CSD Working Paper Series: Towards a New Indian Model of Information and Communications Technology-Led Growth and Development

ICT in Agriculture Value Chain, especially during post-harvest operations in India

ICT India Working Paper #52

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July 2021

Center for Sustainable Development
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Acknowledgements

I would like to thank Dr. Nirupam Bajpai, Columbia University, Mr Thomas Motmans, Basel Agency for Sustainable Energy and Ms. V N Saroja, Agriwatch, for their comments on an earlier draft of this paper. However, I am solely responsible for the views expressed and any errors and omissions that remain are mine.

Abstract

Inefficiencies in the post harvest value chain in Indian agriculture stifle farmer incomes and are a barrier to the realisation of the full potential of Indian Agriculture. These inefficiencies arise from losses during harvesting, threshing, drying, poor storage facilities, transportation problems, defective packaging, manual assaying, legacy marketing practices and flawed policies etc. We review the issue of post harvest inefficiencies and the potential of ICTs to help sort some of these issues. Certain recent initiatives of the government in India towards using Information and Communication Technologies (ICTs) in post harvest management like geotagging of agri warehouses, reefer vehicles and cold storages are a step in the right direction. Further, to address the issue of access of smallholder to such facilities, certain innovative pilot projects are being developed. Non-profit as well as private sector initiatives in this space are also showing an encouraging trajectory.

1.0 Introduction:

The post-harvest value chain in Indian Agriculture remains long and the farmers often do not get a fair share of the value. This includes losses, owing both to post harvest operations (in food crops) during harvesting, threshing, drying etc. and once harvesting is over, losses that occur due to several other reasons: poor storage facilities, transportation problems, defective packaging, legacy marketing practices, flawed policies etc. Some of it may be due to lack of awareness and some due to unavailability of infrastructure to manage post harvest activities efficiently. Fair and remunerative prices of crop produce benefits all farmers, including tenants and sharecroppers, who constitute a large majority of Indian smallholder farmers, in a big way. Use of better grading, storage, transportation and packing is the key to reducing these inefficiencies. It is thus imperative to facilitate the farmers for utilizing these improved facilities to enhance incomes and margins, from either the same crop or by diversifying to other crops which are more profitable.

Ours is a Columbia University project in collaboration with TERI, New Delhi, which is called ‘Towards a New Indian Model of ICT led growth and Development’. In this paper, we are looking at the role that ICT can play in post harvest operations in the agricultural value chain. We first look at the estimates of post harvest losses incurred in India. Then we undertake a brief review of relevant literature focusing on aspects which pertain to post harvest management, specially storage and the eNAM initiative of the government. Then we provide the status of post harvest facilities in India. After this we note the recent policy initiatives of the government of India that promote the use of Information and Communication Technologies (ICTs) in post harvest management of agricultural produce. It is important to note here that eNAM is a very important initiative in the use of ICT in the marketing of agricultural produce, which has been in operation since 2016 and which we have covered in detail in our earlier works (Saroja V.N. and Beriya A., 2019; Beriya A., 2021). After this, we note an ongoing pilot project by some non-profit organisations which aims to enable smallholders to access sustainable cooling facilities through a servitization business model. Then we list some initiatives of the non-profit as well as private sector in India that are working in post harvest management and finally conclude.

2.0 Estimation of post harvest losses in India:

An APEDA report (2016) notes that harvest and post-harvest loss of India's major agricultural produce is estimated at Rs 92,651 crore ($13 billion). It is striking to note that this loss amount was almost 3 times the budget for the agriculture sector in that year (the budget was 35,984 crore (approx. $5 billion) in the year 2016-17). Out of this total loss amount, the major share was of fruits and vegetables, valued at Rs 40,811 crore ($6 billion), or about 16% of the total production of fruits and vegetables. The food-processing ministry also reported that 7% of meat, valued at Rs 3,942 crore ($590 million), was lost, about 60 percent of it, during storage. These estimations of post-harvest losses have been made through a study conducted by CIPHET, Ludhiana to assess the extent of harvest and post-harvest losses of major Indian agricultural produce. The detailed estimates for different crop categories are given in the table below.

ESTIMATED PERCENTAGE LOSS OF MAJOR AGRICULTURAL PRODUCE IN INDIA

Crops	Cumulative Wastage (%)	
	As per Report 2010	As per Report 2015
Cereals	3.9–6.0	4.65–5.99
Pulses	4.3–6.1	6.36–8.41
Oil seeds	2.8–10.1	3.08–9.96
Fruits & Vegetables	5.8–18.0	4.58–15.88
Milk	0.8	0.92
Fisheries (Inland)	6.9	5.23
Fisheries (Marine)	2.9	10.52
Meat	2.3	2.71
Poultry	3.7	6.74

(Source: Annual Report 2019-20, Ministry of Food Processing Industries)

It is seen that most of the wastage is occurring in fruits and vegetables. With adequate processing facilities, much of this wastage can be reduced thus providing remunerative price to the producer as well as ensuring greater supply to the consumer.

3.0 Literature relevant to storage and logistics in the agricultural value chain

Nuthalapati et al, (2020), in a recent paper on electronic markets in the agricultural space in Karnataka, argue with empirical evidence that adequate physical infrastructure is crucial for the functioning of an electronic market along with other related policy measures to have a significant improvement in agricultural marketing , even though price realisations are slightly higher in electronic markets.

Pavithra S et al conducted a case study of e-tendering system in Karnataka and published the results in a 2018 paper. They too find that 'effective implementation of e-NAM also requires infrastructure in the form of storage, warehousing, banks, grading and assaying facilities, etc. within the market yard, the absence of which may discourage traders from far off places to participate in e-tendering.' Further, farmers benefit from e-trading, according to the study, but farmers also feel that farm-level grading of produce is expensive while market officials feel that the practice of grading in the market yard would be time consuming. Thus, there is a need for awareness creation among different stakeholders like farmers of the benefits of e-trading and to train them in relevant practices like online banking and grading of produce at farm level. For these reasons, there is a need to organize farmers into collectives like Farmer Producer Organizations (FPOs) to achieve economies of scale. The study ends with the need for adequate assaying facilities for grading and quality because traders have a strong preference for physical examination of produce due to quality concerns.

Chaudhary and Suri (2020), while examining the adoption of eNAM for transforming agricultural marketing in India, via a primary study in the Meerut APMC of Uttar Pradesh, find that in even in eNAM, the logistics are left to traders to handle and there is a demand–supply gap in storage. They suggest that for facilitating more intra and interstate trading, the physical logistic support to farmers will be a progressive step for strengthening NAM.

In another case study of Bhatapara APMC in Chhattisgarh in the context of eNAM, Bachaspati and Pathak (2018) find that the price and arrivals of the major commodities moved in the following manner post unification with eNAM. Paddy arrivals decreased 8.01 percent; while mustard crop registered a high increase in arrival of 232.41 percent, followed by red gram (124.70 percent), lentil (67.69 percent), gram (14.60 percent) and wheat (7.76 percent). Paddy prices appreciated 14.65 percent while wheat, red gram, gram and lentil had shown decrease in price in proportion of 1.16 percent, 16.46 percent, 33.28 percent and 24.53 percent respectively. There was no provision of storage as well as cold storage facilities in

Bhatapara APMC as per this study. The study pins the fluctuation in prices after unification with eNAM primarily on demand and supply and the provision of physical sampling without elaborating (in the paper) with more details.

Boss and Pradhan, in an evaluation study across the Indian states of Bihar, Uttar Pradesh, and Odisha, find that post-harvest management of crops plays a crucial role in both value generation as well as value distribution along crop value chains, by mitigating post-harvest losses. This study defines post harvest management as 'after production, agricultural produce undergoes a series of post-harvest operations, handling stages and storage before they reach the consumers. Each post-harvest stage results in some losses and has an effect on the value distribution. These are the factors that determine the gap between consumer and farmer prices of a product'. This study finds that storage loss has a material consequence for the farmers. This is because farmers incur higher losses compared to other stakeholders down the value chain like wholesalers, processors etc. owing to value chains being poorly developed, in terms of storage facilities at the farm level, transportation, and food processing units, especially in case of the perishables.

4.0 Status of Post Harvest Facilities in India:

India has an estimated capacity of 162 million MT of agri warehousing, cold storage, reefer van facilities etc. The major public sector players in warehousing sector are Food Corporation of India (FCI), Central Warehousing Corporation (CWC) and state-level warehousing corporations (SWCs). The FCI controls about 76 million tonnes capacity — both its own and hired from CWC, SWCs and private sector — which is nearly half of the total capacity of the country. SLCM group, NCML, StarAgri and LTC Commercial are some of the major companies in the private sector, which has about 35% share in the total warehousing space. (Financial Express, February 2020)

The government of India agency National Center for Cold Chain Development (NCCD) completed a comprehensive "All India Cold-chain Infrastructure Capacity (Assessment of Status and Gaps)" in August 2015. The key findings of the "All India Cold-chain Infrastructure Capacity (Assessment of Status and Gaps)" (AICIC-2015) are tabulated below

Type of Infrastructure	Infrastructure Requirement (*A*)	Infrastructure Created (*B*)	All India Gap (*A-B*)	% share of Gap to Required
Pack-house	70,080 nos.	249 nos.	**69,831 nos.**	**99.6%**
Reefer Vehicles	61,826 nos.	9,000 nos.	**52,826 nos.**	**85%**
Cold Storage (Bulk)	341,64,411 MT	318,23,700 MT	**32,76,962 MT**	**10%**
Cold Storage (Hub)	9,36,251 MT			
Ripening Chamber	9,131 nos.	812 nos.	**8,319 nos.**	**91%**

- AICIC-2015 – NCCD -

Source: - AICIC-2015 – (NCCD Cold Chain Report 2016)

Thus we can see from the table above that three of four components – pack houses, ripening chambers and reefer vehicles – in the cold chain are almost entirely inadequate and have a huge gap from what is required. Another aspect is that out of around 8000 cold stage warehouses in the country, more than half of the capacity is being used to store potatoes. The remaining 30% is made up of multi-commodity cold storage. The states of Uttar Pradesh and West Bengal make up nearly 55-60% of cold storage as the biggest potato producers in the country (Business Insider India FEB 1, 2020).

5.0 Government as well as non-government initiatives towards smoothening the aspects identified with post harvest management in India:

In the Indian federal budget for the year 2020-2021, it was announced that National Bank for Agriculture and Rural Development (NABARD) would undertake an exercise to map and geo-tag agri-warehousing, cold storage, reefer van facilities in the entire country. Accordingly, NABARD has so far surveyed 82000 agri storage infrastructures (ASIs) out of 0.108 million structures across the country. This total number (.11 million) is in the range of only a quarter of the total of half a million storage structures in the country, the majority of them being non compliant with the Indian official agency Warehouse Development and Regulatory Authority (WDRA) norms Post verification, the GPS coordinates and the data are planned to be uploaded to a mobile app, which can be used by the farmers to locate the nearest warehouses and store their produce, reducing the risk of wastage.

Further, to facilitate a seamless national cold supply chain for perishables, inclusive of milk, meat and fish, the Indian Railways launched the “Kisan Rail” service on 7th August 2020 and already transported approximately fifty thousand tonnes of perishables including fruits and vegetables across the country. (PIB Release 03 FEB 2021) Krishi Udaan Scheme provides air-freight subsidy of 50% for the agri-perishables of NER States and 4 Himalayan

States/UTs for the benefit of farmers of these states and caters to more than 22 perishable crops. (PIB Release 09 FEB 2021)

The government of India has also launched a financing facility of Rs 1 lakh crore under the Agri-Infra Fund with the purpose of improving post-harvest infrastructure in villages and boosting farmers' income. The scheme will support farmers, farmer cooperatives and producer organisations (PACS, FPOs), agri-entrepreneurs, etc. in building community farming assets and post-harvest agriculture infrastructure. These assets will enable farmers to get greater value for their produce as they will be able to store and sell at higher prices, reduce wastage, and increase processing and value addition. (PIB Release 09 August, 2020; India Budget Speech, 01 February 2020; The Economic Times 08 February, 2021, theprint.in 13 August, 2020)

6.0 Your Virtual Cold-Chain Assistant

The two Swiss organizations BASE (the Basel Agency for Sustainable Energy) and Empa (Swiss Federal Laboratories for Materials Science and Technology), are collaborating[1] on a project to build and deploy 'Your Virtual Cold-Chain Assistant', which will enable smallholders to access sustainable cooling facilities through the servitization business model, and to benefit from available data and market information to optimize decisions on produce and farm management. To do so, they are creating an open access, data-science-based mobile application, using machine learning and physics-based food modeling. The project team will use various data inputs including weather & climate data, geographical location data, fresh-produce yields, hygrothermal cold-storage sensor data, forecasted remaining shelf life of produce & real-time market prices. Compared to existing mobile applications in agriculture, this application is tailored to smallholder farmers. Smallholder farmers (< 2 hectares) currently produce 30-34% (Ricciardi V. et al, 2018) of the world's food. However, this farmer group is underserved with respect to ICTs such as mobile apps and affordable cooling technology solutions.

[1] The Virtual Cold Chain Assistant is a project as a part of the data.org global innovation challenge, in which, BASE and Empa will create an open access, data- science-based mobile application. The details about the project and the tool have been sourced through personal communication and details about the project are also available at https://energy-base.org/projects/your-virtual-cold-chain-assistant/

By using the Cooling as a Service[2] model, farmers gain access to the most efficient, reliable and sustainable off-grid cooling while only paying for the amount of food they store (per kg-day) in the cold rooms, avoiding any upfront investment. Service providers own and maintain the cooling facilities, thereby covering the operational costs. This long-term commitment serves as an incentive for them to install the most energy-efficient equipment, and perform high-quality maintenance.

The Your Virtual Cold Chain Assistant application will provide real-time instructions to guide farmers on how to control storage of products to minimise food loss and energy use, and on when to sell their produce to maximise market value.

The objective of the program is to enable smallholders to make decisions on cooling based on lifecycle benefits, rather than upfront costs; have access to easy to use information so that they can make optimal decisions on produce and farm management; break the negative cycle of poverty – while also improving food security, and minimizing the impact of food production on the global climate.

The application complements machine learning models with physics-based food quality modeling and will include the following components:

- ✓ Identify smallholder farmers that currently do not have access to cooling facilities and have the largest potential to adopt and implement our solution.
- ✓ Predict the current quality of the stored food.
- ✓ Forecast remaining postharvest life for the current cold storage conditions.
- ✓ Use predictive market analytics to inform farmers about the optimal time to sell
- ✓ Provide cold chain control of the facility to maximize energy efficiency

BASE and Empa are partnering with local entrepreneurs in India to pilot the tool with different types of crops, targeting 200 to 500 smallholder farmers.

This two-year endeavour is projected to reduce food loss for smallholders substantially and thus increase their yearly income by nearly 30%, and reduce greenhouse gas emissions by up to 50%. Reducing postharvest losses also helps reduce related CO2 emissions, further

[2] The Cooling as a Service business model was developed by BASE through its Cooling as a Service Initiative, a global effort launched in early 2019 by BASE and K-CEP to scale up investments in clean and efficient cooling by mainstreaming the Cooling as a Service business model. More information here: www.caas-initiative.org or here: https://energy-base.org/projects/cooling-as-a-service-initiative/

amplified by removing the use of harmful refrigerants (such as R-22) and diesel generators from the cold chain. By ensuring that clean technology is used instead of fossil-fuel dependent technologies, that cost less upfront but are more expensive to operate, the impact on climate change is mitigated.

The project developers intend to make use of the pilot to create case studies, to share and promote the open-access Virtual Cold Chain Assistant amongst cooling entrepreneurs - with the aim of replicating the model in developing & emerging economies globally.

7.0 Startups and other Private sector initiatives in the post harvest value chain:

Some notable private sector initiatives working in the post harvest (direct marketing, quality grading etc.) in India are listed below.

Ninjacart: They serve thousands of farmers and retailers across metros (major operations in Bangalore and Chennai) by connecting vegetables and fruit farmers directly with businesses.

Crofarm: Crofarm is a B2B initiative that buys fresh vegetables and fruits directly from farmers and supplies them to online and offline retailers like BigBazaar and Big Basket.

Intello Labs: AI based quality assessment. Intellolabs mobile App can be used for quality grading of commodities, pest/disease detection in crops, yield estimation using image processing and AI.

Bigbasket: bigbasket.com is India's largest online food and grocery store with doorstep delivery. Farmers deliver their produce to the collection centre nearest to the farmers' village from where the produce is transported/aggregated at the Bigbasket managed distribution centres/warehouses for sale.

Tan 90 Thermal Solutions: They provide decentralised cold storage solutions to transport perishables in a cost-effective, monitored, and safe manner.

GreenPod Labs: Using nanotechnology to extend the shelf life of fruits and vegetables during storage and transport.

Agrograde: They are a Maharashtra based Agri-tech startup developing solutions to improve marketability of fruits and vegetables using AI based grading and sorting solutions. They claim that their solutions detect color, size, defects, foreign objects, surface quality, diseases, shape and variety of a commodity upon grading. They have centered their solutions on

improving marketability of the commodities, reducing post-harvest losses and enabling an efficient and transparent trading process.

MistEO: Bringing parametric insurance in agriculture and growing the discipline focusing on computation and financial mitigation solutions addressed to meet sustainability targets.

New Leaf Dynamics: Refrigeration systems powered by biomass or farm waste.

8.0 Conclusion:

The initiative to geo-tag all agri-warehousing, cold storage, reefer van facilities is a significant application of ICT in ensuring efficiencies in the post harvest operations and which will help curb distress sale by farmers and help them get a remunerative price for their produce by timing their sale rightly. By providing the farmers proper agri infrastructures, they can be encouraged to shift to high-value horticulture produce from food grains, which are in excess production and thereby induce diversification as well as generate higher income for farmers. This is also an environmentally positive development and also supports better nutrition in the population. Further, rigorous quality norms followed in the case of exports for grading, packing and traceability, should also be gradually introduced for domestic markets too to improve both quality of produce and incomes of the farmers.

We believe that the issue of access is as important as the availability of infrastructure of these post harvest initiatives (including eNAM) for the smallholder farmers to meaningfully benefit from these. The government initiative 'Formation and Promotion of 10,000 Farmer Produce Organizations (FPOs)' can be a game changer in this regard. Collectivisation of farmers, specially smallholder farmers, tenants and sharecroppers can provide them 2 important strengths, benefit of economies of scale as well as collective bargaining power. FPOs can thus, ease access, capacity building and gap assessment issues. Private and non-profit initiatives like the virtual cold chain assistant can be very powerful supplements to reduce access and information asymmetry for smallholder farmers by making technologies and knowhow like cold storage and market dynamics available to them by using ICTs.

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