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Smart Supply Chain Management System for Apple fruits in India

Richa Ojha[1], Rishabh Ojha[2], Amber Jain[3], Pankaj Jain[4]

M.Tech Student, Gyan Ganga College of Technology, Jabalpur, Madhya Pradesh, India [1]

B.E Student, Gyan Ganga College of Technology, Jabalpur, Madhya Pradesh, India [2]

B.E Student, Gyan Ganga Institute of Technology & Sciences, Jabalpur, Madhya Pradesh, India [3]

Assistant Professor, Gyan Ganga College of Technology, Jabalpur, Madhya Pradesh, India [4]

ABSTRACT: Indian diet consists of a significant amount of fruits and vegetables, with the growth in population and accretion in the disposable income fruit and vegetable consumption has also increased. Although, the production of fruits and vegetables in the Indian sub-continent has grown by over 89% in the past decade, there has been no advancement in relation to the post harvest technologies to protect fruits and vegetables before they reach the end consumer. This paper elucidates on the existing supply chain of apple fruits in India with the individual role of different actors in it. This paper also annotates on the aggregate relationship between these actors in the year 2017-2018. Furthermore, it discerns the discrepancies in the existing apple fruit supply chain of the country, and also proposes possible resolution to the suggested problems. Finally, it proposes a novel apple fruit supply chain system in India that corroborates the existing actors in functioning collectively. The proposed supply chain's collective measure allays the plight of individual actors, while simultaneously providing a better end produce to the end consumer at a more competitive market price.

I. INTRODUCTION

Apples have a significant trace in the history of mankind, they are a part of the Hebrew Bible's Book of Genesis chapter on Adam and Eve. Apples are also associated with the discovery of gravity by Sir Isaac Newton, who got the idea of gravitational pull after he observed apples falling down to the ground, rather than floating up in the air. This historic echo of apples can be contributed to its health benefits that were known since ancient times.

Researches suggest that phytochemicals including phenolics, flavonoids and carotenoids have significant health benefits. As they alleviate the risk of life threatening diseases such as cardiovascular disease and cancer[5]. Studies also clarify on the link between consumption of apples with lower risk of specific types of cancers, asthma, diabetes, and cardiovascular diseases. Such health benefits of apples can be attributes to the presence of a variety of phytochemicals in apples; these phytochemicals include but are not limited to catechin, chlorogenic acid, quercetin, and phloridzin, which are all of strong antioxidants. Although, the amount of phytochemicals in apples may vary on the basis of its variety, almost all of the varieties contain traces of these phytochemicals.

Indian climatic conditions are salutary for fruit and vegetable cultivation. This is one of the reason India is the largest producer of fruits such as bananas, and mangoes. The variance in temperatures, from low in the northern regions such as Jammu and Kashmir, moderate in most parts of central India, to warm in south. India provides a great environment for the horticulture activities. These apt climatic conditions bolsters the Indian economy, as approximately 15 to 16% of the India's GDP is directly related to agriculture; which results in the direct and indirect employment close to 53.2% of the entire population of the nation. However, with the accretion in population world wide, clubbed with the projected growth in the disposable income, portrays substantial growth in the agriculture sector.

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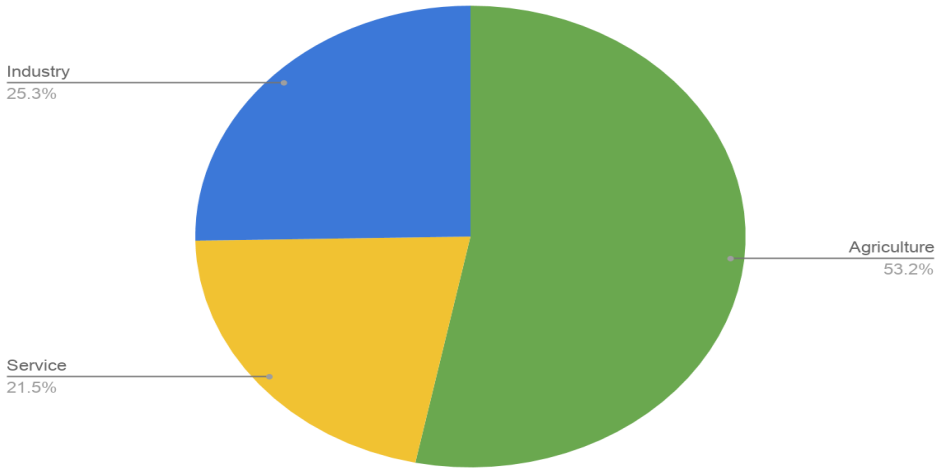

Figure 1: Economic sector wise workforce distribution for year 2009-10
Source: data.gov.in Employment by Sector
Description: This figure illustrates the percentage population that is directly of indirectly employed in the agriculture sector

As clear from figure-1, over 50% of the Indian population is dependent on agriculture directly or indirectly as major source of income. One significant advantage of the agriculture sector is that a major part of the diaspora employed through this sector is female, which significantly helps in the upliftment of not just them, but also of the whole family. Though the percentage of female employment in the agriculture sector has gone down by almost 20% since 1991, from 76% to 56%, as shown in figure-2; women still contribute significantly to the agriculture workforce of the nation.

Sectors	Employment (in millions) 1999-2000	Employment (in millions) 2004-05	Employment (in millions) 2009-10
Agriculture	23767	25893	24485
Manufacturing	4405	5577	5074
Mining	217	264	295
Electricity, Gas & Water Supply	113	130	125
Construction	1754	2602	4404
Services	9420	11281	11634

Table 1: Economic sector wise workforce from 1999 to 2010
Source: Source: data.gov.in Employment by Sector
Description: Given tables illustrated on the women employment in the agriculture sector

As mentioned earlier agriculture contributes over 15% to the GDP, a significant portion of which is related to thevegetable and fruit horticulture production of India, also generating employment. These trends of agriculture are not

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recent, agriculture has always been a major contributor in the employment sector. As clear from table-1 agriculture sector has generated over 50% employment since last 20 years. However, a significant percentage of the agriculture produce is wasted post-harvest. In case of semi-perishable items the post-harvest losses are estimated to be 10 to 25% of the total produce, which although significant, seems to be miniscule when compared to the post-harvest losses of fruits and vegetables which is estimated to be around 30 to 40% of the produce[3]. In countries like India where over 17.3% of 1st and 2nd grade children are malnourished, such a prodigal wastage of food is aghasting. Most of this wastage throughout the country is attributed to the problems such as lack of transportation and lack of store houses[6] as mentioned in table-2.

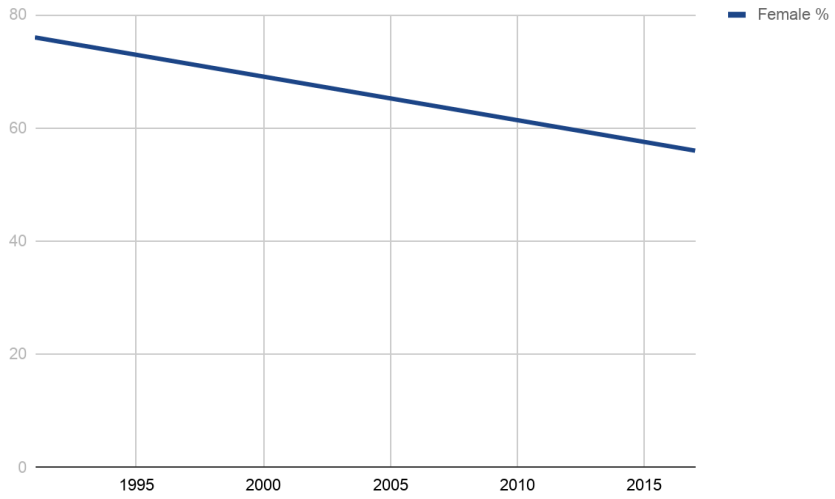

Figure 2: Female employment in agriculture sector from 1991 to 2017 in India
Source: World Bank data employment in agriculture, female
Description: The graph illustrates female employment in agriculture in India

Major cause of food wastage	Possible solutions
Lack of transport facilities	Better transportation
Lack of store houses	Store houses with more capacity
Lack of proper organisation	Implementation of proper supply chain management strategy

Table 2: Major causes for postharvest food wastage in India with possible solutions
Description: The table describes major food wastage problems with their solutions

As several studies have pointed out that such a lavish wastage of food can be prevented with the implementation of a proper supply chain management system in the agriculture sector. However, it must also be noted that implementing a single chain to handle the supply of every single agriculture produce is not possible. Different agriculture produce have different properties such as storage temperature, moisture presence, life-time, etc. Therefore, implementing a universal chain that deals with all these mentioned attributed at once is not palpable, and different chains must be implemented to deal with different categories of produce.

The maximum post harvest wastage is for the fruits and vegetables which is close to 40% as mentioned earlier, therefore, the most grievous need of proper supply chain is in that sector. Additionally, as already mentioned it is

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required to have distinct supply chains to manage different type of items, we need different supply chains to manage different varieties of fruits and vegetables.

Fruit	Production(Tonnes)
Banana	29,134.83
Mango	15,026.70
Papaya	5,667.05
Orange	4,112.73
Guava	4,047.78
Grapes	2,590.02
Apple	2,521.10
Lemon	2,437.58
Pomegranate	2,306.45
Pineapple	1,924.24
Citrus	1,562.25
Sapota	1,293.76
Litchi	558.76

Table 3: Fruit production in India by quantity for year 2015-16
Source: APEDA agriXchange database
Description: The table illustrates the major fruits produced in India in descending order

Table-3 presents a clear picture of the fruits produced in India. As clear form the table, India is the top producer of bananas throughout the world, producing close to 29,134.83 tonnes of banana in the year 2015-16. But, as the APEDA data suggests over 40% of the banana produced was wasted prior to consumption, which if converted to tonnes results in a appalling amount of 11653.932 tonnes.
Apple which is produced approximately 2,521.10 tonnes every year is the 7th most produced fruit in India. Still the country has to import apples from China and USA to fulfill local demand of apples. Due to which different strategies are used to improve the production of apples by farmers. However, rather than focusing on better production of apple, one must focus more energy and time in eliminating the apple wastage in India which is close to 12 to 14% of the produce. This paper talks in detail about the implementation of a intelligent supply chain to reduce the apple fruit wastage.

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II. LITERATURE SURVEY

In literature survey it was found that most of the research was based on the generalized approach of creating a supply chain for the entire food and vegetable combined, without considering the individual properties of different products, a significant literature covered during this research is listed here.

Bhardwaj R. K., Bhardwaj Aditi &Gangwar S. K. (Distribution Pattern of Apples in Indian Subcontinent: Constraints and Strategies) [1] 2012. This paper delves into great detail about the very specifics of apple distribution system. It also elaborates upon the different functionaries and parties involved in the supply of apple from the fields to the end consumers. This paper also throws light upon the plight of farmers and the main reasons behind the current situation. Although, this paper is limited in scope to the Azadpur fruit and vegetable market, Delhi, it greatly covers the main problems associated with the supply of apples. The authors in their research cover some of the major problems such as lack of packaging material availability, lack of market intelligence, improper connectivity, and much more.

SauravNegi and Neeraj Anand, (Issues And Challenges In The Supply Chain Of Fruits & Vegetables Sector In India: A Review) [2] 2015. In this paper the authors have presented their research on the generalised supply chain of fruits and vegetables in the Indian market. They have also discussed in great depth about the challenges and issues pertaining to the existing supply chain of fruits and vegetables in India. Also, the authors have suggested some important remedies for the existing supply chain. Some of the most important suggestions presented by the authors are the integration of the fragmented supply chain, linkages and communication between partners, and market information. Moreover, the authors have suggested that if the suggestions presented in the research are implemented it is going to have a positive impact on the market of fruits and vegetables in India.

Hegazy and Rashad (Post-harvest Situation and Losses in India) [3] 2013. This paper discusses in great details about the postharvest losses of fruits and vegetables in India. The paper presents factual data to corroborate the losses suggested. Also, it presents a juxtaposition of postharvest losses in India with the postharvest losses of other countries such as United States of America. Moerver, the paper sheds light on the existing post harvest process in India and the roles and contributions of different actors in it.

Somashekhar I. C., Dr. J. K. Raju, and Dr. Hema Patil (Agriculture Supply Chain Management: A Scenario in India", Research Journal of Social Science & Management) [4] 2014. This paper takes a different view on the postharvest losses recorded in India. It also elaborates on the different supply chains such as agriculture supply chain management, agriculture marketing in India, agri-food supply chain management, private sector initiatives, and contract farming. Moreover, it presents a big picture of the entire system of supply chains in food and agriculture sector in India.

Nidhi & N. J., Ardeshna& B N, Kalsariya& Reddy, Shilpa V C. (Problems of Agricultural Marketing in India) [6] 2017. This paper covers a great deal of problems associated with the agriculture marketing in India. Jeanelle Boyer and Rui Hai Liu (Apple phytochemicals and their health benefits) [5] 2014. This paper discusses about the health benefits of apples. Dandage K., Badia-Melis R. &Ruiz-García L. (Indian perspective in food traceability: A review) [7] 2016. This review paper gives a detailed view of the food traceability system in India. It also elaborates on the issues affecting the proper implementation of food traceability system in India.

III. OBJECTIVE

Post harvest losses of produce is a looming problem in India that must be addressed as early as possible, otherwise with the growth in agriculture production, these losses will also significantly increase. However, supply chain management provides hope in controlling these losses, it is impossible to forge a universal supply chain that is capable of dealing with all the varieties of fruits and vegetables produced in India. Therefore, discitint supply chains must be constructed, dealing with fruits and vegetables having different properties. Our objectives for this study is to:

- Study the existing supply chain of apples with its flaws.
- Establishing a Smart Supply Chain to deal with apple fruits, and fruits having similar properties such as apples.

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IV. EXISTING SUPPLY CHAIN OF APPLES

To understand the reason behind the extravagant 14% wastage of apple fruit, we first have to understand the existing supply chain of apples from farmers to the end consumers.

State	Production (tonnes)	Share(%)
Jammu & Kashmir	1,672.72	66.35
Himachal Pradesh	777.13	30.83
Uttarakhand	61.94	2.46
Arunachal Pradesh	7.28	0.29
Nagaland	2.01	0.08
Tamil Nadu	0.02	0
Sikkim	0	0

Table 4: State wise apple production in India for year 2015-16
Source: APEDA agriXchangenhb database
Description: The presented table gives the state wise production of apples in India

The state of Jammu & Kashmir with the state of Himachal Pradesh amounts for over 90% of apple production of India, which is over 2449 tonnes. This magnanimous production of apples by these states can be attributed to the favourable low temperature conditions present in these states making them apple farming panaceas. Farming of apples starts with the planting of apple orchids in the months of January and February. The usual planting strategies used to plant the maximum number of plants using minimum area generally implements the hexagonal or square systems of planting for the apple valleys, whereas a special contour method is used for apple plantation on the slopes. 114 cm of water is required for apple plant cultivation over a year, scheduled at different time intervals over the year depending upon the weather conditions.

Special protection measures must be taken to protect the plant from insects, pests, and diseases. Insect pests frequently observed in apple plantation are white scale (Pseudoulacaspis sp.), San Jose Scale (Quadraspidiotusperniciosus), blossom thrips (Thripsrhopalantennalis), wooly apple aphid (Eriosomalanigerum) etc. Suitable intercultural steps, with planting resistant rootstocks, and sprinkling with fenitrothion, chloropyriphos, carbaryl etc. are considered among the effective pest controlling strategies.

The most frequently reported diseases are apple scab (Venturiainaequalis), collar rot (Phytophthoracactorum), die-back diseases, crown gall (Agrobacterium tumefaciens), ,sclerotius blight (Sclerotiumrolfsii), cankers etc. Most effective strategy to counter with these problem is to eliminate the infected plants, and use of disease resistant plant for the purpose of cultivation. Application of copper carbendazim, oxychloride, mancozeb and other fungicides are considered to be effective in administering these diseases.

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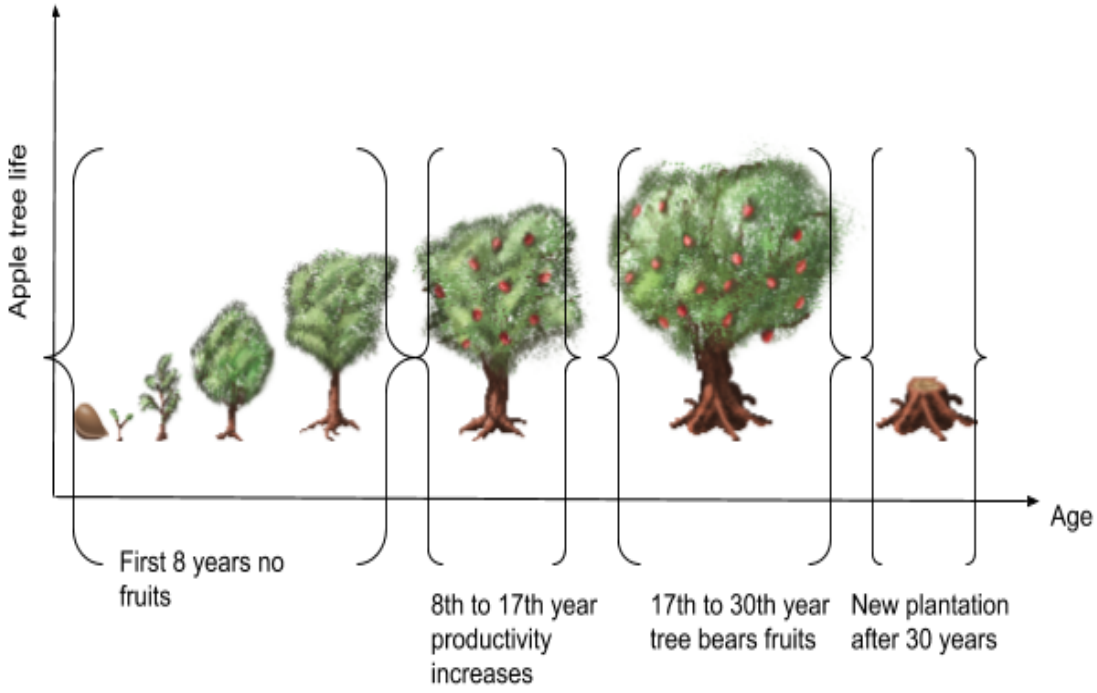

Figure 3: Stages in life of apple tree
Description: The given figure describes the life-cycle of an apple tree

Apple trees bear no fruits till the reach 8 years age. It is only after trees attain the age of 8 years that they start to bear fruits. From the age of 8 till the age of 17, the productivity of apple tree keeps on aggregating till they attain the age of 17. The apple tree keeps on producing apples till the age of 30, after which they are usually no longer fruitful, and therefore are cut down for next cultivation.

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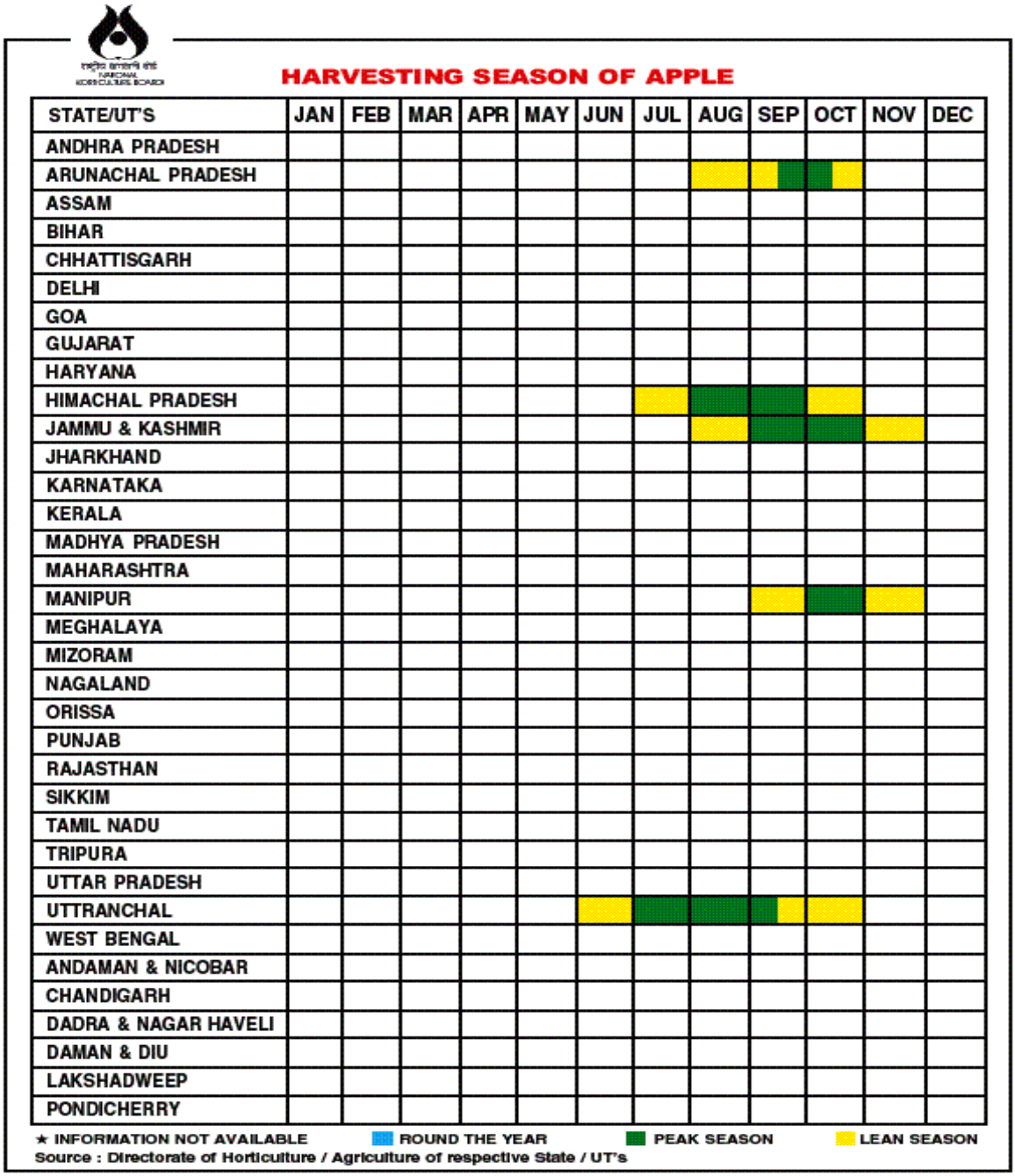

Figure 4: State wise apple harvesting season in India.
Source: APEDA agriculture database
Description: The given figure presents the harvesting seasons of apples in India

Care must be exercised post harvesting, otherwise the quality of produce might degrade, or worse, the produce might be tarnished. The most common harvesting months of apples are mentioned in figure-4. Following are the set of activities that are performed post harvest for protecting the produce till the reach the end consumer:

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- Pre-Cooling:
  - Fruits collected from the apple tree are at field temperatures.
  - If packed in this situation the fruits might erode.
  - Pre-cooling serves another purpose of eliminating the excessive moisture from the surface of the fruit, making it apt for grading and packing.
- Grading:
  - Grading of apples is mostly carried out using only the physical characteristics.
  - Mostly the characteristics graded are the physical appearance of the apple, and the size of the apple.
  - Apples are generally graded into 3 or more classes, depending upon the apples.

S. No	Grade Name
1	AAA
2	AA
3	A
4	B
5	C
6	Extra Fancy
7	Fancy Class I
8	Fancy Class II

Table 5: Different grades of apples
Source: APEDA apple farming documentation
Description: The given table describes the grading table of apples

A. *Storage*
- Apples have a great post harvest life if stored properly.
- In proper conditions apples might last for over 4 to 8 months after harvesting.
- For proper storage apples must be stored at temperatures of close to 0 to 1.1 degree celsius.
- And, humidity must be in the range of 80 to 90% relative humidity.

B. *Packing*
- Two types of packing are prevalent for apples
- First one is the wooden box packing of apples of 10 to 20 kgs per box.
- Second one is the cardboard box packing approximately 10 to 15 kgs per box.
- Wooden packing is much more sturdy as compared to cardboard packing.
- The packing is corroborated with paper shreds to protect apples from damage during transportation.

C. *Transportation*
- The most popular medium of transport is the road transport.
- However, it occasionally creates problem due to adverse conditions of roads from Himachal Pradesh and some parts of Jammu and Kashmir.
- The roads connecting apple farms with collection centers are also not is fatigued condition.

D. *Marketing*
- The apple produce market is mostly controlled by commission agents, and wholesalers.
- They also play a great role in the market price moderation of apples.

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E. *Retailers*:

- They purchase the produce from the wholesalers or commission agents, and bring them to the retail market.

V. PROBLEMS WITH THE EXISTING SYSTEM

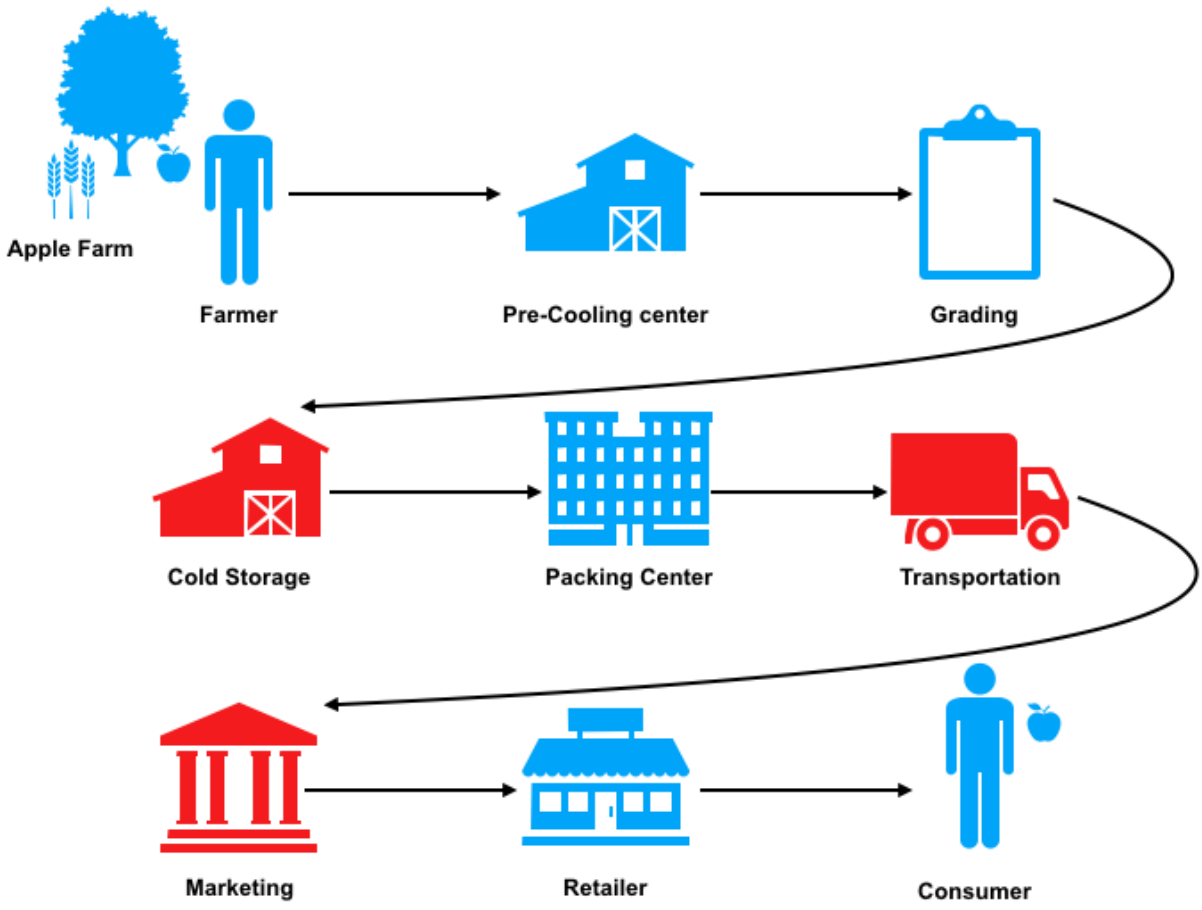

Figure 4: Existing apple Supply Chain
Describles: This figure portrays the existing supply chain for apples

The steps that are demarcated as red in the existing supply chain portrayed in figure-4, are the steps where the chances of apple wastage is the most. The detailed reason behind such losses is discussed in detail below.

A. Cold Storage Problem

- The looming problem of lack of cold storage facilities is the major cause of post harvest wastage.
- There are not sufficient cold storages close to the markets that can hold the produce until proper price of the produce is received, forcing farmers to sell their produce at low rates.

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- Even if cold storage facilities are available in some places they are not managed well, due to which there is no advantage of keeping the fruit in cold storage as it will degrade eventually.
- Another problem with the cold storage facilities is that some of the cold storages are not capable of maintaining the required temperatures of 0 to 1.1 degree celsius.

B. Transportation problem

- The major problem with transportation is the lack of road facilities from the farms to the collection centers.
- This results in delay in getting fruits from the farm to collection centers, which eventually results in decay of fruit quality.
- Another major problem is with the transportation facilities available from the packaging center to the market.
- This is mainly due to the high cost of fuel, which eventually results in high cost of transportation, which in-turn results in high fruit prices in the market.

C. Problems with Market

- Market is supposed to be a place where farmers can bring their produce and put it on bidding, selling the produce to the highest bidder.
- But, the major problem that arises in the market is the lack of management that results in improper bidding, resulting in low bidding price of the produce.
- Another problem linked with the market is lack of storage facilities close to the market, making it difficult for farmers to reject lower bidding price in the market. As, if they do not sell it for the offered price the quality of produce might degrade.

VI. ESTIMATED COST OF PRODUCING APPLES IN ONE ACRE

*All the values mentioned in the table are in Rupees

Sl. No.	Component		Proposed Expenditure
1.	**Cultivation Expenses**		
	(i)	Cost of planting material	2500
	(ii)	Manures & fertilizers	7700
	(iii)	Insecticides & pesticides	3000
	(iv)	Land Preparation	4200

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	(v)	Others, if any, (Power)	3600
		Sub Total	**21000**
2.	**Irrigation**		
	(i)	Borewell	25000
	(ii)	SIP & Electrical Installation	25000
	(iii)	Others, if any	-
		Sub Total	**50000**
3.	**Cost of Drip/Sprinkler**		**20000**
4.	**Infrastructure**		
	(i)	Store & Pump House	20000
	(ii)	Labour room	5000
	(iii)	Agriculture Equipments	10000
	(iii)	Others, if any, please specify	
		Sub Total	**35000**
5.	**Land Development**		
	(i)	Soil leveling	4000

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	(ii)	Digging	-
	(iii)	Fencing	20000
	(iv)	Others, if any, please specify	-
		Sub Total	**24000**
6.	**Land, if newly purchased** (Please indicate the year)*		
	Grand Total		**1,50,000.00**

Table 6: Estimated Cost of apple farming for one Acre for year 2001-02
Source: APEDA agriculture database
Description: The given table presents the per acre cost of apple plantation

As evident from table-6 the cost of producing apples in one acre of land is close to 1,50,000 rupees. This data is for year 2001-02, now this price has increased due to inflation. Inflation data puts this cost of producing apples in one acre of land close to 4,68,000 rupees due to the staggering rate of inflation (data compiled from inflationtool.com). Therefore, the farmers must try to limit the wastage to increase the profit. This will also help in meeting the growing apple demand in the country.

VII. PROPOSED SMART SUPPLY CHAIN FOR APPLES

Building a supply chain specifically designed for apples produced in India, can help alleviate the profligate 14% loss of apples post harvest. This paper proposes a supply chain that is constructed keeping the problem of the existing apply supply chain in mind, in turn lowering the wastage of apple fruits post the harvest. Although, certain problems cannot be addressed by simple implementation of a smart supply chain, such as the problem of transportation can only be solved by the government, we can still make use of smart supply chain for the purpose of solving other issues related to the post harvest wastage of apples in the country.

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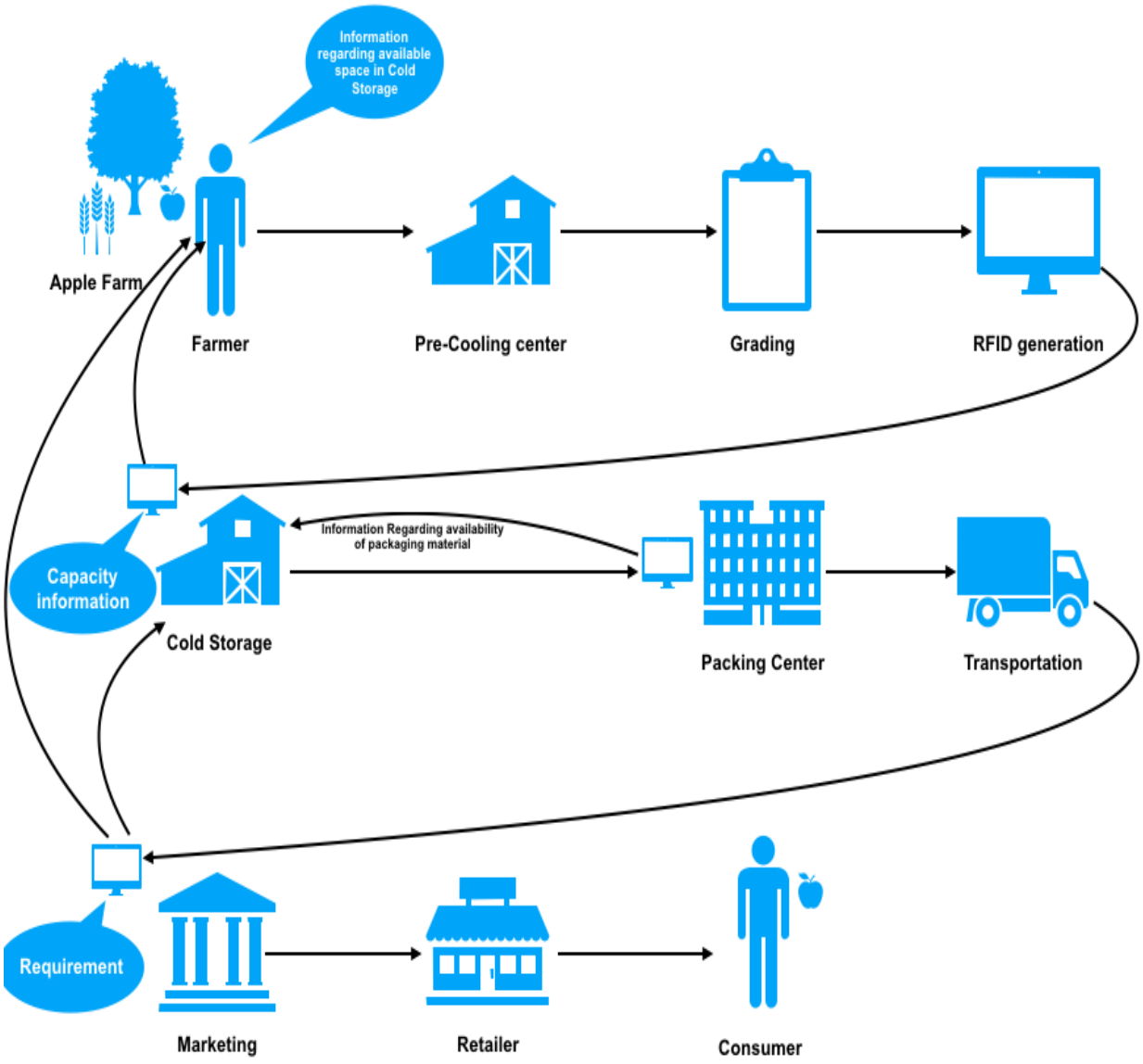

Figure 5: Proposed Smart Supply Chain for better management of apples post harvest
Description: The given diagram presents the proposed Smart Apple Supply Chain

The Smart Supply Chain for better management of apples postharvest proposed in figure-5, has the following working:

A. *Farmers*

- Rather than randomly harvesting apples, without any prior knowledge about the market rate, or the availability of cold storage, farmers first get all this information from the cold storage center and the markets.

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- This information is collected with skilled individuals in every district, who later distribute this information throughout the farmer community of an area.
- Based upon this information farmers make an educated decision whether to harvest their crops, or to wait for some more time for until there is proper availability of space in cold storage.
- The farmers can also differ the harvesting of apples, if the market is already flooded with apples,reducing its price.
- Finally, if the farmer finds all the conditions to be favourable, they harvest the apples and send them to the pre-cooling centers.

B. *Pre-cooling centers*

- Apples are stored in the pre-cooling centers until they lose the farm heat, and excessive moisture making them eligible to be graded.
- From here, after the process in completed, apples are transferred to the grading center.

C. *Grading Center*

- In the grading center the apples are graded according to their quality.
- With the quality inspection, the apples are also segregated according to their quality analysis.
- These segregated apples are then supplied with a special RFID code that later helps in identifying the quality of apple, and also collect other data regarding apples such as their harvesting date, and the condition of the cold storage where they were stored.

D. *Cold Storage*

- Cold storages contain a special system having information regarding the cold storage capacity, and the space-left that can be filled with apples.
- This information is stored in a system through which the farmers can directly query data regarding the space available.
- The system on pre-defined time intervals will share this data with the district centers with skilled individuals.
- Farmers can also make reservation for their produce in the cold storages using this technology.
- The condition of fruits is constantly monitored in the cold storage and this information is supplied to the farmers as well.
- Also, the temperature readings and the moisture content of the cold storage is consistently monitored and this data can be attached with the RFIDs of the produce stored in the cold storages.

E. *Packaging Center*

- One of the most sincere problems associated with the packaging centers is the lack of availability of good quality packaging material.
- This problem can be solved by using a system at the packaging center that can monitor the supply of the packaging material.
- If the packaging material is not enough to supplant with the incoming produce, the packaging center will generate an alter.
- Informing the cold storage to not to send anymore produce as the packaging center is out of packaging material to pack it.
- If everything is fine the packaging center will inform this to the cold storage, and the cold storage can move stored apples to the packaging center for packing.

F. *Transportation*

- Although, major problems related to transportation cannot be solved by simply using supply chain, we can still take advantage of smart supply chain by scheduling the proper transport media according to the quantity of produce.
- Better connectivity of roads must be provided to deal with this issue.

G. *Marketing*

- Market is made up of auctioneers, who take the produce from the farmers and put it on auction.
- The produce is sold to the highest bidder.

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- Auctioneers can provide the data regarding the average auction bidding of the apples, so that the farmers can take a educated decision regarding the right time to sell the produce.
- Also, the farmers can compare data from different markets to select the one which gives them the maximum price.
- If the price in market is going low due to constant influx of apples, the system can generate an alert to inform the cold storages and the farmers to not to sell apples in the market at the moment, as they are not expected to get good price for it.
- However, if the demand of apple is more in the market than the supply, system can request the farmers, as well as, the cold storages to start sending apples to the market. As, they are expected to get good price for their produce.

H. *Retailers*

- Retailers get their produce from the wholesalers, who are mostly the bidders in the market.
- The wholesalers purchase high volume of apples from the market which they then sell to the retailers.

I. *Consumers*

- The common people who purchase the produce from the market are known as consumers.
- The price that the consumer has to pay can be significantly low if the money spent by farmers on transportation and cold storages can be brought down, which is the whole purpose of this novel smart supply chain.

VIII. SIMULATION RESULTS

In this section we explanation of the method used for the purpose of generating the results for the proposed work. For the purpose of this research work we are using the mathematical method of problem optimization, specifically we are using the method of minimization as a means to find the minimum loss value that can be achieved using the proposed research.

The apple fruit production per acre in India is between 20 thousand to 30 thousand apples. For research simplicity we can consider this amount to be the average of the two extremes around 25 thousand apples. On an average the weight of one apple piece is between 100 to 200 grams, for ease of calculation we can consider this value to be the average, approximately 150 grams per apple. Therefore, it takes nearly 7 pieces of apples for make 1 kilogram of apple. Finally, we can assume the production of apples from one acre of plantation to be nearly 3572 kilograms.

The loss of apples fruits postharvest varies significantly depending upon factors as discusses; however, the average postharvest loss is 14 percent, and the maximum post harvest loss in case of fruits and vegetables is 35 percent in India. Postharvest losses can be broadly classified into four categories namely, loss in cold storage, loss during transportation, loss during marketing, and other losses. To simulate these loss conditions and to optimize these losses to minimum we can use the following minimization mathematical model.

$$min\text{-}\ 428.64\, x_1 - 500.08\, x_2 - 642.96\, x_3$$

Subjected to,

Cold Storage loss:

$$105.02\, x_1 + 137.73\, x_2 + 214.32\, x_3 \leq 178.6$$

Transportation loss:

$$167.88\, x_1 + 296.47\, x_2 + 110.73\, x_3 \leq 142.8$$

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Market loss:

$$135.73\,x_1 + 39.29\,x_2 + 160.74\,x_3 \leq 125.02$$

Other losses:

$$46.43\,x_1 + 28.57\,x_2 + 67.86\,x_3 \leq 178.6$$

$$x_1, x_2, x_3 \geq 0$$

Function used

$$linprog(f, A, b, Aeq, beq, lb, ub)$$

On applying minimization to the above set of linear equations, using MATLAB linprog() function, we get the result as given in table-6.

X	Minimum loss
x_1	0.3500
x_2	0.1528
x_3	0.3500

Table 6: Minimizes loss values using linprog() function in MATLAB
Description: This table presents results of optimization

In the equation x_1 & x_3 are scenarios based on existing supply chain for apples, as clear from the model they are expected to incur a loss tantamount to 35 percent. On the other hand, case x_2 is based on the proposed smart supply chain. As clear from the mathematical minimization the minimum loss out of the three was in case of x_2 which is around 15 percent, giving efficienciencies nearly 20 percent less than the existing models.

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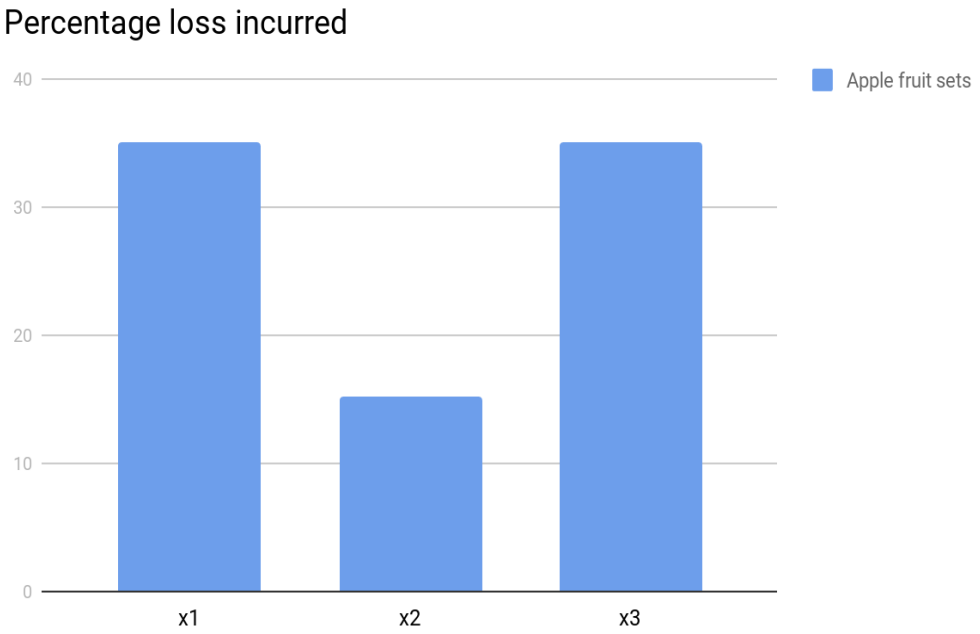

Figure 6: Graphical depiction of minimization values of existing supply chain (x_1 & x_2) and proposed smart supply chain (x_3)
Description: Optimization results presented in graphical format

As clear from figure-6, the proposed smart supply chain significantly reduces the cost as compared to the existing supply chain for apple fruits in India.

VIII. CONCLUSION

Implementation of the Smart Supply Chain Management System for Apples will help in reducing the post harvest wastage of the healthy fruit by over 20 percent as compared to the current scenario, while simultaneously increasing the fruit quantity in the market. More produce in the market will help in meeting the demand of the Indian market, as the current supply chain falls short in meeting the market demand. Therefore, if the demand of the Indian market is met properly, apple imports will eventually diminish. Also, implementation of the proposed smart chain will help farmers in increasing their income as they will be able to make smarter choices having all the data readily available with them, as a result contributing towards India's GDP. Furthermore, it will also help to exploit the maximum capacity of the cold storages, and will also bolster the fruit quality with the help of RFID tagging. Finally, making the end produce consumed by the consumer much cheaper as farmers and middlemen will be able to save the extra money that earlier used to be wasted in the system.

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