729	48.88
2016	259247000	64811750	34050359	30761391	47.46
2017	271090000	67772500	34673886	33098614	48.84
2018	280487790	70121948	36209480	33912468	48.36
2019	281137000	70284250	36770637	33513613	47.68
2020	290364000	72591000	37425097	35165903	48.44
2021	302926000	75731500	37634076	38097424	50.31
2022	316650000	79162500	38224006	40938494	51.71
2023	322755890	80688973	39417231	41271742	51.15
2024	320185870	80046468	39596277	40450191	50.53

Source: Author's compilation.

Note:

1. Required storage capacity is assumed as 25 percent of total production.
2. Gap is calculated by subtracting the Actual storage capacity from Required storage capacity.
3. Gap percent = $\frac{\text{Gap}}{\text{Required storage capacity}}$ x 100.



Source: author's compilation

Figure 4.2.1: Trend of Storage Gap (%) between Required and Actual Cold Storage Capacity (2015–2024).

Table 4.2.1 reveals a significant and persistent shortfall between the required and actual storage capacity for fruits and vegetables. The gap percentage remains high, ranging between 47.46 and 51.71 percent during the study period, indicating that nearly half of the required storage capacity is not met. Moreover, Figure 4.2.1 shows an upward trend in the gap percentage, indicating a widening imbalance between the cold storage requirements for fruits and vegetables and available capacity.

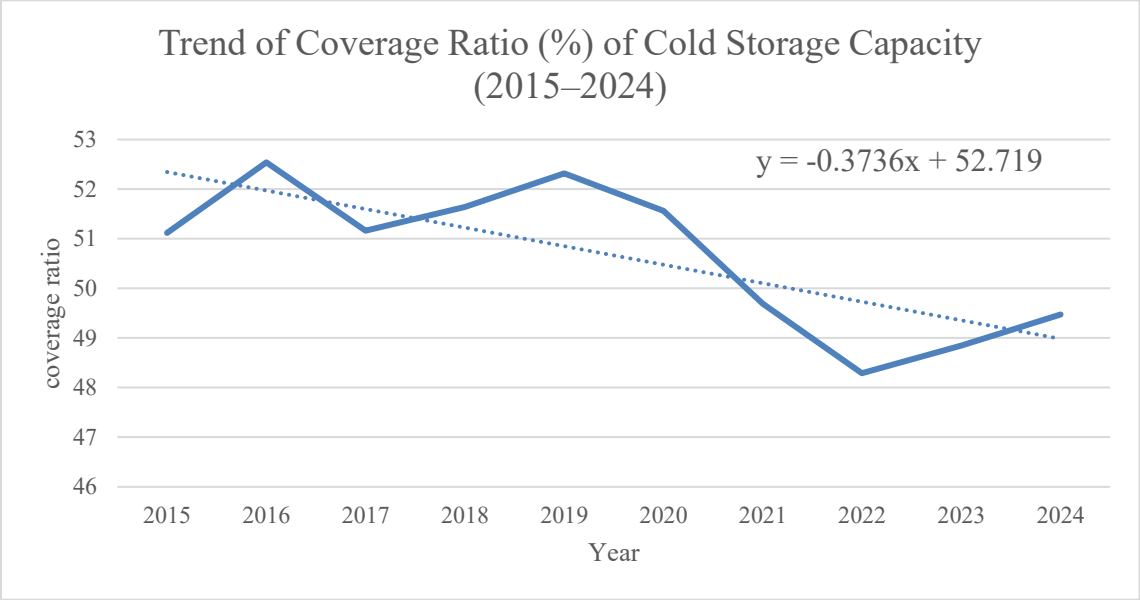
4.3 Coverage ratio analysis or Adequacy analysis of cold storage capacity.

Table 4.3.1 Coverage ratio of available cold storage capacity.

Year	Available storage capacity	Total Production	Coverage Ratio	Coverage Ratio (%)
2015	32729271	256080000	0.51	51.12
2016	34050359	259247000	0.53	52.54
2017	34673886	271090000	0.51	51.16
2018	36209480	280487790	0.52	51.64
2019	36770637	281137000	0.52	52.32
2020	37425097	290364000	0.52	51.56
2021	37634076	302926000	0.50	49.69
2022	38224006	316650000	0.48	48.29
2023	39417231	322755890	0.49	48.85
2024	39596277	320185870	0.49	49.47

Source: Author's compilation.

Note: Coverage Ratio (%) = $\frac{\text{Total Production}}{\text{Available storage capacity}}$ x 100



Source: Author's compilation.

Figure 4.3.1 Trend in coverage ratio per cent

Table 4.3.1 shows that, coverage ratio ranges from 52.54 to 48.29 during the study period. This indicates that only half of the production of fruits and vegetables is supported by the cold storage infrastructure. Moreover, Figure 4.3.1 shows a downward trend over the years, which indicates a gradual reduction in the adequacy in the storage infrastructure. In conclusion it can be stated that, the decreasing coverage ratio suggests that the growth in cold storage capacity has not kept pace with the increasing production of fruits and vegetables. As a result, a smaller proportion of total production is being supported by storage facilities over time.

4.4. Correlation and Regression Analysis.

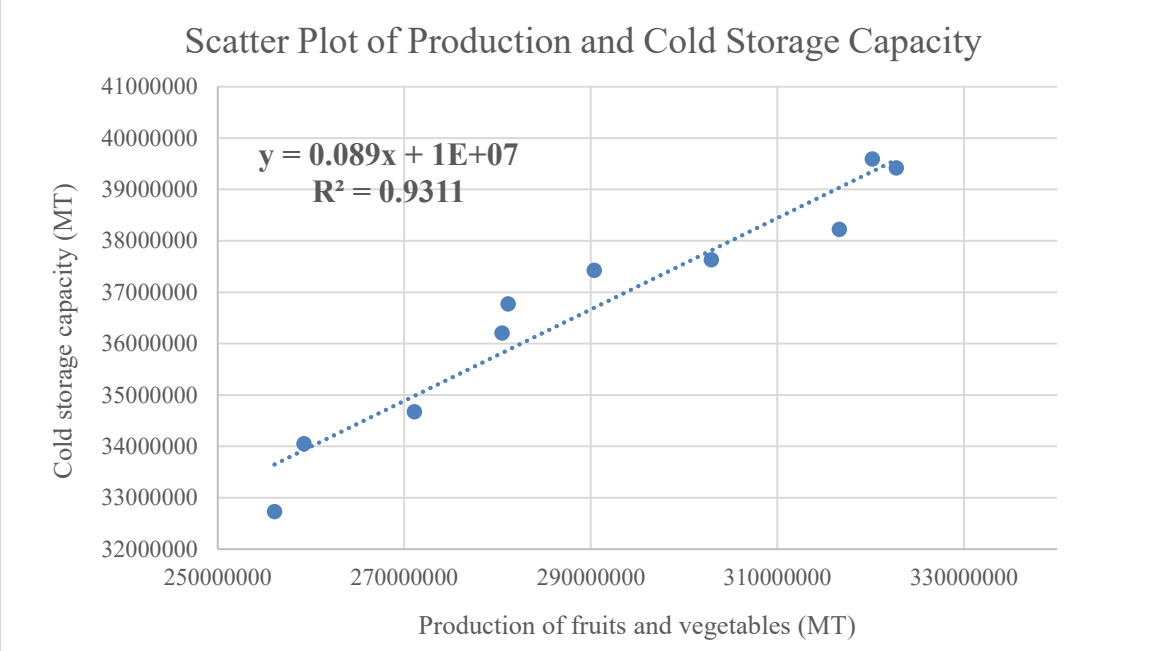
Table 4.4.1 Correlation and Regression Analysis result

Particulars	**Value**
Correlation Coefficient (r)	0.9649
R Square (R^2)	0.9311
Adjusted R^2	0.9225
F-value	108.0828
Significance F	0.00
Slope Coefficient (Production)	0.08897
Intercept	10864278.43
p-value (Slope Coefficient)	0.00
Number of Observations	10

The results of correlation and regression analysis reveal a strong positive relationship between the production of fruits and vegetables and cold storage capacity. The correlation coefficient (r = 0.9649) indicates a very high degree of association between the variables.

The R Square (R^2) value of 0.9311 suggests that approximately 93.11% of the variation in cold storage capacity is explained by changes in the production of fruits and vegetables, indicating a good fit of the regression model. The F-statistic (108.08) along with a very low significance value ($p < 0.05$) confirms that the model is statistically significant.

The regression coefficient of production (0.08897) is positive and statistically significant, indicating that an increase in production leads to an increase in cold storage capacity.



Source: Author's compilation.

Chart 4.4.1: Scatter Plot Showing the Relationship between Production and Cold Storage Capacity.

The scatter plot diagram exhibits a clear upward trend, indicating a strong positive relationship between production of fruits and vegetables and cold storage capacity. The close clustering of data points around the regression line suggests a high degree of consistency and confirms the strength of the relationship between the variables.

The close clustering of data points around the regression line suggests a high degree of consistency and confirms the high degree of correlation and model fit.

4.5 Hypothesis Testing

The p-value obtained from the regression analysis is less than the significance level of 0.05. Therefore, the null hypothesis (H_0) is rejected. This indicates that there is a statistically significant relationship between the production of fruits and vegetables and cold storage capacity.

5. CONCLUSIONS

The present study reveals a strong and positive relationship between the production of fruits and vegetables and cold storage capacity, as supported by the correlation and regression analysis. It is also observed that, both the production and cold storage capacity has exhibited a steady growth trend over the years. However, the production is growing at a faster pace than the cold storage capacity.

The gap analysis between required and actual storage capacity has shown an upward trend, reflecting a significant and widening shortfall in the actual storage capacity over the years. This reflects widening imbalance between the production and the cold storage infrastructure. This is further supported by the coverage ratio, which shows a downward trend, indicating decreasing support of cold storage infrastructure for the production of fruits and vegetables.

Overall, the findings suggest that although the cold storage infrastructure is expanding, it is not meeting the growing pace of production of fruits and vegetables. This imbalance may further lead to significant post-harvest losses, and adversely affect agricultural sustainability and food security as a whole. Therefore, appropriate policy measures are needed to encourage more investment in the cold storage sector for the expansion and strengthening of cold storage infrastructure in the country to mitigate the post-harvest losses, and secure agricultural sustainability and food security.

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