Determinants of Post- Harvest Losses in Fruits and Vegetables: An Empirical Study of Punjab

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Abstract

Post-harvest losses in fruits and vegetables is one of the major problems faced by the cultivators as 15 to 50% loss is faced due to poor handling in storage, transportation, packaging and processing etc. (Roy 1989 and Kiaya, 2014). In this study an effort has been made to examine the causes of post-harvest loses in fruits and vegetables and also the state of various facilities, which can support in reducing the post-harvest losses, available in the state of Punjab. Study is based on the views of the 300 farmers, 50 each collected from the six agro-climatic zones as divided by Punjab Agriculture University, Ludhiana based on the climate and soil texture. To check the association between quantum of post-harvest losses and the factors responsible for it, we have used Chi-square non-parametric test. Though there has been increase in the area under cultivation of fruits and vegetables in the state of Punjab during the last twenty-eight years covered in this study, but the increase in area under-cultivation as well as the increase in quantity produced has been less. Lack of transportation facility, cost of transport, cold storage facility, facility of ripening chambers, processing facility, distance of markets from farms, grading facility, regulation of markets, availability of government facility in the market place is found statistically significantly connected with post-harvest losses. However, we couldn't find any association between mechanical drying facility and post-harvest losses. Though farmers expressed satisfaction with the network of markets available and also were found happy with the regulation system of these markets but they expressed dissatisfaction as the cost of transportation was stated on higher side, there was lack of ripening chambers as well as the processing and grading facilities in the state.

Keywords: Post Harvest Losses, Transport Facility, Storage, Processing facility JEL Code: Q13

1. Introduction

India ranks at number two in the world after china so far as the production of fruits and vegetables is concerned (Hegazy, 2016). India's contribution to the total production of fruits and vegetables in the world respectively is 12.40% and 13.30%. Despite being the second largest producer, per capita availability of vegetables and fruits in India respectively is 207g/day and 104g/per day against the world average of 300g/per day and 120g/day (Gajanana, et.al. (2011)). One of the primary reasons for this poor performance is the post-harvest losses across the states in the country. After harvest, fruits and vegetables suffer huge losses between 15% to 50% due to poor handling in storage, transportation, packaging, processing etc. which is one of the major causes of concern (Roy, 1989: Kiaya, 2014). Approximately 40% fruits and vegetables are lost in a year owed to poor storage, handling, packaging, and transportation (Singh et.al., 2014). Committee on Doubling Farmers' Income (2019) has reported that the farmers are unable to sell about 40% of the total fruits and vegetables produced in the market or lose around Rs. 63,000 crore every year for not being able to sell their

produce at all India level (DownToEarth, https://www.downtoearth.org.in/news/agriculture/every-year-farmers-lose-rs-63-000-crore-for-not-being-able-to-sell-their-produce-59497).

"Post-harvest fruits and vegetable of value over Rs 2 lakh crore each year get wasted largely as a reason to the lack of food processing units, cold storages and uncaring behaviour in tackling the grave issue of post-harvest losses," stated Assocham in a study(Economic Times, 2013, https://economictimes.indiatimes.com/news/economy/agriculture/indias-post-harvest-losses-over-rs-2-lakh-crore-annually-assocham/articleshow/21652094.cms?from=mdr).
Of the total produce of fruits and vegetables, in India only 2.2 % is processed, whereas USA and China are much ahead of India in reducing the wastage and adding the additional value to the farm products by processing 65% and 23% of their produce of fruits and vegetables respectively. The post-harvest losses in fruits and vegetables are estimated to be exorbitantly high in India and have increased from 30 to 40 per cent (Hegazy, 2016).

Post-harvest losses have first-order effects on almost 86.2% of the Indian farmers as they being small and marginal farmers (Mint 2018, https://www.livemint.com/ Politics/k90ox8AsPMdyPDuykv1eWL/Small-and-marginal-farmers-own-just-473-of-crop-area-show.html). Small farmers in India have another agony too, as they have to sell their produce at low prices soon after the harvest due to lack of storage facility. Therefore, it is important for India to enhance the efficiency and effectiveness in handling, storing, processing of fruits and vegetables so as to reduce the post-harvest losses.

This study investigative the determinants of post-harvest losses in Punjab as the state has played a phenomenal role in bringing green revolution in the country and making the country self-reliant in food grains requirements, but with the passage of time the rotational cultivation of paddy and wheat is not only reducing the income of farmers but is also causing ecological issues like reduced soil fertility and decline in water table. This is a high time that, shift from traditional crop cultivation is made and farmers are encouraged to cultivate horticulture crops which is expected to not only increase the farmers income but will also help in maintaining the ecological balance and though government has put in rigorous efforts in the past to promote horticulture farming but the results have not been that encouraging. Moreover, the soil is mostly sandy loam with pH range 7.5 – 8.5. Therefore, it has good potential for cultivation of various horticultural crops (Horticulture Mission Report, P2018, https://punjabhorticulture.com/ Documents/Events/Horticulture _Status_Report.pdf)). Out of the various issues which may be acting as hurdle in adopting horticulture farming in the state of Punjab can be the requirement of proper post-harvest handling of horticulture produce which if not taken care can result in produce getting damaged, resulting in huge loss to farmers. Therefore, in this study as attempt has been made to find out the causes of post-harvest loss in fruits and vegetables in the state of Punjab.

2. Paper Plan

Section 1 of this paper deals with literature review, Section 2 describes the research methodology, Section 3 deals with trend of area and production of selected fruits and vegetables since liberalization, Section 4 focusses on determinants of post-harvest losses in fruits and vegetables in selected districts of Punjab.

Section 1

3. Review of Literature

Pantastico (1977) in a study covering Philippines and Pakistan reported post-harvest losses of 28.1% for fruits and 42.2% for vegetables in Philippines. Pakistan experienced 2 to 18% for reddish and 44 and 52% for tomato and spinach respectively due to lack of transportation, storage, packing and handling inefficiencies. **FAO(1981) e**stimated that in developing countries the post-harvest losses vary from fruits to fruits and in case of papaya it is as large as hundred percent. In case of vegetables, losses were estimated between the range of 5 to 100%. Various studies have found the extent and reasons for post-harvest losses in the different states of India. **Mandal et. al (1981)** found out that post-harvest losses in Brinjal were 14% and in Ocra were estimated to be 25% respectively in the Calcutta market. It was noted that these losses were incurred only account of poor facilities of handling, transportation and discoloration etc. **Maini (1983)** reported that post-harvest losses are more in Bhadhurgarh Onion than Gujrat Onion because of the traditional storage system which results in spoilage ranging from 25 to 40% of the total production. **Subramanyum(1986)** estimated post-harvest losses in potato as 25 to 40% due to cuts on the bulbs during harvesting, rotting, handling and transport, shriveling and structuring during storage. **Madan et. al. (1993)** found that the post-harvest losses of tomatoes in Delhi were estimated to be in the range of 7.2 to 34.7%, in Maharashtra 15-20% and in UP 4 to 10%. Push cart vendors suffered higher losses as compared to shop vendors. **(George and Mwangangi, 1994)** highest postharvest losses of bananas in terms of increased physical damage incidence and severity occurred due to long transport distance on ill maintained roads. **Rana et.al. (2005)** in their study estimated the quantitative PHL(Post Harvest Losses)

for Kinnow fruits in Punjab, Himachal and Haryana at three different stages, firstly, at orchid level, secondly at commission agent and thirdly at retailer level. The study has estimated that the combined physical losses for these three stages were 28.5% for Punjab, 30.4% for Haryana and 15.7% in Himachal Pradesh. It was found that the main causes in Punjab and Haryana for the Post Harvest Losses (PHL) were due to rotting, transport injuries during crushing-pressing and packing and during plucking. Singh et al., (2009) Losses during the transportation stage and storage are one of the current problems in Indian fresh produce supply chain. **Kishor et al (2006)** in their study stated a loss of 10.42 per cent in onion of which 6.21 per cent, 1.85 per cent and 2.36 per cent losses respectively happened at the field level, at the wholesaler and at the retailer level. In case of potato, of the total loss of 12.97 per cent, 7.34 per cent, 2.22 per cent and 3.41 per cent losses respectively occurred at the farm level, wholesaler and retailer level. **Mitrannavar and Yelledalli(2014)** in a study conducted in Karnataka reported overall loss at different stages of around 177.71 kg (22.86 %) in potato. The maximum loss was reported at the commission agent including wholesaler level. Overall loss including loss at all the stages was reported to be 27.44 %, 21.61% and 22.36% in tomato, brinjal and beans respectively. Retail level reported maximum losses for tomato and brinjal, in respect of beans maximum loss was found to occur at the commission agent-cum-wholesaler level. **Bantayehu, et. al., (2018)** experience and educational levels of producers in fruit production and shortage of labour were the determinant factors of fruit losses during harvesting.

Review of literature points out towards post-harvest losses which ranges from 5% to almost 45% depending upon the type of fruit and varies from state to state and region to region. The main causes reported for huge quantum of post-harvest losses are the poor transportation facilities, ill maintained roads, lack of storage facilities, mishandling during packaging etc. Though a large number of studies on assessment of post-harvest losses have been found a comprehensive study representing the state of Punjab couldn't be found, hence in this study we have analysed the status of post-harvest losses in fruits and vegetables in Punjab State.

Section 2

4. Research Methodology

To assess the situation of post-harvest losses in fruits and vegetables in Punjab, we have selected six districts as the sample size based on regional classification of Punjab made by Punjab Agriculture University, Ludhiana on the basis of soil textures and climatic features. Punjab Agriculture University, Ludhiana has divided Punjab based on soil texture and climatic features in six regions i.e. Sub Mountainous undulating region, Undulating plain region, Central plain region, Western plain region, Southern plain region and Flood Plain/Bet Area (https://dolr.gov.in/sites/default/files/SPSP-Punjab.pdf). For the purpose of primary survey, we have taken one district from each region, therefore in total six districts of Punjab i.e. Hoshiarpur, Mohali, Ludhiana, Ferozepur, Moga and Patiala one from each of the stated regions according to the agro-climatic zones are covered.

The districts covered in this study are scattered in the state and belong to different regions. The sample of 300 farmers from six districts (50 from each district) was selected on the basis of stratified random sampling method. Empirical data was collected from the farmers with the help of structured questionnaire and through personal interviews. As during pre-testing of the questionnaire, it was observed that the respondent farmers were not quoting a specific percentage as post-harvest losses rather they were giving estimates like 2 -3%, 3 to 5%, therefore the responses from the farmers were taken in the form of range which was later converted to one specific figure by taking the average of the range. Analysis of post-harvest losses in fruits and vegetables has been made with respect to the major selected categories of fruits and vegetables for the six selected districts of Punjab. Determinants responsible for the post-harvest losses were identified on the basis of previous research studies (Halder and Patti(2011), Bhardwaj and Palaparthy(2008), (Jain (2007), Mathi (2007), Sharma and Singh(2011), Sharma and Singh(2011), Singh et al.(2009), Narula(2011)) and the qualitative responses from the farmers and agriculture scientists obtained through interviews. The determinants of post-harvest losses considered for the purpose of this study include transport facility, cost of transportation, standardization of weights, cold storage, ripening chambers, mechanical drying facility, grading facility, distance of market, market regulation, government facilities.

Following Hypotheses were formulated to examine the association between Post Harvest Losses and the Determinants considered responsible for such losses:

H1: There is no significant association between transport facility and the post-harvest losses

H2: There is no significant association between cost of transport and the post-harvest losses

H3: There is no significant association between standardization of weights and the post-harvest losses

H4: There is no significant association between facility of cold storage and the post-harvest losses

H5: There is no significant association between facility of ripening chambers and the post-harvest losses

H6: There is no significant association between processing facility and the post-harvest losses

H7: There is no significant association between mechanical drying facility and the post-harvest losses

H8: There is no significant association between availability of grading facility and the post-harvest losses

H9: There is no significant association between distance of market and the post-harvest losses

H10: There is no significant association between regulated market and the post-harvest losses

H11: There is no significant association between availability of government facility and the post-harvest losses

Association between selected determinants and the magnitude of post-harvest losses is examined using non-parametric chi-square statistical test for independence:

$$\chi_c^2 = \sum \frac{(O_i - E_i)^2}{E_i}$$

Section 3

5. Data Analysis and Results

Trend of area under Vegetables Cultivation Since 1991

In this section of the paper, an analysis of the trend of area put under vegetables cultivation is examined, the period covered ranges from 1991 to 2018. Figure 1.1 and Table 4.1 below respectively shows the area under vegetables cultivation in Punjab and compound annual growth rate with which area under and vegetables cultivation increased in Punjab during the stated period.

Figure 1.1: Area Under Vegatable Cultivation in Hectares
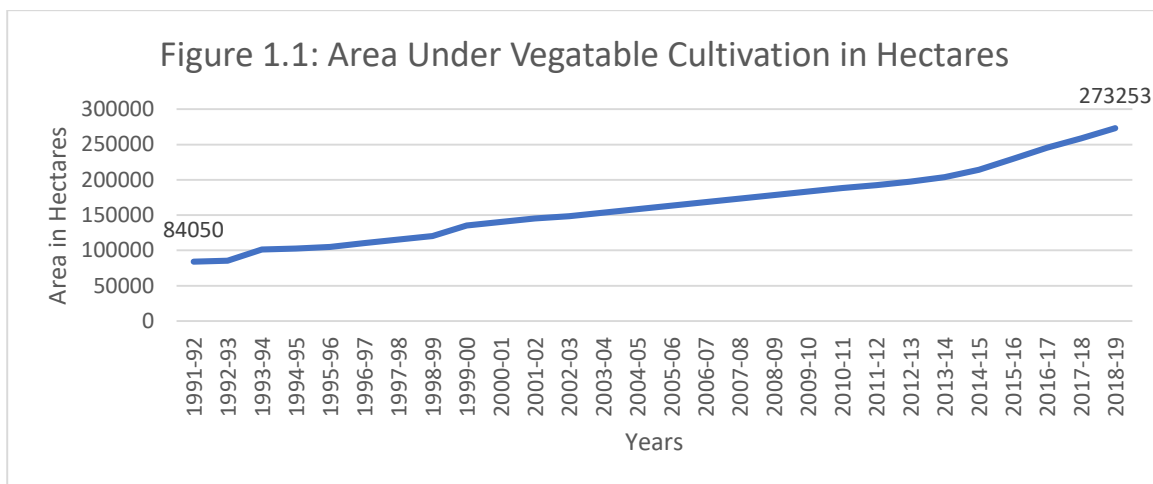
Source: Directorate of Horticulture, Government of Punjab

Table 4.1: Compound Growth Rate of Area Under Vegetables

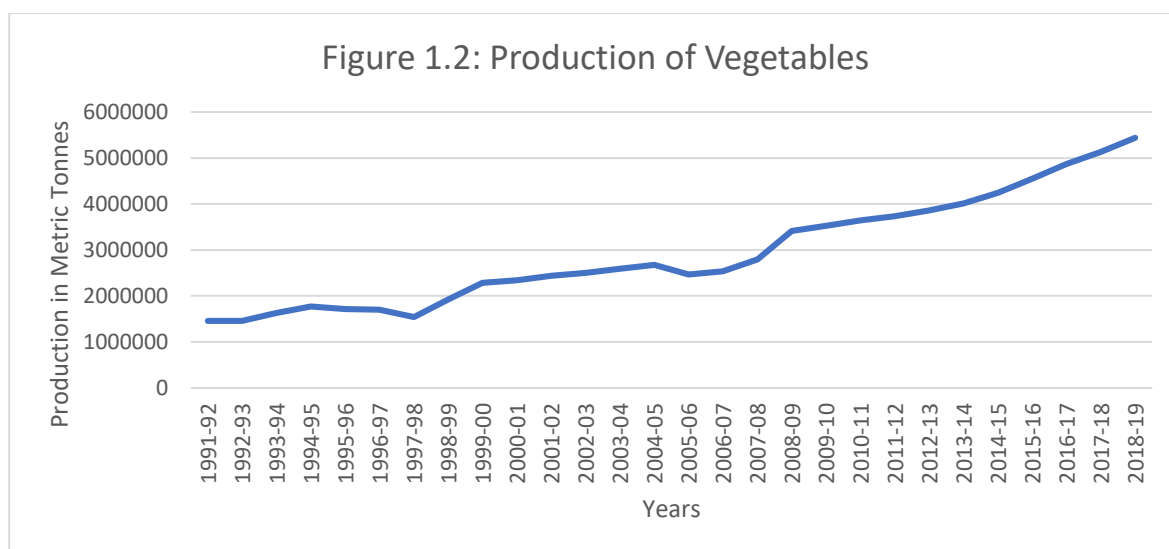|	Unstandardized Coefficients		Standardized Coefficients		
	B	Std. Error	Beta	T	Sig.
Case Sequence	1.040	.001	2.691	900.861	.000
(Constant)	87936.289	1620.210		54.275	.000

The dependent variable is ln (VA).

The area under vegetables has been increasing over time, as indicated in the graph. During the year 1991-92, it was 84.05 thousand hectares and had shown an increasing trend till 2018 and it is clearly reflecting from the

graph that an area of 273.25 thousand hectares is under vegetables cultivation. The table 4.1 shows that the area under vegetable cultivation has grown at a compound growth rate of 4% during the period of 28 years since 1991 and found significant at 1%. The remarkable increase has been witnessed and 32% increase in area is attributed in the last 28 years, the results are further shown through graph 1.1. It was a step towards diversification as initiated by the government under National Horticulture Mission (NHM) to boost horticulture crops. Johal Committee (1986) published its report to suggest diversification as shifting from paddy cultivation to vegetables is a major step towards Punjab growth in agriculture and to save Punjab from acute water shortage problems in coming years.

Trend of Vegetables Production Since 1991

Figure 1.2 and Table 4.2 below shows the growth trend and compound annual growth rate of the quantity in metric tons of the vegetables produced during the period 1991-92 to 2017-18.

Source: Directorate of Horticulture, Government of Punjab

**Table 4.2:** Compound Growth Rate of Vegetable Production 1991-2018

	Unstandardized Coefficients		Standardized Coefficients		
	B	Std. Error	Beta	T	Sig.
Case Sequence	1.050	.002	2.679	608.933	.000
(Constant)	1.339E6	36505.942		36.687	.000

The dependent variable is (VP).

The production of vegetables too has witnessed remarkable increase as can be seen from the graph 1.2. Over a period of 28 years the compound growth rate of 5% is witnessed in the production of vegetables and is also found significant @1%. The production has increased from 145.30 metric tons to 544.22 thousand metric tons, which shows a phenomenal increase. The APMC act in 2002 led towards boosting of marketing of these crops which shows the increase in vegetable production in an overall scenario.

Trend of Area Under Cultivation of Fruits Since 1991

Figure 1.3 and Table 4.3 below respectively shows the trend and compound rate of growth of area put under of fruits in the state of Punjab since 1991.

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Figure 1.3: Area Under Fruit Cultivation in Hectares
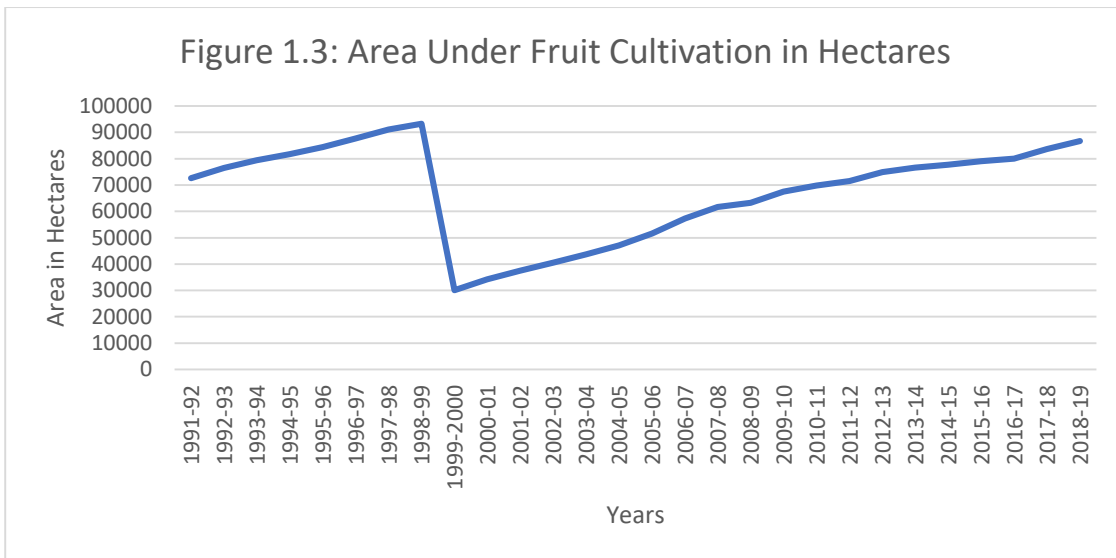
Table 4.3: Compound Growth Rate of Area Under Fruit Cultivation

	Unstandardized Coefficients		Standardized Coefficients		
	B	Std. Error	Beta	T	Sig.
Case Sequence	1.005	.008	1.139	133.248	.000
(Constant)	60460.190	7531.317		8.028	.000

Significant @1% level

The graphic analysis in the graph 1.3 and the tabular analysis shown in table 4.3 shows that though there is overall increase in area under fruit cultivation from 1991(72.665 hectares to 86.673 hectares) till 2018, but the CGR worked out has shown a 0.5% increase in area under fruits cultivation, which means that though there is increase but this increase is painfully slow. According to NHM, there is need to boost the area under fruits cultivation to meet the diversification requirements. The fruit crops are grown in 4% of the total area under agriculture in the country (TOI, Jan.16, 2019). This clearly suggest that there is need to increase the area under fruits in Punjab to explore the potential as in Punjab, the total area under fruits is 86.67 hectares.

Trend of Production of Fruits in Punjab Since 1991

Figure 1.4 and Table 4.4 below respectively shows the trend of growth in production of fruits and compound annual growth rate of fruit production in the state of Punjab during the period from 1991 to 2018.

Figure 1.4: Production of Fruits
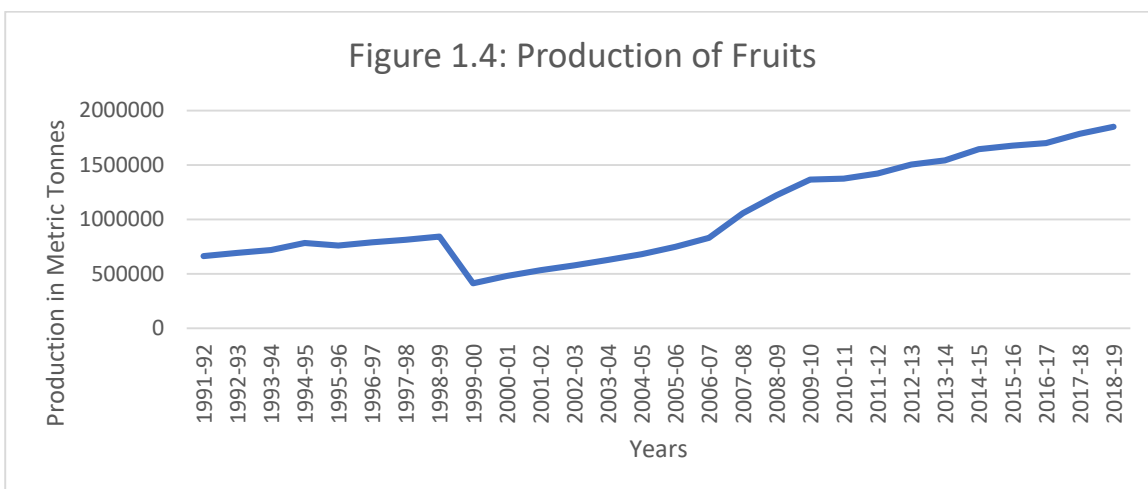
Table 4.4: Compound Annual Growth Rate of Fruit Production from 1990-2019

	Unstandardized Coefficients		Standardized Coefficients		
	B	Std. Error	Beta	T	Sig.
Case Sequence (Constant)	1.045 498309.537	.006 50159.957	2.269	164.893 9.934	.000 .000

The dependent variable is ln (FP).

The table 4.4 and the graph 1.4 show that there is increase in fruit production but it has many curvy features, the path does not show continuous increase rather witnessed high variability in fruit production over the last 28 years. The overall increase has been found to be significant at 1% with a compound growth rate of 4.5%. In India, fruit crop now occupies 6.4 million hectares yielding 94.9 million metric tons of fruits annually (TOI, Jan.16, 2019).

District-wise Area and Production of Fruits and Vegetables

Table 4.5 below shows the district wise compound growth rate of fruits and vegetables produced between 1991-92 and 2017-18. It can be seen from the table that for the crop of Kinnow highest growth rate of 0.13 was found in Hoshiarpur and lowest rate of CAGR was found in Ferozepur district, w.r.t. CAGR of Sweet Orange district Hoshiarpur experienced highest growth in Punjab, whereas Moga and Ferozepur had CAGR of -1.

Table 4.5: District-wise Compound Growth Rate of Area under Fruits and Vegetables

	Ferozepur	Hoshiarpur	Ludhiana	Moga	Mohali	Patiala
KINNO	0.00668933	0.134751	0.11954	0.11697	0.05750	0.046011
SWEET ORANGE	-1	0.101737	0.10784	-1	0.07188	-0.00309
LEMON	0	-0.04476	0.02918	-0.06562	0.02336	-0.00853
MANGO	-1	0.195563	0.05233	#DIV/0!	0.04030	0.020402
LITCHI	0	0.101424	-0.04018	#DIV/0!	0.04901	-0.02981
GUAVA	0.009625748	0.103982	0.07504	0.03915	0.04674	0.07067
PEAR	0.189207115	0.051875	0.06186	0.00986	0.03205	0.023159
PEACH	0.189207115	0.173249	0.048646	0.012929	0.034361	0.088167
PLUM	0.18920711	0.289847	0.02011	0.01763	0.01175	0.055881
GRAPES		-1	-0.00411	-1	-1	-0.10065
BER	0.01504187	-0.03987	0.06176	-0.05538	-0.02091	0.007328
OTHERS	-1	#DIV/0!	0.04577	0.06462	0.02168	0.042497
TOTAL	0.003197994	-0.02687	#DIV/0!	0.03980	0.04286	0.046356
POTATO	0.25645754	0.071568	0.05049	-0.11982	0.021181	-0.00304
ONION	0.7063837	0.111891	0.13099	0.25814	-0.04675	0.0044
GARLIC	0.04949179	0.119037	0.11767	0.28674	0.030647	0.064687
TOMATO	0.582574273	0.170419	0.03734	0.43134	0.03896	0.147404
BRINJAL	0.695635914	0.104054	0.10146	0.40019	-0.0337	0.189524
CAWLIFLOWER	0.29304342	0.036674	0.10690	0.10466	0.116971	0.059833
CABBAGE	0.191266356	0.096464	0.122318	0.243947	0.042081	0.158745
OKRA	0.156595049	0.06966	0.122595	0.482898	0.095301	0.069192
CHILLIES	0.233886757	0.077943	0.093223	0.293353	0.002439	0.01909
PEAS	0.381670296	0.134429	0.103578	0.422408	0.097486	0.054838
MUSK MELON	0.060004836	0.1702	0.055284	0.476643	0.048888	0.049257
WATER MELON	0.084038423	-0.03314	0.051515	-1	-0.01441	0.041651
VINE-VEG	0.203852706	0.001835	0.059424	0.164328	0.029678	0.023008
ROOT-VEG	0.256174106	-0.03907	0.07722	0.379605	0.023916	-0.00319
OTHERS	0.356502546	#DIV/0!	0.128145	0.420343	0.048965	0.111537
TOTAL	0.239656792	0.025459		0.042924	0.016435	0.020805

Table 4.6: Proportion of Vegetables Production in Total Production of Vegetables

Districts	POTA TO	ONIO N	GARL IC	TOMA TO	BRINJ AL	CAULI- FLOW ER	CABBA GE	OKR A	CHILLI ES	PEA S	MUSK MEL ON	VIN E- VEG	ROO T- VEG	OTHE RS
Ferozepu r	25.40	3.20	8.90	6.70	8.23	3.52	2.03	1.12	2.48	4.63	1.38	7.36	23.44	0.80
Hoshiarp ur	68.88	3.83	2.04	4.01	3.79	3.28	3.33	1.84	0.33	1.70	3.12	2.75	4.22	0.49
Ludhian a	50.09	18.74	1.71	2.40	2.18	4.01	2.46	1.35	0.17	1.98	0.90	2.66	10.81	0.19
Moga	11.81	10.02	9.93	9.91	9.52	7.77	8.18	4.50	0.84	4.49	7.41	5.80	8.49	1.31
Mohali	29.53	13.95	1.33	6.56	2.11	16.31	4.32	1.55	0.40	1.64	3.31	9.24	8.90	0.36
Patiala	34.79	14.62	1.65	10.38	4.34	6.51	5.10	1.34	0.50	6.84	2.48	4.03	6.80	0.29

Six districts were selected according to six geographical zones classified by Agronomy department, Panjab Agriculture University, Ludhiana. From the six zones, major districts such as Ferozepur, Hoshiarpur, Mohali, Ludhiana, Moga and Patiala were selected. According to the table 4.6 the principal crop of vegetable in Ferozepur district is Potato and Root veg crops, which contributes almost 50% to the total production of vegetables in Ferozepur. In the Hoshiarpur district, Potato crop is found to be most significant, as it has the highest percentage of 68.88 contribution in the total vegetables produced in the district. In the district Ludhiana, the percentage of Potato crop production to the total production of vegetables is 50.09, whereas onion contributes 18.74% in the total production among vegetables. In the Moga district, though all the major vegetable crops contribute in the same percentage, but Potato and Onion together contribute more than 20%. In the Mohali district, the main vegetable crop grown is Potato, which contribute 30% in the total production of vegetables of the district and other significant crops are cauliflower contributing 16.31% and onion contributing 13.9% in the total vegetable production of the district. In Patiala district the Potato crop contributes to around 35% in total production pool and onion contributes around 14.6% in total production.

Table 4.7: Proportion of Fruits Production in Total Production of Fruits

	Kinnow	Sweet Orange	Lemon	Mango	Litchi	Guava	Pear	Peach	Plum	Grapes	Ber	Amla	Banana	Others
Ferozepur	20.84	0.00	0.00	0.00	0.00	67.64	1.64	1.22	1.21	0.00	6.09	0.00	0.00	0.00
Hoshiarpur	71.91	0.89	0.63	13.39	3.78	2.91	1.05	1.56	0.53	0.00	0.05	2.32	0.03	0.95
Ludhiana	15.20	0.52	1.86	8.77	0.14	40.89	8.85	4.78	0.39	1.41	6.13	0.32	6.07	4.68
Moga	44.57	0.00	0.33	0.00	0.00	50.72	0.47	0.74	0.39	0.00	0.56	0.00	0.00	2.23
Mohali	15.53	0.31	1.22	24.98	3.08	38.91	2.97	2.80	0.22	0.00	0.88	1.02	0.24	7.85
Patiala	3.81	0.39	1.35	12.61	0.30	49.60	6.20	6.76	0.66	0.11	4.60	0.14	0.00	13.46

District-wise Production of Fruits

Table 4.7 above shows the contribution of each fruit in percentage terms in the total quantity of production of fruits of the district. It is evident from the above table that Guava contributes around 67.64% in Ferozepur district and Kienow is the second most significant crop with a contribution of 20.84%. The Kinnow has the highest contribution in the district Hoshiarpur with 71.71% contribution in the total production of fruits in the district and the second most grown crop in Hoshiarpur is mango with 13.39% contribution to the total production of fruits. In the Ludhiana district, table 4.7 shows that Guava is the main fruit produced with a contribution of 40.89% and Kinnow stands at number 2 with a contribution of 15% in the total production of fruits in the district. Moga district is concentrating on the production of only two fruits i.e. Guava with a production share of 50.72 and Kinnow with a share of 44.57% in the total production of fruits. District Mohali produces mainly Kinnow with a production share of 15%, and Guava with a production of 38.91%. In the Patiala district Guava is the main crop with 49.60% contribution to the total pool of fruits and Mango is the second largest contributor in the district with 12.61%.

Section 4

6. Determinants of Post-Harvest Losses

The report published in the economic times dated January 16, 2019 stated that the country is incurring post-harvest losses worth Rs. 2 lakh crores per annum due to lack of storage and processing facilities. As reported in the study, India is the second largest producer of the fruits and vegetables in the world and due to non-availability of appropriate cold storage, refrigerated transportation facility, the fruits and vegetables worth crores get spoiled every year (Bhosale, 2013). The major factors which contribute to the post-harvest losses of the

different fruits and vegetables are the harvesting methods, handling, transportation facility, preservation techniques, market availability, storage and lack of pre-cooling facilities (Singh, et. al. (2014)). The results of chi-square regarding determinants of post-harvest losses in fruits and vegetables in the selected six districts of Punjab are given in table 4.8 below:

Table 4.8: Factors Affecting the Post-Harvest Losses in the state of Punjab

	Very bad		Bad		Satisfactory		Good		Very Good		Weighted Avg. Score
	Count	Row N %	Count	Row N %	Count	Row N %	Count	Row N %	Count	Row N %	
Transportation	184	61.3%	12	4.0%	6	2.0%	2	.7%	88	29.3%	674
Cost of transportation	252	84.0%	48	16.0%	0	.0%	0	.0%	0	.0%	348
Standardised weights	230	76.7%	66	22.0%	2	.7%	0	.0%	2	.7%	378
Cold Storage	209	69.7%	70	23.3%	2	.7%	16	5.3%	3	1.0%	434
Ripening chambers	251	83.7%	49	16.3%	0	.0%	0	.0%	0	.0%	349
Processing Facilities	249	83.0%	37	12.3%	2	.7%	4	1.3%	0	.0%	345
Facility for Mech. Drying	260	86.7%	36	12.0%	4	1.3%	0	.0%	0	.0%	344
Grading Facility	191	63.7%	101	33.7%	5	1.7%	3	1.0%	0	.0%	420
Markets Nearby	24	8.0%	1	.3%	11	3.7%	136	45.3%	128	42.7%	1243
Regulated Markets	0	.0%	4	1.3%	4	1.3%	60	20.0%	230	76.7%	1410
Government facilities for Marketing	106	35.3%	99	33.0%	25	8.3%	20	6.7%	48	16.0%	699

To calculate weighted average score, Very Bad is multiplied by 1, Bad by 2, Satisfactory by 3, Good by 4 and Very Good by 5. Weighted Average Score indicates the relative positioning of each factor chosen in the state of Punjab. Higher score indicates that particular factor is in a relatively better condition as compared to other factors. Table 4.8 above shows the status of the factors which can help in reducing the post-harvest losses in the fruits and vegetables. It can be seen that so far, the availability of the markets at near distance from farms and regulation of such markets in Punjab is concerned, the state of affairs is much better as compared to other factors as indicated by the highest scores of 1410 and 1243 respectively, but the state of facilities with respect to mechanical drying, cost of transportation, processing facilities, ripening chamber etc is not in a very good state of affairs. Further cost of transportation is also felt to be on a higher side by the respondents as indicated by a very low score of 348. Further, there is a need to scale up the grading facility in the state.

Table 4.9: Association Between Factors and Post-Harvest Losses

Sr. No.	Factors	Person's Chi Square Value	p value	Phi Value
1	Transport Facility	91.695	0.000	.553
2	Cost of Transportation	34.544	0.000	.339
3	Standardized Weights	1.20	0.000	.634
4	Cold Storage	1.051	0.000	.592
5	Ripening Chamber	61.396	0.000	.452
6	Processing Facility	53.578	0.030	.423
7	Mechanical Drying	21.845	0.239	.239
8	Grading Facility	1.311	0.000	.661
9	Distance of Market	1.998	0.000	.816
10	Regulated Market	3.6652	0.000	1.103
11	Government Facilities in Marketing	2.019	0.000	.820

As can be seem from table no. 4.9 all the above null hypotheses stand rejected at 1% level of significance, except the hypotheses H7 i.e. statistically significant association is found between the availability of transportation facility, cost of transport, availability of cold storage facility, facility of ripening chambers, processing facility, distance of markets from farms, grading facility, regulation of markets, availability of

government facility in the market place. However, null hypothesis H7 is accepted as statistically association between availability of Mechanical Drying Facility and Post-Harvest losses is found to be insignificant.

7. Conclusion

It is found that the area under vegetable cultivation has grown at a compound annual growth rate of 4% during the period of 28 years since 1991 whereas quantity produced has gone up by 5%. Increase in area under fruit cultivation from 1991 till 2018 has painfully been very less at 0.5%, but there has been seen a good increase in quantity produced at 4.5%. Among the vegetables grown in the state of Punjab, potato is most grown vegetable and similarly among the fruits, Guava and Kinnow are the main crops in the selected districts of Punjab.

It is found that the factors contributing to post harvest losses include availability of transportation facility, cost of transport, availability of cold storage facility, facility of ripening chambers, processing facility, distance of markets from farms, grading facility, regulation of markets, availability of government facility in the market place. However, we couldn't find any association between mechanical drying facility and post-harvest losses.

Study also found that availability of the markets at near distance from farms and regulation of such markets in Punjab is concerned, the state of affairs is much better as indicated by the highest scores of 1410 and 1243 respectively, but the state of facilities with respect to mechanical drying, cost of transportation, processing facilities, ripening chamber etc is not in a very good shape in the state. Further cost of transportation is also felt to be on a higher side by the respondents. Further, there is a need to scale up the grading facility in the state. In the light of above, state is advised to put efforts in the direction of providing low-cost transportation facility, ramp up processing and grading facility for fruits and vegetables and also provide ripening chambers in the markets of Punjab to help in reducing the post-harvest losses.

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