Report on
Assessment of Quantitative Harvest and Post-Harvest Losses of Major Crops and Commodities in India

Sponsor: Ministry of Food Processing Industries (Govt. of India)

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FOREWORD

India is the third largest producer of agricultural produce, be it plant based, animal and poultry based or marine based produce; third after China and USA. Our production levels must keep in pace with the ever increasing population to meet the food demands. Infinitely increasing the production levels will suffer the sustainability in agriculture. Furthermore, the shrinking land and water resources, global warming, and increased costs of labour and other inputs will restrict our food production levels.

On the other hand, huge quantities of harvested produce are lost in the post-harvest systems. Minimizing such losses will result in availability of greater quantities of food for our consumption and for marketing. A grain saved is a grain produced. Continued research efforts of our scientists have helped in developing and adopting numerous tools and techniques, processes and products for the reducing these losses. It becomes imperative that we estimate the losses at various stages in the post-harvest chain for making policy decisions on food production, and for reorienting our research focuses in storages, post-harvest processing and value addition.

ICAR had taken up first study in 2005-07 to estimate the harvest and post-harvest losses to our produce, upon the recommendations of Parliamentary Standing Committee on Agriculture. In 2012, ICAR has again taken up, using the funds provided by the Ministry of Food Processing Industries, Govt. of India, a second study to determine the current levels of losses and to ascertain if there were changes in losses since the first study period.

The results of this study are now being brought out in a book form. The information contained in this book will be helpful in quantifying the post-harvest losses in various agro climatic zones and identifying the areas of high losses. The book also discusses the reasons for such losses and has suggested interventions needed for reducing the post-harvest losses. I greatly appreciate the inputs from a large spectrum of professionals, policy makers at the stage of finalizing the report and financial support given by MoFPI. I am sure the data will help policy makers, researchers and funding agencies in the sector.

I congratulate the team of scientists of All India Coordinated Research Project on Post-harvest Technology (AICRP on PHT) and field workers who carried out this massive and much needed work and completed the same on prescribed time.

(S. Ayyappan)

Date : 27th March, 2015
New Delhi

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CHAPTER I
INTRODUCTION

Agriculture is one of the important sectors of the Indian economy. It contributes about 14% to the GDP of India and about 11% of its total exports. About 50% Indian population still depend on agriculture as its principal source of income and the agriculture serves as a source of raw material for a large number of industries. India accounts for only about 2.4% of the world's geographical area and 4% of its water resources, but it supports about 17% of the world's human population and 15% of the livestock. Accelerated growth of agriculture production is therefore necessary, not only to achieve higher contribution towards GDP and meet the rising demand for food, but also to increase farmers' income to ensure their inclusiveness.

Indian agriculture had shown tremendous evolution since independence and converted India as exporting country from importer even after four fold increase in population. India produced 273.81 million tonnes food grains, 235.85 million tonnes horticultural produce, 132.4 million tonnes milk, and 9.02 million tonnes fish during 2012-13 (Table 1.1; DoAC, 2013). India ranks second in the world in production of fruits, vegetables and inland fish and milk production is the highest. Thus the boom in production brought the country in a position to provide food for about 1.25 billion people. Ever-increasing population however pose serious challenges to prolong this scenario and ways has to be thought of to provide safe and quality food to the masses..

Table 1.1: Production of different commodities in India (Source: Directorate of Economics and Statistics, Department of Agriculture & Cooperation, 2013)

S. No.	Name of Crop/ Commodity	Production (million tonnes)		
		2010-11	2011-12	2012-13
1	Cereals	244.49	259.29	255.36
2	Pulses	18.24	17.09	18.45
3	Oilseeds	32.48	29.80	31.01
4	Fruits	71.52	76.42	79.40
5	Vegetables	134.10	156.33	156.45
6	Plantation crops	11.93	16.36	16.39
7	Spices	4.02	5.95	5.79
8	Milk	121.8	127.90	132.40
9	Eggs (Billion numbers)	63.00	66.50	69.70
10	Fish	8.23	8.67	9.02
11	Meat	4.80	5.50	-

Increase in agricultural production is constrained by limited land area under cultivation. The net sown area under crops is now stagnant or declining as demands of land for other sectors are rising. The net sown area in 2000-01 was 141.3 million hectares. It has come down to 140 million ha in 2009-10 (DoAC,

2013). The increase in crop production may be achieved by increasing cropping intensity. The cropping intensity ratio of gross cropped area to net sown area has increased from 1.31 in 2000-01 to 1.37 in 2009-10 (DoAC, 2013).The increase in cropping intensity has been possible because of expansion in irrigation, availability of suitable crop varieties, mechanization, application of modern technologies and investments made in agriculture that help to improve productivity. But these efforts have strained our natural resources too much in several states of the country.

Increasing agricultural production is one aspect of fulfilling food demand. Delivering food to the consumers by saving produced commodities from losses in fields, transport, storage, retailing, processing etc. without straining our fields, water and environment seems much better option. After production, agricultural produce undergo series of post-harvest unit operations, handling stages and storage before they reach to the consumers. Each operation and handling stage results some losses. These post-harvest losses result into decrease in food availability. A recent study showed that 3.9-6.0% cereals, 4.3-6.1% pulses, 2.8-10.1% oilseeds, 5.8-18.1% fruits, and 6.9-13.0% vegetables are lost during harvest, post-harvest operations, handling and storage in India (Nanda et. al. 2012). Thus a huge quantity of agricultural production is reduced from the food chain. A grain saved is considered as a grain produced. Therefore it becomes inevitable to identify the operations and channels where losses are considerable. Improvement in technology in future for these operations and channels will lead towards more availability of produce. The farmer can save his valuable produce and get more prices in the market. The reduction in losses in different channels will help in providing the quality produce for the consumers and hence all stakeholders including farmers, marketing persons and consumers will be benefited. Reduction in post-harvest losses will also be helpful in ensuring food security of the country.

Consistent and contemporary data on extent of post-harvest losses of different crops and livestock produce at all India level were collected in year 2005-07 by the All India Coordinated Research Project on Post-Harvest Technology on the recommendations of Parliamentary Standing Committee on Agriculture (PSCA). This report provided trustworthy estimates of harvest and post-harvest losses of crops and commodities at national level for the first time. As previous study provided foundation data on estimates of harvest and post-harvest losses, with passage of about 5-6 years it was not sure whether the losses are increasing or decreasing after technological interventions. Recently it was also felt that the channels in harvest and post-harvest operations in which substantial losses are taking place need to be identified for further technological interventions.

The Ministry of Food Processing Industries (MoFPI) therefore sponsored a project to conduct the nation-wide concurrent repeat study to assess the post-harvest losses of crops and commodities. In order to assess the change in magnitude of losses and to identify the initiatives to be taken in reducing losses, it was imperative to conduct a survey in continuation of the previous study.

Hence, the step towards "Assessment of Quantitative Harvest and Post-harvest Losses of Crops/ Commodities" was taken by the Council in February 2012 and decided that the work will be done by the AICRP on PHT through its centres located in different parts of the country. MoU was signed between ICAR and MoFPI on February 29, 2012 to conduct the second study with following specific objectives.

Objectives

1. To carry out a systematic quantitative assessment of the extent of harvest and post-harvest losses of all major crops representing cereals, millets, pulses, oilseeds, fruits, vegetables, plantation crops and spices & condiments as well as livestock produce comprising meat, fish, egg and milk at the national level covering all the agro-climatic zones.
2. To estimate the losses, starting from harvesting, at all post-harvest on-farm operations, transportation, storage and distribution in various marketing channels.
3. To evolve/refine appropriate methodology and measurement techniques for the above estimation, viz. schedules for all crops and livestock produce selected for collection of data by enquiry and by observation, suitable software for computerized data entry, and statistical procedure to give a single estimate from the two sets of data (enquiry and observation) collected.
4. To identify the specific crop/ commodity as well as the specific unit operation inducing significant losses in order to prioritize the points of remedial intervention.

CHAPTER II
REVIEW OF LITERATURE

Minimizing the losses taking place in pre-production, harvest and post-production stages is undeniably option of increasing the food availability. It has been a matter of apprehension to government agencies and researchers alike. Methodology of assessing post-harvest losses is also an important aspect of such studies. Therefore, large number of studies on methodological aspects, assessing post-harvest losses and identifying farm operations and channels affecting these losses are published in various journals and reports. However, most of these studies deal with laboratory scale experiments and are limited to one or more crops/commodities for specific locations. Entomological storage studies are not particularly relevant to estimation of post-harvest losses since the sampling and experimental designs are study-specific and will not provide the actual extent of damage done by the insects in the field conditions of storage. The present review therefore covers the methodologies developed, extent of losses particularly reported in relevance/context of post-harvest losses at the national level.

2.1 Data Collection Methodologies

Consideration for adoption of methodology for assessment of harvest and post-harvest losses in numerous unit operations and market channels in large population are mainly important for getting consistent results. Correct sampling procedure, data collection and loss measurement techniques are fundamentals for trustworthy results and their uniformity may help in comparing the results from different studies.

Post-harvest food loss is defined as measurable qualitative and quantitative food loss along the supply chain, starting at the time of harvest till its consumption or other end uses (De Lucia and Assennato, 1994; Hodges et al, 2011). Food losses can be quantitative as measured by decreased weight or volume, or can be qualitative, such as reduced nutrient value and unwanted changes in taste, color, texture, or cosmetic features of food (Buzby and Hyman, 2012).

The Indian Agricultural Statistical Research Institute conducted a pilot level methodological survey in 1973-74 (IASRI, 1975) in Aligarh district of Uttar Pradesh, India to study food grain losses in storage under farmer's conditions. In this survey 24 clusters of villages were selected from 6 community development blocks and in each cluster the data of food grains stored, losses and causes of losses were collected from 6 randomly selected cultivators of each villages fortnightly. Results of the survey provided considerable information on methodology for estimating losses in storage.

The report of post-harvest grain losses assessment methods published by the American Association of Cereals Chemists (1978) has dealt with assessment problems in detail. In this review the concepts, definitions and measurement techniques have been dealt systematically and the statistical approach has also been mentioned in brief, which could be adopted in the studies to be made in different countries with necessary modifications suited to local conditions.

The importance of the problem of post-harvest food grain losses, prompted the FAO to come out with a manual on "Assessment and Collection of Data on Post-Harvest Food Grain Losses", published in 1980 for the benefit of developing and underdeveloped countries. The manual was prepared with an aim to study the extent of post-harvest losses of cereals based on actual observations in the field. This manual provides detailed methodology for data collection on losses in different operations and channels. However, the manual was applicable for estimation of losses of food grains only.

Diwakar et al (1983) suggested a methodology for the estimation of losses in food grains caused by rats while Narain and Khosla (1984) discussed the methodological aspects of estimating food grain losses at different post-harvest stages at farm, intermediary and warehouse level. Nawab Ali (1983) proposed a methodology for assessing storage loss of durable commodities based on clearly defined objectives reproducible methods and representativeness of sampling.

Bathla et al (2005) conducted a pilot level sample survey to develop methodology for estimation of harvest and post-harvest losses of milk, meat, poultry meat, egg, inland fish and marine fish. The methodologies were evaluated in the survey and finalized, while Wanjari et al (2005) conducted a pilot sample survey to develop methodology for data collection by observation for estimating post-harvest losses of five oilseed crops namely mustard, soybean, cottonseed, sunflower and groundnut. The methodology was evaluated and performance for estimating post-harvest losses was found to be satisfactory.

Vishwakarma et al (2007) conducted a survey in Junagarh district of Gujarat to assess the quantitative loss of groundnut in different farm operations and channels (harvesting, handling and threshing stages at farm and storage at household, market, oil mill and godown levels). They developed methodology for estimation of losses during storage and tested the same during the survey. The most recently Nanda et al (2012) developed methodologies and schedules for a nationwide survey in 2005-07 to assess the harvest and post-harvest losses by both enquiry and observations. The methodologies for data collection, data analysis procedures and interpretation of results are discussed in detail and the same were used for assessment of harvest and post-harvest losses of 46 major crops and commodities including livestock produce at national level.

2.2. Post-Harvest Losses of Durables

In early sixties, Government of India appointed Panse Committee to assess the post-harvest losses of food grains in the country (Government of India, 1971). The committee collected considerable information on magnitude of losses from various government agencies and research institutions. The estimates of losses averaged over three years (1962-63, 1963-64 and 1964-65) for the food grains covered in this survey are presented in Table 2.1. The total losses reported by them in food grains varied from 6% in Bajra to 11% in Paddy.

Majumdar and Parpia (1967) reported losses of different food grains in different countries. In the report the extent of losses in all food grains was estimated to be 50% (25% field loss, 15% storage loss, 7% handling and processing loss and 3% other losses) referring the Research Industry Conference report held at CFTRI Mysore in 1965.

Table 2.1: Estimates of food grain losses in percent at different stages (GOI, 1971)

Stage at which loss occurred	Wheat	Paddy	Sorghum	Bajra	Maize	Gram	Millet	Pulses (excl. gram)
Threshing yard	1.0	2.5	2.0	0.5	0.5	0.5	1.0	0.5
Transport	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Processing	-	2.0	-	-	-	-	-	-
Storage	6.5	6.0	7.5	5.0	6.5	8.5	5.5	8.5
Total	8.0	11.0	10.0	6.0	7.5	9.5	7.0	9.5

Mookherjee et al (1968) indicated the losses due to insects during storage of cereals (paddy, wheat, maize, barley, sorghum, and bajra) for different zones of the country. However, the estimates were based on very limited data. Krishnamurthy (1968) however reported the total storage loss of food grains in different organizations. A loss of about 0.2%, 1-3% and 1% were estimated during storage by Food Corporation of India, cooperative organizations and warehousing corporations, respectively. In the rural level storage, 2.03 to 9.52% loss was estimated due to insects in wheat as reported by respective organizations.

Srivastava et al (1973) reported weight loss due to damage by insects in villages to the extent of 9.7% and kernel damage to the tune of 30.1%. Girish et al (1974) observed farm storage loss of wheat in different regions of Uttar Pradesh ranging from 0.6 to 9.7 %. Girish et al (1975) found the average loss of wheat due to insect damage as 2.90, 0.85 and 0.95 % after 7 months of storage in grain markets of Western Uttar Pradesh, Punjab and Haryana, respectively.

A Seminar on Post-harvest Technology of Food Grains, sponsored by the Indian National Science Academy, Indian Council of Agricultural Research, Council of Scientific and Industrial Research and Food Corporation of India, held in New Delhi (India) in December 1972 (Pingle et al, 1972) covered the problems of losses in harvesting, drying, processing, storage, transport, etc., with respect to cereals and pulses. Prof. B.R. Seshachar, President, Indian National Science Academy said that about 10 million tonnes of food grains were lost annually during the process of drying, transportation, storage and distribution. Other speakers gave different extent of losses owing to different causes occurring at different stages. Girish and Krishnamurthy (1974) reviewed the extent of losses owing to different causes such as insect pests, diseases, storage systems, birds and rats for different periods of storage. They also mentioned that the methods of assessment of losses were not uniform and, hence, these losses were not comparable. They suggested that the assessment of losses from farm storage, markets, large-scale storage, should be made by random sampling techniques.

Krishnamurty (1975) reviewed the work on post-harvest losses in food grains in India and abroad and reported that the Food Corporation of India estimated losses of food grains in rail transit of 1% during 1970-71 in a small scale study. He also assessed the loss in commercial storage of food grains as 3 to 5 %

when storage was for 8 months and around 1% when the storage was up to 4 months; while in underground structures the loss was about 6 to 10 %. He observed that a loss of 3 % was due to use of hooks; 0.1 to 0.2 % due to spillage, and 0.5 % due to loss of moisture in general during storage.

A supporting study on post-harvest grains losses (Administrative Staff College of India, Hyderabad, 1976) of the main study "All India Grains Storage and Distribution" prepared by the Administrative Staff College of India, Hyderabad presented review of work on post-harvest grain losses and gave 170 references in this field. The results obtained from surveys in two regions, Punjab (Ludhiana) and Andhra Pradesh (West Godavari and Medak), on wheat and maize crop respectively were also included in the work. The stratified random sampling technique was adopted in these two regions. Topics such as stages of losses, grain losses with their causes and measurement, farm storage, trade and market level storage, public storage, transportation loss and loss in processing, have been dealt with for this supporting study.

FAO (1977) prepared a manual summarizing the reports regarding the post-harvest crop losses in the developing countries. In this manual, losses in cereals, fruits, vegetables, animal and fish products have been covered. The estimated post-harvest losses for different countries across the continents during 1977 are also reported. Chaudhary (1979) reported the wheat grain losses in bullock threshing, mechanical threshing, tractor threshing and combine harvester amounted to be 3.11, 2.68, 2.01and 1.2%, respectively.

In 1972-73, the Directorate of Marketing and Inspections (DMI), Department of Agriculture, Government of India conducted a large-scale sample survey for estimation of marketable surplus and post-harvest losses of food grains (DMI, 1978). Another study was conducted again by DMI in 1996-97 and completed in 2002 covering paddy, wheat, sorghum, bajra, maize, barley, ragi, pigeon pea, chickpea, black gram, green gram and lentil (DMI, 2002). This study covered 25 States, 100 selected districts and 15,000 cultivator households in the country with adoption of stratified multi-stage random sampling design. The estimates of losses in different farm operations and storage are presented in Table 2.2.

The estimates of post-harvest losses of this survey were based on the data collected by enquiry only. In addition, several important operations (such as harvest, market channels, etc.) have not been covered. This report however provides fairly good estimates of losses in operations and channels covered for food grains and pulses.

Basappa et al (2007) conducted a study during 2003-04 in Karnataka for estimating post-harvest losses of maize in different stages at farm level and found that the losses during harvest, threshing, cleaning, drying, packaging, transportation and storage were 0.46%, 0.18, 0.05, 0.21, 0.08, 0.21 and 0.33%, respectively. Basavaraja et al (2007) estimated post-harvest losses at different stages of rice and wheat in India based on the data collected from one district for each crop in Karnataka. The data were collected by enquiry from 100 farmers, 20 wholesalers, 20 processors and 20 retailers in each crop for the year 2003-04. The estimated post-harvest losses are tabulated in Table 2.3.

Table 2.2: Estimates of food grain losses in percent (DMI, 2002)

S. No.	Crop	Operation					
		Threshing	Winnowing	Transport	Transport (From field to threshing floor)	Storage (From threshing floor to store)	Total
1	Paddy	0.89	0.48	0.79	0.16	0.40	2.71
2	Wheat	0.73	0.28	0.49	0.13	0.16	1.79
3	Bajra	0.62	0.32	0.54	0.19	0.22	1.89
4	Sorghum	0.65	0.32	0.68	0.21	0.34	2.20
5	Maize	0.80	0.53	0.58	0.19	0.35	2.45
6	Barley	0.70	0.27	0.57	0.28	0.34	2.16
7	Ragi	0.77	0.76	0.62	1.13	0.53	3.81
8	Pigeon pea	0.61	0.43	0.58	0.23	0.35	2.20
9	Chickpea	0.77	0.78	0.81	0.82	0.56	3.74
10	Green gram	0.63	0.61	0.67	0.19	0.29	2.38
11	Black gram	0.65	0.62	0.70	0.19	0.30	2.46
12	Lentil	2.21	1.01	2.20	1.08	0.64	7.14

Table 2.3: Post-harvest losses of rice and wheat (Basavaraja et al, 2007)

Stages	Loss (%) in Rice	Loss (%) in wheat
Harvesting	0.40	0.36
Threshing	0.52	0.44
Cleaning/winnowing	0.20	0.14
Drying	0.80	0.66
Packaging	0.20	0.22
Transportation	0.50	0.51
Storage	1.20	0.95
Total losses at farm level	3.82	3.28
Total losses at wholesale level	0.29	0.20
Total losses at processor level	0.03	0.03
Total losses at retailer level	1.06	0.82
Total post-harvest losses	5.19	4.32

In a survey conducted during 2003-04 under National Agricultural Technology Project in Junagadh district of Gujarat for groundnut, losses at harvest, handling and threshing stages were estimated to be 3.72, 2.44 and 2.08%, respectively by enquiry, whereas the losses of 1.57, 0.00 and 0.47% were estimated by observation (Vishwakarma et al, 2007). Losses of 0.59 and 0.44% were observed in bulk and bag

storage systems at farm level. At intermediary level, loss of 1.86% was estimated by enquiry and the loss was 2.90% by observation. In oil mill storage loss of 3.93% was found by enquiry, whereas the loss was 1.78% by observation.

Hodges et al (2011) compiled the data of estimated post-harvest loss and computed the financial value of weight losses for sixteen countries in East and Southern Africa (developing countries) for the decade 2001-2010.

The study on estimate of losses done by Nanda et al (2012) is one of the important studies from national point of view. They collected the data by enquiry as well as observation in fields covering almost all operations (harvesting, collection, threshing, winnowing, drying, packaging and transportation) and storage channels (household, godown/warehouse, wholesaler, retailer and processing units) through which a commodity reaches to consumer. The estimated losses for durables are reported in Table 2.4.

2.3 Post-Harvest Losses of Perishables

Horticultural crops, being good sources of vitamins, minerals and anti-oxidants, are essential for nutritionally balanced diet. Most of loss estimation studies in past were focused mainly on the food grains because of their importance in daily diet as staple. The perishable crops like fruits and vegetables however are intrinsically more susceptible to deterioration because of high moisture content, softness and susceptible to environmental conditions. Post-harvest losses of perishables vary widely because of wide variations in environmental and handling conditions during transport and marketing. Estimations of most of post-harvest losses studies conducted previously were mainly focused at regional level.

2.3.1 Fruits

Srinivas et al (1997) conducted a survey in Karnataka to assess post-harvest losses of 'Totapuri' (Bangalora) and 'Alphonso' (Badami) mangoes. Total post-harvest losses of 17.9% (3.5% orchard/field, 4.9% transportation, 4.1% storage and 5.4% retail level) and 14.4% (1.9% orchard/field, 3.7% transportation, 3.5% storage and 5.3% retail level), respectively, were observed. Murthy et al (2002) however assessed the post-harvest losses of Banganapalli mango at farm to about 15.6% whereas total losses from harvest to consumption have reported to be in tune of 29.7% in Andhra Pradesh. The major causes of losses indicated in the order of their occurrence were mechanical injuries, spoilage, either harvesting of over or under mature one, pilferage, and damage by birds and hailstorms. Wanjari et al (2002) conducted a survey in two districts of Andhra Pradesh to assess the post-harvest losses of acid lime and observed 3.89-4.08% losses at market level.

Several investigators have attempted to estimate post-harvest losses of fruits in Himachal Pradesh. Out of total production, the post-harvest losses in selected fruits in Himachal Pradesh namely apple (Singh, 2002), mango, peach and kinnow (Prasher and Negi, 2000) were 14.48, 24.85, 18.31 and 24.5%, respectively. The losses were more at wholesaler's/ retailer's level in all the selected fruits except apple.

Gajanana (2002) conducted a survey in two districts of Tamil Nadu to estimate the post-harvest losses of banana (c.v. Poovan) in the local market. He observed a loss of 3.9% at farm level sorting. The

Table 2.4: Harvest and post-harvest losses of durables in percent at national level (Nanda et al, 2012)

S. No	Crop	Harvesting	Collection	Threshing	Winnowing▲	Drying	Packaging	Transport	Total loss in farm operations	Farm level storage	Warehouse	Wholesaler storage	Retailer level storage	Processing unit storage	Total loss in Storage	Overall Total Loss
1	Paddy	1.2	0.7	1.1	0.4	0.2	0.1	0.1	**3.9**	0.64 (1.9)	0.03 (0.5)	0.22 (1.3)	0.02 (0.7)	0.39 (0.9)	1.3	**5.2**
2	Wheat	1.7	0.6	1.6	0.5	0.0	0.1	0.2	**4.7**	0.59 (1.5)	0.06 (0.5)	0.13 (0.7)	0.04 (0.8)	0.48 (1.7)	1.3	**6.0**
3	Maize	0.5	0.2	1.6	0.2	0.2	0.1	0.1	**2.8**	0.41 (1.7)	0.01 (0.2)	0.66 (1.7)	0.11 (0.7)	0.11 (0.7)	1.3	**4.1**
4	Bajra	0.9	0.6	1.3	0.3	0.3	0.3	0.2	**3.8**	0.56 (1.4)	0.01 (0.3)	0.24 (0.6)	0.12 (1.1)	0.07 (0.7)	1.0	**4.8**
5	Sorghum	0.7	0.4	0.7	0.4	0.3	0.2	0.1	**2.8**	0.36 (1.6)	0.03 (0.6)	0.66 (1.1)	0.04 (0.4)	0.01 (0.6)	1.1	**3.9**
6	Pigeon pea	0.5	0.4	0.7	1.0	0.5	0.2	0.1	**3.4**	1.36 (2.3)	0.01 (0.2)	0.23 (2.2)	0.09 (0.8)	0.31 (1.7)	2.0	**5.4**
7	Chick pea	0.7	0.6	0.8	0.4	0.6	0.2	0.2	**3.4**	0.31 (1.3)	0.02 (0.2)	0.37 (1.0)	0.08 (0.6)	0.12 (0.6)	0.9	**4.3**
8	Black gram	1.1	1.0	1.6	0.3	0.5	0.2	0.1	**5.0**	0.73 (1.4)	0.01 (0.1)	0.16 (0.9)	0.09 (0.7)	0.11 (0.8)	1.1	**6.1**
9	Green gram	0.9	0.6	1.6	0.3	0.3	0.1	0.2	**4.1**	0.67 (2.1)	0.01 (0.2)	0.47 (1.6)	0.21 (0.8)	0.04 (0.4)	1.4	**5.5**
10	Mustard	4.5	1.1	1.8	0.3	0.2	0.2	0.2	**8.4**	0.24 (0.8)	0.02 (0.3)	0.10 (0.4)	0.04 (0.4)	0.10 (0.3)	0.5	**8.9**
11	Cottonseed▲	0.6	0.2	-	0.9▲	0.3	0.1	0.1	**2.2**	0.02 (0.1)	-	0.52 (0.9)	-	0.06 (0.3)	0.6	**2.8**
12	Soybean	3.1	0.5	1.2	0.5	0.2	0.1	0.2	**5.8**	0.10 (0.8)	0.01 (0.1)	0.24 (0.5)	0.04 (0.4)	0.01 (0.1)	0.4	**6.2**
13	Safflower	0.5	0.7	1.1	0.5	0.3	0.1	0.1	**3.3**	0.03 (0.6)	0.00 (0.0)	0.08 (0.3)	-	0.29 (0.5)	0.4	**3.7**
14	Sunflower	1.1	0.5	1.3	0.5	0.3	0.1	0.1	**3.9**	0.04 (2.2)	0.01 (0.1)	0.19 (0.9)	0.01 (0.2)	0.35 (0.5)	0.6	**4.5**
15	Groundnut	4.8	0.7	2.7	0.3	0.3	0.2	0.1	**9.1**	0.16 (1.6)	0.00 (0.0)	0.50 (1.2)	0.07 (0.6)	0.27 (0.8)	1.0	**10.1**

Figures in parentheses indicate the percent loss in the channel.

▲ *In cottonseed, the loss during ginning instead of winnowing is reported.*

loss during transport ranged from 2.19% to 2.52%. At wholesale and retail market storage, the losses were 2.52% and 7.5%, respectively. They suggested box packaging for long distance transportation to fruits to reduce post-harvest losses.

Sreenivasa Murthy et al (2007) studied the marketing losses and their impact on marketing margins of banana in Karnataka. They identified three stages, viz. field level, transit and wholesale and retail marketing level. Simple averages and percentages were used for estimation of post-harvest losses at these stages. The study was conducted in one district (Bangalore rural) and observed losses of 5.53% at field and assembly level, 6.65% at wholesale level and 16.66% at retail level in wholesale marketing system, whereas in the cooperative marketing system, the losses were 7.82, 1.77 and 8.72%, respectively.

Murthy et al (2004) conducted a survey in Bijapur district of Karnataka on grapes and reported 7.31% loss during sorting and grading, 4.24% during transportation to wholesale market, 2.85% and 3.27% during local and distant retail marketing, respectively. The aggregate post-harvest loss in grapes ranged from 14.4% in the local retail market to 21.3% in distant market.

Rana et al (2005) estimated the quantitative post-harvest losses in kinnow at orchard, commission/ forwarding agent, and retailer levels in Punjab, Himachal Pradesh and Haryana. According to them combined physical losses for three stages were 28.5% in Punjab, 30.4% in Haryana and 15.7% in Himachal Pradesh. Economic losses in Punjab (29.3% gross and 19.3% net) and Haryana (29.8% gross and 18.7% net) were higher than in HP (12.7% gross and 6.23% net). Transport damage followed by rotten fruits, damage during harvesting and other losses were the main reasons for losses in Himachal Pradesh, while in Punjab and Haryana the losses occurred due to dropping and bird's injury followed by rotting, transport injuries during crushing/ pressing in packaging and damage during plucking.

Gangwar et al (2007) undertook a study in Punjab for estimating losses of Kinnow mandarin. They advocated the inclusion of marketing loss in the estimation of marketing margins, price spread and efficiency. A majority of kinnow producers were observed to sell their orchards at pre-harvest stage to the contractors /traders. The aggregate post-harvest losses from orchards to consumers ranged from 14.87% in Delhi market to 21.91% in Bangalore market. The study indicated the necessity of establishing kinnow processing industries for development of value-added products at regional level for minimizing post-harvest losses and providing remunerative price to farmers.

The most recent post-harvest losses study, which is the base of present study, was conducted by Nanda et al (2012) in 2005-07 at national level. They estimated the harvest and post-harvest losses of eight fruits viz. apple, banana, citrus, grapes, guava, mango, papaya and sapota in five farm operations and five market channels during storage (Table 2.5). The overall total losses were observed to be 6.4% (citrus) to 18.1% (guava). Harvesting, sorting/grading, transportation, storage at wholesaler and retailer levels were the main operations and channels where losses were found to be substantial.

2.3.2 Vegetables

Meijers (1981) studied post-harvest losses during storage of potatoes due to sprouting, respiration, evaporation and microbial action and some guidance were provide to control them. Waheed et al (1986)

Table 2.5: Harvest and post-harvest losses of fruits in percent at national level (Nanda et al, 2012)

S. No.	Crop	Harvest-ing	Collection	Sorting/ grading	Packag-ing	Trans-port	Total loss in farm operations	Farm level storage	Godown/ cold storage	Whole-saler level storage	Retailer level storage	Processing unit level storage	Total loss in storage	Overall Total Loss
1	Apple	4.6	0.4	4.8	0.1	1.2	**11.1**	0.04 (2.3)	0.12 (1.5)	0.52 (1.0)	0.23 (1.1)	0.29 (1.7)	1.2	**12.3**
2	Banana	1.3	0.4	0.9	0.4	1.1	**4.2**	0.04 (1.6)	0.16 (3.3)	1.83 (2.4)	0.36 (2.4)	0.01 (0.3)	2.4	**6.6**
3	Citrus	0.9	0.5	1.8	0.3	1.3	**4.8**	0.03 (1.9)	0.00 (0.0)	0.69 (1.3)	0.77 (2.3)	0.01 (0.2)	1.5	**6.4**
4	Grapes	0.9	0.2	3.2	0.3	1.9	**6.6**	0.41 (5.5)	-	0.54 (1.6)	0.84 (2.2)	0.30 (2.7)	1.7	**8.3**
5	Guava	4.4	1.2	4.6	0.9	2.8	**13.9**	0.41 (2.1)	-	1.83 (5.9)	1.80 (3.8)	0.06 (5.7)	4.1	**18.1**
6	Mango	4.1	0.7	2.8	0.5	2.5	**10.6**	0.06 (1.5)	-	0.92 (2.5)	0.93 (2.7)	0.19 (0.9)	2.1	**12.7**
7	Papaya	1.4	0.3	2.0	0.2	1.1	**5.1**	0.08 (2.1)	0.00 (0.0)	1.02 (2.3)	1.20 (2.4)	0.00 (0.0)	2.3	**7.4**
8	Sapota	1.5	0.2	1.4	0.1	1.1	**4.3**	0.02 (0.8)	-	0.75 (1.7)	0.73 (1.7)	-	1.5	**5.8**

Figures in parentheses indicate the percent loss in the channel.

studied post-harvest losses in leafy vegetables (cabbage, salad, and spinach), roots and tubers (beetroot, carrot, onion, radish, potatoes) and others (bitter gourd, okra, cauliflower, peas, tomato, and cucumber). Data showed that maximum (52%) quantitative loss was recorded in spinach, of which 25% was at retailer's shop.

Schoenemann (1986) reported post-harvest losses of potatoes during storage in the USA, and described how such losses could be reduced and the potato quality be maintained. Basic principles of good storage management were listed, e.g. need to reduce moisture loss, need to slow down respiration and need to avoid condensation in the storage building. Three main phases of potato storage, namely wound healing, holding and the removal period, require proper management.

Misener et al (1989) studied the effects of mechanical injury on post-storage marketability of potatoes (cv. Russet Burbank) from 10 commercial storage facilities in New Brunswick. Three treatments namely hand dug from the field, randomly picked from the bulk truck as it unloaded at storage, and selected damaged tubers from the base of the pile. The results indicated that the amount of mechanical injury to potatoes during harvesting and subsequent handling were the most significant factor affecting the marketable tubers. Mechanical harvesting resulted in 60.1% more post-storage losses of marketable potatoes than hand harvesting. The damage level does not significantly affect the proportion of the loss due to moisture loss from the potatoes. The extent of ventilation and humidification capabilities of the storages was reflected in both lower storage loss and weight loss of the product. Results suggested that the efforts to minimize the injury imparted to potatoes during harvesting and handling should be stressed in order to reduce losses of marketable surplus.

Singh and Ezekiel (2003) determined weight loss in potatoes (cv. Kufri Chandramukhi and Kufri Jyoti) stored at three relative humidity (RH) levels (30-35%, 60-65% and 90-95%) and temperature of 28-30°C. In dormant tubers, weight loss was the highest at 30-35% RH but once dormancy was broken and sprout growth had started, higher RH levels favored greater sprout growth leading to higher weight loss. Greater weight loss occurred in tubers with uncured skin. Weight loss showed a non-significant relationship with number of sprouts/tuber, length of the longest sprout, surface area of tubers and periderm thickness.

Kumar et al (2006) conducted survey in two districts of Karnataka to assess the post-harvest losses in onion and potato. For each crop, one district was taken for data collection by enquiry. The estimated losses at field level were 6.21% and 7.34% for onion and potato, respectively. Losses of 1.85% and 2.22% were observed at the wholesalers' level. The losses at the retail level were 2.36% and 3.41% in onion and potato, respectively. The functional analysis showed that inadequate storage and transportation activities coupled with bad weather conditions significantly influenced the post-harvest losses at the farm level.

Singh et al (1989) stored tomatoes (cv. Pusa Ruby & Roma) at 20°C and 30°C with and without treatment of fungicide 'guazatine' and examined for storage losses. Dipping in a 2% guazatine solution for 5 or 20 min was ineffective in preventing natural infections in fruits held at 20°C and 30°C. An increase in solution concentration to 4% (dip time 5 min) extended shelf life by 2-6 days at 20°C and 30°C.

Sankar Pal (2002) conducted experiments in the Odisha state of India to determine the extent of post-harvest losses occurring at different stages of handling and transportation of tomato, cabbage and cauliflower. Total losses on these vegetables during different post-harvest operations were found to be 30.3-39.6, 24.9-30.4 and 28.6-35.1%, respectively and concluded that the maximum quantity of losses occurred during transportation from rural to urban markets.

Post-harvest losses in vegetables, viz. tomato, green pea, capsicum, cauliflower and cabbage in Himachal Pradesh were reported to be 24.79%, 18.98%, 22.76%, 28.25% and 25.33% of the total production, respectively (Singh and Vaidhya, 2005). The losses were more at production level of most of the vegetables.

The national level post-harvest losses study conducted by Nanda et al (2012) covered eight vegetables viz cabbage, cauliflower, green pea, mushroom, onion, potato, tapioca and tomato. Five farm operations and five market channels of storage were covered in the study (Table 2.6). The overall total losses were observed to be 6.9% (cauliflower) to 13.0% (tomato). Harvesting, sorting/grading, transportation, storage at wholesaler and retailer levels were the main operations and channels where losses occurred substantially.

2.4 Post-Harvest Losses of Plantation Crops and Spices

Egan (1971) observed the post-harvest deterioration losses of sugarcane over a period of 3 years (1962-66). During storage over weekends, rakes of chopped cane showed average apparent CCS (commercial sugar percentage in cane) losses of 0.64, 0.91 and 1.31 units, compared with whole stalk cane, representing at least 6%, 8.8% and 11.0% of original CCS present. It was concluded that safe storage periods for whole cane were unacceptable for chopper-harvested cane, which should be crushed as soon as possible.

Siddhant et al (2008) conducted a study with ten sugarcane cultivars of early and late maturing type and assessed post-harvest losses due to staling for periods of 0-5 days and reduction in cane weight from February through June. The results revealed that the fibrous varieties of late maturing group such as CoSe 92423, CoS 97261 and CoS 8432 showed less reduction in cane weight and higher reduction in polarization percentage whereas the less fibrous type of early maturing group like CoS 95255, CoS 96268 and CoS 8436 showed less reduction in pol percentage and higher loss in cane weight.

Mohammed et al (1992) examined post-harvest losses and quality changes in fresh yellow and red hot peppers at five stages in the roadside marketing system in Trinidad i.e. at harvest, on arrival at the packing house, during storage, at a roadside market display, and at the consumers' table. Total post-harvest losses were 28.6% and 38.7% of initial commodity weight in dry and wet seasons, respectively. Bruising was the major cause of loss, followed by physiological and pathological damage in the field and packinghouse during storage. Chilling injury induced during storage at 2-4°C and 50-60% RH increasingly visible at roadside display stalls, which accounted for higher levels of physiological and pathological damage during the last two stages.

Table 2.6: Harvest and post-harvest losses of vegetables in percent at national level (Nanda et al, 2012)

S. No	Crop	Harvest	Collection	Threshing	Sorting/ Grading	Packaging	Transport	Total loss in farm operations	Farm level storage	Godown/ cold storage	Wholesaler level storage	Retailer level storage	Processing unit level storage	Total loss in storage	Overall Total Loss
1	Cabbage	1.1	0.3	-	1.6	0.3	1.3	**4.6**	0.14 (2.1)	0.06 (1.1)	0.88 (2.2)	1.19 (2.6)	0.03 (2.3)	2.3	**6.9**
2	Cauliflower	0.8	0.3	-	1.7	0.2	1.9	**4.8**	0.06 (1.5)	0.04 (0.5)	1.00 (2.2)	0.89 (2.3)	-	2.0	**6.9**
3	Green pea	3.5	1.1	-	3.3	0.2	0.5	**8.6**	0.06 (1.2)	0.01 (0.3)	0.71 (1.3)	0.92 (2.4)	-	1.7	**10.3**
4	Mushroom	1.4	1.8	-	4.3	1.6	2.0	**11.0**	-	-	-	1.50 (1.7)	-	1.5	**12.5**
5	Onion	2.7	0.2	-	1.6	0.1	0.4	**5.2**	0.54 (2.7)	0.38 (2.2)	0.81 (2.2)	0.56 (2.6)	0.01 (0.1)	2.3	**7.5**
6	Potato	3.2	0.7	-	2.2	0.1	0.5	**6.7**	0.36 (3.9)	0.78 (1.4)	0.96 (3.9)	0.19 (2.4)	0.01 (0.4)	2.3	**9.0**
7	Tomato	1.7	1.1	-	3.2	0.8	3.1	**9.9**	0.17 (4.6)	0.01 (1.6)	1.23 (2.7)	0.98 (2.3)	0.11 (2.0)	2.5	**13.0**
8	Tapioca	3.6	0.5	-	1.5	0.5	1.3	**7.5**	1.09 (4.1)	-	0.58 (1.5)	0.44 (1.7)	0.19 (2.3)	2.3	**9.8**

Figures in parentheses indicate the percent loss in the channel.

The post-harvest losses study for plantation crops and spices is in scarce even at regional level. The study conducted by Nanda et al (2012) covered eight plantation crops/spices namely arecanut, black pepper, cashew, chili, coconut, coriander, sugarcane, and turmeric. Seven farm operations (harvesting, collection, sorting/ grading, threshing, winnowing, drying, packaging and transportation) and five market channels of storage (farm, godown/ warehouse, wholesaler, retailer and processing unit) were covered in the study (Table 2.7). The overall total losses were observed to be 1.1% (cashew) to 8.6% (sugarcane). Harvest, threshing, staling (for sugarcane), storage at wholesaler and processing unit levels were the main operations and channels where losses were found to be substantial.

2.5 Post-Harvest Losses of Livestock Produce

Livestock produce (fish, meat, egg, milk) are important sources of protein for non-vegetarian population. Harvest, handling, processing and distribution of these commodities provide livelihood for millions, besides valuable foreign exchange earnings to the country. These are highly perishable food, requiring proper handling, storage, processing and distribution. Global demand for livestock produce is growing and reduction in post-harvest losses can make a major contribution in satisfying this demand, besides increasing available quantity for consumers and more income to producers.

2.5.1 Marine fish

Disney (1981) discussed the post-harvest aspects of fisheries development in the tropics. Post-harvest losses tend to be higher in small-scale fisheries, particularly in the period between catching and processing or consumption. Large losses also occur due to physical damage or infestation of cured fish. Ways of improving fish utilization in small-scale fisheries such as use of ice, smoking, low-cost solar drying, preparation of minced fish and awareness were suggested to reduce post-harvest losses. FAO (1981) and Wood (1986) have made serious attempts to develop assessment methodologies for accurate information on post-harvest fish losses.

Poulter et al (1987) described the losses of fish that were cured by salting, drying, smoking or by a combination of these processes. Physical losses are often caused by insects, which consume large quantities of fish flesh. Morrissey (1988) enumerated the causes of post-harvest losses in fish as biological and microbiological damage, chemical, biochemical, mechanical, storage, transportation, refrigeration and marketing systems. It cited minimal overall losses in developing countries as 20% of total production of non-grain surplus, perishables and fishes. He further emphasized that a more systematic approach to estimate the loss in developing countries for reduction in post-harvest losses in fish is needed. He defined the term post-harvest as the period of separation of fish from its growth medium.

Clucas et al (1989) found 20% post-harvest losses of an annual fish production of about 13.5 lakh tonnes in 16 Economic Community of West African States. Similar figures were observed in the artisan fisheries sector that contributes about 90% of the total catch. In the absence of proper handling, processing and marketing infrastructure, large quantities of fish were lost each year before consumption (Shimang, 1992).

Table 2.7: Harvest and post-harvest losses of plantation crops and spices in percent at national level (Nanda, et al, 2012)

S. No	Crop	Harve-sting	Collec-tion	Thresh-ing	Sorting/ grading	Winnowing/ cleaning	Drying/ staling*	Packa-ging	Tran-sport	Total loss in farm operations	Farm level store	Godown/ cold store	Whole-saler level store	Retailer level storage	Processing unit level storage	Total loss in storage	Overall Total Loss
1	Arecanut	1.9	0.2	3.3	0.4	0.4	0.2	0.1	0.2	**6.6**	0.03 (1.5)	0.00 (0.0)	0.88 (1.2)	0.27 (1.8)	0.12 (0.7)	1.3	**7.9**
2	Cashew	0.2	0.1	0.4	-	-	0.2	0.0	0.0	**0.9**	0.01 (0.1)	0.00 (0.0)	0.06 (0.2)	0.02 (0.4)	0.11 (0.2)	0.2	**1.1**
3	Coconut	1.6	0.2	-	1.4	-	0.7	0.1	0.2	**4.1**	0.14 (1.9)	0.02 (0.2)	0.46 (1.1)	0.32 (2.1)	0.36 (1.4)	1.3	**5.4**
4	Sugarcane^	2.8	0.9	-	0.3	-	3.5*	0.1	0.2	**7.8**	0.08 (0.8)	-	-	0.01 (0.1)	0.81 (1.2)	0.9	**8.6**
5	Black pepper	0.7	0.2	0.5	-	0.8	0.9	0.2	0.3	**3.6**	0.01 (0.3)	0.00 (0.0)	0.19 (0.6)	0.10 (0.5)	0.00 (0.0)	0.3	**3.9**
6	Chili	1.6	0.7	-	0.7	0.6	0.1	0.1	0.1	**3.9**	0.03 (0.9)	0.03 (0.6)	1.19 (1.8)	0.36 (2.0)	0.09 (1.0)	1.7	**5.6**
7	Coriander	2.2	0.7	3.1	-	0.2	0.3	0.2	0.2	**6.8**	0.09 (1.9)	0.00 (0.0)	0.31 (0.5)	0.10 (0.4)	0.00 (0.0)	0.5	**7.3**
8	Turmeric	3.7	0.8	-	0.7	1.1	0.1	0.1	0.2	**6.7**	0.18 (1.3)	-	0.43 (0.9)	0.08 (0.8)	-	0.01 (0.7)	**7.4**

Figures in parentheses indicate the percent loss in the channel.
^ Staling in case of sugarcane

Post-harvest losses due to spoilage of fresh fish, burning during smoking, insect infestation in dried and smoked fish, breakage and rehumidification have been reported by FAO in 1992. Total losses, which were about 30% in 1970s, were reduced to about 10% in 1992 through extension of the use of insecticides and improved smoking ovens (FAO, 1992). Mengistu (1993) reported that the reduction of post-harvest losses through improved handling, processing, transport and distribution systems in Ethiopia should be given high priority.

Factors such as fishing depth, bottom substrate, or time of day, month or year are directly related to incidental halibut by catch mortality (Adams, 1996). Ward (1997) focused on developing methods to quantitatively assess post-harvest fish losses. The main outputs of the study were: manual of field based loss assessment methodology, fish loss database, predictive macro model and predictive cost model. The two systematic fish loss assessment methodologies developed were formal recall questionnaire survey method and an informal method based on rapid and participatory rural appraisal. Details are also given on how informal data collection techniques were used to generate indicative quantitative data on post-harvest fish losses.

Ward et al (1996) studied the fresh fish marketing between Visakhapatnam and Madras based on a survey programme conducted jointly by Central Institute of Fisheries Technology, Cochin, India and NRI, UK. Mndeme (1996) concluded that the availability of salted fish in markets both within and foreign countries reduced the loss to a great extent. Hodari Okae et al (1996) observed that insect infestation in shrimp resulted in considerable quantitative and qualitative loss. Improper packaging, handling and stacking during transportation leads to fragmentation and spoilage. Ndem and Akande (1996) reported heavy post-harvest losses for cured fish due to inappropriate processing and handling.

Ward and Jeffries (2000) have described three methods for investigating fish losses. The Informal Fish Loss Assessment Method (IFLAM) describes quick way to generate qualitative and quantitative data based on rapid and participatory rural appraisal. The Load Tracking (LT) method uses biometric sampling to measure change in fish quantity and quality loss between stages in the distribution chain. The last method, Questionnaire Loss Assessment Method (QLAM) is based on a formal questionnaire survey approach. However these methods have certain disadvantages viz. the IFLAM method does not generate statistically valid data, the LT method is said to be costly and time consuming and by using the QLAM method it is not easy to quantify the loss levels.

In a study conducted during 2001-04 on assessment of harvest and post-harvest losses of marine fish in one district of Tamil Nadu, range of losses are reported (CIFT, 2004). The loss during catch using craft/gear boats was 3.61% to 14.48%, after unloading from craft/gear was 0.81% to 5.16%, in marketing channels 0.14% to 8.28% and at consumer level 1.93% to 4.95%.

2.5.2 Inland fish

Ward (1996) suggested efficient utilization of fish resources for reducing post-harvest losses. Two systematic fish loss assessment methodologies, (i) a formal recall questionnaire survey method, (ii) an informal method based on rapid and participatory rural appraisal, were developed in U.K. Both methods

complement each other, as one primarily generates quantitative data and the other gives qualitative information. The results suggested that the use of informal tools for fish loss assessment may be taken as a valid approach, but further research is required. Eyo (1997) assessed the quantifiable post-harvest losses using questionnaires at fisher folk, fish processors and fish traders operating within the Kainji Lake basin, Nigeria, and reported that out of 14000 tonnes 1000 tonnes of fish in 1995 was either discarded or lost value due to spoilage during handling by fisher folk.

Enujiugha and Nwanna (1998) examined the impact of post-harvest handling and processing techniques on the supply and demand for African catfish *(Clarias gariepinus)* and Tilapia *(Oreochromis niloticus)*, two common fish species in Nigeria's aqua-habitat. They observed poor handling, inadequate pre-processing, holding conditions and inappropriate processing methods caused serious negative effects on the species conservation in case of diminished supply against increased demand. More than 20% of harvested fishes are lost as a result of inadequate handling and processing. Ward et al (1998) further found that post-harvest fish losses at small scale processors level are excessive during monsoon. Ward and Jeffries (2000) identified some general factors such as unreliable transportation, inadequate preservation techniques, adverse weather conditions, diligence or skills of workers, species of fish, fishing gears used, type of processing methods, fish supply greater than demand and market as causes of post-harvest losses of fish.

Many processors consider losses to be an unavoidable aspect of their business. Gitonga (1998) reported that Nile perch *(Lates niloticus)* constitutes 60% of total landings in the Kenyan waters of lake Victoria. The bulk of Nile perch is harvested from lake Victoria whose landings contribute 90% of total fish production in Kenya. The heaviest losses occur during the rainy season which corresponds to the period of optimum production. The causes of post-harvest losses were found to be bacterial deterioration, blowfly larvae infestation, molds and fragmentation.

Cheke (1997) presented a prototype model for evaluating the economic effects of different interventions to minimize post-harvest losses to fish. The compartmentalized model follows the fate of fish entering and leaving discrete stages between capture and sale at retail markets. The model is described using an example comparing the results of transporting Nile perch caught in three different ways at Lake Victoria, Tanzania transported either by rail or by air to markets in Dar-es-Salaam, in a sequential chain with the highest losses occurring at the processing stage. It is concluded that the most cost-effective method, amongst the six comparisons made, is to catch fish in beach seine nets and to transport them by air. The model was designed to be adopted by other fishery systems and so be a useful tool for policy-makers and fisheries officers.

Ngoan (1997) dealt with a brief account of the current status of post-harvest fisheries technology in Vietnam, detailing the various infrastructures available for fish processing and storage for export. Only about 30% of catches are industrially processed and the remaining is consumed fresh. It is recommended, for improvement of the fisheries industries, that Vietnamese fisheries sector should concentrate on reducing post-harvest losses by utilizing low-cost fish and fish waste; strengthening infrastructure and fish quality and safety; and, diversifying fish products.

In fact contemporary data on harvest and post-harvest losses in inland fisheries from different resources and at different channels are not available in Indian context. Day (1980) reported briefly on FAO efforts to boost the yield from small-scale fishing activities by reducing post-harvest losses, which in many cases approached 50%. The main concerns are dried fish, where infestation by insects is the major cause of losses. The use of solar driers was recommended to reduce drying periods in the open air, improved smoking ovens, storage in insect-proof containers and insect-free surroundings and better protection of the product during transport and distribution (e.g. packaging in double Kraft paper with bitumen between the layers, and a polyethylene liner).

Bathla et al (2004) conducted a pilot sample survey in East Godavari, West Godavari, Khammam district of Andhra Pradesh and Hirakund reservoir of Odisha to estimate harvest and post-harvest losses of inland fisheries at different channels and found losses at producers level was maximum for riverine fisheries (8.56% to 13.94 %) followed by reservoirs (6.52% to 8.89%), estuarine fisheries (6.3%), lake fisheries (3.69% to 4.48%), freshwater aquaculture (2.40%) and brackish water aquaculture (1.86%). Similarly, at market level maximum losses of inland fisheries was reported in wholesale market (up to 10.98%) followed by vendor level (4.10% to 5.52%), retail markets (2.96%), live fish transportation (2.22%) and packaging (0.29%). They further reported that urban household consumers responsible for 4.41% to 4.52% loss, whereas losses of inland fisheries at rural household are 3.96%.

2.5.3 Poultry meat

As far as poultry meat is concerned, except some information on the processing losses arising due to offal's like blood, feathers, head, feet and visceral organs, no information seem to be available in literature. Some pertinent information however are available on the processing losses of inedible poultry byproducts during dressing of chicken. Uijttenboogaart (1981) reported 25.9% and 27.3% total offal losses in chicken broilers and spent hens, respectively. Panda and Singh (1980) and Shrivastava and Singh (1985) reported that poultry processing wastes viz. head, feet and shank, feathers, blood and viscera together constituted around 26 to 29% of live weight of chicken. They also reported that every kilogram live weight of birds processed yielded 35 g blood, 80.7 g feathers, 30 g head, 39 g feet, 9 g lungs and 80 g viscera, making a total losses of 273.7 g which worked out to be 27.4% total offal. Sharma and Rao (1996) found about 26% total losses in broiler chicken. In general, processing losses were much higher in spent laying hens/culled breeding hens due to reproductive organs than in broiler or culled breeding cocks.

Pandey et al (1991) studied the effects of repeated interruptions in electricity supply to frozen chickens (-18°C) on physicochemical (drip loss, storage loss, cooking loss, pH, water holding capacity, TBA value, and sarcoplasmic and myofibrillar proteins), microbiological (total plate and psychrotroph counts), sensory (appearance, flavour, juiciness, texture and overall appearance) quality, and shelf life. Broilers were packaged individually in polyethylene bags and frozen for 48 h, following which daily electricity cuts for 6 or 9 h were evaluated until several samples were spoiled in 28 days. Results indicated that chicken was acceptable for 28 days on exposure to 6 h daily power cuts, vs. 21 days on exposure to 9 h daily power cuts.

2.5.4 Egg

The incidences of broken and cracked eggs have extensively been studied in some industrialized countries. Roland (1977) estimated 7.8% losses of eggs in the layer's house due to poor shell quality, which went up to a total loss of 14.2% during movement of eggs from the farm to the consumers. Berry (1976) studied egg shell damage through retail channels and found 3.4% egg breakage at the processing plant, 1.9% during transport to warehouse and only 0.3% in retail store. A lower incidence of egg shell crack up to 1.7% occurred during laying, gathering and packing at the farm, whereas the same increased to 14.5% during transport, washing, grading and re-packing at the egg processing plants (Orr et al 1977). The incidence of body-checked eggs was only 0.3% for eggs from hens under 40 weeks of age as against 2.0% for eggs from birds over 60 weeks of age. Eggs produced and transported during summer exhibited higher (2.2%) shell damage than winter produced eggs (0.8%) (Lederer, 1978).

Hamilton et al (1979) reviewed data from different countries and reported that approximately 5 to 18% of eggs produced were lost between laying house and retailing to consumers with average annual losses of 6.4, 6.7 and 8% in the USA, the UK and Germany, respectively. These losses were then estimated to cost the American egg producers $ 60 million annually. Detailed study revealed a higher incidence of breakage (3.5%) at the point of lay in cages, 2.2 to 3.6% during mechanical/ manual egg collection, about 3.6% during transportation to packing and grading station, 3.7% during washing, grading and packing at the egg grading station, and about 1% during subsequent transport to retail outlets. Furthermore, Bains (1997) found 5 to 7% loss of eggs at the farm and an additional 10% loss during transport and handling in the marketing channels in Australia.

In a simulated drop test, Denton et al (1981) found that 30 dozen cardboard case afforded greater protection against shell damage (7.9%) due to its better cushioning effect than 24 dozen wire case (20.7% damage). Nethercote et al (1974) found that cross tiers of egg cartons protected eggs better than those stacked in one direction in the egg cases. Carton design appeared more important than the material (pulp/polystyrene) in determining the relative protection against shell damage.

Meager information is available on the incidence of egg breakage in India. Panda (1973) found higher incidence of egg shell damage in bamboo baskets (15.3%) than in improved egg transport boxes (2.3%) during a long distance (2000 km) transport by rail. Subsequently, Brah et al (1991) reported 5% egg shell breakage at poultry breeding farms in Ludhiana in pure and crossbred white leghorn hens between 38 and 40 weeks of age. The incidences of hairline crack were maximum (57.6%) followed by star cracks (37.6%) and holes (4.8%) in these genetic groups. The occurrence of soft-shelled or shell-less egg varied between 2.4 to 16.1% and the incidence of egg shell defects and cracked eggs further increased to 21% under hot tropical environment (Rao and Nagalakshmi, 1998).

Singh et al (2009) assessed the quantitative losses of eggs at farm, market, processing and household consumer level in Bareilly district of Uttar Pradesh. Results showed that the magnitude of the losses of eggs at layer farms, wholesalers, retailers, cold store, egg processing unit and household family level were found to be 0.98%, 1.39%, 3.26%, 2.11%, 1.24% and 3.24%, respectively, which together constituted an overall loss of 12.22% eggs. However, the combined loss of eggs from poultry farms to

household consumers via wholesale and retail channel was found to be 8.87% in the surveyed area. The losses were comparatively more in summer (1.31%) than in rainy (0.88%) or winter (0.75%) season at the farms. The bulk of egg damage at farm level was in the form of straight crack followed by star crack, smashed/leakers, soft shell, holes, shell-less eggs and spoiled (rotten) eggs. Majority of egg damage occurred at poultry farms during collection stage, whereas the same was highest during packing and transport at market and household consumer level, and during mechanical washing at egg processing plants.

2.5.5 Milk

Sharma and Srinivasan (1973) conducted a study to estimate the handling losses in milk and milk solids of experimental dairy at National Dairy Research Institute, Karnal and revealed that average liquid milk loss per day was about 0.67 % of the total milk handled and decreased with the increase in amount of milk handled. On an average there was an increase at a rate of 0.05% for every 500 kg increase in milk handled. Average fat loss was estimated to be 0.79% of fat handled and SNF loss 0.73% of SNF handled. These losses also decreased with the increase in the level of handling, rate of decrease on average, for every 100 kg handled was 0.45% fat and 0.23% for SNF. In another study conducted by Singh and Kalra (1976), milk losses in a dairy plant during separation were 1.27% and 1.18% in the quantitative and monetary terms, respectively. For toned milk packed in bottle the losses were 1.90% and 1.44% in quantitative and monetary terms and for toned milk in sachets the losses were 1.90% and 1.55%, respectively. Baltjes (1978) reported milk losses of 0.25-1.8 kg/day and 0.15-0.64 kg/day from cleaning of equipment and storage tanks, respectively.

Marshall (1978) determined the product losses in different dairy processing factories and found that milk losses from whole milk reception to separation was less than1.5% of milk purchased and during evaporation and spray drying in 3 factories varied between 2% to 6%. Casein losses in 3 casein factories were 5.9% of the casein in the skim milk, losses being made up of tines in the whey (1.1-3.3%), fines in the wash water (0.4-2.7%), low moisture value (0.2-2.1%) and spills of milk and curd (0.8-1.8%). Salplachta (1979) conducted a study on milk losses and effluent contamination resulting from milk tanker washing and concluded that mean milk losses were approximately 0.4 l/m^3 of tanker capacity for a dairy handling 200,000 litre milk per day.

Rawat and Verma (1985), determined milk fat and SNF losses over a 12 month period at a small dairy plant during milk reception, separation, skim milk handling for standardization and in toned milk processing and packaging. Annual losses of fat and SNF during toned milk production were 1.30 and 1.38%, respectively. The mean quantity of toned milk processed monthly being about 71,000 kg the proportion of fat and SNF loss, respectively that occurred at each operation were (a) 37.72% and 27.86%, (b) 0.39 and 5.99%, (c) 0.12 and 7.15%, (d) 61.77 and 59.0%, respectively. Bouman (1985) estimated that whole milk losses/$m^2$of heat exchange surface reached 1.3 kg in a 4-effect evaporator and 1.5 kg in a 7-effect evaporator. Arora et al (1988) reported average fat and total solids losses ranged from 0.24% to 2.71% and 0.58% to 8.04%, respectively in a small sized multi-product dairy plant. They also pointed out that the factory operated at less than 50% of its total capacity throughout three years of operations and the

Table 2.8: Harvest and post-harvest losses of livestock produce in percent at national level (Nanda et al, 2012)

S. No	Crop	Harvesting	Collection	Sorting/ grading	Winnowing/ cleaning	Dry-ing	Packag-ing	Tran-sport-ation	Total loss in farm operations	Farm level storage	Godown/ cold storage	Wholesaler level storage	Retailer level storage	Processing unit level storage	Total loss in storage	Overall Total Loss
1	Egg	-	2.1	-	-	-	1.0	1.8	**4.9**	0.04 (0.8)	-	0.98 (1.7)	0.66 (1.7)	0.02 (2.1)	1.7	**6.6**
2	Inland fish	2.6	0.1	1.6	-	-	0.5	0.3	**5.2**	0.04 (1.0)	-	0.82 (2.4)	0.84 (1.4)	-	1.7	**6.9**
3	Marine fish	-	0.2	0.1	-	-	-	1.6	**1.8**	-	-	0.28 (0.6)	0.28 (1.7)	0.44 (1.7)	1.0	**2.8**
4	Meat	1.4	-	-	-	-	-	-	**1.4**	-	-	0.48 (1.0)	0.42 (0.8)	-	0.9	**2.3**
5	Poultry meat	2.7	-	-	-	-	-	-	**2.7**	-	-	0.31 (0.6)	0.68 (1.5)	0.01 (0.1)	1.0	**3.7**
6	Milk	0.1	0.5	-	-	-	-	0.1	**0.7**	0.02 (0.1)	-	-	-	0.08 (0.2)	0.1	**0.8**

Figures in parentheses indicate the percent loss in the channel.
Livestock produce meat' includes the meat of Sheep and Goat only.
In Marine fish the onboard losses were not estimated. The extent of loss starts after landing of the boat at sea shore.
In milk, only cow and buffalo milk was taken.

reasons for losses were casual approach to standardization and lack of mechanical facilities for processing.

Dyurich and Gertsen (1986) studied ways of reducing milk losses on farms in Ukraine. Study showed that when cows were milked twice daily in ADM-8, UDE-8 and UDT-8 parlors respectively, 0.63%, 0.38% and 0.32% of the milk was lost only for technological reasons. In farm dairies these technological losses decreased from 0.48 to 0.36% incorporating properly designed equipment.

Rao (1990) in his study on reduction of losses in dairy industry identified the major sources of losses as spoilages, wastage of surplus materials, spills, inadequate drainage of milk from plant, packaging losses, losses due to analytical variations and storage losses.

Khatri (1998) conducted a study on post-production losses of milk in rural areas of Rohtak district of Haryana state. The results showed that loss of milk was of the order of 3.0 %, 1.1% and 2.8% at household, cycle vendor and halwai levels, respectively. This prosperous region has fairly good production and marketing infrastructures where the people are reasonably educated and more business minded. The milk losses at different stages are expected to be higher in other less developed areas. Shakeel and Khan (1999) studied milk losses in milk packing film and milk handling system in Gulbarga Co-operative Milk Union and estimated total losses of milk fat and milk solids not fat were 0.73% and total losses of milk as 6.8%.

The national level post-harvest losses study conducted by Nanda et al (2012) for livestock produce is the most recent and realistic study for India covering egg, meat, poultry meat, inland fish, marine fish and milk (Table 2.8). However, some of the operations and channels of the value chain were missing in the study. Nevertheless this study provided base data for the assessment of harvest and post-harvest losses of livestock produce at national level.

The sporadic reports on estimation of harvest and post-harvest losses as discussed include durables and perishables did not follow standard methods (except few studies) and thus may not reflect the accurate scenario of extent of loses at national level. Pattern of change in losses over a period of time is also not reflected. Impact of industrialization, mechanization of agriculture, research and development breakthroughs could not be judged if the studies are not done periodically. It is also observed that the studies conducted for assessment of losses of food grains was relatively more systematic than others. This is expected as food grains dominate in our daily diet. Of late, attention to study the losses in perishables of plant origin, such as fruits and vegetables have picked up as their contributions of nutritionally important vitamins and trace elements are being increasingly realized. Similarly, the literature on estimation of post-harvest losses in perishable livestock produce is somewhat scanty, except for fish. Research workers have dealt with the problem of assessment according to their needs and situations. A comparison of the results of their study may not be fair on account of diverse loss measurement of techniques adopted. The information generated, however, underlines the gravity of the situation. There is, therefore a need to assess the harvest and post-harvest losses of these crops and commodities covering large areas, following standard statistical methodologies at national level to help researchers, policy makers and planners for making future strategic framework to curtail harvest and post-harvest losses further and make more food materials available to feed masses.

CHAPTER III
SURVEY CONSIDERATIONS AND SCHEDULES

Harvest and post-harvest losses of any crops and commodities comprises losses during farm operations, transport, market channels, processing and value addition etc. This study started with an aim to provide estimates of harvest and post-harvest losses of different crops and commodities at national level and compare the same with previous reported results. This study may reflect the change in extent of losses and need for interventions by stakeholders. The assessment of losses was carried out by conducting surveys in 14 agro-climatic zones by enquiry and observation. This chapter deals with definition of losses, assumptions and considerations, selection of crops and commodities and development/ refinement of survey schedules after thorough discussion in various meetings and workshops.

3.1 Concepts, Definitions and Assumptions

Reduction in weight of available amount for human consumption was defined as the quantitative loss. Losses such as quality deterioration, food value, kitchen loss, plate/table loss, loss of goodwill or reputation, seed vigor loss, etc. are difficult to quantify, hence were not considered under quantitative loss. Further, it was decided to estimate the post-harvest losses both by enquiring various stakeholders and actual observations in the field. Major assumptions and considerations taken for this study were :

(i) The data for harvest and post-harvest losses is to be collected for one full crop cycle (one crop year) of the selected commodities.

(ii) Initial point to start data collection in farm operations is to be harvesting operation.

(iii) In case the crops are grown more than once in a year, the data of farm operations are to be collected for each harvest in that year.

(iv) Multiple picking is common practice in perishables, cottonseed, plantation crops and spices. The data on losses in farm operations for such crops are to be collected for at least three harvests/pickings.

(v) No intervention in the farm practice should occur during data collection.

(vi) Actual farm practices are to be followed for collection of data by observation.

(vii) Data collection for losses during storage should start immediately after the selection of respondents.

(viii) The data on losses during harvesting (catch) of marine fish should be collected only by enquiring the selected respondents.

(ix) Selection of respondents, fields, districts etc are to be done using standard statistical methods.

(x) Data should be collected by trained manpower actually appointed for the purpose.

3.2 Commodities, their Channels and Unit operations

Altogether 45 major crops and livestock produce of India were taken up as per MoU with MoFPI for estimating the quantitative harvest and post-harvest losses in different operations and channels. The crops were listed in different groups such as cereals, pulses, oilseeds, fruits, vegetables, plantation crops& spices and livestock produce. Selections of crops/commodities were based on their national production. The farm operations and channels for selected crops/commodities and their extent of coverage in the study are summarized in Table 3.1.

Table 3.1: Farm operations / channels and extent of their coverage for selected crops / livestock produce

S. No.	Operation/ Channel	Extent of coverage of the operation	Crops covered
1	**Harvesting**	Cutting of the standing crop	Paddy, Wheat, Maize, Bajra, Sorghum, Pigeon Pea, Green Gram, Black Gram, Mustard, Sunflower, Safflower, Soybean, Coriander, Chickpea, Green Pea, Sugarcane
		Plucking of fruits/ bunch from tree/ plant/ vines	Cottonseed, Apple, Banana, Mango, Papaya, Sapota, Grapes, Black Pepper, Citrus, Guava, Chili, Arecanut, Coconut, Cashew, Tomato, Cauliflower, Cabbage, Mushroom
		Digging/ uprooting of the tubers from soil	Onion, Potato, Tapioca, Turmeric
		Uprooting of plants from soil and collection of leftover pods	Groundnut
		Catch	Inland Fish, Marine Fish
		During milking of animal (Cow/ Buffalo)	Milk
		Slaughter of the animal/ bird	Meat, Poultry Meat
2	**Collection**	Stacking, bundling and transportation up to threshing floor	Paddy, Wheat, Maize, Sorghum, Pigeon Pea, Green Gram, Black Gram, Chickpea, Mustard, Sunflower, Safflower, Soybean, Coriander, Groundnut, Black Pepper, Bajra
		Stacking, filling in baskets/bags, and transportation to sorting/ grading place	Apple, Banana, Mango, Papaya, Sapota, Grapes, Onion, Citrus, Guava, Arecanut, Coconut, Cashew, Chili, Cauliflower, Cabbage, Potato, Tapioca, Green Pea, Turmeric, Tomato, Cottonseed, Mushroom
		Removal of leaves, stacking, bundling	Sugarcane
		Separation from net, filling in baskets/ transport tanks	Inland Fish
		Filling, unloading at collection centre	Milk
		Collection of eggs from cages, transportation up to packaging yard	Egg
		Unloading the fish from boat at landing centre	Marine Fish

S. No.	Operation/ Channel	Extent of coverage of the operation	Crops covered
3	**Sorting/ grading**	Separation of material not fit for human consumption due to damage & injury, unripe harvest, removal of soiled portion of mushroom, removal of first layer of cabbage leaves	Apple, Banana, Mango, Papaya, Sapota, Grapes, Citrus, Guava, Chili, Cauliflower, Cabbage, Onion, Potato, Green Pea, Turmeric, Tomato, Mushroom, Sugarcane, Egg, Meat, Poultry Meat
		Separation of dead, uneconomical, small fish and discarding them	Inland Fish, Marine Fish
		Trimming of tubers	Tapioca
4	**Threshing/ Dehusking**	Separation of grain/ seed from plant/ pods, removal of husk from nuts	Paddy, Wheat, Maize, Bajra, Sorghum, Pigeon Pea, Green Gram, Black Gram, Chickpea, Mustard, Sunflower, Safflower, Soybean, Arecanut, Coriander, Groundnut, Black Pepper, Coconut, Cottonseed, Cashew
5	**Winnowing/ cleaning**	Collection of threshed material, winnowing to remove chaff, dust etc	Paddy, Wheat, Maize, Bajra, Sorghum, Pigeon Pea, Green Gram, Black Gram, Chickpea, Mustard, Sunflower, Safflower, Soybean, Coriander, Groundnut, Black Pepper, Arecanut, Chilli, Turmeric
		Ginning	Cottonseed
6	**Drying**	Collection of material after cleaning, spreading for drying, heaping after drying	Paddy, Wheat, Maize, Bajra, Sorghum, Pigeon Pea, Green Gram, Black Gram, Chickpea, Mustard, Sunflower, Safflower, Soybean, Coriander, Groundnut, Black Pepper, Arecanut, Coconut, Cashew, Cottonseed, Turmeric, Chili
		Transportation from field to crushing unit, before crushing starts (Staling)	Sugarcane
7	**Packaging**	Collection after winnowing/ cleaning/ drying/ sorting/ grading/ threshing (in case of use of thresher having blower), filling in the bags/ baskets/ other packaging material	Paddy, Wheat, Maize, Bajra, Sorghum, Pigeon Pea, Green Gram, Black Gram, Chickpea, Mustard, Sunflower, Safflower, Soybean, Coriander, Groundnut, Black Pepper, Arecanut, Chili, Turmeric, Apple, Banana, Mango, Papaya, Sapota, Grapes, Citrus, Guava, Coconut, Cashew, Cauliflower, Cabbage, Onion, Potato, Tapioca, Green Pea, Tomato, Mushroom, Sugarcane

S. No.	Operation/ Channel	Extent of coverage of the operation	Crops covered
		Packaging in filler flats, stacking filler flats	Egg
		Packaging of seed into bags after ginning	Cottonseed
		Application of ice, packaging for transport	Inland Fish
8	**Transportation**	Loading of packed material in threshing yard/ sorting/ grading place, transportation to farmers, store, unloading, transportation from threshing yard/sorting/ grading place/ store to market yard and unloading at market yard	Paddy, Wheat, Maize, Bajra, Sorghum, Pigeon Pea, Green Gram, Black Gram, Chickpea, Mustard, Sunflower, Safflower, Soybean, Coriander, Groundnut, Black Pepper, Arecanut, Coconut, Cashew, Cottonseed, Turmeric, Chili, Apple, Banana, Mango, Papaya, Sapota, Grapes, Citrus, Guava, Cauliflower, Cabbage, Onion, Potato, Tapioca, Green Pea, Tomato, Mushroom, Inland Fish, Milk, Egg, Marine Fish, Sugarcane
9	**Storage at farm/ household level**	During storage, cleaning/ grading before sending to market for sale or own consumption	Paddy, Wheat, Maize, Bajra, Sorghum, Pigeon Pea, Green Gram, Black Gram, Chickpea, Mustard, Sunflower, Safflower, Soybean, Coriander, Groundnut, Black Pepper, Arecanut, Coconut, Cashew, Cottonseed, Turmeric, Chili, Apple, Banana, Mango, Papaya, Sapota, Grapes, Citrus, Guava, Cauliflower, Cabbage, Onion, Potato, Tapioca, Green Pea, Tomato, Inland Fish, Milk, Egg, Sugarcane
10.	**Storage at godown/ warehouse/ cold stores**	Unloading, during storage, loading for further sale/ disposal	Paddy, Wheat, Maize, Bajra, Sorghum, Pigeon Pea, Green Gram, Black Gram, Chickpea, Mustard, Sunflower, Safflower, Onion, Soybean, Coriander, Groundnut, Black Pepper, Arecanut, Coconut, Cashew
		Unloading, during storage, loading for further sale/ disposal (in cold stores)	Chili, Apple, Banana, Papaya, Citrus, Cauliflower, Cabbage, Potato, Green Pea, Tomato
11.	**Storage at wholesale level**	Unloading, during storage, loading for further sale/ disposal	Paddy, Wheat, Maize, Bajra, Sorghum, Pigeon Pea, Green Gram, Black Gram, Chickpea, Mustard, Sunflower, Safflower, Soybean, Coriander, Groundnut, Black Pepper, Arecanut, Coconut, Cashew, Cottonseed, Turmeric

S. No.	Operation/ Channel	Extent of coverage of the operation	Crops covered
		Unloading and loading, during storage, sorting/ grading for sale	Chili, Apple, Banana, Mango, Papaya, Sapota, Grapes, Citrus, Guava, Cauliflower, Cabbage, Onion, Potato, Tapioca, Green Pea, Tomato, Inland Fish, Egg, Marine Fish, Meat, Poultry Meat
12.	**Storage at retailer level**	Unloading and loading, during storage of raw material.	Paddy, Wheat, Maize, Bajra, Sorghum, Pigeon Pea, Green Gram, Black Gram, Chickpea, Mustard, Sunflower, Soybean, Coriander, Groundnut, Black Pepper, Arecanut, Coconut, Cashew, Turmeric, Chili, Apple, Banana, Mango, Papaya, Sapota, Grapes, Citrus, Guava, Cauliflower, Cabbage, Onion, Potato, Tapioca, Green Pea, Tomato, Inland Fish, Egg, Marine Fish, Meat, Poultry Meat, Sugarcane, Mushroom, Milk
13.	**Storage at processing units**	Unloading and loading, during storage of raw material.	Paddy, Wheat, Maize, Bajra, Sorghum, Pigeon Pea, Green Gram, Black Gram, Chickpea, Mustard, Sunflower, Soybean, Coriander, Groundnut, Black Pepper, Arecanut, Coconut, Cashew, Chili, Apple, Banana, Mango, Papaya, Grapes, Citrus, Guava, Cabbage, Onion, Potato, Tapioca, Tomato, Egg, Marine Fish, Poultry Meat, Sugarcane, Milk

3.3 Sampling Design and District Selection

Sampling is a process of selecting a subset of number of respondents from population for a study. This study was planned to estimate the harvest and post-harvest losses of crops/ livestock produce at national level. Therefore stratification of the country was carried out on the basis of climatic conditions, agricultural practices and crops grown. Stratification approved by Planning Commission of India in the form of agro-climatic zones was found to be the most appropriate for this study. The whole country is divided into 15 agro-climatic zones. The island region was not included in the survey as the total contribution in Indian agricultural production from this zone is negligible. Remaining 14 zones were taken for sampling as shown in Fig 3.1.

Districts were selected as the sampling unit in the sampling design for further selection of respondents. To estimate the post-harvest losses accurately using sample survey, it is essential to cover at least 10% units of first stage sampling. Hence total 120 districts were selected from 14 agro-climatic zones (about 20% of the total districts in India, excluding the urban districts where cultivation is not practiced). The number of districts in each agro-climatic zone was proportionately taken after rounded off to the nearest integer.

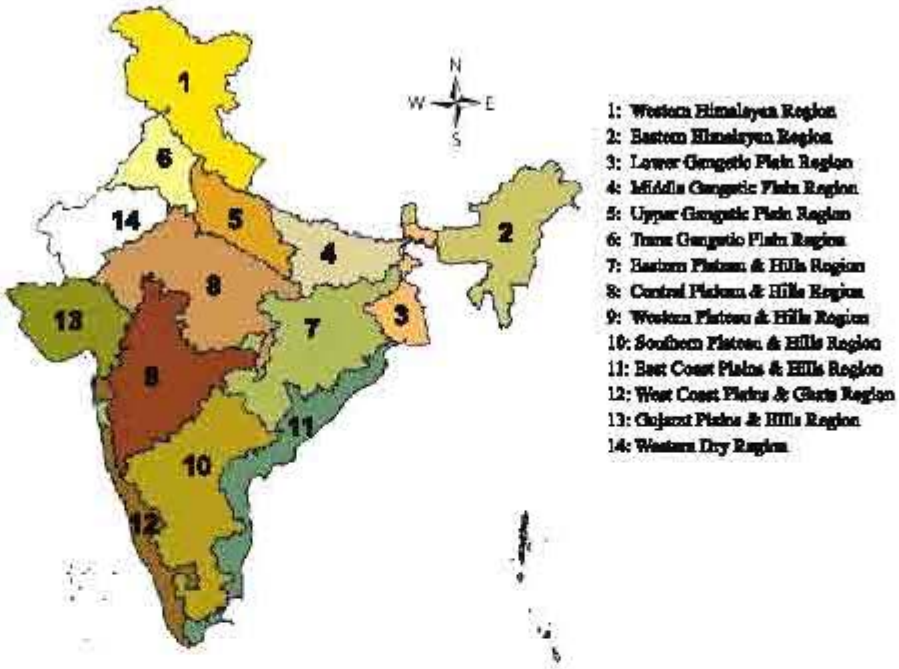

Fig. 3.1: Agro-Climatic Zones of India covered under study

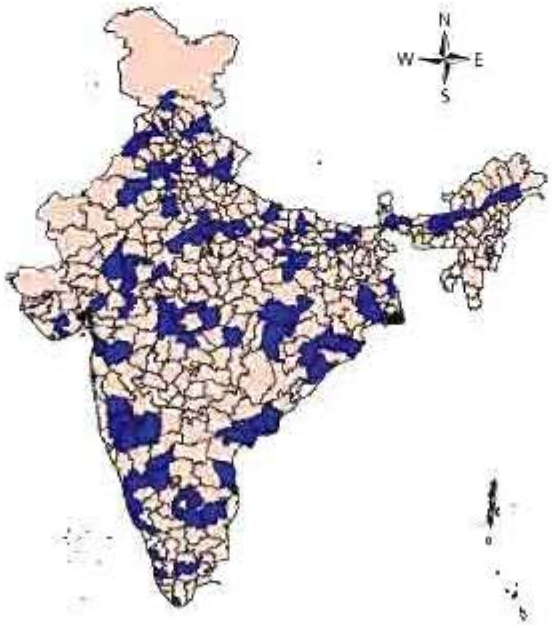

Fig. 3.2: Location of Selected Districts

For selection of respondents to collect the data for assessment of harvest and post-harvest losses, **the stratified multistage random sampling method** was used. The group of agro-climatic zones was considered as a stratum. Districts, blocks, villages and farmers were taken as first, second, third and fourth stage units, respectively in each stratum.

The blocks and villages in each district were selected randomly during the training workshop at CIPHET, Ludhiana. Four additional districts (Sikkim south, Sikkim west, Ranchi and Ramgarh) were added for the survey. The selected districts, blocks and villages were allocated to centers of AICRP on PHT nearer to them (Table 3.2). The locations of selected districts are depicted in the Fig. 3.2.

Table 3.2: List of districts and crops/commodities allotted to the centers of AICRP on PHT

S. No	Name of Centre	State	Allocated districts	Crop/commodity
1.	PDKV, Akola	Maharashtra	Amaravati, Bhandara	Paddy, Sorghum, Bajra, Pigeon Pea, Chickpea, Black Gram, Green Gram, Mango, Groundnut, Sunflower, Soybean, Safflower, Citrus, Banana, Grapes, Onion, Sapota, Papaya, Cabbage, Tomato, Mushroom, Cashew, Sugarcane
2.	AMU, Aligarh	Uttar Pradesh	Bijnor, Firozabad, Hathras, Meerut	Wheat, Paddy, Bajra, Pigeon Pea, Mustard, Mango, Guava, Potato, Green Pea, Sugarcane, Turmeric, Milk, Egg Meat,
3.	ICAR-VPKAS, Almora	Uttarakhand	Almora, Bageshwar	Citrus, Apple, Green Pea, Mushroom, Cauliflower, Milk
4.	ANGRAU (RARS), Anakapalle	Andhra Pradesh	East Godawari, West Godawari	Paddy, Sorghum, Pigeon Pea, Chickpea, Black Gram, Cashew, Green Gram, Groundnut, Sunflower, Cottonseed, Mango, Citrus, Banana, Papaya, Onion, Tomato, Tapioca, Chilli, Coconut, Coriander, Turmeric, Sugarcane, Egg, Poultry Meat, Inland Fish, Marine Fish
5.	UAS, Bangalore	Karnataka	Bangalore (rural), Chittradurga, Kolar	Paddy, Maize, Sorghum, Bajra, Milk, Pigeon Pea Groundnut, Sunflower, Safflower, Mango, Grapes, Guava, Sapota, Papaya, Tomato, Onion, Chilli, Coconut, Arecanut, Egg, Marine Fish

S. No	Name of Centre	State	Allocated districts	Crop/commodity
6.	ANGRAU Bapatla	Andhra Pradesh	Guntur, Krishna, Nellore	Paddy, Sorghum, Pigeon Pea, Chickpea, Black Gram, Cashew, Green Gram, Groundnut, Onion, Sunflower, Coconut, Cottonseed, Mango, Citrus, Banana, Papaya, Tomato, Tapioca, Chilli, Coriander, Turmeric, Sugarcane, Egg, Poultry Meat, Inland Fish, Marine Fish
7.	OUAT, Bhubaneswar	Odisha	Cuttack, Dhenkanal, Ganjam, Kandhamal, Jagatsinghpur, Sonpur	Paddy, Chickpea, Black Gram, Onion, Green Gram, Groundnut, Banana, Chilli, Turmeric, Arecanut, Cashew, Inland Fish, Egg
8.	SRS, AAU Buralikson	Assam	Darrang, Kamrup	Wheat, Citrus, Papaya, Cauliflower, Cabbage, Tapioca, Green Pea, Sugarcane, Meat, Egg, Poultry Meat
9.	ICAR-CIAE, Bhopal	Madhya Pradesh	Dewas, Hoshangabad, Jhabua, Neemuch	Wheat, Maize, Sorghum, Chickpea, Black Gram, Pigeon Pea, Mustard, Soybean, Banana, Mushroom, Coriander, Mango
10.	TNVASU, Chennai	Tamil Nadu	Kancheepuram, Thiruvallur	Sorghum, Bajra, Green Gram, Groundnut, Cottonseed, Mango, Banana, Grapes, Tapioca, Mushroom, Turmeric, Coconut, Sugarcane, Egg, Meat , Poultry Meat, Marine Fish
11.	TNAU, Coimbatore	Tamil Nadu	Dharamapuri, Dindigul, Kanyakumari, Karur, Vellore	Paddy, Sorghum, Bajra, Pigeon Pea, Green Gram, Groundnut, Cottonseed, Mango, Banana, Grapes, Tapioca, Mushroom, Turmeric, Coconut, Sugarcane, Egg, Meat, Poultry Meat, Marine Fish
12.	NDUA&T, Faizabad	Uttar Pradesh	Ambedkarnagar Azamgarh, Balarampur, Pratapgarh, Sonbhadra, Varanasi	Wheat, Paddy, Bajra, Pigeon pea, Mango, Mustard, Guava, Potato Green Pea, Sugarcane
13.	CAU, Gangtok	Sikkim	Sikkim West, Sikkim South	Citrus, Papaya, Mustard, Cauliflower, Cabbage, Green Pea, Sugarcane, Meat, Egg, Poultry Meat

S. No	Name of Centre	State	Allocated districts	Crop/commodity
14.	CCSHAU, Hisar	Haryana	Fatehabad, Hisar, Jind, Karnal, Rohtak	Wheat, Paddy, Mustard, Sorghum, Chickpea, Cottonseed, Cabbage, Mushroom, Potato, Tomato, Cauliflower, Sugarcane, Milk
15.	JNKVV, Jabalpur	Madhya Pradesh	Chhindwara, Gwalior, Shahdol	Wheat, Maize, Sorghum, Banana, Mustard, Pigeon Pea, Chickpea, Black Gram, Green Gram, Soybean, Chilli, Coriander
16.	RAU, ARS, Jaipur	Rajasthan	Alawar, Churu, Karauli, Sikar	Maize, Bajra, Sorghum, Chickpea, Mustard, Soybean, Cottonseed, Groundnut, Coriander
17.	AAU, Jorhat	Assam	Lakhimpur, Nalbari, Tinsukhia	Wheat, Citrus, Papaya, Cauliflower, Cabbage, Tapioca, Green Pea, Sugarcane, Meat, Egg, Poultry Meat
18.	JAU, Junagadh	Gujarat	Amreli, Kheda, Mehsana, Navsari, Porbandar, Valsad	Wheat, Bajra, Pigeon Pea, Green Gram, Black Gram, Groundnut, Mustard, Cottonseed, Mango, Banana, Sapota, Papaya, Potato, Onion, Cauliflower, Milk
19.	AAU, Khanapara	Assam	Barpeta, Naugaon	Wheat, Citrus, Papaya, Cauliflower, Cabbage, Tapioca, Green Pea, Sugarcane, Meat, Egg, Poultry Meat
20.	IIT, Kharagpur	West Bengal	Bankura, Medinipore (West), Purulia	Wheat, Paddy, Black Gram, Mustard, Mango, Guava, Papaya, Potato, Tomato, Cabbage, Cauliflower, Green Pea, Chilli, Coconut, Arecanut, Marine Fish, Inland Fish
21.	ICAR-CPCRI, Kasaragod	Kerala	Kasaragod, Kannur	Paddy, Banana, Sapota, Black Pepper, Coconut, Arecanut, Tapioca, Cashew, Inland Fish, Marine Fish
22.	MPKV (RS&JRS), Kolhapur	Maharashtra	Kolhapur, Sangli	Paddy, Sorghum, Bajra, Pigeon Pea, Chickpea, Black Gram, Green Gram, Mango, Groundnut, Onion, Sunflower, Soybean, Safflower,

S. No	Name of Centre	State	Allocated districts	Crop/commodity
				Citrus, Banana, Grapes, Sapota, Papaya, Cabbage, Tomato, Mushroom, Cashew, Sugarcane
23.	WBUAFS, Kolkata	West Bengal	Jalpaiguri, Medinipore (East), Nadia	Wheat, Paddy, Black Gram, Green Gram, Mustard, Mango, Guava, Papaya, Potato, Tomato, Cabbage, Cauliflower, Green Pea, Chilli, Coconut, Arecanut, Marine Fish, Inland Fish.
24.	PAU, Ludhiana	Punjab	Ferozepur, Jalandhar, Moga	Wheat, Paddy, Mustard, Potato, Citrus, Mushroom, Egg, Poultry Meat, Inland Fish
25.	ICAR-IISR, Lucknow	Uttar Pradesh	Chandauli, Deoria, Etawah, Kanpur (Dehat), Unnao	Wheat, Paddy, Bajra, Pigeon Pea, Potato, Mustard, Mango, Guava, Onion, Green Pea, Sugarcane, Turmeric
26.	KVA&FSU, Manglore	Karnataka	Dakshin Kannada, Shimoga	Paddy, Maize, Sorghum, Bajra, Milk, Pigeon Pea, Groundnut, Sunflower, Safflower, Mango, Grapes, Guava, Sapota, Papaya, Tomato, Onion, Chilli, Coconut, Arecanut, Egg, Marine Fish
27.	MAFSU, Mumbai	Maharashtra	Nasik, Satara	Paddy, Sorghum, Bajra, Pigeon Pea, Chick Pea, Black Gram, Green Gram, Mango, Groundnut, Sunflower, Soybean, Safflower, Citrus, Banana, Grapes, Onion, Sapota, Papaya, Cabbage, Tomato, Mushroom, Cashew, Sugarcane
28.	GBPUA&T Pantnagar	Uttarakhand	Haridwar, Nainital	Citrus, Apple, Green Pea, Mushroom, Milk, Cauliflower, Cabbage.
29.	RAU, Pusa	Bihar	Bhabhua, Darbhanga, Samastipur, Supaul, Vaishali	Maize, Pigeon Pea, Green Gram, Black Gram, Mango, Guava, Potato, Tomato, Onion, Cauliflower, Cabbage, Inland Fish

S. No	Name of Centre	State	Allocated districts	Crop/commodity
30.	UAS, Raichur	Karnataka	Belgaum, Bijapur, Bellary	Paddy, Maize, Sorghum, Bajra, Milk, Grapes, Pigeon Pea Groundnut, Sunflower, Safflower, Onion, Tomato, Chili, Arecanut, Mango, Guava, Sapota, Papaya, Coconut, Egg, Inland Fish, Marine Fish
31.	IGKVV, Raipur	Chhattisgarh	Bilaspur, Jaspur, Kawardha, Rajgarh, Raipur	Paddy, Wheat, Green Gram, Black Gram, Onion, Tomato, Guava
32.	BAU, Ranchi	Jharkhand	Ramgarh, Ranchi	Maize, Pigeon Pea, Green Gram, Black Gram, Mango, Guava, Potato, Tomato, Onion, Cauliflower, Cabbage, Inland Fish
33.	YSPUH&F, Solan	Himachal Pradesh	Chamba, Kinnore, Shimla, Una	Apple, Potato, Cauliflower, Cabbage, Green Pea, Mushroom
34.	SKUAS&T, Srinagar	Jammu & Kashmir	Baramula, Jammu, Pulwama	Wheat, Apple, Potato, Green Pea, Cauliflower, Egg, Meat, Poultry Meat
35.	KAU, Tavanur	Kerala	Kottayam, Wayanad	Paddy, Black Pepper, Banana, Coconut, Arecanut, Cashew, Marine Fish, Tapioca
36.	CTCRI, Trivandrum	Kerala	Palakkad	Paddy, Black Pepper, Banana, Coconut, Arecanut, Cashew, Marine Fish, Tapioca
37.	MPUAT, Udaipur	Rajasthan	Banswara, Baran, Chittorgarh, Rajsmand, Udaipur	Maize, Bajra, Chickpea, Onion, Groundnut, Sorghum, Mustard, Soybean, Cottonseed, Coriander

3.4 Training Workshop for Assessment of Post-Harvest Losses

Two workshops of AICRP on PHT of all Research Engineers/PIs to elaborate sampling techniques and method of data collection for assessment of harvest and post-harvest losses of crops/commodities were held at CIPHET, Ludhiana and RAU, Jaipur during 2012. It was also stressed that the data on harvest and post-harvest losses should be carefully estimated both by enquiry and actual observation using the methodology given in guidelines of data collection uniformly by all the centers, to project the realistic

scenario of losses at national level. Survey schedules as discussed in section 3.5, guidelines for data collection, data entry software, implementation schedule, and other necessary instructions for assessment of losses were distributed to the Research Engineers and scientists and instructed to impart proper training and conduct mock exercise for filling schedules to all field Investigators to be appointed for data collection before sending them to the field.

3.5 Survey Schedule Development

The schedules for data collection developed in the previous study were adopted with following modifications after thorough discussions in workshop and Coordination Committee Meeting of AICRP on PHT.

i) Information regarding any new post-harvest technologies adopted by the farmers in past 10 years was included in enumeration schedule (Schedule 1).

ii) Season of harvest was included in collecting data of harvest and post-harvest losses during farm operations (Schedule 2A).

iii) Removing discrepancies in units, rewording of fields to make them simple and understandable (Schedule 5 and Schedule 6).

iv) Information about the crop in the identity slip and analysis slip (Schedule 6-C1 and 6-C2).

Survey schedules used in this study are listed in *Appendix-I*.

3.6 Sampling Size

The survey was conducted in farmers' fields, villages, markets, public and private agencies, godowns, cold storages, and processing units. The sample size for data collection was decided on the basis of standard statistical sampling procedures. Selections of farmers, and respondents in market channels were performed using random sampling method. The sample size for each operation and channel and sampling procedure are described here under different sub-sections.

3.6.1 Farm operations: Two blocks, in which survey were conducted in previous study, were taken from each selected district. Two blocks were selected randomly from every newly added district (Sikkim West, Sikkim South, Ramgarh and Ranchi districts). Then five villages were randomly taken from each block according to the random number allocated to each of them. A random sample of ten farmers was drawn from each village for data collection by enquiry at farm level and two farmers from the list of 10 selected ones for data collection by actual observations.

3.6.2 Storage at producer level: Same sample of farmers (as taken for data collection in farm operations) was taken for data collection by enquiry and observation at this level.

3.6.3 Storage at market level: Two units of each channel such as wholesaler, retailer, godown, and processing unit for each crop/livestock produce were taken randomly from the list of the

respondents prepared after complete enumeration of units for each channel of each selected district. In case a particular channel was not available in the selected district then nearby districts for data collection by enquiry/actual observation were considered. The data by enquiry as well as by observation were collected from all selected respondents.

3.7 Sampling Procedure

Selection of sampling units was based on random sampling technique without replacement for each crops/commodities. The sampling procedure followed for each stage is as follows:

3.7.1 Selection of blocks in the district: A list of all blocks of the district was prepared and two of them were selected randomly as laid down in standard statistical survey method.

3.7.2 Selection of villages: List of villages falling in the selected block was prepared. The villages, which were not growing the selected crops of the region, were removed from the list and five villages were selected randomly from the remaining list. In some of the cases where villages were big with more than 1500 households, one segment of the village was enumerated and farmers were selected from that list only.

3.7.3 Selection of farmers: After complete enumeration of each selected village, the households not related to the identified commodities of the agro-climatic zone were discarded and list of farmers growing or expected to grow the identified crops/commodities in the current survey period were prepared. The farmers were sub-stratified into two categories i.e. the farmers growing more than 70% of the selected commodities available in the village (nearest integer number) and farmers growing less than 70% of selected commodities. Random samples of 6 farmers were selected from the first list. Remaining four farmers were randomly selected from the second list. In case the number of farmers in the first list was less than 6, all these farmers were selected and rest of the farmers were taken from the second list.

3.7.4 Selection of field and plot: This selection was for recording the losses data for each field crop such as cereals, pulses, oilseeds, spices, sugarcane, fruits and vegetables during farm operations by observation. A list of fields of selected farmer growing the selected crop was prepared. One field for particular crop was selected randomly and plots of 5m×5m (for plains) or 2m×10m (for hilly regions having contour or terrace farming) were demarcated to assess the losses by actual observation.

For **horticultural crops,** the orchard (A cluster of minimum 12 fruit bearing trees of particular crop on a single piece of land) was demarcated for assessment of losses by observation. Four fruit bearing trees were selected randomly from this demarcated area for harvesting.

For **fishponds,** all the fishponds of the village were completely enumerated and two ponds were selected randomly from this list for the purpose.

For **milk, egg, meat and poultry meat,** information on all the milch and meat animals of the selected households in the selected villages were recorded in the schedule 1. In case of Egg and poultry birds, all the egg and poultry units in the village were completely enumerated and out of these two units were selected randomly for data collection. In case the poultry farm was not available in the selected villages, two poultry farm in the district were taken for data collection by both enquiry and observation methods.

3.7.5 Selection of wholesalers: A list of market yards/mandies at the district headquarter was prepared and one grain mandi and one fruits/vegetables mandi were selected randomly. The market yard/mandi was enumerated and two wholesalers for each commodity were selected randomly from the list. Priority was given to the wholesalers handling more than one crop/commodity.

3.7.6 Selection of retailers: A list of main retail markets at district headquarters including the retail fruit and vegetable markets was prepared. One market for food grains and another market for fruits and vegetables were randomly selected and enumerated. Two retailers were selected randomly for each allocated crop giving priority to the retailer handling more than one crop.

3.7.7 Selection of processing units: A list of processing units for the identified crops/livestock produces was prepared for each district and two units were selected randomly for each crop/commodity. In case the processing unit was not available in the identified districts, units located in neighboring district were taken.

The number of respondents (farmers) for different farm operations and sample size (total number of responses) whose data have been used for estimation of loss during storage in different channels of each crop/commodity have been tabulated in the *Appendices-II* and *III,* respectively.

The plan of the study was made to represent as much of production bases of the selected commodities as was possible. In some cases, however, representation was comparatively less due to operational difficulties like concentration of production in particular pockets of district. In case of apple, for example the study represented as high as 52.09% of the production base, while the representation was as low as 1.13% in case of coriander. For food grains and oilseeds production area represents between 1.24% (safflower) to 22.95% (cottonseed). Low representations in case of few commodities are because of lower level of production/processing units allotted to the centers and less number of centers specializing in livestock produce for the study. The actual commodity-wise coverage of production bases at the completion of the study has been tabulated in *Appendix-IV.*

CHAPTER IV
DATA COLLECTION AND SCRUTINY

Success of a survey depends mainly on the manner of collecting requisite and relevant information. It is therefore essential to develop or adopt appropriate format in which information has to be recorded. Questionnaires/ schedules were adopted from previous study with minor modifications and updation to collect the data by both enquiry and observations. The data were collected in the schedules by the trained field investigators of the respective AICRP on PHT centers and were sent for scrutiny and digitization. Survey schedules and data collection methods are described below.

4.1 Data Collection by Enquiry

Five schedules were prepared for data collection by enquiry. The schedules 1and 3 were for complete enumeration of the selected villages and market channels, respectively. Based on the enumeration, farmers and respondents from market were selected. Schedule 2A was for collection of loss data from farm operations such as harvesting, collection, threshing/ dehusking, sorting/ grading, winnowing/ cleaning, drying, packaging and transportation. Data of losses during storage at farm/ household level and market channels were collected in Schedules 2B and 4, respectively. All schedules are attached in *Appendix-I*.

4.1.1 Complete enumeration of households of the selected village (Schedule 1)

This schedule was filled with information of the all households in the selected village at the beginning of survey. The information collected in this schedule were identification of particulars such as agro-climatic zone, state, district, tehsil, block, name of village etc and details of farmer including operational holding, crop/commodities grown or expected to grow in current year, area under crop etc. Information regarding new post-harvest technologies adopted by the farmer in past 10 years and their benefit was also recorded. Every household of the selected villages was enumerated in this schedule and the selection of farmers for data collection was carried out based on information collected in this schedule.

4.1.2 Losses during farm operations by enquiry (Schedule 2A)

It covers the data collected by enquiry for losses during harvesting and other farm operation prior to storage. The data were collected at the time of harvest or within one week after harvest. Subsequent visits were made to record the loss in other operations. Season of crop was also recorded. In case the crop was grown more than once in a year, the data of losses were recorded for each harvest. In case of fruits, plantation crops, meat, fish, egg & poultry, multiple harvesting within the considered year was performed. The field investigator therefore visited at the end of each operation or within 5 days from completion of operation of at least three harvests (preferably first harvest, middle harvest and final harvest). The data for operation, method of operation, equipment used, quantity handled and quantity lost

etc. were recorded. Reasons of loss for each operation were also recorded. The farmers were interviewed and asked to give their superior judgment about the quantitative loss in each farm operation.

4.1.3 Losses at producer level during storage (Schedule 2 B)

This schedule was prepared to collect the data of losses during storage at farmers' level. The periodicity of data collection was once in every month for durables and continued for a year. Available stocks from previous year, addition/ withdrawal, total quantity stored, and loss during the inquiry period were recorded. Type of storage and causes of loss were recorded carefully after cross-verification. More visits within a month in case of fruits, vegetables and plantation crops were undertaken, as storage periods at farmers' level were expected to be less than a month. Design of this schedule automatically checks the validity of data because the total quantity stored at one visit should be equal to the previous balance in the next visit. In case of any difference, the corrections in data were made for maintaining accuracy.

4.1.4 Complete enumeration of market channels (Schedule 3)

This schedule was to enumerate the market channels after selecting the mandi, retail market, processing units etc. In this schedule, name of stockiest/ retailer/ processing unit/ godown and its address, crop/commodity handled, types of storage structure were recorded. Wholesalers, retailers, processing units and godowns were selected by the concerned AICRP on PHT center for recording the data.

4.1.5 Losses during storage at market level (Schedule 4)

This schedule was for recording the losses by enquiry during storage at market level. The frequency of data collection was once in every month for durables and continued for one year. Type of storage, quantity stored, withdrawal, addition, losses during storage, total quantity stored and causes of loss etc were also recorded. In case of processing units, the loss was recorded till the crop/commodity was in store and not processed. Design of this schedule automatically provides check for validity of data. In case of fruits, vegetables and plantation crops, frequent visits within a month were made as the storage periods were expected to be quite less.

This survey was planned to cover one-year crop cycle for all selected crops and livestock produce. Complete enumeration of the selected villages and market channels began in October 2012. Based on the enumeration reports, some of the villages were replaced with other villages of same block because of non-availability of selected crops. The data collection by enquiry and observation started in December 2012 and was completed in June 2014.

4.2 Data Collection by Observation

Survey schedules for data collection by observation developed in the previous study (Nanda et al, 2012) were adopted with minor modifications based on experience. AICRP on PHT centers were asked to provide copy of guidelines to all field investigators and supervising scientists.

Altogether 18 schedules were developed for data collection by observation. These schedules were grouped into two categories namely data collection by observation in farm operations (group of schedule

number 5, total 12 schedules) and data collection by observation during storage at farm and market channels (group of schedule 6, total 6 schedules). A brief description of schedules and type of data collected is described here under different subsections.

4.2.1 Losses at farm level in cereals and coriander (Schedule 5-C)

This schedule was for data collection of losses during harvesting, threshing and cleaning/ winnowing of wheat, paddy, sorghum, bajra, maize and coriander due to similarity in operational protocols. Particulars of farmers, selected fields, variety of crops, soil conditions, dates of sowing, harvesting dates, method of harvesting, equipment used, etc were recorded. In case of traditional harvesting, manual harvesting or harvesting with reaper, a plot of 5m×5m / 2m×10m was demarcated and harvested with the method exactly followed by the farmer. Harvested crop was collected separately; fallen grains were collected and weighed or counted as case may be. Yield of the demarcated plot was recorded after threshing it separately.

In case of harvesting the crop with combine harvester, the production from demarcated field was recorded after completion of harvesting operation. After measuring actual area of the selected field in which harvesting was carried out by combine harvester, the yield from 5m×5m/ 2m×10m plot was estimated. Thereafter a plot of 5m×5m or 2m×10m as applicable was demarcated in the harvested field. The fallen grains from the demarcated area were collected and weighed or counted as the case may be.

For estimating the loss during threshing/shelling, the harvested crops of 5m×5m/ 2m×2m were threshed following the usual practice by the farmer. The produce and straw were weighed separately. A sample of 250g straws was drawn and grains coming in the straw were separated and weighed or counted.

To estimate the losses during cleaning/winnowing a sample of 10kg uncleaned grains-straw mixture was drawn or complete grain-straw mixture obtained from the demarcated plot of 5m×5m / 2m×10m after threshing was taken. Winnowing/cleaning of the lot was performed using the method followed by the farmer. Grain and straws were collected separately. A sample of 250g drawn from the straws and grains escaped with the straws were separated and counted/ weighed.

4.2.2 Losses at farm level in oilseeds and pulses (Schedule 5-O)

Pulses and oilseeds belong to the family of Leguminosae and these are dicotyledonous crops. Therefore these crops were grouped together and schedule was prepared for collecting the loss data during harvesting, threshing and winnowing stages of oilseeds and pulses (mustard, soybean, groundnut, sunflower, safflower, cottonseed, pigeon pea, chickpea, green gram and black gram).

For estimating losses during harvesting (for pulses and safflower), a plot of 5m×5m was demarcated and loss was estimated by the method followed for cereals. In case of groundnut, the plants of 5m×5m plot were uprooted by the method followed by the farmer and pods obtained from the plants as well as pods left in the soil were collected and weighed. This resulted in the production from demarcated 5m×5m plot. Again another plot of 5m×5m was demarcated after a few days when farmer stopped ploughing and

picking the left over pods. The weight/numbers of remaining pods in the soil of demarcated area were recorded.

For mustard and soybean, 5m×5m area was demarcated in a field and 10 plants were randomly taken out from the selected area. Number of siliques/ pods present in each plant including shattered siliques/ pods, if any, were counted. Farmer was then allowed to harvest the complete field including the demarcated plot as usual. When all harvested crop of the field reached to the threshing floor, 10 plants were randomly selected once again after ensuring that the selected plants contain all branches and have been harvested from main stem. Number of shattered siliques/pods of each selected plant were counted and recorded.

For sunflower, same size of area was demarcated and ten plants were selected as followed in case of mustard crop. Number of seeds present in each plant prior to harvest were counted and the flowers were marked. The farmer was then allowed to harvest the crop by his own method. After harvesting and before collecting the flowers for transporting to threshing floor, the same marked flowers were taken once again and numbers of seeds shattered from each flower were counted and recorded.

In case of cottonseed, the farmer was allowed to pick the cotton bolls with usual practice. After last picking, a plot of 5m×5m was demarcated from which 10 plants were selected randomly. Number of bolls already plucked and opened balls remaining unplucked were counted in each plant and recorded. Thereafter the bolls fallen on ground and unplucked open ones near or in the selected plants were collected and weighed to record as losses in harvesting. Then total number of cotton bolls obtained from 10 selected plants were calculated and weight was recorded as production from the selected plants.

For estimating the loss during threshing for pulses, safflower and groundnut, harvested crop of 5m×5m / 2m×10m plot was demarcated and threshed with the method followed by the farmer. The grain/pod and straw obtained after threshing were weighed separately. A sample of 250g straws was drawn and analyzed. The number/ weight of seeds in the straw were counted/ weighed. In case of sunflower, mustard and soybean, a sample of 3 bundles of harvested crop of the same field were drawn, threshed and analyzed with the method similar to that of cereals.

To estimate loses during cleaning/ winnowing; the methodology was same as that for cereals. In cottonseed, losses during threshing and cleaning/ winnowing were not estimated because these operations are not performed at farmers' field.

4.2.3 Losses at farm level in fruits and plantation crops (Schedule 5-H)

Data on losses during farm operations such as harvesting, grading/sorting and transport of fruits and plantation crops were included in this schedule.

To estimate the losses during harvesting, the fruits were harvested from the selected trees using the method followed by the farmer. Multiple picking is common in some fruits, and therefore data of multiple pickings were recorded, if available at the farmer place. Productions from all selected trees were recorded after each harvest. The harvested produce was thereafter analyzed for damages and injuries during

harvesting, bird eaten, immaturity etc. The fruits not suitable for human consumption and thrown during the operation were taken as loss in this case. Causes of such loss were also recorded.

For estimating the losses during grading/sorting a sample of 10kg / 50 numbers of fruits were drawn randomly and graded or sorted following the usual method of farmer. The number/quantity of damaged or discarded fruits during this operation was recorded.

To estimate the loading, transportation and unloading loss (farm to market), a sample of 10 kg or 50 number or 5 boxes (if packed in boxes) were drawn randomly after unloading in the market. The undamaged and spoiled pieces were separated and their weights/numbers were recorded.

For Cashew, the sample size for loss estimation during grading/sorting and transport was taken 5 kg and methodology was followed similar to that of the fruit.

4.2.4 Losses at farm level in vegetable crops (Schedule 5-V)

Data on loss during farm operations in vegetables were collected in this schedule. For estimating losses during harvesting, a plot of 5m×5m / 2m×10m was demarcated and harvested with the method followed by the farmer to get the production data of the demarcated plot. To estimate the losses, the methods followed are described below.

For onion, potato and turmeric, in case of manual harvesting, the leftover produces in the soil of the demarcated plot were collected. In case of mechanical harvesting, the production of 5m×5m plot was recorded as usual and then again a plot of 5m×5m (excluding the already selected plot) was demarcated and the leftover produce in the soil from the plot was collected.

In chili and tomato, the crop was harvested from the demarcated 5m×5m / 2m×10m plot following the usual method. The harvested produces of selected plot were analyzed for damages. The produce fallen on the ground were also collected. Weight of damaged produce and fallen one gave the loss in demarcate plot during harvesting. For cabbage, mushroom, cauliflower and green pea, the losses during harvest were not estimated by observation. In these cases estimates were given by the Research Engineers through visual observation after harvesting of complete field.

For Tapioca, 10 plants in a row (continuous) in place of 5m×5m / 2m×10m plot were taken to estimate the loss during harvest. Harvesting was performed using the practice followed by the farmer. The leftover produce in the soil of the area of 10 selected plants were collected and taken as loss. To estimate the loss during grading/ sorting, the operation actually performed for tapioca is termed as trimming. Sample of 50 kg tapioca was drawn in place of 10kg / 50 numbers and the weights of produce/ part of produce rejected during trimming were recorded as loss.

For estimating the loss during grading/sorting and transportation of vegetables, the same methodologies as for fruits were followed. Samples of 10 kg were taken in case of green pea, mushroom, onion, potato and tomato, whereas 50 units were taken for estimating losses of cabbage and cauliflower. Weight of 50 fruits and damaged parts (leaves of cabbage, broken buds, crushed flowers etc.) separated from the selected pieces were recorded to estimate the loss.

4.2.5 Losses of black pepper at farm level (Schedule 5-Pepper)

To estimate the losses during harvest, four vines of black pepper were selected as was followed for fruits/ plantation crops. To estimate the loss during threshing, 5 kg of unthreshed produce was taken and threshed using the method followed by the farmer. Other procedures and methodologies were similar to that followed for cereals. For loss during winnowing/ cleaning, a sample of 5 kg uncleansed black pepper was taken and cleaned with the method followed by the farmer. Other procedures were similar to that of cereals.

4.2.6 Sugarcane losses at farm level (Schedule 5-S)

This schedule was used for estimation of loss in farm operations of sugarcane. In estimating the loss during harvest, a plot of 5m×5m was demarcated and then farmers were allowed to harvest their field. The produces of the demarcated plot were collected separately and weighed to get the production data. After harvesting, the stubbles left in the demarcated plot were separated and collected. Weight of stubbles and unpicked sugarcane pieces in the demarcated area gave the losses during the harvest.

To estimate the loss during staling of sugarcane, three bundles of sugarcane were prepared and weighed in the field. The weighed bundles were transported to the crushing unit/ sugar mills following the usual practice and kept them in the crushing yard till the farmer/mill went for crushing. These bundles were weighed again immediately before crushing. The period of staling was the time elapsed between bundling and immediately before crushing. The difference in the weight of bundles gave loss during staling.

4.2.7 Losses of egg at producer level (Schedule 5-E)

Data on losses during collection and packaging of eggs at poultry farm were collected in this schedule. One poultry shed of the poultry farm was selected randomly. The workers were allowed to collect all the eggs laid in the selected shed. Total number of eggs collected and damaged one were counted separately and recorded. To estimate the loss during packaging, the worker was allowed to pack the collected eggs of the selected shed and total numbers of eggs packed and damaged during the operation were counted.

4.2.8 Losses of inland fish at fisherman level (Schedule 5-IF)

Catching of fish was considered as harvest operation for fish. This schedule was prepared to collect the data of loss during catch of inland fish. To record the losses during catch of inland fish, weight of total catch on the date of visit was recorded and then the fisherman was asked to sort the fish (fishes not fit for human consumption) and the same were recorded for computation of losses.

4.2.9 Losses of marine fish at landing centre (Schedule 5-MF)

This schedule was prepared to record the loss of marine fish at the landing center. After unloading of fish from boat and weighing the total fish landed, the boat was checked for any fish left in the boat. The

fishes (uneconomical/small fish, damaged or spoiled one) remained in boat, were weighed and losses were computed.

4.2.10 Losses of meat at producer level (Schedule 5-M)

Slaughter of animal was considered equivalent to harvesting operation. The data of loss during slaughtering of animal were collected in this schedule. Two butcher's shop and two slaughtering houses (organized) were selected in a district. The data on losses during slaughtering were collected once in every month for one year. To record the loss during slaughtering, the data of 5 animals slaughtered continuously were recorded. After slaughtering and dressing (removal of offal), weight of fresh carcass was taken. Parts of carcass removed by the butcher, which was not considered fit for human consumption due to damages, injury, diseased parts etc, were weighed and losses were computed.

4.2.11 Losses of poultry meat at producer level (Schedule 5-PM)

Data on loss of poultry meat during slaughtering (harvesting) and storage at poultry meat producer level were collected in this schedule. Two slaughter houses and two butcher's shop, where poultry birds were slaughtered, were taken in each district for data collection. The frequency of data collection was once in every month for one year. To estimate the loss, the methodology followed was the same as that of meat.

To estimate the loss during storage, the type of storage, capacity etc used for storing dressed chicken was recorded. Five number of chicken (carcass) were randomly drawn from the store and checked for their condition. Weight of these five carcasses, their spoiled portions was taken and losses during storage were computed.

4.2.12 Post-harvest losses of milk (Schedule 5- Milk)

Estimation of loss in milk was difficult to record by observation method. Therefore loss at each stage was assessed by the Research Engineer /Associates of the project personally and reported the same.

4.3 Observation Schedules for Data Collection in Storage Channels

Estimation of losses during storage at farm and in market channels were recorded systematically in these observation schedules. For estimating losses during storage of cereals, pulses, oilseeds and coriander, samples were drawn from the stored produce (when respondent allowed for taking the sample). These samples were brought to the concerned AICRP on PHT center, where analyses of the samples were carried out to estimate the losses. In case of fruits, vegetables, plantation crops, egg, and fish, the appropriate size of samples were taken from the stored material of respondent. Analysis of samples were carried out on the spot and samples were returned to the respondent. Schedules and type of data collected for losses during storage of different crops/commodities by observations are briefly described hereunder.

4.3.1 Losses during storage in different channels for cereals, pulses, oilseeds and coriander (Schedule 6-C)

Data on losses during storage of cereals, pulses, oilseeds and coriander at farm level and different

channels were collected in this schedule. Samples of 50-100 g were taken every month (if withdrawl was done by the farmer during the enquiry period) subject to the availability with the respondent and willingness to provide the same. Addition in the stock, consumption, sale or processed stock in the previous month and remaining stock were recorded for the enquiry period. The samples were packed into polythene bags with the identity slips. These samples were brought immediately to concerned AICRP on PHT center for further analysis after filling the identity slip for the sample in schedule 6-C1. Parameters such as moisture content, 1000 grains weight, number of undamaged grains, and infested/damaged grains and their weight were recorded in schedule 6-C2 for computing losses during storage.

4.3.2 Losses during storage in different channels of fruits, vegetables and plantation crops (Schedule 6-H)

The data on losses during storage of fruits, vegetables and plantation crops in different channels were recorded in this schedule. The storage periods for some of these crops were less than one month in all channels. In those cases, the field investigator visited the respondent at the time of disposal even before one month. To estimate loss during storage, the data about increase or decrease owing to additional harvest / procurement or sale / consumption / quantity processed were recorded. Then, a sample of 10 kg or 50 numbers or 3 packets, whichever was applicable to produce, were drawn (when respondent allowed drawing the sample). The damaged produces were separated and weighed/counted. For Cashew, a sample of 5 kg was drawn for loss estimation and methodology for sample analysis remained the same as that of fruits/vegetables.

Loss during storage was not estimated by observation for black pepper because of high product cost and farmers were not willing to provide the sample.

4.3.3 Egg Losses during transportation and storage in different channels (Schedule 6-E)

This schedule was to collect the data on losses of eggs by observation during transportation and storage at wholesaler and retailer level. For estimating the loss during transportation, mode of transport, total distance of transportation and time taken for transportation (days) were recorded. At the time of unloading, 5 packages of filler flats were selected randomly. Total numbers of eggs present and number of damaged eggs in the selected filler flats were counted. For estimating loss during storage, five packages of filler flats were selected randomly from the store and numbers of eggs present and damaged were counted for the purpose.

4.3.4 Losses at market level storage and transportation of inland fish (Schedule 6-IF)

The loss during transport at the time of unloading at market/ processing unit and storage at market/processing unit were recorded in this schedule for inland fish. To record the loss during transportation a sample of 10 kg fish or complete pack (whichever is allowed by the respondent) was drawn and weighed. The fish spoiled during transport/storage were sorted and weighed for computation of losses during transport and storage.

4.3.5 Market level storage, drying and transportation loss of marine fish (Schedule 6-MF)

Data on loss during transportation, drying and storage of marine fish were collected in this schedule. The methodologies for transportation and storage were similar to that of for inland fish (schedule 6-IF). Data were collected during each operation performed by farmers themselves.

To estimate the loss during drying, the details of drying method and other particulars were also recorded. A sample of 5 kg was drawn randomly from the fish kept for drying. The spoiled fishes due to drying operation were weighed and losses were computed.

CHAPTER V
DATA ANALYSIS

Key of success of any survey is the way data are collected and analyzed. Number of respondents, volume of data, variables and inferences to be drawn from the analysis actually drive the methods, tools and techniques to be used for analysis of data. Here main aim was to compute post-harvest losses at national level form the data collected from fields at farm, block and district levels and then pooling them at agro–climatic zone and national levels. This chapter briefly describes data analysis techniques, formula and equations used for computing the post-harvest loss and errors in the same.

5.1 Analysis Tools and Techniques

The data collected by the designated AICRP on PHT centers were entered in data entry software developed by ICAR-IASRI, New Delhi. In this software, functionality of internal consistency checks of data at the time of data entry were inbuilt. The digital data were sent by the centers to PC (PHT) unit for further scrutiny and analysis.

The data received from centers were scrutinized for any discrepancies and errors during their collection and entry. Wherever there were inconsistencies, possible corrections were made after referring records in the filled schedules of concerned centers and revalidating the same by resending field investigators to field. If it was not possible to rectify the errors/ discrepancies, data were discarded.

The scrutinized data of enquiry method were analysed using Statistical Analysis Software (SAS) whereas data obtained by observation method were analysed using advance version of Microsoft Excel at district level and results were pooled by assigning appropriate weights at agro-climatic zone levels. In this analysis, sampling weights were obtained for each record according to sampling design implemented for data collection at district level (i.e. weightage of sample, no. of farmers, villages and blocks to their actual number).

For estimating the losses at agro-climatic zone level, weightage was assigned based on the production of the specific crop/commodity in all the sampling districts, obtained separately from the state report. Similarly, post-harvest losses at the national level were estimated by assigning weightage on the basis of the production of a specific crop/commodity in all the agro-climatic zones in which data for a particular crop and operation were collected. The procedure for analysis of data is described below and the symbols and notations used have been explained in the end of this chapter.

5.2 Data Analysis Procedure

The estimation of losses were carried out at district level for enquiry and observation separately before pooling at agro-climatic zone level. Thereafter both data were merged to obtain final estimates of loss at district level. Then inquiry and observation data were pooled separately at agro-climatic zone level and final estimates of losses at agro-climatic zone level were obtained by merging enquiry and

observation estimates. National level estimates of losses were obtained by pooling the final estimates of agro-climatic zone levels.

Different standard mathematical equations and formulas employed to estimate the harvest and post-harvest losses at various levels are described hereunder different subheads:

5.2.1 Estimation of loss in farm operations

After maturity of crop, usually complete produce pass through a series of farm operations (harvesting, collection, sorting/grading, threshing, winnowing, drying, packaging and transportation). Each operation is performed separately and hence the losses are also different. Therefore the estimation procedures of farm operations and storage channels were different and have to be computed separately both for data obtained by inquiry and observation method.

5.2.1.1 Estimation of loss at district level

Data collected by inquiry: Total quantity of a crop/commodity handled for a particular farm operation in a district was obtained using Eqn. 5.1.

$$\hat{\bar{Y}}_i = \frac{B_i}{b_i}\sum_{b=1}^{b_i}\frac{V_{ib}}{v_{ib}}\sum_{v=1}^{v_{ib}}\frac{F_{ibv}}{f_{ibv}}\sum_{f=1}^{f_{ibv}} y_{ibvf} \qquad (5.1)$$

In the preceding equation, the quantity of produce handled in a given farm operation by a farmer is taken to the total quantity handled at the village level, then to the block level and finally to the district level. Total quantity of the crop/commodity lost in the same farm operation in a particular district can be computed using Eqn. 5.2.

$$\hat{\bar{\delta}}_i = \frac{B_i}{b_i}\sum_{i=1}^{b_i}\frac{V_{ib}}{v_{ib}}\sum_{v=1}^{v_{ib}}\frac{F_{ibv}}{f_{ibv}}\sum_{f=1}^{f_{ibv}} \delta_{ibvf} \qquad (5.2)$$

In Eqn. 5.2, the quantitative loss in a given farm operation was taken from farmer level through the village block and finally to the district level. The loss (%) obtained by enquiry for the crop/commodity in i^{th} district was estimated by dividing the total quantity lost by the total quantity handled, using the Eqn. 5.3.

$$\hat{\bar{L}}_i = \frac{\hat{\bar{\delta}}_i}{\hat{\bar{Y}}_i} X100 \qquad (5.3)$$

Estimated variance of $\hat{L}_i$ was calculated using Eqn. 5.4, after ignoring higher order terms:

$$\hat{\bar{V}}\left(\hat{L}_i\right) = \left(\frac{\hat{\bar{\delta}}_i}{\hat{\bar{Y}}_i}\times 100\right)^2 \left(\frac{\hat{V}\left(\hat{\bar{\delta}}_i\right)}{\left(\hat{\bar{\delta}}_i\right)^2} + \frac{\hat{V}\left(\hat{\bar{Y}}_i\right)}{\left(\hat{\bar{Y}}_i\right)^2}\right) \qquad (5.4)$$

in which the estimate of variance of $\hat{\bar{\delta}}_i$ and $\hat{\bar{Y}}_i$ were obtained using the Eqn. 5.5 and the following expressions.

$$\hat{V}\left(\hat{\bar{X}}_i\right)=\frac{1}{b_i(b_i-1)}\sum_{b=1}^{b_i}\left(\hat{X}_{ib}-\hat{\bar{X}}_i\right)^2 \qquad (5.5)$$

where,

$$\hat{X}_{ib}=\frac{V_{ib}}{v_{ib}}\sum_{v=1}^{v_{ib}}\frac{F_{ibv}}{f_{ibv}}\sum_{f=1}^{f_{ibv}}x_{ibvf}$$

$$\hat{\bar{X}}_i=\frac{1}{b_i}\sum_{b=1}^{b_i}\hat{X}_{ib}$$

where $\hat{\bar{X}}_i$ is the mean of variable (Quantity handled or Quantity lost) for i^{th} district and X_{ib} is estimate of quantity handled/lost for b^{th} block in i^{th} district.

Data collected by actual observation: The estimates of quantity handled for an operation of a crop/commodity in the district was obtained in a manner similar to that of the data collected by inquiry, by using the following estimator (Eqn. 5.6).

$$\hat{\bar{Y}}_i'=\frac{B_i}{b_i}\sum_{b=1}^{b_i}\frac{V_{ib}}{v_{ib}}\sum_{v=1}^{v_{ib}}\frac{F_{ibv}}{f_{ibv}}\sum_{f=1}^{f_{ibv}}y'_{ibvf} \qquad (5.6)$$

Similarly, estimate of quantity lost was obtained by Eqn. 5.7.

$$\hat{\bar{\delta}}_i'=\frac{B_i}{b_i}\sum_{b=1}^{b_i}\frac{V_{ib}}{v_{ib}}\sum_{v=1}^{v_{ib}}\frac{F_{ibv}}{f_{ibv}}\sum_{f=1}^{f_{ibv}}\delta'_{ibvf} \qquad (5.7)$$

and the percentage loss for the district was calculated by Eqn. 5.8.

$$\hat{\bar{L}}'_i=\frac{\hat{\bar{\delta}}_i'}{\hat{\bar{Y}}_i'}\times 100 \qquad (5.8)$$

Estimate of variance of $\left(\hat{L}\right)$ was obtained by the Eqn. 5.9 (after ignoring higher order terms).

$$\hat{\bar{V}}\left(\hat{L}_i'\right)=\left(\frac{\hat{\bar{\delta}}_i'}{\hat{\bar{Y}}_i'}\times 100\right)^2\left(\frac{\hat{V}\left(\hat{\bar{\delta}}_i'\right)}{\left(\hat{\bar{\delta}}_i'\right)^2}+\frac{\hat{V}\left(\hat{\bar{Y}}_i'\right)}{\left(\hat{\bar{Y}}_i'\right)^2}\right) \qquad (5.9)$$

in which, the estimate of variances of $\hat{\bar{\delta}}_i$ and $\hat{\bar{Y}}_i$ were obtained employing Eqn. 5.10.

$$\hat{V}\left(\hat{X}_i'\right)=\frac{1}{b_i(b_i-1)}\sum_{b=1}^{b_i}\left(\hat{X}_{ib}'-\hat{\bar{X}}_i'\right)^2 \qquad (5.10)$$

where X is a variable for quantity handled / quantity lost in i^{th} district as expressed below:

$$\hat{X}_{ib}'=\sum_{v=1}^{v_{ib}}\sum_{f=1}^{f_{ibv}}x_{ibvf}'$$

$$\hat{\bar{X}}_i'=\frac{1}{b_i}\sum_{b=1}^{b_i}\hat{X}_{ib}$$

Pooling of data obtained through enquiry and observation: In order to estimate the loss during farm operations at district level for different crops/commodities, the loss (%) through inquiry and through observation were pooled using weighted estimator (Eqn. 5.11):

$$\hat{\bar{L}}_i^{(c)}=\frac{\hat{\bar{S}}_i'^2\hat{\bar{L}}_i+\hat{\bar{S}}_i^2\hat{\bar{L}}_i'}{\left(\hat{\bar{S}}_i'^2+\hat{\bar{S}}_i^2\right)} \qquad (5.11)$$

The standard error of estimate of percent loss for the above pooled equation was obtained using Eqn. 5.12.

$$\hat{\bar{S}}_i=\sqrt{\frac{\hat{\bar{S}}_i^2\hat{\bar{S}}_i'^2}{\hat{\bar{S}}_i^2+\hat{\bar{S}}_i'^2}} \qquad (5.12)$$

5.2.1.2 Estimation of loss in farm operations at agro-climatic zone level

Data collected through enquiry: The estimate of loss of a crop/commodity in a farm operation at agro-climatic zone level was carried out using Eqn. 5.13.

$$\hat{\bar{L}}_z=\frac{\sum_{i=1}^{d}\hat{P}_{iz}\times\hat{\bar{L}}_{iz}}{\sum_{i=1}^{d}\hat{P}_{iz}} \qquad (5.13)$$

In the Eqn. 5.13, the loss at district level was taken to agro-climatic zone level by weighted average of production of the selected districts.

Data collected through actual observation: The estimate of loss of a crop/commodity in a farm operation at agro-climatic zone level was estimated using Eqn. 5.14.

$$\hat{\bar{L}}_z'=\frac{\sum_{i=1}^{d}\hat{P}_{iz}\times\hat{\bar{L}}'_{iz}}{\sum_{i=1}^{d}\hat{P}_{iz}} \qquad (5.14)$$

The standard error of estimate of loss for data collected through inquiry / observations were computed using Eqn. 5.15.

$$\hat{\bar{S}}_z = \sqrt{\frac{\sum_{i=1}^{d} P_{iz}^2 \hat{V}(\hat{\bar{L}}^*_{iz})}{\left(\sum_{i=1}^{d} P_{iz}\right)^2}} \qquad (5.15)$$

where,

$\hat{\bar{S}}_{iz}$: standard error of estimate by using data of enquiry/observation in the ith district of zth Agro-climatic zone as using Eqns. 5.4 and 5.9.

$\hat{\bar{L}}^*_{iz}$: loss percent obtained by collecting data through enquiry/observations in the ith district falling in zth agro-climatic zone.

The estimate of loss (%) and its standard error for pooled data collected through enquiry and observation at agro-climatic zone level were obtained using estimator similar to Eqns. 5.11 and 5.12 respectively.

5.2.1.3 Estimation of Loss in farm operations at national level

Estimation of losses at national level in different farm operations were obtained from pooled estimates of loss (inquiry and observation) at agro-climatic zone level. The estimates of loss were obtained using weighted estimator Eqn. 5.16.

$$\hat{\bar{L}}_N^{(c)} = \frac{\sum_{i=1}^{a} \hat{P}_{iN} \times \hat{\bar{L}}_{iN}}{\sum_{i=1}^{a} \hat{P}_{iN}} \qquad (5.16)$$

where,

$\hat{\bar{L}}_N^{(c)}$ loss (%) of crop/commodity at national level,

$\hat{P}_{iN}$: production of crop/commodity in ith agro-climatic zone, and

$\hat{\bar{L}}_{iN}$: estimated loss (%) of crop/commodity after pooling the enquiry and observation data of ith agro-climatic zone.

The standard errors of estimated loss at national level were obtained using Eqn. 5.17.

$$\hat{\bar{S}}_N = \sqrt{\frac{\sum_{i=1}^{a} \hat{P}_{ia}^2 \hat{V}(\hat{\bar{L}}^*_{ia})}{\left(\sum_{i=1}^{a} \hat{P}_{ia}\right)^2}} \qquad (5.17)$$

Production data of some of the crops were not available at district level and agro-climatic zone level. In such cases, the number of observations were taken in place of production to obtain standard error using Eqn. (5.17) and simple averages were taken to estimate the loss.

5.2.2 Estimation of loss during storage

In order to estimate loss percent from the data collected through enquiry and observation, district-wise estimates were computed separately and then pooled through optimum pooling technique.

5.2.2.1 Estimation of farm level storage loss at district level

Data collected through enquiry: Total quantity of crop/ commodity withdrawn in a district was computed using Eqn. 5.18

$$\hat{\bar{P}}_i = \frac{B_i}{b_i}\sum_{b=1}^{b_i}\frac{V_{ib}}{v_{ib}}\sum_{v=1}^{v_{ib}}\frac{F_{ibv}}{f_{ibv}}\sum_{f=1}^{f_{ibv}}\left(\sum_{t=1}^{T} p_{ibvft}\right) \qquad (5.18)$$

and the estimated total quantity lost in the i^{th} district was calculated using Eqn. 5.19.

$$\hat{\bar{\zeta}}_i = \frac{B_i}{b_i}\sum_{b=1}^{b_i}\frac{V_{ib}}{v_{ib}}\sum_{v=1}^{v_{ib}}\frac{F_{ibv}}{f_{ibv}}\sum_{f=1}^{f_{ibv}}\left(\sum_{t=1}^{T} \zeta_{ibvft}\right) \qquad (5.19)$$

The loss (%) through enquiry in i^{th} district was estimated using following formula (Eqn. 5.20), and

$$\hat{\bar{L}}_i = \frac{\hat{\bar{\zeta}}_i}{\hat{\bar{P}}_i}\times 100 \qquad (5.20)$$

the estimated variance was obtained using Eqn. 5.4.

Data collected through observation: Formulae to estimate the loss (%) for data collected through observation used was Eqn. 5.21.

$$\hat{\bar{L}}_i' = \frac{\frac{B_i}{b_i}\sum_{b=1}^{b_i}\sum_{v=1}^{v_{ib}}\sum_{f=1}^{f_{ibv}}\left(\sum_{t=1}^{T} d_{ibvft}\right)}{\frac{B_i}{b_i}\sum_{b=1}^{b_i}\sum_{v=1}^{v_{ib}}\sum_{f=1}^{f_{ibv}}\left(\sum_{t=1}^{T} d_{ibvft} + \sum_{t=1}^{T} u_{ibvft}\right)}\times 100 \qquad (5.21)$$

and approximate estimate of variance of above estimator was given by Eqn. 5.22.

$$\hat{\bar{V}}\left(\hat{\bar{L}}_i'\right)=\left(\hat{\bar{L}}_i'\right)^2\left\{\frac{\left(\hat{\bar{S}}_i'(d_i)\right)^2}{\left(\frac{B_i}{b_i}\sum_{ib=1}^{ib}\sum_{ibv=1}^{ibv}\sum_{ibvf=1}^{ibvf}\left(\sum_{t=1}^{T}d_{ibvft}\right)\right)^2}+\frac{\left(\hat{\bar{S}}_i'(TG_i)\right)^2}{\left(\frac{B_i}{b_i}\sum_{ib=1}^{ib}\sum_{ibv=1}^{ibv}\sum_{ibvf=1}^{ibvf}\left(\sum_{t=1}^{T}TG_{ibvft}\right)\right)^2}\right\} \quad (5.22)$$

The estimate of variance of d_i (numerator part-I of Eqn. 5.22) and TG_i (numerator part-II of eqn. 5.22) were obtained as (Eqn. 5.23):

$$\hat{V}\left(\hat{\bar{X}}_i\right)=\frac{1}{b_i(b_i-1)}\sum_{b_i=1}^{b_i}\left(\hat{X}_{ib}-\hat{\bar{X}}_i\right)^2 \quad (5.23)$$

in which

$$\hat{X}_{ib}=\sum_{v=1}^{v_{ib}}\sum_{f=1}^{f_{ibv}}\sum_{t=1}^{T}x_{ibvft} \quad \text{and}$$

$$\hat{\bar{X}}_i=\frac{1}{b_i}\sum_{b=1}^{b_i}\hat{X}_{ib}$$

where X is the variable d_i or TG_i.

Merging the estimates loss percentages by the data collected through inquiry and observation were carried out using Eqns.5.11 and 5.12.

5.2.2.2 Estimation of loss in storage and marketing channels (Wholesaler, Retailer, Godown and Processing Unit) at district level

Data for this purpose were collected from respondents of different marketing channels selected using stratified multistage random sampling as described in Chapter 3. The estimate of loss (%) for different crops /commodity and its estimate of variance for data collected through inquiry were obtained using Eqns. similar to 5.18, 5.19 and 5.20.

Data collected by actual observation: Estimates of loss (%) for data collected through actual observation were obtained using Eqn.5.24:

$$\hat{\bar{L}}_i=\frac{\sum_{b=1}^{b_i}\sum_{t=1}^{T}d_{ibt}}{\left(\sum_{b=1}^{b_i}\sum_{t=1}^{T}d_{ibt}+\sum_{ib=1}^{ib}\sum_{t=1}^{T}u_{ibt}\right)}\times 100 \quad (5.24)$$

where $\hat{L}_i$ denotes loss in percent during storage in i[th] district.

The approximate estimate of variance was obtained as given in Eqn. 5.25:

$$\hat{V}\left(\hat{\bar{L}}_i'\right) = \left(\hat{\bar{L}}_i'\right)^2 \left\{ \frac{\left(\hat{\bar{S}}_i'(d_i)\right)^2}{\left(\sum_{b=1}^{b_i}\sum_{t=1}^{T} d_{ibt}\right)^2} + \frac{\left(\hat{\bar{S}}_i'(TG_i)\right)^2}{\left(\sum_{b=1}^{b_i}\sum_{t=1}^{T} TG_{ibt}\right)^2} \right\} \qquad (5.25)$$

The estimate of variance of *di* and *TGi* was obtained as given by Eqn. 5.23. Again, merging the estimates of loss from data collected through inquiry and observation were carried out using Eqns. 5.11 and 5.12.

5.2.2.3 Estimation of storage loss in different channels at agro-climatic zone level

After production of crop, the produce is distributed in different channels where it is stored or used for further processing and consumption. Production therefore may not be used as weights. The estimates of loss of a crop/commodity therefore during storage in a channel at agro-climatic zone level were estimated separately for inquiry and observation data using Eqn. 5.26.

$$\hat{\bar{L}}_s' = \frac{\sum_{i=1}^{d}}{d}\left(\hat{\bar{L}}_{iz}\right) \qquad (5.26)$$

in which

$\hat{\bar{L}}_s'$: loss during storage at agro-climatic zone level.

d : number of districts in z[th] agro-climatic zone.

The standard errors of estimate of storage loss for data collected through inquiry/ observation were obtained using Eqn. 5.27.

$$\hat{\bar{S}}_Z = \sqrt{\frac{\sum_{i=1}^{d}\hat{V}\left(\hat{\bar{L}}_{iz}\right)}{d}} \qquad (5.27)$$

The estimates of loss (%) and its standard error for pooled data collected by inquiry and observation at agro-climatic zone levels were obtained using estimator similar to Eqns. 5.11 and 5.12.

5.2.2.4 Estimation of storage loss in different channels at national level

National level estimates of losses in a channel were obtained from pooled data of loss at agro-

climatic zone level. The estimates of loss were obtained using Eqn. 5.28.

$$\hat{\bar{L}}_{SN}^{(c)} = \frac{\sum_{i=1}^{a} \hat{\bar{L}}_{iS}}{a} \qquad (5.28)$$

where

$\hat{\bar{L}}_{SN}^{(c)}$: loss during storage at national level.

a : Number of agro-climatic zones for selected crops.

The standard error of estimate at national level for each crop/commodity was computed using Eqn. 5.29.

$$\hat{\bar{S}}_{SN} = \sqrt{\frac{\sum_{i=1}^{a} \hat{V}\left(\hat{\bar{L}}_{is}\right)}{a^2}} \qquad (5.29)$$

5.3 Procedure for Estimation of Total Loss of Crop/ Livestock Produce at National Level

In order to estimate the overall total loss of a crop/livestock produce at national level, it is essential to know the quantity of crop/ commodity retention/handling in each operation and storage channels. Since, the total produce is handled in each of the farm operations, the total loss of a crop/ livestock produce in all farm operations was taken as arithmetic sum of losses in individual operations. However to estimate the total loss during storage in various marketing channels, data of percent retention in each market channel was required. Therefore the percent retention reported by Nanda et al (2012) in the previous study was used (Table 5.1).

Table 5.1: Estimates of percent storage of major crops and livestock produce in different channels at national level (Nanda et al, 2012)

S. No	Crop/ commodity	Retained by farmer	Stored in godowns	Retained by wholesaler	Retailer level storage	Stored in processing unit
Grains (Cereals, Pulses, Oilseeds)						
1	Paddy	33.2	6.6	15.5	2.7	42.0
2	Wheat	37.8	11.8	17.8	4.9	27.7
3	Maize	23.4	8.7	38.2	14.4	15.3
4	Bajra	39.2	4.5	36.6	10.6	9.1
5	Sorghum	22.7	4.9	59.8	10.9	1.7
6	Pigeon pea	57.7	4.5	9.7	10.0	18.1
7	Chick pea	23.5	8.1	37.2	13.5	17.7
8	Black gram	50.8	6.6	17.4	12.6	12.6

S. No	Crop/ commodity	Retained by farmer	Stored in godowns	Retained by wholesaler	Retailer level storage	Stored in processing unit
9	Green gram	33.2	0.5	30.0	27.2	9.1
10	Mustard	28.9	5.4	24.8	8.5	32.4
11	Cottonseed	8.3	4.2	56.4	10.5	20.6
12	Soybean	12.2	12.6	50.7	9.2	15.3
13	Safflower	5.6	4.0	28.0	5.0	57.4
14	Sunflower	1.7	2.5	22.3	4.2	69.3
15	Groundnut	9.4	6.7	40.2	10.1	33.6
Fruits						
16	Apple	1.9	8.2	51.3	21.3	17.3
17	Banana	2.6	5.0	77.2	14.9	0.3
18	Citrus	2.2	1.8	54.8	34.2	7.0
19	Grapes	0.3	14.6	33.7	39.7	11.7
20	Guava	20.2	0.0	31.0	47.6	1.2
21	Mango	4.4	1.9	36.8	34.7	22.2
22	Papaya	3.6	0.4	44.2	49.8	2.0
23	Sapota	1.1	9.6	42.7	41.8	4.8
Vegetables						
24	Cabbage	7.2	5.2	40.4	46.1	1.1
25	Cauliflower	5.5	7.6	46.0	39.6	1.3
26	Green pea	5.2	0.1	54.4	37.9	2.4
27	Mushroom	12.5	0.0	0.0	87.5	0.0
28	Onion	20.3	18.1	38.0	22.3	1.3
29	Potato	9.0	55.6	24.7	7.8	2.9
30	Tomato	26.3	0.0	39.7	25.7	8.3
31	Tapioca	4.0	0.0	46.6	43.7	5.7
Plantation crops and spices						
32	Arecanut	1.0	0.0	70.3	14.0	14.7
33	Black pepper	4.2	28.8	28.7	17.0	21.3
34	Cashew	1.9	0.9	31.6	5.8	59.8
35	Chilli	3.3	5.6	65.7	17.3	8.1
36	Coconut	7.1	11.4	41.5	14.8	25.2
37	Coriander	4.7	0.6	61.4	25.7	7.6
38	Sugarcane	8.9	0.0	19.4	5.0	66.7
39	Turmeric	12.0	23.0	45.5	9.1	10.4

S. No	Crop/ commodity	Retained by farmer	Stored in godowns	Retained by wholesaler	Retailer level storage	Stored in processing unit
Livestock produce						
40	Egg	5.2	0.4	56.2	37.5	0.7
41	Inland fish	4.4	1.0	34.5	60.0	0.1
42	Marine fish	0.1	15.1	43.7	15.6	25.5
43	Meat	1.0	1.1	47.3	50.5	0.1
44	Poultry meat	1.1	0.2	52.6	45.2	0.9
45	Milk	20.6	0.0	30.7	16.4	32.3

The total percentage loss of a crop/ commodity during storage in different channels was estimated using the Eqn. 5.30.

$$\hat{L}_{TS} = \frac{\hat{L}_F \times \hat{R}_F + \hat{L}_G \times \hat{R}_G + \hat{L}_W \times \hat{R}_W + \hat{L}_R \times \hat{R}_R + \hat{L}_P \times \hat{R}_P}{100} \qquad (5.30)$$

and the overall total loss of a crop/commodity at National Level was calculated adding the total loss in farm operations and total loss during storage in different channels.

5.4 Testing Statistical Significance of Difference between Losses of Present and Previous Study (conducted in 2005-07 by Nanda et al., 2012)

In order to test statistical difference between losses at α-level of significance, Z test was applied for individual operational channels. Let $\hat{L}_C^{(1)}$ denotes percent loss at channel/operation C in the previous study and $\hat{L}_C^{(2)}$ denotes percent loss in the same channel/operation in the present study. Also $\hat{V}_C^{(1)}$ and $\hat{V}_C^{(2)}$ denotes their estimated variance respectively. Then Z- test can be written as Eqn. 5.31.

$$Z = \sqrt{\frac{\hat{L}_C^{(1)} \quad \hat{L}_C^{(2)}}{\hat{V}_C^{(1)} \quad \hat{V}_C^{(2)}}} \sim Z_\alpha \qquad (5.31)$$

In this study, the test was applied at 5% level of significance. Further, based on this test 95% confidence intervals (1.96±SE) were also computed for each channel and reported.

Testing difference between overall total losses in studies: To test overall difference between percent of losses between two studies, analysis of variance (ANOVA) was performed. In this, year was considered as treatment i.e., one source of variation and channel was considered as blocks i.e., second source of variation. The ANOVA has been presented in Table 5.2.

Table 5.2: Analysis of variance for comparing the estimates of two studies

Source of variation	d.f.	Sum of square	Mean sum of square	F-value
Years	y-1	YSS	MYSS=YSS/Y-1	MYSS/MESS
Channels	c-1	CSS	MCSS=MCSS/C-1	MCSS/MESS
Error	(y-1)(c-1)	ESS	MESS=ESS/(Y-1)(C-1)	
Total	yc-1	TSS	MTSS	

The overall differences of pooled losses were tested at 5% level of significance using F-test. In case the variances of both studies were not statistically significant, t-test assuming equal variance was performed to check the significance of difference between overall total losses in two studies. When the variance of both studies were found statistically significant, t-test assuming unequal variance was performed.

5.5 Symbols and Notations used in the Analytical Tools

$\hat{\bar{Y}}_i$	Estimate of quantity handled for a particular farm operation of the crop/commodity in i^{th} district (by inquiry)
B_i	Total number of blocks in i^{th} district
b_i	Number of selected blocks in i^{th} district
V_{ib}	Total number of villages in b^{th} selected block of i^{th} district
v_{ib}	Number of selected villages in b^{th} selected block of i^{th} district for a farm operation
F_{ibv}	Total number of farmers growing a particular crop/commodity in v^{th} selected village of b^{th} selected block from i^{th} district
f_{ibv}	Number of selected farmers growing a crop/commodity in v^{th} selected villages of b^{th} selected block of i^{th} district for a farm operation
y_{ibvf}	Quantity handled for a farm operation of a crop/commodity by the f^{th} selected farmer in v^{th} selected village of b^{th} selected block of i^{th} district (by enquiry)
$\hat{\bar{\delta}}_i$	Estimate of quantity lost for a farm operation of a crop/commodity in i^{th} district (by enquiry)
δ_{ibvf}	Quantity of crop/commodity lost at a particular farm operation by the f^{th} selected farmer in v^{th} selected village of b^{th} selected block for i^{th} district (by enquiry)
$\hat{\bar{L}}_i$	Estimate of percent loss by enquiry for i^{th} district
$\hat{V}(\hat{\bar{L}}_i)$	Estimate of variance of percent loss by enquiry for i^{th} district
$\hat{V}\left(\hat{\bar{\delta}}_i\right)$	Estimate of variance of quantity lost (by enquiry) for an operation in the crop for i^{th} district
$\hat{V}\left(\hat{\bar{Y}}_i\right)$	Estimate of variance of quantity handled (by enquiry) for an operation in the crop for i^{th} district
$\hat{\bar{Y}}_i'$	Estimates of quantity handled at a particular farm operation of the crop/commodity in i^{th} district(by observation)
y'_{ibvf}	Quantity handled at a particular farm operation of the crop/ commodity of the f^{th}selected farmer in v^{th} selected village of b^{th} selected block of i^{th} district (by observation)
$\hat{\bar{\delta}}_i'$	Estimates of quantity lost for a particular farm operation of the crop/ commodity in i^{th} district (by observation)
δ'_{ibvf}	Quantity lost at particular farm operation of the crop/ commodity by the f^{th}selected farmer in v^{th} selected village of b^{th} selected block of i^{th} district (by observation)
$\hat{\bar{L}}_i'$	Estimate of percent loss by observation for i^{th} district
$\hat{V}(\hat{\bar{L}}_i')$	Estimate of variance of percent loss by observation for i^{th} district

$\hat{V}\left(\hat{\bar{\delta}}_i'\right)$	Estimate of variance of quantity lost (by observation) for an operation in a crop / commodity of i^{th} district
$\hat{V}\left(\hat{\bar{Y}}_i'\right)$	Estimate of variance of quantity handled (by observation) for an operation in a crop/ commodity for i^{th} district
$\hat{\bar{L}}_i^{(c)}$	Estimate of combined percent loss in a farm operation of i^{th} district for c^{th} crop
$\hat{\bar{s}}_i'$	Standard error estimate of loss% in a farm operation of i^{th} district obtained by observation.
$\hat{\bar{s}}_i$	Standard error estimate of loss% in a farm operation of i^{th} district obtained by enquiry.
n_i	Number of data points obtained through method of actual observation in a particular farm operation for a particular crop/commodity in i^{th} district
n_i'	Number of data points obtained through method of enquiry in a particular farm operation for a particular crop/commodity in i^{th} district
$\hat{\bar{S}}_i$	Estimate of standard error of combined loss% in a farm operation of i^{th} district
$\hat{P}_{iz}$	Production of crop/commodity for the i^{th} district falling in z^{th} zone in the agricultural year 2012-13
$\hat{\bar{L}}_{iz}$	Estimate of percent loss (by enquiry) of the crop/commodity in a farm operation for the i^{th} district falling in z^{th} zone
$\hat{\bar{L}}_z$	Estimated percent loss of the crop/commodity in a operation for z^{th} agro-climatic zone (by enquiry)
$\hat{\bar{L}}_{iz}'$	Estimate of percent loss (by observation) of the crop/commodity in the operation for the i^{th} district falling in z^{th} zone
$\hat{\bar{L}}_z'$	Estimated percent loss of the crop/commodity in an operation for z^{th} agro-climatic zone (by observation)
$\hat{\bar{L}}_N^{(c)}$	Loss percent of crop/commodity at national level.
$\hat{\bar{L}}_{iN}$	Estimated loss% of crop/commodity after pooling the enquiry and observation data of i^{th} agro-climatic zone.
$\hat{\bar{L}}_s'$	Loss during storage at agro-climatic zone level.
$\hat{\bar{L}}_{SN}^{(c)}$	Loss during storage at national level.
$\hat{P}_{iN}$	Production of crop/commodity in i^{th} agro-climatic zone
$\hat{\bar{s}}_{iz}$	Standard error estimate of loss% in a farm operation of i^{th} district in z^{th} agro-climatic zone by enquiry / observation
$\hat{\bar{S}}_z$	Estimate of standard error of loss percent in a farm operation of z^{th} agro-climatic zone by enquiry/observation
$\hat{L}_z$	Combined estimated percent loss of a crop/commodity in the operation of z^{th} Agro-climatic zone

$\hat{S}_z$	Combined standard error estimate of percent loss of a crop/commodity in a farm operation for z^{th} Agro-climatic zone
P_z	Production of crop/commodity for the z^{th} zone in the agricultural year 2013-14
$\hat{L}_N$	Estimated percent loss of the crop in an operation at National Level
$\hat{S}_N$	Standard error estimate of loss (%) of the crop in a farm operation at National Level
$\hat{\bar{P}}_i$	Total quantity withdrawal from the store of crop/commodity from selected farmers of the i^{th} district during total enquiry period.
p_{ibvft}	Quantity withdrawal from the storage of crop/commodity between previous and t^{th} visit to f^{th} selected farmer in v^{th} selected village of b^{th} selected block of i^{th} district (by inquiry)
$\hat{\bar{\zeta}}_i$	Estimate of total quantity loss of crop/commodity of selected farmers of the i^{th} district during total enquiry period.
ζ_{ibvft}	Quantity loss of crop/commodity between previous and t^{th} visit to f^{th} selected farmer in v^{th} selected village of b^{th} selected block of i^{th} district (by inquiry)
d_{ibvft}	Weight/number of crop/commodity damaged in the sample drawn at the time of t^{th} visit to f^{th} selected farmer in v^{th} selected village of b^{th} selected block of i^{th} district (by observation)
u_{ibvft}	Weight/number of crop/commodity undamaged in the sample drawn at the time of t^{th} visit to f^{th} selected farmer in v^{th} selected village of b^{th} selected block of i^{th} district (by observation)
TG_{ibvft}	Total weight/number of crop/commodity of the sample drawn at the time of t^{th} visit to f^{th} selected farmer in v^{th} selected village of b^{th} selected block of i^{th} district (by observation)
$\hat{\bar{S}}'_i(d_i)$	Estimate of standard error of weight/number of crop/commodity damaged in stores of farmers of i^{th} district (by observation)
$\hat{\bar{S}}'_i(TG_i)$	Estimate of standard error of total weight/number of crop/ commodity drawn from stores of farmers of i^{th} district (by observation)
d_{ibt}	Weight/number of crop/commodity damaged in the sample drawn at the time of t^{th} visit to b^{th} respondent (Godown/wholesaler/retailer/ processing unit) of i^{th} district (by observation)
u_{ibt}	Weight/number of crop/commodity undamaged in the sample drawn at the time of t^{th} visit to b^{th} respondent (Godown/ wholesaler/ retailer/ processing unit) of i^{th} district (by observation)
SE	Standard Error of estimates
$\hat{L}_{TS}$	Total loss during storage in different marketing channels
$\hat{L}_F$	Estimated loss of crops / commodity during storage at farm
$\hat{R}_F$	Estimated percent retention of crops / commodity in storage at farm
$\hat{L}_G$	Estimated loss of crops / commodity during storage at godown
$\hat{R}_G$	Estimated percent retention of crops / commodity in storage at godown
$\hat{L}_W$	Estimated loss of crops / commodity during storage at wholesaler level

$\hat{R}_W$	Estimated percent retention of crops / commodity in storage at wholesaler level
$\hat{L}_R$	Estimated loss of crops / commodity during storage at retailer level
$\hat{R}_R$	Estimated percent retention of crops / commodity for storage at retailer level
$\hat{L}_P$	Estimated loss of crops / commodity during storage at processing unit
$\hat{R}_P$	Estimated percent retention of crops / commodity for storage at processing unit
d	Number of districts in z^{th} agro-climatic zone.
a	Number of agro-climatic zones for selected crops.
d.f.	Degrees of freedom
Y	Years
C	Channels
YSS	Year sum of squares
CSS	Channel sum of squares
ESS	Error sum of squares
TSS	Total sum of squares

CHAPTER VI
RESULTS AND DISCUSSION

Data collected using 23 schedules by enquiry and observations from 120 districts were scrutinized as discussed in previous chapter IV. Data which were found not fit or could not get verified were discarded. The remaining data of 107 districts were analyzed and harvest and post-harvest losses of 45 crops and commodities were estimated at agro-climatic zone and national level using suitable statistical tools and techniques as discussed in chapter V.

Data collection, scrutinizing, analysis methods and their results were presented in annual workshop of AICRP on PHT on 08 January, 2015 under the chairmanship of Dr. K. Alagusundaram, DDG (Engg) ICAR. All research engineers, scientists and invited experts of different ICAR crops and commodities institutes and state agricultural universities participated and deliberated on the results of the survey in detail and approved the same. Thereafter a special meeting of experts and various stakeholders was held on 23 January, 2015 at IIT Chennai under the chairmanship of Dr. U. Venkateswarlu, Join Secretary MoFPI and Dr. K. Alagusundaram, DDG (Eng) ICAR. Various DDGs, Directors of about 20 ICAR crop institutes and other stakeholders were invited in the meeting. Dr. S.N. Jha, PC AICRP on PHT presented the draft report of the findings and deliberated the same. The report was approved by the committee with suggestion such as reasons of increase or decrease in losses as compared to last study, to be included in the final report.

After inclusion of suggestions of Chennai meeting, the final report was presented on 27 February, 2015 in a meeting held in MoFPI chaired by Smt. Harsimarat Kaur Badal, the Hon'ble Minister of FPI and attended by Secretary MoFPI, Shri Siraj Hussain, Joint Secretary Dr. U.Venkateswarlu, Director IASRI, Director CIPHET, ADG (Horticulture) and other officials. Methodology, results and reasons in variations in losses were explained in detail. Hon'ble minister, Secretary, Joint Secretary MoFPI and other officials appreciated the results and the explanations given. The final report was accepted and asked to submit the same.

This chapter thus presents the final results and discusses them crop-wise. Percentage loss out of total amount stored in different storage channels at national level are reported in Appendix – V. Losses of crops and livestock produce in different agro-climatic zones of India are given in Appendix–VI. The contribution of each channel in total quantitative storage loss was calculated by multiplying the percent retention values in each channel as given in Table 5.1. The extent of losses in different operations, storage channels and overall total loss at national level are reported in Tables 6.1 to Table 6.7.

6.1 Food Grains

Paddy is one of the important staple foods in India. Losses in paddy were estimated in ten agro-climatic zones of the country. At regional level the highest loss (7.26%) was observed in lower gangetic plain region (West Bengal), whereas minimum loss of 3.12% was observed in transgangetic plain region (Punjab and Haryana). It indicated wide variations in losses at regional levels. Mechanization of farm

operations led towards reduction in losses particularly in Punjab and Haryana. Harvesting and threshing operations mainly contributed to the loss in farm operations (Table 6.1). Total loss in farm operations at national level was 4.67%. The loss during storage in different channels at national level was 0.86% and total losses were 5.53%. This total loss of paddy was slightly higher than that of previous study (5.19%), however the increase in loss was not significant. The increase in loss was mainly contributed by increase in loss during harvesting of paddy as compared to previous study. Rainfall in October and November months in year 2013 due to two cyclones resulted in delay of harvesting and shattering of crops. The loss during storage of paddy at processing unit level decreased significantly in comparison to previous study. Improved storage structures at processing unit level may be the main reason for this decrease. Thus, there is a need to focus on reducing losses during harvesting operation by educating farmers and introducing further better machinery and technologies.

The data for estimating loss of **wheat** was collected in eleven agro-climatic zones covering all wheat growing regions of India. At regional level the highest loss (7.04%) was observed in Gujarat plains and hills region (Gujarat), whereas minimum loss of 3.36% was observed in western plateau and hills region (Madhya Pradesh and Maharashtra). Mechanization of farm operations led towards reduction in losses particularly in Punjab, Haryana, Madhya Pradesh and Maharashtra. The overall total loss in northern part of India (Bihar, Uttar Pradesh, Haryana and Punjab) was around 4%. Total loss in farm operations at national level was found to be 4.07% and total loss during storage in different channels was 0.86% (Table 6.1). Harvesting and threshing were the main operations in which the losses were more. Total loss of 4.93% was observed in wheat at national level. The loss in storage at processing unit level decreased significantly indicating improvement probably in infrastructural facilities. Overall total loss of wheat was significantly lower than that of previous study (5.93%). There is however a need to focus on reducing losses in farm operations and storage at household level, which contributed most in losses of wheat at national level.

Survey for estimating harvest and post-harvest losses of **maize** was carried out in five agro-climatic zones mostly in maize producing areas. At regional level the highest loss (6.89%) was observed in central plateaus and hills region (Rajasthan), whereas minimum loss of 2.00% was observed in eastern plateau and hills region (Madhya Pradesh). However, the comparison of regional variations in losses may not be made because some of the channels were not covered in some regions. Total loss in farm operations at national level was found to be 3.90%, whereas loss during storage was 0.75%. Harvesting and threshing among farm operations and wholesaler level storage were the main channel where losses were high. The loss in farm operations was significantly higher in comparison to estimates of previous study. However, the loss during storage has decreased significantly in comparison to losses observed in previous study. The overall total loss in maize was 4.65% which was significantly higher than that of previous study (4.10%). The main reasons for increase in losses were delayed harvesting due to untimely rain and storm when crop was ready for harvesting in some cases and lesser use of technologies at farm levels.

Survey for estimating loss in **bajra** was carried out in seven agro-climatic zones covering all major production areas. At regional level the highest loss (8.01%) was observed in Gujarat plains and hills region (Gujarat), whereas minimum of 2.81% was in upper Gagnetic plain region (Western Uttar

Pradesh), which indicated wide variation in losses at regional levels. Mechanization of farm operations led towards reduction in losses particularly in Western Uttar Pradesh. Overall total loss was 5.23%, which was slightly higher than that of previous study (4.80%). However the increase was statistically not significant. Harvesting and threshing operations caused more loss, whereas losses during storage at farm level and at wholesaler level mainly contributed towards storage loss. Higher loss in threshing operation was due to poor threshing method used by the farmers. In some part of country such as Bihar, Eastern Uttar Pradesh, Karnataka, and Andhra Pradesh, farmers usually place the harvested crop on road and threshing takes place due to tyre treading. This method results in breakage of grain as well as more spillage. Therefore the farmers should be trained to use multi-crop threshers.

Harvest and post-harvest losses of **sorghum** was estimated in five agro-climatic zones. Highest loss (7.45%) was observed in western plateaus and hills region (Madhya Pradesh and Maharashtra), whereas minimum loss of 3.76% was observed in west coast plains and ghats region (Karnataka and Tamil Nadu), indicating wide variations in losses at regional levels. Mechanization of farm operations led towards reduction in losses particularly in southern parts of India. Significant increase in losses during farm operations were observed in comparison to that of previous study. This increase was attributed mainly due to improper harvesting and threshing operations. Farmers usually thresh the sorghum using the method followed for bajra and therefore, appropriate threshers need to be adopted. Total loss during storage at national level increased significantly in comparison to previous study. Wholesaler level storage needs attention because it is the main contributor to overall storage loss. Overall total loss of sorghum was 5.99%, which was significantly higher than that of previous one (3.87%).

In cereals, the losses in farm operations have increased in comparison to that of previous study. Combined harvesting usually caused more losses, however the combined harvesting comprises harvesting, collection and threshing operations together. The combined harvesting loss was lesser as compared to that of the collective losses in traditional methods in which all these operations are performed separately. Besides this, expenditure and drudgery to farmers are also reduced due to use of combined harvesting. It is important to note that in past few years combine harvesters from Punjab and Haryana usually go to Uttar Pradesh, Bihar, Madhya Pradesh and Rajasthan in harvesting seasons. Thus many a time delay or early harvesting is done, which leads to higher loss. Therefore there is a need to create facility for timely availability of such machinery at local levels.

The losses during storage of cereals have decreased significantly (except for sorghum) in comparison to that of previous study. Better infrastructure and transport systems probably are the main reasons for such benefit. Scenario of losses during storage at wholesale level is still almost unchanged. The godowns used by them are usually not made scientifically and holding excess produce comparatively for longer period lead towards more losses in this channel.

6.2 Pulses

Pulses are very important for Indian population as source of vegetarian protein. At present India imports about 3.8 MT of pulses (DoAC, 2013) and therefore reduction of harvest and post-harvest losses are important to reduce this dependency. Estimated losses of pulses are reported in Table 6.2.

Table 6.1: Harvest and post-harvest losses of cereals in percent at national level

Crop	Operations							Total loss in farm operations	Storage Channels						
	Harvesting	Collection	Threshing	Winnowing cleaning	Drying	Packaging	Transport		Farm	Godown	Wholesaler	Retailers	Processing unit	Total loss in storage	Overall Total Loss
Paddy	2.08* ±0.79	0.37 ±0.29	1.44 ±0.39	0.50 ±0.50	0.10 ±0.15	0.08 ±0.04	0.09 ±0.06	**4.67** ±0.44	0.39 ±0.15	0.07 ±0.03	0.21 ±0.07	0.02 ±0.01	0.16# ±0.04	**0.86** ±0.14	**5.53** 0.34 (5.19)
Wheat	1.43 ±0.47	0.56 ±0.22	1.43 ±0.41	0.40 ±0.19	0.07 ±0.09	0.10 ±0.07	0.08 ±0.04	**4.07** ±0.29	0.53 ±0.14	0.03 ±0.02	0.10 ±0.07	0.02 ±0.01	0.17# ±0.04	**0.86** ±0.13	**4.93#** ±0.20 (5.93)
Maize	1.42* ±0.31	0.42 ±0.16	1.20 ±0.40	0.40 ±0.65	0.18 ±0.24	0.16 ±0.06	0.13 ±0.09	**3.90*** ±0.33	0.21 ±0.20	0.04 ±0.03	0.30 ±0.17	0.12 ±0.07	0.08 ±0.06	**0.75#** ±0.20	**4.65*** ±0.29 (4.10)
Bajra	1.15 ±0.54	0.43 ±0.42	2.15 ±0.32	0.19 ±0.09	0.16 ±0.22	0.20 ±0.12	0.15 ±0.16	**4.43** ±0.33	0.38 ±0.09	0.02 ±0.01	0.21 ±0.12	0.12 ±0.03	0.06 ±0.03	**0.79** ±0.09	**5.23** ±0.24 (4.80)
Sorghum	1.47 ±0.48	0.33 ±0.06	2.04 ±0.38	0.47 ±0.20	0.08 ±0.05	0.28 ±0.14	0.09 ±0.03	**4.78*** ±0.28	0.24 ±0.09	0.08* ±0.01	0.73 ±0.18	0.15* ±0.05	0.02 ±0.01	**1.21** ±0.10	**5.99*** ±0.20 (3.87)

* *Estimated losses are significantly higher in comparison to losses observed in 2005-07(previous study).*
\# *Estimated losses are significantly lower in comparison to losses observed in 2005-07(previous study).*
Loss during harvest of paddy and wheat includes manual and mechanical both operations.
Figures in parenthesis represent the losses of previous study 2005-07.

The losses in **pigeon pea** were estimated covering seven agro-climatic zones. The total loss was highest (10.65%) in eastern plateaus and hills region (Jharkhand, Chhattisgarh, Eastern part of Madhya Pradesh and Odisha) whereas minimum loss (3.52%) was observed in Gujarat plains and hills region (Gujarat) showing wide variability at regional level. The eastern plateau and hills region was affected by rain at the time of harvest which may be the main reason for higher loss. Total loss in farm operations at national level was 4.69%, mainly contributed by harvesting and threshing operations. These losses were higher particularly in main pigeon pea producing areas including Bihar, Uttar Pradesh, Madhya Pradesh and Maharashtra (Appendix - VI). The loss in threshing operation was significantly higher than that of previous study. The loss during storage of pigeon pea was 1.67% owing to storage at farm and processing unit levels. Storage in these two channels is usually long, but the storage conditions are not good. Thus attack of bruchids takes place resulting in higher storage loss particularly during rainy season. The loss during storage at godown level has increased significantly in comparison to the loss observed in previous study. The duration of godown storage was very less (up to 3 months) in the previous study, whereas storage period was prolonged (more than 6 months including rainy season) in this study. Pigeon pea storage on CAP or in godowns made for cereal storage attracts bruchids. In addition, improper storages practices probably caused higher losses. Higher overall total loss (6.36%) than that of previous study (5.39%) was found to be statistically non-significant.

In **chick pea**, the survey for loss estimation was covered in six agro-climatic zones. The total loss at regional level varied from 2.50% in east cost plains and hills region (Odisha and Andhra Pradesh) to 11.15% in central plateau and hills region (Madhya Pradesh and Maharashtra). Loss in farm operations at national level was 7.23% owing to harvesting, collection and threshing operations. The highest loss in farm operations was observed in central plateau and hills region (Madhya Pradesh and Maharashtra), which is the major producing area of chick pea. Delayed harvesting was the main reason for harvesting and collection losses. Earlier farmers were using small capacity threshers for threshing chick pea. It was observed that farmers were using higher capacity wheat threshers for threshing chick pea without any change in machine parameters, which probably resulted in more losses during threshing. Total loss during storage at national level was 1.18%, which was mainly contributed by farm, wholesaler and processing unit level storage. The reasons for these losses are similar to those of pigeon pea. In comparison to previous study, the overall total loss of chick pea was significantly higher, mainly because of significantly higher loss in threshing operation, godown and processing unit level storages. Long duration storage at godown and processing unit levels were another factor which resulted in attacks of bruchids and further adding in losses of chick pea. Overall total loss of chick pea at national level was 8.41%, which was significantly higher in comparison to estimated loss in previous study (4.28%).

Eight agro-climatic zones were covered for assessing the losses of **black gram**. About 2.37% loss in southern plateau and hills region (Karnataka, Andhra Prades and Tamil Nadu) to 10.11% of losses in central plateau and hills region (M.P., Rajasthan and Maharashtra) were found in black gram during harvest and post-harvest operations indicating wide variability at regional level. At national level, the total loss in farm operations was found to be 5.89% owing to harvesting, collection and threshing operations (Table 6.2) which was higher than that of previous study (4.96%). The difference was however statistically non-significant. Shattering of pods particularly in Madhya Pradesh, Maharashtra and

Table 6.2: Harvest and post-harvest losses of pulses in percent at national level

Crop	Operations							Total loss in farm operations	Storage Channels					Total loss in storage	Overall Total Loss
	Harvesting	Collection	Threshing	Winnowing/cleaning	Drying	Packaging	Transport		Farm	Godown	Wholesaler	Retailers	Processing unit		
Pigeon pea	1.18 ±0.38	0.39 ±0.29	2.13* ±0.71	0.41 ±0.59	0.18± 0.18	0.22 ±0.26	0.19 ±0.31	**4.69** ±0.45	1.02 ±0.15	0.10* ±0.03	0.08# ±0.04	0.16 ±0.05	0.32 ±0.06	**1.67** ±0.13	**6.36** ±0.30 (5.39)
Chick pea	1.87 ±0.53	1.19 ±0.39	2.60* ±0.59	0.58 ±0.19	0.40 ±0.24	0.25 ±0.08	0.35 ±0.08	**7.23*** ±0.38	0.41 ±0.11	0.04* ±0.01	0.34 ±0.11	0.17 ±0.05	0.21* ±0.03	**1.18** ±0.10	**8.41*** ±0.26 (4.28)
Black gram	1.82 ±0.42	1.01 ±0.55	1.94 ±1.04	0.48 ±0.31	0.26 ±0.26	0.23 ±0.04	0.15 ±0.04	**5.89** ±0.53	0.62 ±0.20	0.04* ±0.02	0.20 ±0.05	0.19 ±0.05	0.13 ±0.01	**1.18** ±0.15	**7.07** ±0.39 (6.04)
Green gram	2.00 ±0.39	0.76 ±0.20	1.54 ±0.86	0.36 ±0.52	0.33 ±0.32	0.22 ±0.03	0.14 ±0.03	**5.37** ±0.47	0.41 ±0.17	0.00 ±0.00	0.39 ±0.11	0.31 ±0.09	0.13* ±0.04	**1.24** ±0.15	**6.60** ±0.35 (5.51)

** Estimated losses are significantly higher in comparison to losses observed in 2005-07(previous study).*
 # Estimated losses are significantly lower in comparison to losses observed in 2005-07(previous study).
Figures in parenthesis represent the losses of previous study 2005-07.

Rajasthan was observed to be the main reason for high harvesting losses. The total loss during storage of black gram was 1.18%, which was higher than that of previous study (1.07%). Storage loss was mainly during storage at farm and wholesaler levels. The loss during storage in godown increased significantly in comparison to previous study. This was mainly due to longer storage period in godowns. Overall total loss at national level in black gram was found to be 7.07%, which was higher than that of previous study but was statistically non-significant.

For **green gram** the survey was carried out in seven agro-climatic zones across the country. Total loss was lowest in lower gangetic plain region (2.57%, West Bengal) and highest in western plateau and hills region (8.03%, Maharashtra) indicating high regional variations. At national level, the total loss during farm operations was about 5.37%, which was mainly due to harvesting and threshing operations (Table 6.2). The farm operations loss was slightly higher than that of previous study (4.96%). Shattering of pods, delayed harvesting due to rain at harvesting time probably resulted in higher harvesting losses. Threshing loss took place due to rain before threshing in eastern plateau and hills regions (Chhattisgarh, Odisha Maharastra and Madhya Pradesh). The total loss during storage was 1.24%, which decreased slightly in comparison to previous study (1.42%). The storage loss mainly occurred during storage at farm, wholesaler and retailer level storages. Major reasons for storage losses were bruchid attack and rodents. The storage loss in processing unit also increased significantly in comparison to that of previous study. Prolonged storage of green gram was observed in processing units due to insect attack and resulted in increased loss. Overall total loss of green gram, at national level was found to be in 6.60%, which was higher than that of previous study (5.51%), but difference was found to be statistically non-significant.

In general, overall total harvest and post-harvest losses in pulses increased at national level. Losses were found higher in major farm operations such as harvesting and threshing. Delayed harvesting due to unseasonal rain may be the main cause of concern. In threshing, use of high capacity wheat thresher resulted in high loss. Therefore, the operating conditions and machine parameters of high capacity thresher used for pulse threshing, needs to be optimized to reduce the post-harvest losses. Pulse storage losses at national level remains almost similar to that of previous study. However, the loss in storage at godowns increased significantly for all pulses under study. Bag storage is being used in godowns and duration of storage was found to be longer, which includes rainy season that causes attack of bruchids. Proper storage management practices of pulses therefore needs to be popularized to further curtail the harvest and post-harvest losses of pulses.

6.3 Oilseeds

Oilseeds play very important role in Indian agriculture due to its value as main source of energy and animal feed. India imported 10.66 MT edible oil in 2012-13 (DoAC, 2013). Thus, the reduction of harvest and post- harvest losses of oilseeds are very important to save foreign exchange. Altogether six oilseeds were taken for the assessment of losses in this study. The extent of losses is reported in Table 6.3.

Mustard is one of the most popular oilseeds of the country. Survey for estimating the losses were conducted in ten agro-climatic zones covering all major mustard producing regions of India. Lowest total

loss of mustard was observed to be 3.56% in western dry region (Rajasthan), whereas highest loss was found to be in eastern himalayan region (7.77%, Assam), which showed that extent of losses were lower in major mustard producing regions (Rajasthan, Madhya Pradesh, Uttar Pradesh and Bihar). Total loss in farm operations at national level was 5.32%, which is significantly lower than that of previous study (8.43%). This reduction was mainly attributed by change in harvesting loss. Mechanization played important role as harvesting of mustard is now being carried out using combine harvesters in Rajasthan. Total loss during storage of mustard was about 0.22% which was less than the loss observed in previous study (0.45%). Improved storage facilities may be the main reason of reduction in storage loss. The reduction in storage loss was not significant statistically, however overall total loss (5.54%) in mustard was found to be significantly lower than that of the previous study.

The survey for estimating losses of **cottonseed** was carried out in six agro-climatic zones covering all major cotton producing regions of India. The losses varied between 2.30% in Gujarat to 6.94% in central plateau and hills region (Maharashtra). Comparatively higher losses in Maharashtra showed problems pertaining to practices and system. Total loss in farm operations at national level was 2.54%, which was slightly higher than that of previous study. The high loss in farm operations was mainly due to harvesting operation. Picking of cotton bolls is labour intensive job and affects the harvesting operation. No significant change in loss during storage of cotton seed was observed. Overall total loss of 3.08% of cotton seed was not significantly higher than that of the previous study (2.75%).

Data for estimating loss of **soybean** covering three agro-climatic zones (Madhya Pradesh, Rajasthan, Andhra Pradesh and Maharashtra) were collected. In central plateau and hills region (Madhya Pradesh), the overall total loss of 13.16% was observed. This zone is the major producer of soybean and harvesting loss in this region was 7.63%. Shattering of pods during harvesting was found to be the main source of harvesting loss. High temperature in day time results in pod shattering which suggests harvesting of soybean crop should be carried out in early morning. At national level, total loss in farm operation was found to be 8.95%, which was significantly higher than that of previous study. It is important to mention that in previous study, the data was not collected from Madhya Pradesh for soybean and hence the increase in loss during farm operations may not be explained. Harvesting, collection and threshing were main farm operations contributing towards major loss. The total loss during storage at national level was about 1% and increase in storage loss was observed in each channel. Overall total loss of 9.96% was observed in soybean which was significantly higher than that of the previous study.

The survey was carried out in two agro-climatic zones covering main producing region of **safflower**. Shift in safflower growing districts was observed in Maharashtra. Total loss in farm operations at national level was found to be about 2.80%, which was slightly lower than that of previous study. Overall total loss at national level was 3.24% which was slightly lower than that of previous study (3.68%) and found to be statistically non-significant.

Data were collected from two agro-climatic zones covering main producing regions of **sunflower**. Total loss in farm operations at national level was found to be 3.65%, slightly lower than estimates of 2005-07 study. Total loss during storage at national level increased significantly to 1.61% from 0.62% in

Table 6.3: Harvest and post-harvest losses of oilseeds in percent at national level

Crop	Operations							Total loss in farm operations	Storage Channels					Total loss in storage	Overall Total Loss
	Harvesting	Collection	Threshing	Winnowing/cleaning	Drying	Packaging	Transport		Farm	Godown	Wholesaler	Retailers	Processing unit		
Mustard	1.85 ±0.88	0.54 ±0.29	1.78 ±0.52	0.64 ±0.30	0.19 ±0.05	0.18 ±0.12	0.14 ±0.08	**5.32**[#] ±0.45	0.11 ±0.06	0.02 ±0.02	0.06 ±0.03	0.03 ±0.03	0.01 ±0.01	**0.22** ±0.06	**5.54**[#] ±0.31 (8.88)
Cotton-seed	2.01 ±0.57	0.32 ±0.34	- -	- -	0.02 ±0.01	0.05 ±0.05	0.14 ±0.11	**2.54** ±0.37	0.04 ±0.03	0.01 ±0.01	0.47 ±0.24	0.02[*] ±0.01	0.00 ±0.00	**0.54** ±0.06	**3.08** ±0.28 (2.75)
Soybean	5.45[*] ±0.52	1.17 ±0.62	1.45 ±0.31	0.52 ±0.37	0.07 ±0.06	0.16 ±0.11	0.14 ±0.10	**8.95**[*] ±0.38	0.12 ±0.06	0.14[*] ±0.04	0.34 ±0.19	0.15[*] ±0.04	0.25[*] ±0.01	**1.00**[*] ±0.07	**9.96**[*] ±0.30 (6.26)
Safflower	1.08 ±0.53	0.49 ±0.36	0.49 ±0.46	0.25 ±0.14	0.11 ±0.02	0.20 ±0.11	0.17 ±0.12	**2.80** ±0.35	0.01 ±0.00	0.02[*] ±0.01	0.30 ±0.13	-	0.11 ±0.00	**0.44** ±0.09	**3.24** ±0.27 (3.68)
Sunflower	0.96 ±0.22	0.40 ±0.07	1.76 ±0.30	0.25 ±0.19	0.11 ±0.07	0.10 ±0.10	0.07 ±0.05	**3.65** ±0.18	0.04 ±0.02	0.02[*] ±0.01	0.16 ±0.06	0.05[*] ±0.01	1.34[*] ±0.49	**1.61**[*] ±0.21	**5.26**[*] ±0.19 (4.55)
Groundnut	2.05 ±0.60	0.52 ±0.28	1.64 ±0.51	0.43 ±0.25	0.13 ±0.13	0.19 ±0.08	0.12 ±0.07	**5.09**[#] ±0.37	0.09 ±0.04	0.06[*] ±0.01	0.44 ±0.15	0.06 ±0.17	0.30 ±0.14	**0.95** ±0.11	**6.03**[#] ±0.28 (10.06)

[*] *Estimated losses are significantly higher in comparison to losses observed in 2005-07(previous study).*

[#] *Estimated losses are significantly lower in comparison to losses observed in 2005-07(previous study).*

Loss during harvest of mustard, soybean and safflower includes manual and mechanical both operations

Figures in parenthesis represent the losses of previous study (2005-07).

previous study. Significant increase in losses during storage in godown and processing units were the main contributors for this increase. Insect attack was the main reason for this loss. Overall total loss in sunflower at national level was 5.26% which was significantly higher than that of previous study (4.55%).

In assessing the loss of **groundnut**, eight agro-climatic zones of India covering all major groundnut producing states, were surveyed. Total loss in groundnut varied from 3.54% in western dry region (Rajasthan) to 9.54% in eastern plateau and hills region (Madhya Pradesh). Wide variation in losses was observed in different regions of India. In Gujarat, which is the main groundnut producing state, the overall total loss was 7.91%. Total loss in farm operations at national level was 5.09%, which was significantly lower than that of previous study (9.11%). The loss in farm operation was mainly attributed by harvesting and threshing operations. Mechanization has played important role in reducing the harvesting and threshing losses of groundnut. Almost no change in total loss during storage of groundnut was observed but the loss during storage at warehouse level increased significantly. Long duration storage in bag storage structures without following proper management practices is attributed to be the main reason for the higher loss at godown level. Overall total loss in groundnut at national level was found to be 6.03%, which is significantly lower than that of previous study (10.06%).

In general, overall total harvest and post-harvest losses in oilseeds decreased at national level (except for soybean and sunflower). Major operations for higher losses in farm operations were harvesting and threshing. Delay in picking of cotton bolls due to labour problem may be the main concern. In soybean, harvesting in day hours may result in shattering of pods. The loss in storage at godowns and at retailer level has increased for all oilseeds under study. Bag storage is being used in godowns for longer period in humid conditions, which causes attack of bruchids and other insects/pests. Proper storage management practices of oilseeds, therefore needs to be popularized to further curtail the post-harvest losses.

6.4 Fruits and Vegetables

6.4.1 Fruits

For assessment for harvest and post-harvest losses of fruits, eight major fruits namely apple, banana, citrus, grapes, guava, mango, papaya and sapota, which contribute to about 84% of total fruit production of India were included in the study. The extent of losses in different operations and storage channels are reported in Table 6.4.

Survey for assessment of losses in **apple** was conducted in only one agro-climatic zone i.e. western Himalayan regions comprising of Jammu & Kashmir, Himachal Pradesh and Uttarakhand, the only apple growing region in India. Total loss in farm operations was 9.08% owing to harvesting, sorting/grading and transportation operations. The practices of farm operations are different in these states. In Jammu & Kashmir, the farmers harvest the fruits and pile them in temporary structure made in the orchards. The vehicle for transport is called thereafter which takes 3-10 days. In the mean time sorting and packaging of

fruits are carried out. Long duration keeping of apple in fields caused higher loss in sorting operation. In Himachal Pradesh and Uttarakhand the farmers usually harvest the apple after confirming vehicle availability for transport. In some cases unripe fruits are also plucked, which leads to higher loss thereafter. There is a need to synchronize various operations properly to curtail these losses. It is important to note that the loss during transportation of apple has been reduced significantly in comparison to previous study. This probably happened due to improved roads and transport systems in the past few years. Total loss during storage was 1.31%, which was slightly higher than that of previous study (1.21%). The increase in storage loss was mainly due to higher losses at retailer level storage. Overall total loss in apple was found to be 10.39%, which was lower than that of previous study (12.26%) but the difference was found to be statistically non-significant.

The survey for assessment of losses of **banana** was carried out in five agro-climatic zones. The overall total loss varied from 4.36% in west coastal plains and ghats region (Kerala, Karnataka, Tamil Nadu) to 10.60% in western plateau and hills region (Andhra Pradesh).The losses were found to be lower than that of the national average in major banana producing regions like Maharashtra, Tamil Nadu and Kerala. At national level, the total loss during farm operations was found to be 6.04%. The farm operation losses were mainly during harvesting, sorting and transportation. Total loss during storage of banana at national level is 1.72% which was slightly lower than that of previous study (2.42%). The decrease in storage loss was due to significant decrease in loss during storage at godown level. Overall total loss in banana was 7.76%, which was higher in comparison to previous study (6.60%). This increase was mainly due to increase in losses during farm operations.

The data for assessment of losses in **citrus** was collected from five agro-climatic zones by covering all citrus fruits except lime. Major citrus producing areas like Punjab, Andhra Pradesh and Maharashtra were covered to estimate the losses. At regional level, the overall total loss was lowest (6.10%) in trans-gangatic plain region (Punjab) and highest (12.97%) in western plateau and hills region (Maharashtra). In Punjab, the citrus (kinnow) is harvested in winter season (December-January) when temperature is low. In kinnow producing regions of Punjab, number of waxing, grading and packaging plants for kinnow have been installed after 2005, which might have helped in reducing losses in sorting/grading, packaging and transportation. On the other hand, harvesting of citrus (orange) in Maharashtra is performed in early summer season (February-March), when climate is relatively warm. Orange is sent to the market without any waxing resulting in more sorting, packaging and transportation loss. Climatic conditions and mechanization plays important role in post-harvest losses. At national level, the total loss in farm operations was found to be 7.55%, which was significantly higher than that of previous study (4.84%). Harvesting, sorting and transportation operations mainly contributed towards farm operation losses. The loss during storage at national level was 2.14% with significant increase as compared to previous study (1.54%). Increased losses in godown, wholesaler and retailer level resulted in higher storage losses. In fact the production of citrus has increased whereas the infrastructure facilities to handle the produce in market have not been improved to the extent required. Overall total loss of citrus at national level increased significantly from 6.38% (previous study) to 9.69% in this study due to reasons explained above.

Results and Discussion

The survey to assess the losses of **grapes** was conducted in two agro-climatic zones comprising Maharashtra, Karnataka and Andhra Pradesh. The pattern of losses was similar in both regions. The total loss in farm operations at national level was 6.52%, with almost no change in comparison to losses in 2005-07. The losses in farm operations were mainly contributed by harvesting, sorting and transport operations. National level loss during storage was 2.11% and slight increase in comparison to that of previous study was observed. The increase in storage loss at market level was the main reason indicating scarcity of cold stores in mandies. Overall total loss of grapes at national level was 8.63%, which is higher in comparison to previous study but the increase in loss was found to be statistically non-significant at 5% level of significance.

Guava is usually harvested in two seasons' viz. monsoon and winter. The extent of losses estimated in this study for guava covers both seasons in five agro-climatic zones. At regional level the overall total loss varied from 6.61% in lower gangetic plain region (West Bengal) to 19.48% in eastern plateau and hills region (Jharkhand, Chhattisgarh and Odisha). In fact the losses in main guava producing regions (Uttar Pradesh, Bihar), were found to be 15.47%, which indicates poor management of this crop in this region. At national level the total loss in farm operations was found to be about 11.90%, which was less in comparison to previous study but the decrease was found to be statistically non-significant. Harvesting, sorting and transportation were found to be the main operations contributing losses of guava. The loss during harvest was mainly due to fall of overripe fruits during night hours. In sorting, the bird eaten and insect infested lots were also observed, and therefore discarded. Improper packaging in gunny bags and overloading in trucks/trolleys further cause the losses in transport. However significant decrease in transport losses were observed in guava at national level due to probably better roads. The total loss during storage of guava at national level decreased from 4.13% (in 2005-07) to 3.98% in present study, however, this decrease in storage loss was statistically non-significant. Overall total loss of guava at national level was found to be 15.88% with non-significant decrease in comparison to previous study (18.64%). Overall scenario of guava is still almost unchanged.

To estimate the loss of **mango**, the survey was conducted in eight agro-climatic zones covering all major mango producing areas of India. At regional level, the overall total loss in mango varied from 4.91% (western plateau and hills region comprising alphanso variety growing area of Maharashtra) to 10% (middle and upper gangetic plain region comprising Uttar Pradesh and Bihar growing Dasheriari, Langra /Maldah varieties). It indicated that the high value alphanso variety was handled properly particularly in Maharashtra. The total farm operation losses at national level in mango were 6.92% significantly lower than that of previous study (10.64%) in 2005-07. Harvesting, sorting and transportation operation contributed mainly to the loss in farm operations. This reduction in loss was cumulative effect of reduction in loss in several operations. In storage losses at national level was found to increase slightly due to increase in retailer level loss. Overall total loss at national level in mango was 9.16%, which was significantly lower than the estimates of year 2005-07 (12.74%). Thus the post-harvest handling or loss scenario of mango has improved to some extent in past 10 years.

Survey to estimate the loss of **papaya** was conducted in six agro-climatic zones of India. The overall total loss at regional level was lowest (3.16%) in east coast regions (Andhra Pradesh), whereas highest

Table 6.4:Harvest and post-harvest losses in percent fruits at national level

Crop	Operations					Total loss in farm operations	Storage Channels					Total loss in storage	Overall Total Loss
	Har-vesting	Collect-ion	Sorting/ Grading	Packag-ing	Trans-port		Farm	Godown cold store	Whole-saler	Retailer	Process-ing unit		
Apple	4.33 ±0.35	0.29 ±0.22	3.94 ±0.44	0.11 ±0.11	0.42 ±0.19	**9.08**# ±0.30	0.02 ±0.00	0.13 ±0.02	0.57 ±0.08	0.34 ±0.29	0.25 ±0.11	**1.31** ±0.11	**10.39**# ±0.24 (12.26)
Banana	1.62 ±0.35	0.26 ±0.14	2.06* ±0.37	0.19 ±0.31	1.91 ±0.40	**6.04** ±0.33	0.03 ±0.01	0.08# ±0.04	1.16 ±0.35	0.45 ±0.07	0.00 ±0.00	**1.72** ±0.17	**7.76** ±0.29 (6.60)
Citrus	1.68 ±0.48	0.33 ±0.10	3.71 ±0.59	0.18 ±0.13	1.65 ±0.24	**7.55*** ±0.38	0.04 ±0.01	0.02* ±0.01	0.91 ±0.13	1.12 ±0.20	0.06 ±0.07	**2.14*** ±0.11	**9.69*** ±0.29 (6.38)
Grapes	1.77 ±0.2	0.30 ±0.05	3.36 ±0.42	0.10 ±0.06	0.98 ±0.18	**6.52** ±0.26	0.01# ±0.00	-	0.78 ±0.14	1.24 ±0.17	0.09 ±0.03	**2.11** ±0.15	**8.63** ±0.22 (8.30)
Guava	5.33 ±1.78	0.31 ±0.28	4.95 ±1.86	0.09 ±0.20	1.21# ±0.64	**11.90** ±1.24	0.23 ±0.06	-	1.62 ±0.52	2.08 ±0.73	0.04# ±0.03	**3.98**± 0.55	**15.88** ±1.11 (18.04)
Mango	2.09 ±0.71	0.30 ±0.44	3.26 ±0.77	0.23 ±0.07	1.04 ±0.14	**6.92**# ±0.54	0.11 ±0.01	0.01 ±0.01	0.69 ±0.39	1.18 ±0.42	0.25 ±0.09	**2.24** ±0.28	**9.16**# ±0.50 (12.74)
Papaya	0.98 ±0.45	0.42 ±0.15	1.46 ±0.47	0.34 ±0.06	0.92 ±0.39	**4.12** ±0.37	0.05 ± 0.02	0.01* ±0.00	0.79 ±0.17	1.71 ±0.25	0.03* ±0.01	**2.58**± 0.12	**6.70**± 0.26 (7.34)
Sapota	2.53 ±1.18	0.35 ±0.07	2.55 ±0.56	0.28 ±0.17	1.70 ±0.48	**7.41*** ±0.67	0.01 ±0.01	0.25* ±0.05	0.89 ±0.20	1.13 ±0.13	0.03* ±0.02	**2.31*** ±0.09	**9.73*** ±0.46 (5.77)

** Estimated losses are significantly higher in comparison to losses observed in 2005-07(previous study).*

 # Estimated losses are significantly lower in comparison to losses observed in 2005-07(previous study).

Figures in parenthesis represent the losses of previous study 2005-07.

loss of 12.25% was observed in eastern himalayan region (North-eastern states). High regional variability in losses was observed in papaya. Total loss in farm operations at national level was 4.12% while the loss in 2005-07 was 5.06% showing statistically non-significant decrease. Sorting followed by harvesting and transportation were the main contributors towards loss of papaya. Total loss during storage at national level was found to be 2.58%, slightly higher than that of previous study (2.28%). Retailer followed by wholesaler level storage losses contributed more towards total storage losses. The storages of papaya at wholesale and retail levels were not found to be done in cold storages. High losses, therefore, were observed particularly in summer. Estimated overall total loss of papaya at national level was found to be 6.70% and showed decreasing trend from previous study (7.34%).

The data were collected from three agro-climatic zones to estimate the losses in **sapota**. The overall total loss at regional level was higher than 8.5% in all three zones with maximum value of 11.98% in western plateau and hills region (Maharashtra). At national level the total loss in farm operations was 7.41%, significantly higher in comparison to previous study (4.31%). Increase in values of losses was observed in each farm operation. Sorting followed by harvesting and transportation mainly contributed towards losses in farm operations. Delayed harvesting was the main reason of loss because of poor shelf life of sapota. Fall in prices was another reason that forced farmers to delay the harvest and subsequently the higher loss reflected in each operation. The total loss during storage of sapota was found to be increased significantly from 1.46% in 2005-07 to 2.31% in present study. Highly significant increase in storage loss however was observed in godown and processing unit storages. In fact the storage of sapota was not seen in cold storages and increased production in recent years also resulted in glut. Overall total loss of sapota at national level was about 9.73%, which was significantly higher than that of the previous study (5.77%).

Overall scenario of harvest and post-harvest losses of fruits has improved to some extent particularly in terms of farm operations losses. In fact, the reduction in loss during transport indicated improvement in roads and infrastructure. Poor situation in farm operations are still a problem and needs to be addressed. The losses during storage of fruits increased in general. Numbers of cold storages have not increased sufficiently to handle the increased production in recent years. Therefore many fruits, which found the space in cold stores earlier, are now being stored in warehouses. The loss in retail level storage increased for all fruits and it is main contributor to storage loss. The loss in retail level can be curtailed if cooling facilities at vendors level are provided. Therefore, all the above problems should be dealt in holistic manner by providing training to farmers for following proper harvesting techniques, post-harvest handling and developing complete cold chain supply system.

6.4.2 Vegetables

Assessments of losses in vegetables were carried out selecting eight vegetables (cabbage, cauliflower, green pea, mushroom, onion, potato, tomato and tapioca). The extent of losses in different operations and channels are reported in Table 6.5.

Data for assessing the losses in **cabbage** were collected from eight agro-climatic zones. There was wide variation in losses at regional level because the overall total loss was 4.38% in western himalayan

region (Himachal Pradesh and Uttarakhand) whereas it was 12.81% in eastern plateau and hills region (Part of Maharashtra, Jharkhand, western part of West Bengal). Climatic conditions play important role for the loss variability in different regions. At national level, the total loss in farm operations was 6.81% which was found to be higher in comparison to the loss observed in previous study (4.61%). The farm operation losses were mainly attributed by harvesting, sorting and transport operations. Glut in the market during March-April resulted in price fall and many times farmers left the produce in the field itself. Demand of only high quality produce forces the farmers to remove several leaves of cabbage. The storage loss of cabbage at national level was about 2.56% slightly higher than previous study (2.33%). This increased in storage loss of cabbage at national level was 9.37% which is higher than that in 2005-07 (6.94%) though the difference was found to be statistically non-significant.

To estimate the losses of **cauliflower**, the data was collected in seven agro-climatic zones covering almost all northern and north eastern parts of India. Regional variations in overall total loss of cauliflower were observed. Lowest loss was (6.86%) observed in trans-gagnetic plain region (Punjab and Haryana), whereas highest loss of 11.23% was in north-eastern states of India. At national level farm operations loss was found to be 7.55% which was significantly higher than that of previous study (4.85%). Sharp fall in prices of cauliflower during February- March months forced the farmers not to harvest the produce. These factors resulted in higher harvesting and sorting losses, whereas transportation losses were reduced to some extent probably due to better road conditions. The loss during storage in different channels at national level remains almost unchanged. Overall total loss of cauliflower at national level was estimated to be 9.56% and was significantly higher than that of previous study estimate of 6.88%. Diversion of cauliflower in February and March for value addition may be helpful in reducing the post-harvest losses.

Altogether five agro-climatic zones were covered to estimate the losses of **green pea**. The states mainly fall under these zones are Jammu & Kashmir, Himachal Pradesh, Uttarakhand, Assam, West Bengal, Bihar and Uttar Pradesh. Regional variation of 4.78-9.11% in overall loss was observed in green pea. At national level, the farm operations loss was 5.72%, which is lower than that of previous study (8.58%), though the difference was statistically non-significant. Harvesting and sorting operations contributed more towards these losses. Multiple picking of green pea is labour intensive operation and therefore, many times, the produce is left for seed purpose. Breakage of stem during harvest also resulted into loss. Immature pods were usually harvested and then separated in sorting operation which contributes in post-harvest losses. In some varieties majority of the pods mature at the same time, which were found to be useful in reducing such losses. The total loss during storage at national level remained almost unchanged. Overall total loss in green pea was 7.45%, which was significantly less in comparison to estimates of previous study (10.28%).

The data for estimating losses of **mushroom** was collected from four agro-climatic zones. Total loss in farm operations was found to be 7.32% mainly ascribed by sorting/grading operation. In sorting operation of mushroom, soiled part of stem was cut and thrown as waste, whereas it is edible, provided soil is removed. Suitable technology needs to be devised for using this portion of mushroom for value addition. It is important to note that the total loss in farm operations was significantly lower than that of

previous study (11.03%). Total storage loss of mushroom at national level was 2.19%. Comparison of this loss could not be done with previous study as farm storage was not covered earlier. Overall total loss at national level was 9.51%, which is significantly lower than the estimates of 2005-07 (12.54%).

Estimated losses of **onion** were based on data collected from six agro-climatic zones across the country. Regional level overall total loss of onion varied from 5.49% in Gujarat to 12.72% in western plateau and hills region (including the main onion production region of Maharashtra). The wide regional variation in losses was observed. Total loss in farm operations at national level was found to be 6.05%, which is not significantly higher in comparison to estimates of 2005-07. Harvesting and sorting/grading operations mainly contributed to losses in farm operations. Total loss in storage at national level was 2.16%. Storage loss of onion was mainly during storage at wholesaler and retailer levels. Overall total loss in onion at national level was found to be 8.20%, which is slightly higher but statistically non-significant in comparison to estimates of 2005-07 (7.51%).

Data for estimating losses of **potato** was collected from nine agro-climatic zones. Almost all major potato producing regions were covered. The overall total loss in different regions of India varied between 5.01% - 7.96% (except for Assam where loss was only 3.92%). It indicated almost uniform kind of pattern in losses of potato in different regions of India. The loss of potato in farm operations at national level was 6.54%, which is almost near to level of losses observed in the previous study. Harvesting and sorting operations contributed more towards losses. The total loss during storage of potato at national level has decreased significantly from 2.26% in 2005-07 to 0.78% in present study which may be attributed to better availability of cold stores and other infrastructures. The storage loss of potato has decreased almost in all channels. The reduction in storage loss of potato may be the perfect example of impact of cold storage. About 1066 cold storages have been installed in India during 2009-2012 (capacity 5.56 million tonnes), whereas there were 2862 cold storages (capacity 18.44 million tonnes) for potato storage in 2009. Therefore almost 58% of total potatoes produced in India are stored in cold storages. The overall total loss of potato at national level has also decreased significantly to 7.32% in comparison to estimates of 8.99% in 2005-07.

Survey for data collection was carried out in eight agro-climatic zones of India for **tomato**. All major tomato producing regions were covered in this study. Minimum loss of 9.83% was observed in southern plateaus and hills region (Karnataka), whereas highest loss of 18.34% was observed in western plateaus and hills region (Maharashtra) of India. In fact the losses in different regions varied between 10-13%, indicating poor post-harvest management in all regions. Thus the regional factors affecting loss are not so responsible, whereas market forces were found to be more effective for higher losses of tomato. The total loss in farm operations at national level was 9.41%, almost the same as that of previous study. All farm operations contributed towards losses which indicates need to address the problems in holistic manner at farm level as well. The total loss during storage at national level was 3.03%, which was higher than that estimated in previous study (2.53%). Market channels (wholesale and retail) are mainly responsible for higher storage losses. Overall total loss of tomato at national level remained almost unchanged.

Table 6.5:Harvest and post-harvest losses in percent of vegetables at national level

Crop	Operations					Total loss in farm operations	Storage Channels					Total loss in storage	Overall Total Loss
	Harvesting	Collection	Sorting/ Grading	Packaging	Transport		Farm	Godown/ cold store	Wholesaler	Retailer	Processing unit		
Cabbage	1.74 ±0.55	0.38 ±0.16	3.32 ±0.46	0.36 ±0.06	1.02 ±0.49	**6.81** ±0.42	0.16 ±0.06	0.08 ±0.02	0.89 ±0.15	1.42 ±0.35	0.02 ±0.01	**2.56** ±0.21	**9.37** ±0.36 (6.94)
Cauliflower	2.21 ±0.79	0.26 ±0.38	3.78 ±0.48	0.38 ±0.13	0.92 ±0.49	**7.55**[*] ±0.52	0.09 ± 0.07	0.07 ± 0.05	0.83 ±0.25	1.00 ±0.38	0.00 ±0.00	**2.00** ±0.22	**9.56**[*] ±0.45 (6.88)
Green pea	2.25 ±0.46	0.32 ±0.12	2.41 ±0.47	0.13 ±0.09	0.61 ±0.08	**5.72** ±0.32	0.05 ±0.02	0.00 ±0.00	1.09 ±0.27	0.55 ±0.34	0.03[*] ±0.03	**1.73** ±0.21	**7.45** ±0.28 (10.28)
Mushroom	0.99 ±0.14	0.04 ±0.00	5.34 ±0.33	0.18 ±0.06	0.77 ±0.06	**7.32** ±0.19	0.66 ± 1.22	-	-	1.52 ±1.66	-	**2.19** ± 1.45	**9.51**[#] ± 0.65 (12.54)
Onion	2.62 ±0.25	0.44 ±0.32	2.35 ±0.72	0.12 ±0.27	0.51 ±0.15	**6.05** ±0.40	0.35 ± 0.19	0.30 ± 0.08	0.77 ± 0.16	0.72 ± 0.14	0.01[*] ± 0.01	**2.16** ± 0.17	**8.20** ±0.28 (7.51)
Potato	2.58 ±0.84	0.25 ±0.30	2.93 ±0.99	0.06 ±0.07	0.72 ±0.18	**6.54** ±0.63	0.15 ± 0.06	0.17 ± 0.18	0.34[#] ± 0.08	0.11 ± 0.05	0.02 ±0.01	**0.78**[#] ± 0.06	**7.32** ± 0.44 (8.99)
Tomato	3.16 ±0.53	0.52 ±0.22	3.74 ±0.48	0.24 ±0.14	1.75 ±0.29	**9.41** ±0.39	0.12 ± 0.04	-	1.26 ± 0.20	1.63 ± 0.33	0.02 ± 0.00	**3.03** ± 0.23	**12.44** ± 0.35 (12.47)
Tapioca	1.23 ±0.39	0.30 ±0.07	0.99 ±0.16	0.09 ±0.05	0.61 ±0.18	**3.22**[#] ±0.24	0.28 ± 0.23	-	0.31 ± 0.06	0.59 ± 0.20	0.17 ± 0.02	**1.36** ± 0.20	**4.58**[#] ± 0.23 (9.77)

[*] *Estimated losses are significantly higher in comparison to losses observed in 2005-07(previous study).*

[#] *Estimated losses are significantly lower in comparison to losses observed in 2005-07(previous study).*

Figures in parenthesis represent the losses of previous study 2005-07.

The estimation of loss of **tapioca** was performed by collecting data from four agro-climatic zones covering all major tapioca producing regions of India. The range of losses at regional level was 2.50-8.34%. In fact high loss was observed in Assam (8.34%) but its impact at national level was very less due to low contribution in national production from this region. At national level the total loss in farm operations was 3.22%, which was significantly lower than the estimates of previous study (7.47%). Reduction in losses was observed in all farm operations indicating better handling of produce at farm. The storage loss at national level has also decreased and this reduction was in all channels. Overall total loss of tapioca at national level has decreased significantly to 4.58% from 9.77% in previous study. The effect of product diversification for value addition of tapioca probably was reflected in terms of reduction in post-harvest losses.

The harvest and post-harvest losses of vegetables varied between 4.58 - 12.44%. Harvesting and sorting were the important farm operations contributing towards losses. Transport loss however decreased to some extent indicating the effect of improvement in road and logistics. Glut in the market is a problem for all vegetables and needs to be addressed. The impact of cold storage in reducing the storage loss clearly observed in potato and needs to be used for other vegetables too. Construction of ICAR-CIPHET evaporatively cooled storage structure of 5 tonne capacity at farm level may help in reducing losses for both fruits and vegetable to a great extent. Produce diversification for value addition helped in reducing the loss in tapioca and the same may be encouraged for other crops too.

6.5 Plantation Crops and Spices

Survey for assessment of harvest and post-harvest losses was conducted for four plantation crops (arecanut, cashew, coconut and sugarcane) and four spices (black pepper, chili, coriander and turmeric). Estimated losses in different farm operations and storage are reported in Table 6.6.

Survey to assess the losses of **Arecanut** was carried out in three agro-climatic zones. The loss in southern plateau and hills region (Karnataka and Kerala) was found to be 3.80%, whereas in north-eastern part of India the loss was 6.49%. Regional variation in losses was observed in arecanut. The national level loss in farm operations decreased significantly to 3.94% from 6.62% estimated in 2005-07. This decrease was mainly due to significant decrease in threshing loss, which now is mostly carried out using mechanical threshers. The storage losses at national level also decreased significantly from 1.26% to 0.97%. This reduction is mainly attributed to significant reduction in wholesale level storage loss. Overall total loss of arecanut reduced to 4.91% from 7.87%, which was found to be statistically significant at 5% level of significance.

The data for estimating loss of **black pepper** was collected from west coast plains and ghats region (Kerala, Tamil Nadu and Karnataka). Total loss of black pepper in farm operations was found to be 0.99%, which is significantly less in comparison to previous study (3.60%). The decrease in loss was observed in all farm operations indicating overall improvement in farm operation practices. The storage losses of black pepper also reduced to some extent. Overall total loss at national level was about 1.18%, which was found to be significantly lower than that of previous study (3.86%). Escalating prices of black pepper might have also forced the farmers and other stakeholders to think to handle the produce carefully in order to get more profit.

Estimation of loss in **cashew** was computed after collecting data from three agro-climatic zones covering all major cashew producing regions. The loss varied from 2.49% in west coast plains and ghats region (Kerala and Karnataka) to 7.72% in east coast plain and hills regions (Andhra Pradesh and Tamil Nadu) followed by 4.68% loss in Odisha. Unexpected high losses were observed in Odisha, Andhra Pradesh and Tamil Nadu. Natural calamities like cyclones hit the east coast frequently during the study period, which probably resulted in poor production and higher losses. The loss in farm operations at national level was found to be 3.82%, which was significantly higher than the previous study (0.89%). Improper harvesting, collection, threshing operations and storage were found to be more responsible for higher losses at national level from 1.12% in previous study to 4.17% in present one.

Data were collected from four agro-climatic zones for estimating losses of **chili**. The pattern of losses in all four regions was almost similar. The losses in farm operations at national level were found to be 5.11%, which is non-significantly higher than that of 2005-07. Sorting followed by harvesting and collection mainly contributed to losses in farm operations. The losses during storage of chili at national level were only about 1.40%, slightly lower than estimated in previous study. Slight non-significant increase in overall total loss (6.51%) in case of chili at national level was observed mainly due to increase in losses during farm operations.

To assess the loss of **coconut**, the survey was conducted in four agro-climatic zones covering West Bengal, Andhra Pradesh, Karnataka, Tamil Nadu, Kerala and Maharashtra. The regional level loss varied between 3.78%-6.87%. The losses were higher in east coast (Andhra Pradesh), whereas low losses were observed in west coast region (Tamil Nadu, Kerala and Karnataka). Effect of cyclones in the east coast during the survey period reflected in the losses as well. Total loss in farm operations at national level decreased to 3.45% due to reduction in harvest and threshing losses. No appreciable change in storage loss at national level was observed. Overall total loss of coconut at national level decreased to 4.77% from 5.36% in 2005-07 survey. In fact the supply of raw coconut to non-coconut producing states increased in last 10 years. This change of marketing scenario has put positive impact on production, storage aspects and thereby probably resulted in reduction in losses.

Data of **coriander** were collected from two agro-climatic regions comprising Madhya Pradesh and Rajasthan only. Pattern of losses were similar in both regions. Total loss in farm operations of coriander was found to be 5.33%, which is lower than 2005-07 estimate (6.81%). Significant reduction in threshing loss was the main reason for decrease in loss. About 10 years back, the wheat threshers were used for threshing coriander. At present the thresher has been modified for coriander and appreciable reduction in threshing have been achieved through mechanization. No appreciable change in storage loss was observed. Overall total loss of coriander at national level was found to be 5.87%, significantly lower than 7.31% of previous study.

The loss of **sugarcane** was estimated after collecting data from seven agro-climatic zones. It covered all major sugarcane producing regions of India. Wide variations in losses were observed at regional level which ranged from 2.30% in Assam to 7.07% in east coast (Andhra Pradesh). Effect of cyclone in Andhra Pradesh might have reflected in terms of higher loss. The national level farm operation

Table 6.6: Harvest and post-harvest losses in percent of plantation crops and spices at national level

Crop	Operations								Total loss in farm operations	Storage Channels					Total loss in storage	Overall Total Loss
	Harvesting	Collection	Sorting Grading	Threshing	Winnowing/ cleaning	Drying	Packaging	Transport		Farm	Godown	Wholesaler	Retailers	Processing unit		
Arecanut	1.24 ±0.35	0.39 ±0.10	-	0.71# ±0.27	1.19* ±0.35	0.19 ±0.15	0.05 ±0.01	0.17 ±0.06	**3.94#** ±0.23	0.02 ±0.00	-	0.48 ±0.31	0.10# ±0.06	0.36 ±0.5	**0.97#** ±0.15	**4.91#** ±0.22 (7.87)
Black pepper	0.47 ±0.19	0.21 ±0.10	-	0.23 ±0.11	0.02 ±0.10	0.04 ±0.04	0.01 ±0.00	0.00 ±0.00	**0.99#** ±0.11	0.01+ 0.00	-	0.00#± 0.00	0.18 ±0.14	-	**0.20** ±0.07	**1.18#** ±0.11 (3.86)
Cashew	1.45 ±1.59	0.57 ±2.23	-	1.34* ±0.53	0.30 ±0.76	0.07 ±0.08	0.00 ±0.00	0.07 ±0.04	**3.82*** ±1.12	0.00 ±0.00	0.00 ±0.00	0.14 ±0.11	0.03 ±0.03	0.17 ±0.07	**0.35*** ±0.07	**4.17*** ±0.84 (1.12)
Chili	1.60 ±0.34	0.84 ±0.09	2.18 ±0.59	-	-	0.02 ±0.07	0.15 ±0.05	0.30 ±0.36	**5.11** ±0.36	0.03 ±0.00	-	0.99 ±0.24	0.31# ±0.12	0.06 ±0.02	**1.40** ±0.14	**6.51** ±0.28 (5.60)
Coconut	1.37 ±0.27	0.20 ±0.14	-	1.02* ±0.32	0.37* ±0.10	0.36 ±0.13	0.08 ±0.05	0.05 ±0.13	**3.45** ±0.23	0.08 ±0.01	-	0.61 ±0.23	0.25 ±0.10	0.38 ±0.05	**1.32** ±0.07	**4.77** ±0.20 (5.36)
Coriander	2.48 ±0.14	0.92 ±0.05	-	1.07 ±0.21	0.45 ±0.05	0.01 ±0.01	0.09 ±0.01	0.31 ±0.02	**5.33** ±0.10	0.03# ±0.00	-	0.27 ±0.07	0.26 ±0.06	-	**0.55** ±0.05	**5.87#** ±0.09 (7.31)
Sugarcane‡	2.11 ±0.22	0.04 ±0.16	1.02 ±0.08	-	-	3.95 ±0.30	0.07 ±0.01	0.10 ±0.15	**7.29** ±0.18	0.04 ±0.06	-	0.42*± 0.25	0.11* ±0.07	0.04 ±0.05	**0.60** ±0.09	**7.89** ±0.17 (8.65)
Turmeric	2.41 ±0.28	0.10 ±0.19	0.79 ±0.17	-	-	0.16 ±0.13	0.09 ±0.04	0.04 ±0.29	**3.60** ±0.21	0.09 ±0.03	-	0.62 ±0.05	0.06 ±0.05	0.06*± 0.01	**0.84** ±0.04	**4.44** ±0.15 (7.37)

* *Estimated losses are significantly higher in comparison to losses observed in 2005-07(previous study).*

\# *Estimated losses are significantly lower in comparison to losses observed in 2005-07(previous study).*

‡ *Loss during drying depicts staling operation in sugarcane.*

Figures in parenthesis represent the losses of previous study 2005-07.

loss was 7.29% which was slightly lower in comparison to previous estimates (7.80%). Staling was the prominent operation responsible for loss in sugarcane followed by harvesting. Staling loss mainly takes place when the sugarcane reaches to sugar industries, where weighing and delivery is delayed by 3-4 days. Farmers are affected more due to monitory as well as loss of time. The storage loss has decreased slightly, but not to the appreciable level. Overall total loss of sugarcane at national level was 7.89% which was slightly lower than estimated in 2005-07 (8.65%).

The survey for estimating the loss of **turmeric** was conducted in four agro-climatic zones covering Uttar Pradesh, Karnataka, Andhra Pradesh and Tamil Nadu. Regional variations in losses were observed between 2.37 to 4.54%. National level loss in farm operations of turmeric was found to be 3.60%, which was significantly lower than observed value in previous study (6.72%). Appreciable reduction in harvesting operation loss was the main reason for this reduction. Harvesting now is being carried out more carefully using modern tools and techniques. The loss during storage at national level however estimated to be 0.84%, non-significantly higher than 0.66% in previous study. Wholesale level storage loss was the main channel for storage loss in turmeric. Overall total loss of turmeric has significantly reduced to 4.44% from 7.37% in 2005-07.

Plantation crops and spices are grown in specific climatic conditions and regions of India. Therefore natural climate of regions affect the harvest and post-harvest losses of these crops. Farm operation including harvesting and threshing were the main causes of loss in plantation crops and spices whereas storage was not much in this case. Value of product was also found to be responsible for proper handling and care of the produce. Loss in sugarcane due to drying (staling) in the sugar factory premises needs attention. Proper threshers particularly for spices are also needed to reduce the loss of these crops.

6.6 Livestock Produce

Altogether six livestock produces including egg, inland fish, marine fish, meat, poultry meat and milk were selected to assess the harvest and post-harvest losses at national level. The estimated losses in different operations and storage are reported in Table 6.7.

For estimation of losses of **egg,** its collection operation was considered as initial operation in place of harvesting. Data were collected to assess the losses from six agro-climatic zones including Jammu &Kashmir, Punjab, Assam, Uttar Pradesh, Andhra Pradesh, Karnataka and Tamil Nadu. The regional losses varied from 3.70% in Punjab to 8.34% in Andhra Pradesh. Mechanized and organized egg production in Punjab resulted in lower loss, whereas backyard poultry farming and unorganized farms with high temperature conditions caused higher loss in Assam and Andhra Pradesh. It indicates that the organized poultry farming may be helpful in reducing the losses of egg. Almost no changes in losses during farm operations were observed at national level. The collection loss, however, reduced. Sorting/grading operations were not being practiced for egg earlier. Introduction of supermarkets has created demands for uniform size eggs and sorting operation is now performed, which caused loss of about 1.40%. If proper tools and techniques are developed for egg sorting, losses during this operation may reduce appreciably. The total storage loss at national level was 2.31%, which was significantly

higher than the estimated loss in 2005-07 (1.67%).The increase in storage loss was attributed to increase in loss at wholesaler and retailer level storages. It is important to note that egg is not stored in cold stores and hence the reduction in demand of egg, particularly in summer season, leads to higher losses during storage. Overall total loss in egg at national level was found to be increased to 7.19% from 6.55% estimated in 2005-07. The increase in loss however was statistically non-significant.

The loss of **inland fish** was estimated after collecting the data from five agro-climatic zones of India covering West Bengal, Bihar, Punjab, Andhra Pradesh, Tamil Nadu and Kerala states. Regional level losses varied from 1.62% in West Bengal to 8.88% in Bihar. West Bengal is the major consumer of fish and background fish farming enable the farmers to catch the required quantity of fish for their own consumption. However, in Bihar, the fish is captured from rivers or ponds in which sometimes makhana is also grown. Thus the difficulty in catch leads to higher losses. Total losses in farm operations were found to be about 4.18% at national level, which is lower than estimated in previous study (5.18%). The decrease in loss however was not significant. Harvesting, sorting/grading and transportation operations were main contributors towards loss in farm operations. The storage loss of inland fish was about 1.05%, and it decreased in comparison to estimated storage loss of previous study (1.74%). This reduction was due to significant reduction in loss during storage at wholesale level. Icing of fish at wholesale level was attributed to be the main reason for reducing this loss. Overall total loss of inland fish was 5.23% and it was lower than the estimates of loss obtained in previous study (6.92%).

Data were collected in four agro-climatic zones of India for estimating the losses in **marine fish**. The survey was conducted in coastal districts of West Bengal, Andhra Pradesh, Tamil Nadu and Kerala states of India. Losses during catch operation of fish were collected by enquiry only. Pattern of losses in different regions was almost similar. Total loss in farm operations at national level was 9.61%, mainly contributed by harvesting (7.4%). Catch of marine fish is usually performed in high sea, wherein fishermen go in boats with load of ice and remain on board for 3-10 days. After catching, the uneconomical fish are thrown back to sea whereas the high value fish are placed in ice. This practice results into high losses during catch. However, a change in this practice was observed during the survey. Now the fishermen have started bringing home some low value marine fish too. The total storage loss at national level was almost not changed. Overall total loss of 10.52% was estimated in marine fish in this study, significantly higher than the previous study (2.78%) because catch operation was not covered in the previous study.

Estimation of loss in **meat** was carried out done using data collected from five agro-climatic zones. The states covered for data collection include Jammu & Kashmir, Assam, Andhra Pradesh, Tamil Nadu, and Karnataka. Regional variations in losses were not observed because of high prices of the meat. Total loss in farm operations at national level was found to be 1.99% mainly due to loss in slaughtering operation. Loss during storage at nation level was 0.72%, mainly at wholesaler and retailer level. The main reason of storage loss was drying of upper layer of carcass, which is removed and thrown before sale of meat to consumers. This happens because the carcass is kept hanging in open without any cover and causing drying of upper layer. Proper display and cooling system needs to be developed for meat storage

Table 6.7: Harvest and post-harvest losses in percent of livestock produce at national level

Commodity	Operations						Total loss in farm operations	Storage Channels					Total loss in storage	Overall Total Loss
	Harvesting	Collection	Sorting/ Grading	Drying	Packaging	Transport		Farm	Godown/ cold storage	Wholesaler	Retailers	Processing unit		
Egg	-	1.92 ± 0.15	1.40* ± 0.20	-	1.21 ±0.12	0.36 ±0.21	**4.88** ±0.16	0.07 ±0.04	-	1.35 ±0.24	0.89 ±0.19	-	**2.31*** ±0.14	**7.19** ±0.15 (6.55)
Inland fish	1.74 ±0.33	0.37 ±0.00	1.72 ±0.43		0.18 ±0.00	0.17 ±0.00	**4.18** ±0.27	0.09 ±0.00	-	0.24#± 0.15	0.72 ±0.32	-	**1.05** ±0.24	**5.23** ±0.26 (6.92)
Marine fish	7.40* ± 0.01	0.75* ± 0.07	0.41 ± 0.37	0.13* ± 0.00	0.00 ± 0.00	0.91# ± 0.10	**9.61*** ±0.20		-	0.65* ±0.19	0.26# ±0.16	-	**0.91** ±0.17	**10.52*** ±0.19 (2.78)
Meat	1.78* ±0.12	-	0.21* ±0.05	-		0.00 ±0.00	**1.99*** ±0.11	0.00 ±0.00	0.01*± 0.00	0.46 ±0.16	0.25 ±0.11	0.00 (0.00)	**0.72** ±0.07	**2.71*** ±0.10 (2.23)
Poultry meat	1.62# ±0.29	-	0.46 ±1.64	-	0.00 ±0.00	0.66* ± 0.28	**2.74** ±0.72	0.00 (0.00)	-	3.02*± 0.65	0.97 ±0.25	-	**4.00*** ±0.16	**6.74*** ±0.56 (3.65)
Milk	0.21 ±0.17	0.18# ±0.03	-		0.30* ±0.00	0.02 ±0.00	**0.71** ±0.11	0.00 ±0.00	-	-	-	0.21 ±0.20	**0.21** ±0.16	**0.92** ±0.11 (0.77)

* *Estimated losses are significantly higher in comparison to losses observed in 2005-07(previous study).*
\# *Estimated losses are significantly lower in comparison to losses observed in 2005-07(previous study).*
Livestock produce 'meat' includes the meat of Sheep and Goat only.
Harvesting data in marine fish were collected only by enquiry.
Figures in parenthesis represent the losses of previous study 2005-07

and sale at retailer level. Overall total loss in meat at national level was 2.71%, which is significantly higher than that of previous study (2.23%). However, this increase in loss was also due to addition of sorting/grading operation in meat, which was not been practiced during the previous study period. Losses during storage of meat in deep freezers and in cold chain was also assessed in this study, which was not being followed during the previous study.

The estimation of loss in **poultry meat** was performed using data obtained from six agro-climatic zones. The states covered for poultry meat data collection include Jammu & Kashmir, Punjab, Assam, Andhra Pradesh, Tamil Nadu and Karnataka. Variation in regional level losses was from 0.87% in Assam to 8.18% in Tamil Nadu. Such high variation might be due to consumer perception of edible part of poultry meat. In northern regions of India, skin is not included as edible portion; whereas in north-eastern, central and southern part of India, skin of poultry is used for human consumption. The hot and humid conditions of southern part of India might have resulted in more loss during storage of poultry meat as carcass are usually not stored in freezers by small butchers. The total loss in operations at national level was 2.74%, which was almost similar to the estimated value in previous study. However, a change in practice has been observed. About 10 years back, the poultry was slaughtered, then dressed and sold to the customers. At present, the dressed carcasses are sorted into different segments like drumstick, breast part, wings etc due to change in consumer demand. Therefore, now sorting/grading and transportation operations are also performed now. Even after addition of two more operations, no change in losses indicates overall improvement in scenario. The losses during storage at national level were 4.0%, mainly attributed by wholesaler level storage loss of 3.02%. Increase in retailer level storage loss also contributed towards high loss during storage. This indicates the need of proper distribution, cold chain system and refrigerated display in market. Overall total loss of poultry meat at national level was 6.74%, which was significantly higher in comparison to previous study (3.65%).

Data for estimating loss of **milk** were collected in four agro-climatic zones comprising Uttarakhand, Karnataka, Tamil Nadu and Gujarat states. Regional level losses varied from 0.17% in Tamil Nadu to 1.28% in Gujarat. This variation however may not be compared because some operations and channels were not been covered in Tamil Nadu. The total loss in farm operations of milk at national level was found to be 0.71%, which is non- significant to that of previous study. The loss during storage of milk at national level was 0.21% and overall total loss in milk at national level was found to be 0.92%.

Non-availability/improper storage channels for selected commodities of livestock produces in some districts were hindering data collection. The losses in livestock produce varied from 0.92% (milk) to 10.52% (marine fish). Issues related to each livestock produce are different and needs to be dealt accordingly. Poor availability of cold chain for livestock produce (except for milk) is the main reason of loss. Unlike other agricultural produce, livestock produce must be handled in cold chain immediately after harvesting. Problems of small butcher shops and retailers need to be addressed through technological interventions and educating them for hygiene and Hazard Analysis and Critical Control Points (HACCP).

6.7 Economic Value of Harvest and Post-Harvest Losses

Estimates of harvest and post-harvest losses of crops/commodities provide the information about the range of losses in different operations and market channels. It helps in identifying the operations and channels where losses are high and whether the losses may be avoided. It also helps in formulating strategies to reduce the losses. However, the implementation of corrective measures involve investment and therefore, it is pertinent to estimates the economic value of losses. Hence the monitory value of the losses was estimated at national level. Base year of this study was 2013-14 hence the all India production of year 2012-13 for selected crops and commodities were taken to estimate the quantity lost. Average wholesale prices of each crop and livestock produce at national level for the year 2014 was taken to calculate monitory loss. The calculated economic values of the loss for each selected commodity are presented in Table 6.8.

The economic value of quantitative loss of 45 crops/commodities was found to be in the tune of Rs. 92651 crore at average annual prices of 2014 against the value of Rs. 44143 crore at 2008-2009 prices. To

Table 6.8: Estimate of the monitory value of harvest and post-harvest losses in India at production of year 2012-13 and prices of 2014

S. No.	Crop/ Commodity	Production (million tonnes)	Price (Rs/tonne)	Over all total loss (%)	Monitory Value of the losses (Rs. Crore)	Sectorial total loss (Rs. Crores)
Cereals						
1	Paddy	104.40	17918	5.53	10344	20698
2	Wheat	92.46	17309	4.93	7882	
3	Maize	22.23	12662	4.65	1309	
4	Bajra	8.74	12666	5.23	579	
5	Sorghum	5.28	18456	5.99	584	
Pulses						
6	Pigeon pea	3.07	49028	6.36	958	3877
7	Chick pea	8.88	32838	8.41	2453	
8	Black gram	0.83	48159	7.07	282	
9	Green gram	0.46	60912	6.60	184	
Oilseed						
10	Mustard	7.82	34820	5.54	1508	8278
11	Cottonseed	3.49	32275	3.08	347	
12	Soybean	14.68	36984	9.96	5405	
13	Safflower	0.10	26260	3.24	8	
14	Sunflower	0.58	32576	5.26	99	
15	Groundnut	4.75	31769	6.03	911	

S. No.	Crop/ Commodity	Production (million tonnes)	Price (Rs/ tonne)	Over all total loss (%)	Monitory Value of the losses (Rs. Crore)	Sectorial total loss (Rs. Crores)
Fruits						
16	Apple	1.90	68078	10.39	1341	16644
17	Banana	27.06	18601	7.76	3903	
18	Citrus	11.47	14011	9.69	1557	
19	Grapes	2.52	44564	8.63	969	
20	Guava	2.62	20628	15.88	858	
21	Mango	17.29	45355	9.16	7186	
22	Papaya	5.19	16023	6.70	557	
Vegetables						
23	Sapota	1.50	18770	9.73	273	
24	Cabbage	8.53	10928	9.37	874	14842
25	Cauliflower	7.79	16321	9.56	1214	
26	Green pea	3.87	33698	7.45	971	
27	Mushroom	0.04	119049	9.51	46	
28	Onion	16.66	16920	8.20	2312	
29	Potato	41.09	16649	7.32	5008	
30	Tomato	17.85	16510	12.44	3666	
Plantation Crops and Spices						
31	Tapioca	7.32	22436	4.58	751	
32	Arecanut	0.53	182865	4.91	475	9325
33	Black pepper	0.05	570547	1.18	35	
34	Cashew	0.75	76026	4.17	239	
35	Chilli	1.31	64411	6.51	547	
36	Coconut	15.09	28587	4.77	2058	
37	Coriander	0.53	80506	5.87	249	
38	Sugarcane	338.96	2100	7.89	5614	
39	Turmeric	0.98	24845	4.44	108	
Livestock Produce						
40	Egg	69.70	2634	7.19	1320	18987
41	Inland fish	5.74	125306	5.23	3766	
42	Marine fish	3.28	125306	10.52	4315	
43	Meat	1.30	350000	2.71	1235	
44	Poultry meat	3.90	150000	6.74	3942	
45	Milk	132.40	36000	0.92	4409	
Grand Total						**92651**

facilitate comparability and ease of understanding, the loss estimates are presented based on wholesale price index (WPI) at constant prices of 2004-05, shifted the base to 2011-12 following the standard practices and index numbers computed by Reserve Bank of India at base 2004-05=100 (RBI, 2015).

The economic value of loss during 2013-14 was found to be Rs. 38782.75 crore against Rs. 32747.03 crore during 2008-09 at constant price 2004-05, while estimates at 2011-12 prices for 2013-14 and 2008-09 stand at Rs. 74734.37 crore and 63103.53 crore, respectively. It is evident from the results that there is a substantial increase in monitory loss (around 18.43%) at constant price over a period of five years. Such a situation is mainly owing to two reasons, i.e., (i) the higher losses at harvest level in case of cereals, pulses, oilseeds and plantation crops were observed in coastal and adjacent states of India due to natural calamities such as Cyclones Phalin in Odisha, Helen and Lehar in Andhra Pradesh, and (ii) there is a quantum jump in production statistics of agricultural crop and commodities during this period and so is the amount of loss in absolute term/quantity. These causes indicate that development of post-harvest infrastructure, market facility and post-harvest technology need to keep pace with changing production scenario and climate change. The investments in post-harvest infrastructure particularly supply chain management and allocation to post-harvest R&D need to be enhanced. Besides, focus should be on HRD/training component pertaining to strategic post-harvest management practices including better handling, sorting, packing/packaging, storage and marketing practices, and also encourage primary and secondary processing through establishment of **Crop Processing Training-cum-Incubation Centre in production catchments**, so as to reduce the post-harvest loss and contribute towards food and nutritional security.

The major contributors to the economic value of losses in India are paddy, wheat, chick pea, soybean, banana, mango, onion, potato, tomato, coconut, sugarcane, inland fish, marine fish, poultry meat and milk. These commodities are responsible for almost 78% of the total loss (Table 6.8) and need attention on priority basis. Highest contribution (34%) towards economic loss was from horticulture produce sector (fruits and vegetables) followed by cereals (22.3%) and livestock produce (20%). The reasons for high economic loss in fruits and vegetables are: (i) high market prices of fruits and vegetables, (ii) soft texture, high water content, perishable nature make it difficult to handle and store. Thus post-harvest management of fruits and vegetables need immediate attention.

CHAPTER VII
SUMMARY AND CONCLUSIONS

Ensuring availability of food to the Indian population will be a major challenge in future with decreasing agriculture land and ever increasing population. One way of achieving this target is efficient use of food materials produced and saving them as much as possible. Thus, it becomes necessary to know about the route/ channels through which crop and livestock produce reaches to the consumers. Each operation and channel causes some losses of food materials in one or other form. Knowledge of extent of losses and their reasons will help in making strategies for reducing the losses. Therefore, the present study on assessing the harvest and post-harvest losses of 45 crops and livestock produce was taken-up. Data for estimating their losses were collected from 120 districts of India covering 14 agro-climatic zones. Stratified multistage random sampling method as described in Chapter 3 was used to select the respondents. The data were collected though enquiry and by observations visiting the fields by staff of AICRP on PHT centers. Data were cross checked, scrutinized and randomly validated as described in Chapter 4. Data which were found unfit for further analysis were discarded and finally data of 107 districts covering harvesting, collection, sorting/grading, threshing, winnowing, drying, packaging and transportation as well as storage loss at household, warehouse/cold stores, wholesaler, retailer and processing unit level were analyzed using statistical analysis software (SAS) for estimation of loss of each crop at National level. The salient findings of the study are summarized below.

- The losses in cereals were estimated to be in the range of 4.65% (Maize) to 5.99% (Sorghum). Harvesting, threshing and storage at farm and wholesaler level contributed more towards losses.
- The total losses in pulses ranged from 6.36% (Pigeon pea) to 8.41% (Chick pea). Harvesting, threshing, storage at farm and processing units were identified as major contributors in total losses. Use of improper threshers, delayed harvesting and improper storage practices were probably the reasons of losses in pulses.
- Estimated losses of oilseeds ranged from 3.08% (Cottonseed) to 9.96% (Soybean). In some instances highest loss of 12.3% of groundnut at storage level was also seen. Harvesting, collection, threshing and storage at wholesale level were the major contributors towards total loss. Delayed harvesting and improper method, improper thresher, and storage practices were identified as main reasons for losses.
- For fruits, the losses ranged from 6.70% (Papaya) to 15.88% (Guava). Harvesting, sorting/grading, transportation, storage at wholesaler and retailer levels were the main operations and channels where losses were found to be high. Considerable losses during storage in market channels showed the need of multi-crop cold storages. Cold chain is essential to reduce the losses of fruits.
- The losses in vegetables varied from 4.58% (Tapioca) to 12.44% (Tomato) owing to harvesting, sorting/grading, transportation, storage at wholesaler and retailers levels. At retailer level tomato

loss in one instance was even found to be 18.20%. Glut in the market in the production season led to higher loss in farm operations and storage as well. Contribution of storage losses in total loss was considerable. Cold chain, multi-commodity cold storages and low cost short duration structures such as ICAR-CIPHET evaporatively cooled storage structure are essential in checking the loss of fruits and vegetables.

- In plantation crops and spices, the losses ranged from 1.18% (Black pepper) to 7.89% (Sugarcane). In general harvesting, threshing, and storage at wholesaler and processing units level contributed more towards losses. Staling loss of sugarcane due to longer period of holding before crushing caused considerable loss and affected juice recovery. Problem of each crops needs to be addressed separately.
- The loss of egg was 7.19% owing to less use of cold storage in market. Organised poultry farming showed positive impact in reducing the loss in egg.
- The loss of inland fish was 5.23%, whereas loss of marine fish was 10.52%. Throwing uneconomical fish was the major contributor to the loss. Considerable loss during storage at wholesaler and retailer levels advocates the need of cold chain for fish.
- The loss of sheep & goat meat was 2.71%, whereas the loss in poultry meat was 6.74%. Considerable loss at wholesaler and retailer levels indicates the need of proper and hygienic meat shops with cold chain and carcass handling system.
- The loss of milk was observed to be 0.92%. Increase in loss during storage at processing unit needs attention.
- In comparison to losses during 2005-07, the losses during 2013-14 reduced significantly for wheat, mustard, groundnut, mango, guava, mushroom, tapioca, arecanut, black pepper and coriander. The estimated losses however significantly increased in comparison to 2005-07 for maize, sorghum, chickpea, soybean, sunflower, citrus, sapota, cauliflower, cashew, marine fish, meat and poultry meat. For remaining commodities, the changes in losses were statistically non-significant at 5% level of significance.
- Averaged range of losses altogether for food grains, oilseeds and fruits and vegetables were found to be 4.65% to 15.88%, which indicate that overall losses have gone down by about 2% as compared to previous study in 2005-07 despite tremendous increase of production in lost 10 years.
- The economic value of harvest and post-harvest losses of major agricultural and livestock produce was also calculated using production data of 2012-13 and wholesale prices of 2014. The estimated annual value of the losses is about Rs 92651 crore.
- Improvements in infrastructural and transport facilities were found to be helpful on reducing the post-harvest losses. Effects of increased number of cold storages for perishables in reducing storage losses were clearly visible but such storage facilities are still inadequate in number. Development of cold chain and construction of cold store with the pace of production are essential.

- The losses were found to be higher in eastern plateau and hills region (Tribal belt of India comprising Jharkhand, Chhattisgarh, Odisha, eastern part of Maharashtra) and east coast (coasts of Odisha, Andhra Pradesh and Tamil Nadu). Proper training to farmers and other stakeholders and infrastructure therefore are essentially required in these regions.
- Improvements in farm operations are essential and needs to be addressed immediately. R&D interventions are needed for controlling losses during harvesting, threshing, sorting/grading and retailer level storages. Problem of insect-pest particularly in pulses and oilseeds storage need to be dealt with integrated pest management strategies. Infrastructural improvement is required at market level. Location of markets, marketing practices, handling methods and polices needs to be looked into for changed scenario of demand and supply pattern.

This study provides the estimates of losses in various operations and storages in different channels. It also presents the changes in scenario of harvest and post-harvest losses over the past 10 years. Harvesting and threshing practices should be standardized and refinements in machines are needed to reduce the losses further. Appropriate techniques and infrastructure for short-term storages such as ICAR-CIPHET evaporatively cooled storage structure for fruits and vegetables needs to be popularized and made available. Proper processing, value addition, storage of marketable surplus and excess produce during glut period in production catchment have potential to reduce the losses and stabilize the prices as well. Training, demonstrations, incubation and entrepreneurship development, skill development and appropriate publicity of proven post-harvest technologies coupled with favourable policies may help in this regard. Investment in post-harvest infrastructure and mega Food Park is the need of hour for further reduction of losses.

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APPENDICES

Appendix I

List of Schedules Developed for Collecting Data for the Harvest and Post-Harvest Losses

S. No.	Schedule No.	Subject of the Schedule
1.	Schedule 1	Complete enumeration of households of the selected village
2.	schedule 2 A	Losses at producer level : (farm level by enquiry)
3.	Schedule 2 B	Losses at producer level (storage)
4.	Schedule 3	Complete enumeration of wholesaler/retailer/warehouse/ processing unit
5.	Schedule 4	Losses at market level (wholesaler/ retailer/ warehouse/ processing unit)
6.	Schedule 5 –C	Losses at farm level in cereals and coriander (by observation)
7.	Schedule 5-O	Losses at farm level in oilseeds & pulses (by observation)
8.	Schedule 5-H	Losses at farm level in fruits and plantation crops (by observation)
9.	Schedule 5-V	Losses at farm level in vegetable crops (by observation)
10.	Schedule 5-Pepper	Losses at farm level in pepper (by observation)
11.	Schedule 5-S	Losses at farm level in sugarcane (by observation)
12.	Schedule 5-E	Losses of egg at producer level (by observation)
13.	Schedule 5- IF	Losses at farm/ fisherman level in inland fish (by observation)
14.	Schedule 5- MF	Losses at farm/ fisherman level in marine fish (by observation)
15.	Schedule 5- Mt	Losses of meat at producer level (by observation)
16.	Schedule 5- PM	Losses of poultry meat at producer level (by observation)
17.	Schedule 5-Milk	Post harvest Losses in milk (by observation)
18.	Schedule 6-C	Losses during storage at farm/ trader/ godown/ processing unit level for cereals, pulses, oilseeds and coriander (by observation)
19.	Schedule 6-C1	Identity slip for the sample taken from farmer/ traders/ godown/ processing unit level for analysis in the laboratory as per items mentioned overleaf.
20.	Schedule 6-H	Losses during storage at farmer/ trader/ retailer/ processing unit/ godown level in fruits, vegetables and plantation crops (by observation)
21.	Schedule 6- E	Losses of eggs during transportation and storage at farm/ wholesaler/ retailer level (by observation)
22.	Schedule 6-IF	Losses at market level (Wholesale/ retail/ pre-processing/ processing unit Level in inland fish (by observation)
23.	Schedule 6-MF	Losses at market level (Wholesale/ retail/ pre-processing/ processing unit Level in marine fish (by observation)

ALL INDIA COORDINATED RESEARCH PROJECT ON POST-HARVEST TECHNOLOGY
ICAR-CIPHET, P.O. PAU Campus, Ludhiana – 141 004 (Punjab)
Sample Survey for Assessment of Harvest and Post-Harvest Losses

Schedule 1: Complete enumeration of households of the selected village

A) Identification particulars:

1.	Agro-climatic zone		4.	Tehsil / Taluk	
2.	State		5.	Block / Mandal	
3.	District		6.	Village	

(B) Details of households in the village:

S. No.	Name of head of household	Father's name	Operational holding (ha)	Crop/ commodity grown	Area under crop (ha) / fish ponds	No. of milch animal, meat / poultry bird	Name of any new post harvest technology or equipment adopted during last 5 years	(If Yes) Source of the technology	Crop / Operation / Use	Whether effective in reducing loss

Date: _____

_____
Signature of Field Investigator

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Sample Survey for Assessment of Harvest and Post-Harvest Losses
Schedule 2 A: Losses at producer level (Farm level by enquiry)

Date of visit: _____

(A) Identification particulars:

1.	Agro-climatic zone	
2.	State	
3.	District	
4.	Tehsil/Taluk	
5.	Block/Mandal	
6.	Village	
7.	Name of the head of household	
8.	Father/Husband's name	

Name of crops/commodities grown by farmers: _____

(B) Area information

1	i. Owned land (ha.)	
	ii. Leased out land (ha.)	
	iii. Leased in land (ha.)	
	Total Operational holding (ha.)	
2.	Name of the selected crops/fish ponds	Area (ha)
3.	Name of the selected Livestock produce	No. of animals
	Milk	
	Egg	
	Meat	
	Poultry meat	

C. Losses at farm level (by enquiry) during enquiry period

Name of the Crop/Commodity: _____ Date of visit: _____

Season of Crop _____

Operations	Methods of operation	Equipment used	Quantity handled	Quantity lost	Causes of losses
Harvesting/ Picking/ Slaughter/ milking/ catch					
Collection					
Sorting & grading/ Threshing/ dehusking					
Winnowing/Sieving Cleaning					
Drying					
Packaging					
Transport (From threshing floor to store & mandi)					
Any other (specify)					

Date: _____

_____
Signature of Field Investigator

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Sample Survey for Assessment of Harvest and Post-Harvest Losses
Schedule 2 B: Losses at producer level (Storage)

Date of visit: _____ Period of Enquiry: _____

(A) Identification particulars

1.	Agro-climatic zone	
2.	State	
3.	District	
4.	Tehsil/Taluk	
5.	Block/Mandal	
6.	Village	
7.	Name of the head of household	
8.	Father/Husband's name	

Name of crops/commodities grown by farmers: _____

_____

(B) Losses at farm level during storage (by enquiry)

Crop/ commodity	Previous balance (kg)	Addition during enquiry period (kg)	Quantity withdrawal during enquiry period (kg)	Total quantity stored (kg)	Type of storage	Quantity lost (kg)	Causes of losses

Date: _____

_____
Signature of Field Investigator

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Sample Survey for Assessment of Harvest and Post-Harvest Losses
Schedule 3: Complete enumeration of wholesaler/retailer/warehouse/ processing unit

(A) Identification particulars:

1. Agro-climatic zone	
2. State	
3. District	
4. Tehsil/Taluk	
5. Block/Mandal	
6. Name of market/Mandi	

(B) Detail of wholesaler/retailer/warehouse/processing unit

S. No	Name of stockiest	Address	Crop/ commodity handled	Type of storage	Capacity of storage (kg)	Quantity stored (kg)	Quantity handled during previous year (kg)

Date: _____

_____
Signature of Field Investigator

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ICAR-CIPHET, P.O. PAU Campus, Ludhiana – 141 004 (Punjab)

Sample Survey for Assessment of Harvest and Post-Harvest Losses
(Wholesaler, retailer, processing unit and godown of selected marketing channels)

Schedule 4: Losses at market level (Wholesaler/ retailer/ warehouse/ processing unit)

Date of visit: _____ **Period of Enquiry:** _____

(A) Identification particulars

1. Agro-climatic zone	
2. State	
3. District	
4. Tehsil/Taluk	
5. Name of market	
6. Name of trader/processing unit/godown and its address	
7. Whether wholesaler/retailer	

Name of crops/commodities handled: _____

(B)Losses at farm level during storage (by enquiry)

Crop/ commodity	Previous balance (kg)	Addition during enquiry period (kg)	Quantity withdrawal during enquiry period (kg)	Total quantity stored (kg)	Type of storage	Quantity lost (kg)	Causes of losses

Date: _____

_____
Signature of Field Investigator

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Sample Survey for Assessment of Harvest and Post-Harvest Losses

Schedule 5 –C: Losses at Farm Level in Cereals and coriander (BY OBSERVATION)

A. Identification:

	Particulars	
i.	Agro-climatic zone	
ii.	State	
iii.	District	
iv.	Tehsil/Taluk	
v.	Block / Mandal	
vi.	Village	
vii.	Name of the farmer	
viii.	Total land holding (ha)	
ix.	Name of crops grown	
x.	Date of visit	

B. Particulars of the selected field:

	Particulars	
i.	Name of crop	
ii.	Area under the crop (ha)	
iii.	Variety	
iv.	Date of sowing	
v.	Date of harvesting	
vi.	Method of harvesting	Manual/ mechanical
vii.	Equipment used for harvesting	

Date: _____

_____
Signature of Field Investigator

C. Losses during harvesting from randomly selected plot:

Method of harvesting: _____

Equipment used for harvesting: _____

i. Traditional Harvesting:

Production from the selected plot of 5m×5m obtained by crop cutting (kg)	Weight/number of fallen grain (g/no) collected from selected plot of 5m×5m after harvesting

ii. Combine Harvesting:

Actual area of the field (ha)	Production of the total field (kg)	Weight of fallen grain (g) collected from selected plot of 5m×5m after harvesting

D. Loss during Threshing/shelling

S. No	Particulars	
i.	Type of threshing floor	
ii.	Method of threshing (stone roller passing, tractor treading, mechanical thresher, etc.)	
iii.	Number of bundles from 5×5m plot/ 3 bundles (35-40 kg each) from harvested crop (*In case tractor operated bigger threshers are used*)	
iv.	Weight of grain obtained after threshing the bundles/ 10 kg cob samples	
v.	Weight of straw obtained(kg).	
vi.	Weight (kg) / number of grains going with 250g straw sample drawn from the straw of threshed crop	

E. Losses during Cleaning/winnowing

S. No	Particulars	
i.	Method of cleaning/winnowing	
ii.	Weight of sample grain before cleaning (sample size: 10kg)	
iii.	Weight of grain after cleaning (kg)	
iv.	Weight of straw and other materials obtained during cleaning, (kg)	
v.	Weight / number of grains going with 250g straw sample drawn from the straw of cleaned crop	

Date: _____

_____
Signature of Field Investigator

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Sample Survey for Assessment of Harvest and Post-Harvest Losses

Schedule 5-O: Losses at Farm Level in Oilseeds & Pulses (BY OBSERVATION)

A. Identification

	Particulars	
i.	Agro-climatic zone	
ii.	State	
iii.	District	
iv.	Tehsil/Taluk	
v.	Block / Mandal	
vi.	Village	
vii.	Name of the farmer	
viii.	Total land holding (ha)	
ix.	Name of oilseed and pulse crops grown	
x.	Date of visit	

B. Particulars of the selected field:

	Particulars	
i.	Name of crop	
ii.	Area under the crop (ha)	
iii.	Soil type	
iv.	Condition of soil (for groundnut only)	Moist/ normal/ dry
v.	Variety	
vi.	Date of sowing	
vii.	Date of harvesting	
viii.	Method of harvesting	Manual/mechanical
ix.	Equipment used for harvesting	

C (1): Losses during harvesting from randomly selected plot *(for pulses, safflower and groundnut):*

Method of harvesting _____

Production from the selected plot of 5m×5m obtained by crop cutting (kg)	Weight of fallen grains/leftover pods in the soil collected from selected plot of 5m×5m after harvesting/ last picking (for groundnut) (kg)

C (2): Losses during harvesting from randomly selected plot (for sunflower, cottonseed, mustard and soybean)

Method of harvesting _____

Particulars	Plant Number										Average
	1	2	3	4	5	6	7	8	9	10	
Number of pods/ siliques/seed/cotton bolls before harvest											
Number of shattered pods/ siliques/seed/ bolls till threshing floor											
Number of seeds in three pods/ silique											

D. Loss during Threshing

S. No.	Particulars	
i.	Type of threshing floor	
ii.	Method of threshing	
iii.	Number of bundles from 5×5m plot / 3 bundles of harvested crop	
iv.	Weight of grain obtained after threshing of bundles(kg)	
v.	Weight of straw obtained (kg)	
vi.	Weight/ number of grains going with straw of threshed crop and stem, in 250g sample	

E. Losses during Cleaning/winnowing

S. No.	Particulars	
i.	Method of cleaning/ winnowing	
ii.	Weight of sample grain before cleaning (sample size: 10 kg)	
iii.	Weight of grain after cleaning (kg)	
iv.	Weight of straw & other material obtained during cleaning (kg)	
v.	Weight/ number of grains going with 250g straw sample drawn from the straw of cleaned crop	

Date: _____

_____
Signature of Field Investigator

ALL INDIA COORDINATED RESEARCH PROJECT ON POST-HARVEST TECHNOLOGY
ICAR-CIPHET, P.O. PAU Campus, Ludhiana – 141 004 (Punjab)

Sample Survey for Assessment of Harvest and Post-Harvest Losses

Schedule 5-H: Losses at farm level in fruits and plantation crops (BY OBSERVATION)

A. Identification

S.No.	Particulars	
i.	Agro-climatic zone	
ii.	State	
iii.	District	
iv.	Tehsil/Taluk	
v.	Block / Mandal	
vi.	Village	
vii.	Name of the farmer	
viii.	Total land holding (ha)	
ix.	Name of oilseed and pulse crops grown	
x.	Date of visit	

B. Details of fruit/ plantation crops grown by farmer:

S. No	Particulars	Crops			
i.	Name of the crop				
ii.	Extent of area cultivated (ha)				
iii.	Variety				
iv.	Date of sowing/ planting				
v.	Age of plants/ orchard				
vi.	Date of harvesting				
vii.	Method of harvesting				

C: Losses at farm level:

Name of crop _____ Date of harvesting_____

i. Losses during harvest from randomly selected trees:

Method of harvesting _____

a.	Production from 4 selected trees, (kg)/ number	
b.	Weight/ number of produce damaged during harvesting (rejected due to bruise, cuts etc. only)	
c.	Loss (%)	
d.	Causes of loss	

ii. Losses during cleaning/grading and sorting:

a.	Date of cleaning, grading and sorting	
b.	Method of cleaning / grading and sorting	
c.	Weight/number of produce cleaned/ graded/ sorted, (10 kg / 50 numbers)	
d.	Weight/ number of produce rejected/ spoiled (rejected due to damages)	
e.	Loss (%)	
f.	Causes of loss	

iii. Loading, transportation and unloading loss (Farm to market):

a.	Date of visit	
b.	Method of Loading & Unloading *(using hook /dumping/ any other means specify)*	
c.	Mode of transport	
d.	Number of layers stacked	
e.	Total weight of produce transported (kg)	
f.	Weight/number of sample drawn after transportation up to mandi, (10 kg/ 50 numbers/ 5 boxes)	
g.	Weight/number of produce spoiled and rejected	
h.	Loss (%)	
i.	Causes of loss	

Date: _____

_____
Signature of Field Investigator

ALL INDIA COORDINATED RESEARCH PROJECT ON POST-HARVEST TECHNOLOGY
ICAR-CIPHET, P.O. PAU Campus, Ludhiana – 141 004 (Punjab)

Sample Survey for Assessment of Harvest and Post-Harvest Losses

Schedule 5-V: Losses at Farm Level in Vegetable Crops (BY OBSERVATION)

A. Identification

S.No.	Particulars	
i.	Agro-climatic zone	
ii.	State	
iii.	District	
iv.	Tehsil/Taluk	
v.	Block / Mandal	
vi.	Village	
vii.	Name of the farmer	
viii.	Total land holding (ha)	
ix.	Name of oilseed and pulse crops grown	
x.	Date of visit	

B. Details of vegetable crops grown by farmer:

S. No	Particulars	Crops			
i.	Name of the crop				
ii.	Extent of area cultivated (ha)				
iii.	Variety				
iv.	Date of sowing/planting				
v.	Date of harvesting				
vi.	Method of harvesting				
vii.	Equipment used				

C: Losses at farm level:

Name of crop _____ Date of harvesting_____

i. Losses during harvest from randomly selected trees:

Method of harvesting _____

Production from the randomly selected plot of 5m×5m (kg)	Weight of produce collected from selected plot of 5m×5m after harvesting/ picking (kg)

ii. Losses during cleaning/ grading and sorting:

a.	Date of cleaning/ grading and sorting	
b.	Weight/ number of produce sample cleaned/ graded/ sorted, (10 kg/ 50 numbers)	
c.	Weight/ number of produce rejected/ lost (rejected due to damages during grading/ sorting operation) (kg)	
d.	Loss (%)	
e.	Causes of loss	

iii. Loading, transportation and unloading loss (Farm to market):

a.	Date of visit	
b.	Method of Loading & Unloading *(using hooks/ dumping/ any other means specify)*	
c.	Mode of transport	
d.	Number of layers stacked	
e.	Total weight of produce transported (kg)	
f.	Weight/ number of sample drawn after transportation to mandi, (10kg/ 50numbers/ 5boxes)	
g.	Weight/ number of produce spoiled and rejected (kg)	
h.	Loss (%)	
i.	Causes of loss	

Date: _____

_____
Signature of Field Investigator

ALL INDIA COORDINATED RESEARCH PROJECT ON POST-HARVEST TECHNOLOGY
ICAR-CIPHET, P.O. PAU Campus, Ludhiana – 141 004 (Punjab)

Sample Survey for Assessment of Harvest and Post-Harvest Losses

Schedule 5-Pepper: Losses at farm level in pepper *(BY OBSERVATION)*

A. Identification

S.No	Particulars	
i.	Agro-climatic zone	
ii.	State	
iii.	District	
iv.	Tehsil/Taluk	
v.	Block / Mandal	
vi.	Village	
vii.	Name of the farmer	
viii.	Total land holding (ha)	
ix.	Name of oilseed and pulse crops grown	
x.	Date of visit	

B. Details of pepper crop grown by farmer:

S. No	Particulars	
i.	Extent of area cultivated (ha)	
ii.	Variety	
iii.	Date of sowing/ planting	
iv.	Age of plants/ orchard	
v.	Date of harvesting	
vi.	Method of harvesting	

C: Losses at farm level of pepper:

i. Losses during harvest from randomly selected vines/ trees:

Method of harvesting _____

S. No	Particulars	
i.	Production from 4 selected vines/ trees, (kg)	
ii.	Weight/ number of produce damaged during harvesting (rejected due to bruise, cuts etc.) (kg)	
iii.	Loss (%)	
iv.	Causes of loss	

ii. Loss during threshing:

S. No	Particulars	
i.	Type of threshing floor	
ii.	Method of threshing (stone roller passing, tractor treading, mechanical thresher, etc.)	
iii.	Weight of sample taken for threshing, kg (5 kg sample has to be taken)	
iv.	Weight of produce obtained after threshing the sample (kg)	
v.	Weight of straw & waste obtained(kg).	
vi.	Weight of produce going with straw & waste (kg)	
vii.	Loss, %	

iii. Losses during cleaning/grading and sorting:

S. No	Particulars	
i.	Date of cleaning, grading and sorting	
ii.	Method of cleaning / grading and sorting	
iii.	Weight of produce cleaned/ graded/ sorted, (5 kg)	
iv.	Weight of produce rejected/ spoiled (rejected due to damages)	
v.	Loss (%)	
vi.	Causes of loss	

Date: _____

_____
Signature of Field Investigator

ALL INDIA COORDINATED RESEARCH PROJECT ON POST-HARVEST TECHNOLOGY
ICAR-CIPHET, P.O. PAU Campus, Ludhiana – 141 004 (Punjab)

Sample Survey for Assessment of Harvest and Post-Harvest Losses

Schedule 5-S: Losses at Farm Level in Sugarcane *(BY OBSERVATION)*

A. Identification:

S.No	Particulars	
i.	Agro-climatic zone	
ii.	State	
iii.	District	
iv.	Tehsil/Taluk	
v.	Block / Mandal	
vi.	Village	
vii.	Name of the farmer	
viii	Father's name	
ix	Total land holding(ha)	
x.	Area under sugarcane (ha)	
xi	Date of visit	

B. Particulars of the selected field:

S.No	Particulars	
i.	Area of the field (ha)	
ii.	Soil type	
iii.	Variety	
iv.	Date of planting	
v.	Date of harvesting	
vi.	Method of harvesting	Manual/ Mechanical
vii.	Equipment used for harvesting	

C. Losses during harvesting from randomly selected plot:

Production from the selected plot of 5m×5m obtained by crop cutting (kg)	Weight of stubbles left in selected plot of 5m×5m after harvesting (kg)	Loss (%)

D. Loss due to staling of sugarcane:

S.No	Particulars	
i.	Date of harvesting	
ii.	Weight of three bundles of sugarcane after harvest(kg)	
iii.	Date of crushing	
iv.	Period of staling (in hours and days)	
v.	Weight of the same three bundles before crushing (kg)	
vi.	Loss in weight (kg)	
vii.	Loss, %	

Date: _____

_____
Signature of Field Investigator

ALL INDIA COORDINATED RESEARCH PROJECT ON POST-HARVEST TECHNOLOGY
ICAR-CIPHET, P.O. PAU Campus, Ludhiana – 141 004 (Punjab)

Sample Survey for Assessment of Harvest and Post-Harvest Losses

Schedule 5-E: Losses of Egg at Producer Level *(BY OBSERVATION)*

A. Identification:

S.No	Particulars	
i.	Agro-climatic zone	
ii.	State	
iii.	District	
iv.	Tehsil/Taluk	
v.	Block/Mandal	
vi.	Village	
vii.	Name of the farmer/producer	
viii.	Name of the poultry farm	
ix.	Name of poultry species reared (for egg production)	
x.	Date of visit	

B. Particulars of the selected poultry farm/ producer:

S.No	Particulars	
i.	Status of the poultry farm	Private/ co-operative/ contract
ii.	Type of poultry house	Cage type/ Deep litter type/ any other (please specify)
iii.	Number of sheds in the poultry house	
iv.	Containers used for egg collection	Paper pulp filter flat/ plastic filter flat/ plastic bucket/ wire basket
v.	Frequency of egg collection per day	Once/ twice/ thrice
vi.	Packaging material for egg	Plain card board box/ corrugated board box/ any other (pl specify)

C. Loss of eggs at farm/producer level:

(i) Loss during collection of eggs:

Total number of eggs collected from selected shed/ birds	Number of eggs damaged/ spoiled	Causes of loss

(ii) Loss during packaging of eggs:

Total number of eggs to packed	Number of eggs damaged/ spoiled	Causes of loss

Date: _____

_____
Signature of Field Investigator

ALL INDIA COORDINATED RESEARCH PROJECT ON POST-HARVEST TECHNOLOGY
ICAR-CIPHET, P.O. PAU Campus, Ludhiana – 141 004 (Punjab)

Sample Survey for Assessment of Harvest and Post-Harvest Losses

Schedule 5- IF: Losses at Farm/ Fisherman level in Inland Fish *(BY OBSERVATION)*

A. Identification:

S.No	Particulars	
i.	Agro-climatic zone	
ii.	State	
iii.	District	
iv.	Tehsil/Taluk	
v.	Block/Mandal	
vi.	Village	
vii.	Name of the Head of household/ fisherman	
viii.	Father's name	
ix.	Date of visit	

B. Loss during catch of inland fish:

S.No	Particulars	
i.	Source of water body	Pond/ River/ Lake/ Reservoir/ Tank
ii.	Method of catch operation	Manual/ Mechanical
iii.	Equipment used for catch	
iv.	Total catch of fish on the date of visit(kg)	
v.	Weight of fish discarded (Loss)(kg)	
vi.	Causes of loss	

Date: _____

_____
Signature of Field Investigator

ALL INDIA COORDINATED RESEARCH PROJECT ON POST-HARVEST TECHNOLOGY
ICAR-CIPHET, P.O. PAU Campus, Ludhiana – 141 004 (Punjab)

Sample Survey for Assessment of Harvest and Post-Harvest Losses

Schedule 5- MF: Losses at Farm/ Fisherman level in Marine Fish *(BY OBSERVATION)*

A. Identification:

S.No	Particulars	
i.	Agro-climatic zone	
ii.	State	
iii.	District	
iv.	Tehsil/ Taluk	
v.	Block/ Mandal	
vi.	Village	
vii.	Name of the Boat owner (fisherman)	
viii.	Father's name	
ix.	Name of landing center	
x.	Date of visit	

B. Losses at landing center of marine fish:

S.No	Operations	
i.	Type of fishing craft used	Local/ Mechanized
ii.	Type of fishing gear used	Gill net/ Trawl net/ Trawl net with TED/ others (pl specify)
iii.	Total weight of fish received from boat at the time of landing (kg)	
iv.	Loss during transferring (weight of fish left in the boat after unloading)(kg)	
v.	Loss of fish at landing center (weight of fish remain indisposed from fish received after landing) (kg)	
vi.	Loss of fish during grading at landing center (weight of fish discarded) (kg)	
vii.	Loss in other operation, if any (kg)	

Date: _____

_____
Signature of Field Investigator

ALL INDIA COORDINATED RESEARCH PROJECT ON POST-HARVEST TECHNOLOGY
ICAR-CIPHET, P.O. PAU Campus, Ludhiana – 141 004 (Punjab)

Sample Survey for Assessment of Harvest and Post-Harvest Losses of (Slaughter and Post-Slaughter) in Meat

Schedule 5- M: Losses of meat at producer level *(BY OBSERVATION)*

A. Identification:

S. No.	Particulars	
i.	Agro-climatic zone	
ii.	State	
iii.	District	
iv.	Tehsil/ Taluk	
v.	Block/ Mandal	
vi.	Village	
vii.	Name of slaughter house / Butcher's shop	
vii.	Name of livestock species slaughtered (Buffalo, sheep, goat, pig)	
viii.	Date of visit	

B. Particulars of the selected meat producer:

S.No.	Particulars	
i.	Name of livestock slaughtered	Buffalo/ sheep/ goat/ pig
ii.	Total number of animals slaughtered on the date of the visit	
iii.	Place of purchase	Farm/ Market/ any other (pl specify)
iv.	Method of slaughtering	Manual /Mechanical

C. Loss during slaughter of animal:

S.No	Weight of fresh carcass(kg)	Weight of meat removed due to damages and injuries (kg)	Causes of loss
1.			
2.			
3.			
4.			
5.			

Date: _____

_____
Signature of Field Investigator

ALL INDIA COORDINATED RESEARCH PROJECT ON POST-HARVEST TECHNOLOGY
ICAR-CIPHET, P.O. PAU Campus, Ludhiana – 141 004 (Punjab)

Sample Survey for Assessment of Harvest and Post-Harvest Losses of (Slaughter and Post Slaughter) in Poultry Meat

Schedule 5- PM: Losses of poultry meat at producer level *(BY OBSERVATION)*

A. Identification:

S. No.	Particulars	
i.	Agro-climatic zone	
ii.	State	
iii.	District	
iv.	Tehsil/ Taluk	
v.	Block/ Mandal	
vi.	Village	
vii.	Name of slaughter house/ butcher's shop	
viii.	Name of the poultry species slaughtered	
x.	Date of visit	

B. Particulars of the selected poultry meat producer:

S.No	Particulars	
i.	Number of birds slaughtered on visit date	Private/ co-operative/ contract
ii.	Place of purchase	Poultry farm/ Market/ any other (specify)
iii.	Method of transport of poultry birds	Truck/ lorry/ tractor trolley/ auto/ cycle
iv.	Type of cage for keeping live poultry birds	
v.	Catching method employed	Both legs/ both wings/ one leg & one wing/ any other (pl specify)
vi.	Method of slaughtering	Manual/ Mechanical

C. Loss during slaughter of poultry birds:

S.No	Weight of fresh carcass(kg)	Weight of meat removed due to damages and injuries (kg)	Causes of loss
1			
2			

D. Loss during storage of poultry meat:

S.No	Particulars	
i.	Type of storage used for dressed chicken	Freeze/ chiller/ any other (pl specify)
ii.	Capacity of the storage (No)	
iii.	Number of dressed chicken stored in freezer	
iv.	Number of carcass drawn for observation	
v.	Number of dressed chicken spoiled	
vi.	Causes of spoilage	

Date: _____

_____
Signature of Field Investigator

ALL INDIA COORDINATED RESEARCH PROJECT ON POST-HARVEST TECHNOLOGY
ICAR-CIPHET, P.O. PAU Campus, Ludhiana – 141 004 (Punjab)

Sample Survey for Assessment of Harvest and Post-Harvest Losses

Schedule 5-Milk: Post-harvest losses in milk (BY OBSERVATION)

A. Identification:

S.No.	Particulars	
i.	Agro-climatic zone	
ii.	State	
iii.	District	
iv.	Tehsil/ Taluk	
v.	Block/ Mandal	
vi.	Village/ Address of chilling center/ processing unit	
vii.	Name of the farmer/ chilling center/ processing unit	
viii.	Number of milch animal (for farmers only)	
ix.	Quantity of milk produced/ processed/ collected per day (kg)	
x.	Date of visit	

B. Observation of research engineer regarding losses in different stages and channels:

S.No.	Stage/ Channel	Loss %	Causes of loss
i.	While milking		
ii.	Handing loss at producer level		
iii.	Loss at chilling center		
iv	Loss at processing unit		
v.	Any other loss (please specify)		

Date: _____

_____
Signature of Field Investigator

ALL INDIA COORDINATED RESEARCH PROJECT ON POST-HARVEST TECHNOLOGY

ICAR-CIPHET, P.O. PAU Campus, Ludhiana – 141004 (Punjab)

Sample Survey for Assessment of Harvest and Post-Harvest Losses

Schedule 6-C: Losses during storage at Farm/ Trader/ Godown/ Processing unit Level for cereals, pulses, oilseeds and coriander *(BY OBSERVATION)*

A. Identification:

S.No.	Particulars	
i.	Agro-climatic zone	
ii.	State	
iii.	District	
iv.	Tehsil/ Taluk	
v.	Block/ Mandal	
vi.	Village/ Name of Market	
vii.	Name of the farmer/ Trader/ Godown/ Processing unit	
viii.	Total land holding (ha)/Quantity of grain handled (kg)	
ix.	Name of crops grown/ handled	
x.	Period of enquiry	
xi.	Date of visit	

B. Loss during storage:

S No	Crop	Initial Stock		Addition (kg)	Sale / consumption/ Processed/ disposal (kg)	Final Stock (kg)	Period of storage (month)	Whether grain infested (Yes/No)	Whether attacked by rodents (yes/no)	S. No. of identity slip attached with sample	Date of dispatch of sample
		Mode of storage	Quantity stored (kg)								

Date: _____

_____
Signature of Field Investigator

ALL INDIA COORDINATED RESEARCH PROJECT ON POST-HARVEST TECHNOLOGY
ICAR-CIPHET, P.O. PAU Campus, Ludhiana – 141 004 (Punjab)

Sample Survey for Assessment of Harvest and Post-Harvest Losses

Schedule 6-C1: Identity slip for the sample taken from farmer/ Traders/ Godown/ Processing unit Level for analysis in the Laboratory as per items mentioned overleaf.

Serial No. _____

S.No.	Particulars	
i.	Agro-climatic zone	
ii.	State	
iii.	District	
iv.	Tehsil/ Taluk	
v.	Block/ Mandal	
vi.	Village/ Name of Market	
vii.	Name of the farmer/ Trader/ Godown/ Processing unit	
viii.	Type of storage	
ix	Name of crop for which sample was taken	
x.	Weight of the sample drawn (g)	
xi.	Date (day, month & year) of sample drawn for each of the observations.	

Date: _____

_____
Signature of the Field Investigator

(N.B.: This slip should be prepared in triplicate. One copy may be kept inside the sample bag. Second one to be tied outside the bag and the third one to be kept with the Field Investigator for record.)

Date of receipt _____ Signature of Laboratory Assistant _____

Schedule 6-C2: Observation on samples taken from each of the samples sent by the field staff for analysis in the laboratory:

S.No	Particulars	Number	Weight, g
i.	Moisture content of grains, % (d.b.)		
ii.	No. & weight of undamaged grains		
iii.	No. & weight of damaged grains		

Date: _____

_____
Signature of Field Investigator

ALL INDIA COORDINATED RESEARCH PROJECT ON POST-HARVEST TECHNOLOGY

ICAR-CIPHET, P.O. PAU Campus, Ludhiana – 141004 (Punjab)

Sample Survey for Assessment of Harvest and Post-Harvest Losses

Schedule 6-H: Losses during Storage at Farmer/ Trader/ Retailer/ Processing unit/ Godown level in fruits, vegetables and plantation crops (BY OBSERVATION)

A. Identification:

S.No.	Particulars	
i.	Agro-climatic zone	
ii.	State	
iii.	District	
iv.	Tehsil/ Taluk	
v.	Block/ Mandal	
vi.	Village/Market/ Mandi/ Address of processing unit	
vii.	Name of the farmer/ trader/ retailer/ processing unit/ godown	
viii.	Name of fruits & vegetables crops handled	
ix.	Total quantity of commodities handled/ stored in previous month, (kg)	
x.	Period of enquiry	
Xi	Date of visit	

B. Loss during storage:

S. No.	Name of crop	Initial Stock		Addition (kg)	Sale/ consumption/ processed, (kg)	Final Stock, (kg)	Weight/ number of sample drawn (kg)	Weight/ number of damaged produce (kg)	Loss (%)	Causes of loss
		Mode of storage	Quantity stored (kg)							

Date: _____

_____
Signature of Field Investigator

ALL INDIA COORDINATED RESEARCH PROJECT ON POST-HARVEST TECHNOLOGY
ICAR-CIPHET, P.O. PAU Campus, Ludhiana – 141 004 (Punjab)

Sample Survey for Assessment of Harvest and Post-Harvest Losses Egg

Schedule 6- E: Losses of eggs during transportation and storage at farm/ wholesaler/ retailer level (BY OBSERVATION)

A. Identification:

S.No	Particulars	
i.	Agro-climatic zone	
ii.	State	
iii.	District	
iv.	Tehsil/ Taluk	
v.	Block/ Mandal	
vi.	Village	
vii.	Name & address of the farmer/ wholesaler/ retailer	
vii.	Number of eggs handled/ marketed	
viii.	Period of enquiry	
ix.	Date of visit	

B. Loss during transportation:

S.No	Particulars	
i.	Mode of transport (Auto / truck/ any other (pl specify))	
ii.	Total distance of transportation (km)	
iii.	Total number of packages transported	
iv	Time taken during transportation, days	
v.	Number of eggs in packages for loss estimation (5 packages randomly to be taken)	
vi.	Number of eggs damaged during transport	
vii.	Causes of loss	

C. Loss of eggs during storage:

S.No	Particulars	
i.	Type of storage	
ii.	Type of packaging material used Plain card board box/ corrugated board box/ any other (pl specify)	
iii.	Method of preservation	Oil application/ any other (pl specify)
iv.	Total number of eggs in packages drawn for loss estimation (5 packages)	
v.	Number of eggs spoiled/ damaged	
vi.	Causes of loss	

Date: _____

_____
Signature of Field Investigator

ALL INDIA COORDINATED RESEARCH PROJECT ON POST-HARVEST TECHNOLOGY
ICAR-CIPHET, P.O. PAU Campus, Ludhiana – 141 004 (Punjab)

Schedule 6-IF: Losses at market level (Wholesale/ retail/ pre-processing/ processing unit Level in Inland Fish *(BY OBSERVATION)*

A. Identification:

S.No	Particulars	
i.	Agro-climatic zone	
ii.	State	
iii.	District	
iv.	Tehsil/ Taluk	
v.	Block/ Mandal	
vi.	Name of the fish market	
vii.	Name & address of the Wholesaler/ retailer/ processing unit	
viii.	Period of enquiry	
ix.	Date of visit	

B. Losses during transportation:

S.No.	Particulars	
i.	Distance of market from place of loading fish, km	
ii.	Mode of transport	
iii.	Time taken for transportation, h	
iv.	Type of packaging used for transportation	
v. vi.	Whether ice is used for packing Fish: Ice ratio used (in case of ice)	Yes/ No
vii.	Weight of sample drawn for analysis (Minimum 10 kg)	
viii.	Weight of fish discarded (Loss), kg	
ix.	Causes of loss	

C. Losses during storage:

S.No.	Particulars	
i.	Type of storage	Frozen storage/ Refrigerated storage/ Bamboo basket/ Plastic insulated box with ice/ Metal box with ice/ Plastic crate/ any other (pl specify)
ii.	Capacity of storage, kg	
iii.	Duration of storage, days	
iv.	Weight of sample drawn (Minimum 10kg sample or complete pack)	
v.	Weight of fish spoiled in sample, kg	
vi.	Causes of loss	

Date: _____

_____
Signature of Field Investigator

ALL INDIA COORDINATED RESEARCH PROJECT ON POST-HARVEST TECHNOLOGY
ICAR-CIPHET, P.O. PAU Campus, Ludhiana – 141 004 (Punjab)

Schedule 6-MF: Losses at market level (Wholesale/ retail/ pre-processing/ processing unit Level in Marine Fish (BY OBSERVATION)

A. Identification:

S.No	**Particulars**	
i.	Agro-climatic zone	
ii.	State	
iii.	District	
iv.	Tehsil/Taluk	
v.	Block/Mandal	
vi.	Name of the fish market	
vii.	Name & address of the Wholesaler/ retailer/ processing unit	
viii	Period of enquiry	
ix	Date of visit	

B. Loss during transportation:

S. No	Particulars	
i.	Distance of market from place of loading fish	
ii.	Mode of transport	
iii.	Time taken for transportation, h	
iv.	Type of packaging used for transportation	
v.	Whether ice is used for packaging	Yes/ No
vi.	Fish: Ice ratio used (in case of ice)	
vii.	Weight of sample drawn for analysis (Minimum 10 kg)	
viii.	Weight of fish discarded (Loss), kg	
ix.	Causes of loss	

C. Loss during storage:

S.No	**Particulars**	
i.	Type of storage	
ii.	Capacity of storage, kg	
iii.	Duration of storage, days	
iv.	Weight of sample drawn (Minimum 10kg or complete pack)	
v.	Weight of fish spoiled in sample, kg	
vi.	Causes of loss	

D. Loss during drying:

S.No.	**Particulars**	
i.	Method of drying	
ii.	Type of drying floor/ yard/ machine used	
iii.	Time taken for drying, hours and days	
iv.	Weight of sample drawn (5 kg sample of fish)	
v.	Weight of fish spoiled in the sample, kg	
vi.	Causes of loss	

Date: _____

_____
Signature of Field Investigator

Appendix II

Sample Size (No. of respondents) for Estimation of Loss in Farm Operations at the National Level

S. No.	Crop	Harvest-ing	Collec-tion	Sorting/ Grading	Thresh-ing	Winnowing/ Cleaning	Dry-ing	Packag-ing	Transport-tation
Grains (Cereals, Millets, Pulses, Oilseeds)									
1	Paddy	4027	2490	-	2737	3006	1664	3261	3167
2	Wheat	1944	1182	-	1426	1247	591	1589	1657
3	Maize	994	807	-	978	792	774	795	718
4	Bajra	503	403	-	500	249	347	404	401
5	Sorghum	293	216	-	293	228	130	208	233
6	Pigeon pea	467	367	-	464	397	296	370	351
7	Chick pea	339	292	-	339	178	248	291	294
8	Black gram	751	616	-	751	682	400	598	595
9	Green gram	783	587	-	781	723	399	581	531
10	Mustard	766	597	-	764	703	421	644	644
11	Cottonseed	376	255	-	-	-	57	141	314
12	Soybean	491	376	-	473	328	214	394	413
13	Safflower	12	12	-	12	3	3	12	12
14	Sunflower	48	39	-	48	32	34	36	39
15	Groundnut	514	373	-	487	358	311	378	381
Fruits and Vegetables									
16	Apple	470	323	451	-	-	-	371	439
17	Banana	747	553	605	-	-	-	189	623
18	Citrus	442	267	377	-	-	-	349	414
19	Grapes	101	56	101	-	-	-	65	100
20	Guava	116	84	102	-	-	-	91	105
21	Mango	738	545	668	-	-	-	415	701
22	Papaya	317	155	270	-	-	-	242	313
23	Sapota	267	184	267	-	-	-	188	266
24	Cabbage	798	506	587	-	-	-	528	782
25	Cauliflower	937	584	680	-	-	-	703	925
26	Green pea	542	369	442	-	-	-	420	514
27	Mushroom	38	13	38	-	-	-	24	38
28	Onion	630	458	596	-	-	-	419	573
29	Potato	1697	1228	1622	-	-	-	1330	1563
30	Tomato	1133	706	1078	-	-	-	721	1078
31	Tapioca	247	136	236	-	-	-	84	209

S. No.	Crop	Harvest-ing	Collec-tion	Sorting/ Grading	Thresh-ing	Winnowing/ Cleaning	Dry-ing	Packag-ing	Transport-tation
Plantation Crops and Spices									
32	Arecanut	698	554	-	662	384	258	442	556
33	Black pepper	396	330	-	393	382	332	275	238
34	Cashew	104	73	-	80	42	68	72	97
35	Chilli	231	155	227	-	-	52	164	230
36	Coconut	1436	1163	-	1244	197	169	309	851
37	Coriander	62	51	-	60	60	49	49	51
38	Sugarcane	515	319	207	-	-	136	167	408
39	Turmeric	146	113	144	-	-	114	123	145
Livestock Produce									
40	Egg	-	375	155	-	-	-	375	116
41	Inland fish	357	117	111	-	-	-	112	126
42	Marine fish	33	131	103	-	-	14	21	88
43	Meat	322	-	17	-	-	-	-	13
44	Poultry meat	380	-	91	-	-	-	5	71
45	Milk	288	286	-	-	-	-	36	40

Appendix III

Sample Size (No. of observations) for Estimation of Loss in Storage in Different Market Channels at the National Level

S. No.	Crop	Farm Level	Godown Level	Wholesaler Level	Retailer Level	Processing Unit Level
Grains (Cereals, Millets, Pulses, Oilseeds)						
1	Paddy	14976	272	622	423	759
2	Wheat	15754	299	774	565	395
3	Maize	3297	49	192	181	35
4	Bajra	2153	66	350	332	23
5	Sorghum	1420	100	262	103	55
6	Pigeon pea	2870	84	255	506	123
7	Chick pea	1770	76	364	312	108
8	Black gram	2430	29	652	1049	262
9	Green gram	2534	50	557	838	107
10	Mustard	4172	28	420	321	55
11	Cottonseed	783	2	34	5	20
12	Soybean	956	141	86	270	34
13	Safflower	11	12	26	-	10
14	Sunflower	40	12	37	20	24
15	Groundnut	1175	67	299	379	188
Fruits and Vegetables						
16	Apple	1049	27	74	192	27
17	Banana	553	3	339	594	66
18	Citrus	919	41	193	402	13
19	Grapes	2	-	138	169	8
20	Guava	55	-	18	83	5
21	Mango	293	6	149	153	46
22	Papaya	1171	28	211	320	11
23	Sapota	924	13	131	264	4
24	Cabbage	962	31	284	554	12
25	Cauliflower	934	30	266	443	2
26	Green pea	761	26	181	385	15
27	Mushroom	18	-	-	17	-
28	Onion	2280	71	970	1247	83
29	Potato	6545	109	499	707	36
30	Tomato	477	-	684	713	42
31	Tapioca	175	-	40	84	24

S. No.	Crop	Farm Level	Godown Level	Wholesaler Level	Retailer Level	Processing Unit Level
Plantation Crops and Spices						
32	Arecanut	289	-	84	121	11
33	Black pepper	104	-	8	37	-
34	Cashew	92	12	153	137	33
35	Chilli	161	-	202	372	129
36	Coconut	1703	-	150	192	15
37	Coriander	64	-	56	36	-
38	Sugarcane	300	-	20	12	13
39	Turmeric	161	-	161	306	147
Livestock Produce						
40	Egg	822	-	248	209	-
41	Inland fish	20	-	225	182	-
42	Marine fish	-	-	42	48	-
43	Meat	103	10	12	80	12
44	Poultry meat	295	-	11	93	-
45	Milk	11	-	-	-	24

Appendix IV

Extent of National Coverage of Crops and Livestock Produce by Sampling

S. No.	Crop	Agro-climatic zones covered	Districts surveyed	Production in surveyed districts (,000 tonnes)	All India Production (,000 tonnes)	% of National Production
Grains (Cereals, Millers, Pulses, Oilseeds						
1	Paddy	10	53	19512.37	104400.00	18.69
2	Wheat	11	38	9300.79	92460.00	10.06
3	Maize	5	21	3780.17	22230.00	17.00
4	Bajra	7	13	1668.73	8741.98	19.09
5	Sorghum	5	15	805.45	5280.98	15.25
6	Pigeon pea	7	22	295.98	3070.00	9.64
7	Chick pea	6	14	850.78	8880.00	9.58
8	Black gram	8	25	72.30	826.99	8.74
9	Green gram	7	23	102.64	458.55	22.38
10	Mustard	10	22	838.37	7820.00	10.72
11	Cottonseed	6	15	801.20	3490.44	22.95
12	Soybean	3	14	2866.57	14680.00	19.53
13	Safflower	2	2	1.22	98.51	1.24
14	Sunflower	2	6	84.21	580.00	14.52
15	Groundnut	8	24	910.81	4750.00	19.18
Fruits and Vegetables						
16	Apple	1	7	988.16	1897.00	52.09
17	Banana	5	20	1984.94	27055.00	7.34
18	Citrus	5	12	370.32	11470.00	3.23
19	Grapes	2	6	813.27	2519.00	32.29
20	Guava	5	12	105.41	2619.00	4.02
21	Mango	8	25	2728.71	17291.00	15.78
22	Papaya	6	15	111.25	5190.00	2.14
23	Sapota	3	7	180.54	1497.00	12.06
24	Cabbage	8	28	1146.16	8534.23	13.43
25	Cauliflower	7	31	1000.88	7785.00	12.86
26	Green pea	5	24	243.13	3867.00	6.29
27	Mushroom	4	5	1.40	40.60	3.45
28	Onion	6	24	3320.70	16655.00	19.94
29	Potato	9	32	8644.16	41092.00	21.04
30	Tomato	8	31	2574.31	17848.00	14.42
31	Tapioca	4	13	1497.92	7319.00	20.47

S. No.	Crop	Agro-climatic zones covered	Districts surveyed	Production in surveyed districts (,000 tonnes)	All India Production (,000 tonnes)	% of National Production
Plantation Crops and Spices						
32	Arecanut	3	13	229.00	529.00	43.29
33	Black pepper	1	5	8.83	52.00	16.98
34	Cashew	3	7	51.30	753.37	6.81
35	Chilli	4	13	407.56	1305.00	31.23
36	Coconut	4	21	4605.05	15090.00	30.52
37	Coriander	2	2	5.94	526.00	1.13
38	Sugarcane	7	25	6536.59	338960.00	1.93
39	Turmeric	4	8	270.88	976.00	27.75
Livestock Produce						
40	Egg	6	19	1055.95	69700.00	1.51
41	Inland fish	5	15	974.84	5744.00	16.97
42	Marine fish	4	9	252.36	3275.00	7.71
43	Meat	5	12	18.45	1300.00	1.42
44	Poultry meat	6	17	136.37	3900.00	3.50
45	Milk	4	14	3313.68	132400.00	2.50

Appendix V

Percentage Loss out of Total Amount Stored in Different Channels at National Level

Crop	Storage Channels				
	Farm	Godown	Wholesaler	Retailer	Processing unit
Cereals					
Paddy	1.80 ± 0.23	1.05 ± 0.26	1.38 ± 0.23	0.87 ± 0.16	0.39 ± 0.05
Wheat	1.40 ± 0.18	0.28 ± 0.08	0.57 ± 0.19	0.48 ± 0.12	0.62 ± 0.07
Maize	0.90 ± 0.45	0.46 ± 0.15	0.79 ± 0.23	0.81 ± 0.23	0.56 ± 0.19
Bajra	0.97 ± 0.12	0.53 ± 0.15	0.58 ± 0.16	1.09 ± 0.16	0.71 ± 0.15
Sorghum	1.05 ± 0.20	1.57 ± 0.15	1.22 ± 0.15	1.36 ± 0.25	1.04 ± 0.27
Pulses					
Pigeon pea	1.77 ± 0.13	2.20 ± 0.34	0.78 ± 0.19	1.56 ± 0.26	1.78 ± 0.16
Chick pea	1.77 ± 0.23	0.49 ± 0.06	0.93 ± 0.15	1.26 ± 0.18	1.17 ± 0.10
Black gram	1.23 ± 0.20	0.67 ± 0.19	1.14 ± 0.15	1.47 ± 0.19	1.01 ± 0.04
Green gram	1.24 ± 0.27	0.85 ± 0.48	1.29 ± 0.19	1.14 ± 0.16	1.40 ± 0.21
Oilseeds					
Mustard	0.37 ± 0.11	0.30 ± 0.19	0.23 ± 0.07	0.30 ± 0.16	0.04 ± 0.01
Cottonseed	0.46 ± 0.18	0.24 ± 0.15	0.84 ± 0.22	0.23 ± 0.04	0.01 ± 0.00
Soybean	1.02 ± 0.26	1.10 ± 0.16	0.68 ± 0.19	1.62 ± 0.24	1.63 ± 0.03
Safflower	0.24 ± 0.01	0.58 ± 0.01	1.07 ± 0.02		2.13 ± 0.23
Sunflower	2.13 ± 0.50	0.8 ± 0.13	0.73 ± 0.14	1.28 ± 0.18	1.93 ± 0.36
Groundnut	0.95 ± 0.24	0.83 ± 0.08	1.09 ± 0.19	0.62 ± 0.86	0.90 ± 0.21
Fruits					
Apple	1.07 ± 0.05	1.57 ± 0.14	1.11 ± 0.08	1.60 ± 0.70	1.45 ± 0.33
Banana	1.08 ± 0.16	1.54 ± 0.42	1.51± 0.23	3.00 ± 0.25	1.07 ± 0.17
Citrus	1.60 ± 0.22	0.98 ± 0.29	1.66 ± 0.12	3.26 ± 0.30	0.83 ± 0.49
Grapes	3.26 ± 0.01		2.31 ± 0.21	3.11 ± 0.22	0.77 ± 0.14
Guava	1.15 ± 0.15		5.24 ± 0.85	4.38 ± 0.78	3.1 ± 1.15
Mango	2.46 ± 0.15	0.53 ± 0.40	1.86 ± 0.54	3.41 ± 0.62	1.13 ± 0.21
Papaya	1.29 ± 0.32	2.75 ± 0.22	1.78 ± 0.19	3.43 ± 0.26	1.32 ± 0.23
Sapota	0.93 ± 0.59	2.63 ± 0.29	2.08 ± 0.24	2.70 ± 0.16	0.70 ± 0.18
Vegetables					
Cabbage	2.23 ± 0.45	1.53 ± 0.22	2.19 ± 0.19	3.07 ± 0.39	1.37 ± 0.25
Cauliflower	1.70 ± 0.63	0.99 ± 0.32	1.80 ± 0.28	2.54 ± 0.49	0.00 ± 0.00
Green pea	0.96 ± 0.23	1.67 ± 0.43	2.00 ±0.25	1.46 ± 0.46	1.31 ± 0.57
Mushroom	0.66 ± 0.62			1.74 ± 0.97	
Onion	1.74 ± 0.47	1.67 ± 0.21	2.01 ± 0.22	3.25 ± 0.32	1.02 ± 0.24
Potato	1.62 ± 0.35	0.31 ± 0.16	1.37 ± 0.16	1.41 ± 0.33	0.70 ± 0.09

Crop	Storage Channels				
	Farm	Godown	Wholesaler	Retailer	Processing unit
Tomato	3.12 ± 0.49	-	2.70 ± 0.22	3.72 ± 0.38	0.38 ± 0.03
Tapioca	1.08± 0.44	-	0.77 ± 0.08	2.30 ± 0.41	2.10 ± 0.11
Plantation crops and spices					
Arecanut	2.42 ± 0.15	-	0.69 ± 0.22	0.74 ± 0.23	2.44 ±1.75
Black Pepper	0.33 ± 0.02	-	0.01 ± 0.01	1.06 ± 0.41	-
Cashew	0.17 ± 0.07	0.25 ± 0.20	0.45 ± 0.17	0.58 ± 0.23	0.28 ± 0.06
Chilli	0.96 ± 0.03	-	1.51 ± 0.19	1.81 ± 0.35	0.78 ± 0.13
Coconut	1.11 ± 0.08	-	1.48 ± 0.29	1.71 ±0.33	1.50 ± 0.11
Coriander	0.54 ± 0.00	-	0.43 ± 0.06	1.00 ±0.12	-
Sugarcane	0.40 ± 0.36	-	2.16 ± 0.67	2.13 ±0.73	0.05 ± 0.04
Turmeric	0.76 ± 0.14	-	1.37 ± 0.06	0.64 ± 0.31	0.60 ± 0.05
Livestock produce					
Egg	1.42 ± 0.44	-	2.39 ± 0.22	2.39 ± 0.26	-
Inland fish	2.08 ± 0.00	-	0.69 ± 0.22	1.20 ± 0.28	-
Marine fish	-	-	1.50 ± 0.22	1.65 ± 0.52	-
Meat	0.12 ± 0.04	0.50 ± 0.01	0.98 ± 0.17	0.50 ± 0.11	0.06 ± 0.05
Poultry meat	0.07 ± 0.02	-	5.75 ± 0.63	2.15 ± 0.28	-
Milk	0.00 ± 0.00	-	-	-	0.65 ± 0.31

Appendix VI

Harvest and Post-harvest Losses in percent of Crops/ Commodities at Agro-climatic Zone Level

1. Western Himalayan Region (Uttarakhand: 4 districts; H.P: 4; J&K : 3)

Crop	Farm Operations								Total loss in	Storage in Channels					Total	Overall
	Harvest	Collect-ion	Sorting/ Grading	Thresh-ing	Winnow-ing	Drying	Packag-ing	Trans-port	farm operations	Farm	Godown /cold store	Whole-saler	Retailer	Process-ing unit	loss in storage	Total Loss
Apple	4.33 ±0.35	0.29 ±0.22	3.94 ±0.44	-	-	-	0.11 ±0.11	0.42 ±0.19	**9.08** ±0.30	0.02 ±0.00	0.13 ±0.02	0.57 ±0.08	0.34 ±0.29	0.25 ±0.11	**1.31** ±0.11	**10.39** ±0.24
Cabbage	1.51 ±0.69	0.00 ±0.02	1.53 ±0.53	-	-	-	0.01 ±0.02	0.03 ±0.05	**3.08** ±0.40	0.06 ±0.03	0.00 ±0.00	0.60 ±0.09	0.65 ±0.52	-	**1.30** ±0.38	**4.38** ±0.39
Cauliflower	2.42 ±1.35	0.19 ±0.13	2.75 ±0.34	-	-	-	0.51 ±0.20	0.52 ±0.06	**6.39** ±0.66	0.08 ±0.04	0.01 ±0.02	0.70 ±0.13	0.65 ±0.46	0.00 ±0.00	**1.44** ±0.27	**7.83** ±0.56
Citrus	3.21 ±0.53	0.31 ±0.06	1.21 ±0.46	-	-	-	0.04 ±0.06	0.07 ±0.01	**4.84** ±0.32	0.01 ±0.00	0.00 ±0.00	0.59 ±0.27	1.04 ±0.45	0.09 ±0.08	**1.74** ±0.24	**6.58** ±0.30
Egg	-	2.24 ±0.09	-	-	-	-	2.31 ±0.09		**4.55** ±0.09	-	-	-	-	-	-	**4.55** ±0.09
Green pea	2.29 ±0.54	0.07 ±0.07	2.59 ±0.56	-	-	-	0.04 ±0.08	0.55 ±0.08	**5.53** ±0.36	0.07 ±0.01	0.00 ±0.00	0.82 ±0.19	0.30 ±0.39	0.03 ±0.03	**1.23** ±0.22	**6.76** ±0.32
Meat	2.75 ±0.06	-	-	-	-	-	-	-	**2.75** ±0.06	-	-	-	-	-	-	**2.75** ±0.06
Milk	0.33 ±0.22	0.00 ±0.00	-	-	-	-	-	0.00 ±0.00	**0.33** ±0.12	-	-	-	-	0.21 ±0.20	**0.21** ±0.20	**0.54** ±0.13
Mushroom	1.09 ±0.03	0.08 ±0.00	6.80 ±0.17	-	-	-	0.22 ±0.00	0.09 ±0.00	**8.28** ±0.08	0.66 ±1.22	-	-	1.26 ±1.77	-	**1.92** ±1.49	**10.20** ±0.91
Potato	3.57 ±0.69	0.37 ±0.07	2.48 ±0.25	-	-	-	0.18 ±0.10	0.18 ±0.14	**6.78** ±0.36	0.11 ±0.03	0.07 ±0.11	0.47 ±0.08	0.07 ±0.07	-	**0.73** ±0.05	**7.50** ±0.26
Poultry meat	1.37 ±0.11	-	-	-	-	-		-	**1.37** ±0.11	-	-	-	-	-	-	**1.37** ±0.11
Wheat	2.00 ±0.23	0.70 ±0.14	-	2.54 ±0.29	0.12 ±0.29	0.47 ±0.30	0.03 ±0.03	0.00 ±0.00	**5.86** ±0.22	0.19 ±0.03	0.00 ±0.00	0.02 ±0.00	0.01 ±0.01	0.02 ±0.01	**0.24** ±0.03	**6.10** ±0.15

2. Eastern Himalayan Region (Assam: 7 districts; West Bengal: 1)

Crop	Farm Operations								Total loss in farm operations	Storage in Channels					Total loss in storage	Overall Total Loss
	Harvest	Collect-ion	Sorting/ Grading	Thresh-ing	Winnow-ing	Drying	Packag-ing	Trans-port		Farm	Godown /cold store	Whole-saler	Retailer	Process-ing unit		
Cabbage	2.06 ±0.51	0.67 ±0.16	2.83 ±0.18	-	-	-	0.23 ±0.03	2.17 ±0.18	**7.96** ±0.31	0.26 ±0.04	0.09 ±0.02	1.11 ±0.18	1.49 ±0.23	-	**2.95** ±0.11	**10.91** ±0.23
Cauliflower	2.29 ±0.23	0.79 ±0.40	2.40 ±0.35	-	-	-	0.33 ±0.14	2.39 ±0.40	**8.20** ±0.32	0.18 ±0.03	0.14 ±0.06	1.46 ±0.20	1.25 ±0.24	-	**3.03** ±0.13	**11.23** ±0.25
Citrus	2.15 ±0.54	0.39 ±0.04	3.55 ±0.71	-	-	-	0.57 ±0.14	1.87 ±0.27	**8.53** ±0.44	0.06 ±0.01	0.03 ±0.01	0.61 ±0.15	0.84 ±0.18	0.02 ±0.06	**1.56** ±0.06	**10.09** ±0.32
Egg	-	1.09 ±0.14	1.03 ±0.08	-	-	-	1.15 ±0.07	0.81 ±0.11	**4.09** ±0.11	0.11 ±0.05		2.00 ±0.13	1.15 ±0.10	-	**3.26** ±0.07	**7.35** ±0.08
Green pea	1.96 ±0.11	1.19 ±0.01	1.71 ±0.16	-	-	-	0.29 ±0.07	0.85 ±0.10	**6.01** ±0.11	0.12 ±0.04	0.00 ±0.00	1.36 ±0.33	0.94 ±0.29	-	**2.42** ±0.20	**8.44** ±0.17
Meat	0.60 ±0.13	-	0.21 ±0.05	-	-	-	-	0.00 ±0.00	**0.81** ±0.10	0.00 ±0.00	0.01 ±0.00	0.46 ±0.16	0.25 ±0.11	0.00 ±0.00	**0.72** ±0.07	**1.53** ±0.08
Mustard	3.67 ±3.14	-	-	1.64 ±0.51	2.14 ±0.93	0.19 ±0.02	0.00 ±0.00	0.00 ±0.00	**7.64** ±1.36	0.13 ±0.15	-	-	-	-	**0.13** ±0.15	**7.77** ±1.16
Paddy	2.69 ±3.55	-	-	1.01 ±0.88	1.48 ±2.23	0.18 ±0.03	0.00 ±0.00	0.08 ±0.13	**5.44** ±1.84	0.47 ±0.04	0.13 ±0.01	-	-	-	**0.60** ±0.04	**6.04** ±1.45
Papaya	2.50 ±0.39	0.35 ±0.18	2.83 ±0.50	-	-	-	0.58 ±0.07	2.67 ±0.45	**8.93** ±0.38	0.12 ±0.03	0.01 ±0.01	1.24 ±0.15	1.95 ±0.30	-	**3.32** ±0.10	**12.25** ±0.26
Potato	0.94 ±0.85	-	2.89 ±2.35	-	-	-	0.00 ±0.00	0.00 ±0.00	**3.83** ±1.27	0.09 ±0.10	-	-	-	-	**0.09** ±0.10	**3.92** ±1.08
Poultry meat	0.24 ±0.21	-	0.33 ±1.95	-	-	-	-	0.02 ±0.02	**0.59** ±1.21	0.00 ±0.00	-	-	0.27 ±0.12	-	**0.27** ±0.06	**0.87** ±0.68
Sugarcane	1.75 ±0.15	0.30 ±0.01	0.60 ±0.01	-	-	0.44 ±0.01	0.12 ±0.01	0.20 ±0.04	**3.42** ±0.07	0.11 ±0.10	-	0.42 ±0.25	-	-	**0.53** ±0.13	**3.94** ±0.09
Tapioca	2.81 ±0.12	0.83 ±0.01	1.71 ±0.15	-	-	-	0.39 ±0.07	1.23 ±0.27	**6.97** ±0.17	0.41 ±0.26	-	0.45 ±0.08	0.51 ±0.21	-	**1.37** ±0.24	**8.34** ±0.20
Wheat	0.31 ±0.86	0.96 ±0.24	-	2.61 ±0.19	0.85 ±0.12	0.30 ±0.15	0.19 ±0.11	0.05 ±0.03	**5.27** ±0.39	0.70 ±0.26	0.11 ±0.06	0.26 ±0.07	0.03 ±0.01	0.05 ±0.01	**1.15** ±0.24	**6.42** ±0.35

3. Lower Gangetic Plain Region (West Bengal: 4 districts)

Crop	Farm Operations								Total loss in farm operations	Storage in Channels					Total loss in storage	Overall Total Loss
	Harvest	Collect-ion	Sorting/ Grading	Thresh-ing	Winnow-ing	Drying	Packag-ing	Trans-port		Farm	Godown /cold store	Whole-saler	Retailer	Process-ing unit		
Arecanut	1.02	0.00	-	1.91	2.76	0.00	0.00	0.26	**5.95**	-	-	0.53	0.01	-	**0.54**	**6.49**
	±0.46	±0.00		±0.31	±0.11	±0.00	±0.00	±0.02	±0.24			±0.53	±0.02		±0.43	±0.25
Black gram	1.65	0.35	-	0.41	0.19	0.00	0.00	0.00	**2.60**	0.43	-	0.07	0.05	-	**0.55**	**3.15**
	±0.17	±0.28		±0.25	±0.05	±0.00	±0.00	±0.00	±0.16	±0.25		±0.02	±0.03		±0.21	±0.16
Cabbage	0.78	0.02	4.47	-	-	-	0.00	0.04	**5.32**	-	-	-	1.03	-	**1.03**	**6.35**
	±0.10	±0.01	±0.71				±0.00	±0.10	±0.33				±0.65		±0.65	±0.36
Cauliflower	0.89	0.01	7.04	-	-	-	0.00	0.02	**7.95**	-	-	-	1.25	-	**1.25**	**9.20**
	±0.40	±0.08	±0.77				±0.00	±0.06	±0.41				±0.46		±0.46	±0.41
Chilli	2.58	0.04	3.27	-	-	0.00	0.01	0.15	**6.06**	-	-	0.08	0.22	-	**0.30**	**6.37**
	±0.31	±0.10	±0.93			±0.00	±0.05	±0.49	±0.50			±0.05	±0.25		±0.20	±0.49
Coconut	0.41	0.00	-	1.35	3.25	0.00	0.00	0.00	**5.02**	0.01	-	0.20	0.19	-	**0.40**	**5.42**
	±0.13	±0.00		±0.11	±0.10	±0.00	±0.00	±0.00	±0.08	±0.00		±0.23	±0.14		±0.08	±0.08
Green gram	1.33	0.23	-	0.58	0.15	0.00	0.00	0.00	**2.28**	0.29	-	-	-		**0.29**	**2.57**
	±0.25	±0.24		±1.24	±0.17	±0.00	±0.00	±0.00	±0.51	±0.38					±0.38	±0.51
Green pea	0.50	0.02	1.65	-	-	-	0.00	1.74	**3.91**	0.03	-	-	0.84	-	**0.87**	**4.78**
	±0.18	±0.01	±0.10				±0.00	±0.01	±0.10	±0.00			±0.26		±0.23	±0.11
Guava	5.27	0.00	1.33	-	-	-	0.00	0.00	**6.61**	-	-	-	-	-	**-**	**6.61**
	±0.06	±0.00	±1.79				±0.00	±0.00	±0.80							±0.80
Inland fish	1.06	0.00	0.08	-	-	-	0.00	0.00	**1.15**	-	-	0.05	0.43	-	**0.48**	**1.62**
	±0.02	±0.00	±0.01				±0.00	±0.00	±0.01			±0.05	±0.23		±0.18	±0.05
Mango	1.66	0.00	4.75	-	-	-	0.21	0.04	**6.66**	-	-	0.67	0.88	-	**1.55**	**8.21**
	±1.52	±0.00	±1.93				±0.01	±0.01	±1.13			±0.40	±0.75		±0.58	±1.11
Marine fish	5.12	0.41	4.09	-	-	-	0.00	0.13	**9.76**	-	-	0.27	0.19	-	**0.47**	**10.23**
	±0.01	±0.07	±0.59				±0.00	±0.01	±0.31			±0.04	±0.14		±0.07	±0.29
Mustard	2.85	0.67	-	0.91	0.40	0.00	0.00	0.00	**4.84**	0.04	-	0.03	0.02	-	**0.10**	**4.94**
	±0.47	±0.08		±0.52	±0.13	±0.00	±0.00	±0.00	±0.28	±0.04		±0.03	±0.02		±0.03	±0.27
Paddy	2.15	0.67	-	2.40	1.56	0.03	0.07	0.01	**6.91**	0.21	-	0.12	0.02	-	**0.35**	**7.26**
	±0.33	±0.09		±0.35	±0.21	±0.06	±0.10	±0.02	±0.22	±0.10		±0.12	±0.01		±0.10	±0.20
Papaya	0.83	0.01	1.78	-	-	-	0.00	0.07	**2.70**	0.07	-	0.00	1.88	-	**1.94**	**4.64**
	±0.60	±0.06	±0.42				±0.00	±0.01	±0.33	±0.00		±0.00	±0.28		±0.27	±0.31
Potato	2.24	0.08	4.30	-	-	-	0.00	0.21	**6.83**	0.15	-	0.07	0.15	-	**0.37**	**7.19**
	±0.28	±0.14	±0.14				±0.01	±0.05	±0.16	±0.02		±0.04	±0.05		±0.03	±0.14
Tomato	3.91	0.00	4.45	-	-	-	0.01	0.69	**9.07**	-	-	0.17	1.41	-	**1.59**	**10.66**
	±0.32	±0.05	±0.87				±0.07	±0.08	±0.43			±0.08	±0.47		±0.40	±0.43
Wheat	2.14	0.58	-	2.78	0.57	0.00	0.00	0.00	**6.08**	-	-	0.04	0.03	-	**0.07**	**6.14**
	±0.31	±0.10		±0.07	±0.19	±0.00	±0.00	±0.00	±0.15			±0.03	±0.01		±0.02	±0.14

4. Middle Gangetic Plain Region (Bihar: 5 districts; U.P:2)

Crop	Farm Operations								Total loss in farm operations	Storage in Channels					Total loss in storage	Overall Total Loss
	Harvest	Collect-ion	Sorting/ Grading	Thresh-ing	Winnow-ing	Drying	Packag-ing	Trans-port		Farm	Godown /cold store	Whole-saler	Retailer	Process-ing unit		
Black gram	1.49 ±0.50	0.00 ±0.00	-	4.55 ±0.66	0.34 ±0.75	0.04 ±0.06	0.00 ±0.000	0.00 ±0.00	**6.41** ±0.46	0.52 ±0.27	-	0.07 ±0.09	0.21 ±0.09	0.03 ±0.07	**0.83** ±0.22	**7.24** ±0.41
Cabbage	1.63 ±0.74	0.07 ±0.25	2.60 ±0.34	-	-	-	0.26 ±0.01	1.11 ±0.96	**5.67** ±0.60	0.24 ±0.20	-	0.31 ±0.23	1.16 ±0.45	-	**1.71** ±0.31	**7.38** ±0.56
Cauliflower	2.56 ±0.67	0.09 ±0.50	2.81 ±0.53	-	-	-	0.22 ±0.10	0.80 ±0.74	**6.47** ±0.57	0.11 ±0.20	-	0.94 ±0.43	1.17 ±0.44	-	**2.21** ±0.36	**8.68** ±0.55
Green gram	1.91 ±0.36	0.00 ±0.00	-	2.69 ±0.55	0.49 ±0.26	0.03 ±0.08	0.00 ±0.00	0.00 ±0.00	**5.12** ±0.30	0.34 ±0.11	-	0.29 ±0.34	0.20 ±0.14	0.09 ±0.10	**0.92** ±0.12	**6.04** ±0.24
Green pea	2.93 ±0.78	2.08 ±0.80	2.51 ±0.21	-	-	-	0.36 ±0.33	1.22 ±0.26	**9.09** ±0.54	0.01 ±0.01	-	-	-	-	**0.01** ±0.01	**9.11** ±0.43
Guava	4.00 ±2.65	0.30 ±0.32	5.15 ±0.35	-	-	-	0.06 ±0.01	2.47 ±0.74	**11.98**±1.34	0.23 ±0.06	-	1.91 ±0.58	1.35 ±0.43	-	**3.49** ±0.24	**15.47** ±1.17
Inland fish	3.21 ±0.33	0.03 ±0.01	4.47 ±0.55	-	-	-	0.00 ±0.00	0.00 ±0.00	**7.71** ±0.30	0.10 ±0.01	-	0.26 ±0.07	0.80 ±0.29	-	**1.17** ±0.18	**8.88** ±0.25
Maize	0.07 ±0.04	0.00 ±0.07	-	1.65 ±0.35	0.84 ±1.05	0.13 ±0.38	0.01 ±0.04	0.01 ±0.03	**2.71** ±0.42	0.15 ±0.03	-	0.14 ±0.25	0.08 ±0.06	0.02 ±0.01	**0.39** ±0.04	**3.10** ±0.32
Mango	1.88 ±0.74	0.52 ±0.63	4.04 ±0.39	-	-	-	0.02 ±0.01	0.94 ±0.15	**7.41** ±0.49	0.17 ±0.02	-	0.76 ±0.75	1.32 ±0.29	0.25 ±0.21	**2.50** ±0.36	**9.91** ±0.49
Mustard	1.99 ±0.36	0.52 ±0.49	-	0.95 ±0.75	0.67 ±0.38	0.00 ±0.00	0.20 ±0.22	0.19 ±0.17	**4.52** ±0.44	0.09 ±0.01	-	0.02 ±0.01	0.03 ±0.03	-	**0.14** ±0.01	**4.66** ±0.26
Onion	2.51 ±0.34	0.03 ±0.05	2.80 ±0.73	-	-	-	0.00 ±0.00	0.42 ±0.14	**5.75** ±0.38	0.51 ±0.16	-	0.54 ±0.24	0.56 ±0.12	-	**1.61** ±0.17	**7.37** ±0.26
Paddy	1.59 ±0.36	0.30 ±0.15	-	2.45 ±0.75	0.21 ±0.20	0.02 ±0.03	0.06 ±0.02	0.06 ±0.05	**4.69** ±0.31	0.19 ±0.14	-	0.04 ±0.04	0.00 ±0.00	0.34 ±0.21	**0.57** ±0.13	**5.26** ±0.23
Pigeon pea	1.54 ±0.37	0.46 ±0.02	-	2.56 ±0.79	0.30 ±0.28	0.16 ±0.16	0.17 ±0.08	0.12 ±0.08	**5.30** ±0.38	0.38 ±0.25	-	0.07 ±0.04	0.10 ±0.10	0.22 ±0.15	**0.77** ±0.24	**6.07** ±0.33
Potato	2.11 ±1.08	0.59 ±0.47	2.96 ±1.53	-	-	-	0.02 ±0.05	0.16 ±0.07	**5.83** ±0.89	0.23 ±0.08	0.40 ±0.22	0.18 ±0.07	0.17 ±0.04	-	**0.99** ±0.08	**6.82** ±0.57
Sugarcane	0.97 ±0.59	0.00 ±0.00	1.32 ±0.01	-	-	-	-	0.00 ±0.00	**2.30** ±0.35	-	-	-	-	-	**-**	**2.30** ±0.35
Tomato	4.30 ±0.36	0.57 ±0.34	5.04 ±0.43	-	-	-	0.01 ±0.03	1.50 ±0.26	**11.41**±0.33	0.14 ±0.07	-	0.83 ±0.38	1.13 ±0.50	-	**2.10** ±0.33	**13.51** ±0.33
Wheat	0.19 ±0.34	0.36 ±0.34	-	2.44 ±0.78	0.35 ±0.51	0.00 ±0.00	0.07 ±0.06	0.07 ±0.05	**3.48** ±0.40	0.20 ±0.18	-	0.00 ±0.00	-	0.01 ±0.01	**0.21** ±0.17	**3.69** ±0.26

5. Upper Gangetic Plain Region (U.P.: 5 districts)

Crop	Farm Operations								Total loss in farm operations	Storage in Channels					Total loss in storage	Overall Total Loss
	Harvest	Collect-ion	Sorting/ Grading	Thresh-ing	Winnow-ing	Drying	Packag-ing	Trans-port		Farm	Godown /cold store	Whole-saler	Retailer	Process-ing unit		
Bajra	0.13 ±0.59	0.27 ±0.01	-	1.37 ±0.15	0.28 ±0.11	-	0.42 ±0.03	0.07 ±0.04	**2.54** ±0.28	0.16 ±0.13	-	0.04 ±0.05	0.06 ±0.05	-	**0.27** ±0.13	**2.81** ±0.18
Green pea	2.69 ±0.29	0.49 ±0.05	2.40 ±0.99	-	-	-	0.62 ±0.01	0.29 ±0.01	**6.50** ±0.34	-	-	0.44 ±0.64	0.14 ±0.18	-	**0.57** ±0.25	**7.07** ±0.29
Guava	7.88 ±1.17	0.47 ±0.21	3.97 ±3.93	-	-	-	0.14 ±0.18	0.31 ±0.38	**12.78** ±1.85	-	-	-	-	-	**-**	**12.78** ±1.85
Mango	1.92 ±0.64	0.17 ±0.18	4.30 ±2.24	-	-	-	0.07 ±0.08	0.40 ±0.14	**6.86** ±1.05	-	-	-	3.14 ±0.39	-	**3.14** ±0.39	**10.01** ±0.82
Mustard	1.23 ±0.47	0.55 ±0.17	-	2.00 ±0.31	0.94 ±0.06	0.04 ±0.03	0.17 ±0.16	0.07 ±0.04	**5.00** ±0.25	0.03 ±0.07	-	0.02 ±0.03	0.03 ±0.02	-	**0.08** ±0.07	**5.08** ±0.16
Paddy	1.48 ±0.03	0.50 ±0.04	-	1.30 ±0.12	0.44 ±0.05	0.17 ±0.10	0.19 ±0.02	0.07 ±0.01	**4.15** ±0.06	0.19 ±0.13	-	0.02 ±0.02	0.01 ±0.01	-	**0.22** ±0.12	**4.37** ±0.10
Pigeon pea	0.51 ±0.16	0.70 ±0.18	-	1.79 ±0.20	0.47 ±0.03	0.03 ±0.01	0.07 ±0.12	0.02 ±0.05	**3.59** ±0.13	0.25 ±0.15	-	0.03 ±0.06	0.01 ±0.02	-	**0.29** ±0.14	**3.88** ±0.14
Potato	2.98 ±0.89	0.15 ±0.07	2.74 ±0.33	-	-	-	0.14 ±0.09	1.82 ±0.38	**7.83** ±0.49	0.09 ±0.01	-	0.02 ±0.01	0.02 ±0.02	0.00 ±0.01	**0.14** ±0.01	**7.96** ±0.34
Sugarcane	3.31 ±0.01	0.02 ±0.00	1.37 ±0.01	-	-	-	-	0.02 ±0.00	**4.73** ±0.01	0.00 ±0.00	-	-	-	-	**0.00** ±0.00	**4.73** ±0.01
Turmeric	3.06 ±0.80	0.59 ±0.43	0.79 ±0.22	-	-	-	0.00 ±0.00	0.00 ±0.00	**4.44** ±0.42	0.09 ±0.06	-	-	-	-	**0.09** ±0.06	**4.54** ±0.39
Wheat	0.55 ±0.61	0.59 ±0.27	-	2.04 ±0.44	0.35 ±0.08	0.12 ±0.01	0.14 ±0.11	0.07 ±0.06	**3.86** ±0.35	0.22 ±0.14	-	0.03 ±0.02	0.02 ±0.01	0.12 ±0.10	**0.39** ±0.14	**4.25** ±0.23

6. Trans-Gangetic Plain Region (Haryana: 2 districts; Punjab: 3)

Crop	Farm Operations								Total loss in farm operations	Storage in Channels					Total loss in storage	Overall Total Loss
	Harvest	Collect-ion	Sorting/ Grading	Thresh-ing	Winnow-ing	Drying	Packag-ing	Trans-port		Farm	Godown /cold store	Whole-saler	Retailer	Process-ing unit		
Cabbage	3.93 ±0.12	-	-	-	-	-	0.06 ±0.05	1.32 ±0.11	**5.31** ±0.10	-	-	-	-	-	-	**5.31** ±0.10
Cauliflower	5.90 ±0.04	-	-	-	-	-	0.36 ±0.03	0.60 ±0.12	**6.86** ±0.07	-	-	-	-	-	-	**6.86** ±0.07
Citrus	1.97 ±0.03	-	3.22 ±1.04	-	-	-	0.06 ±0.01	0.40 ±0.69	**5.65** ±0.67	0.04 ±0.00	-	-	0.41 ±0.15	-	**0.44** ±0.10	**6.10** ±0.62
Cottonseed	3.06 ±0.10	-	-	-	-	-	0.03 ±0.00	0.33 ±0.02	**3.42** ±0.06	-	-	-	-	-	-	**3.42** ±0.06
Egg	-	1.61 ±0.28	1.42 ±0.12	-	-	-	0.49 ±0.06	0.17 ±0.10	**3.68** ±0.12	-	0.02 ±0.00	-	-	-	**0.02** ±0.00	**3.70** ±0.10
Inland fish	0.33 ±0.27	0.00 ±0.00	1.59 ±1.31	-	-	-	0.00 ±0.00	0.00 ±0.00	**1.93** ±0.60	-	0.01 ±0.01	-	0.33 ±0.37	-	**0.34** ±0.19	**2.27** ±0.44
Mushroom	0.23 ±0.07	0.00 ±0.00	5.89 ±0.45	-	-	-	0.13 ±0.10	0.17 ±0.11	**6.42** ±0.23	-	-	-	1.79 ±0.05	-	**1.79** ±0.05	**8.21** ±0.22
Mustard	2.23 ±0.01	0.26 ±0.01	-	1.74 ±0.01	0.32 ±0.03	-	0.02 ±0.00	0.01 ±0.00	**4.57** ±0.01	0.03 ±0.01	-	-	-	-	**0.03** ±0.01	**4.60** ±0.01
Paddy	2.59 ±0.30	0.02 ±0.00	-	-	0.33 ±0.09	-	0.02 ±0.02	0.02 ±0.01	**2.99** ±0.16	0.12 ±0.02	0.00 ±0.00	-	-	0.01 ±0.05	**0.13** ±0.03	**3.12** ±0.15
Potato	3.97 ±0.23	0.09 ±0.03	0.83 ±0.08	-	-	-	0.01 ±0.00	0.01 ±0.00	**4.92** ±0.12	-	-	-	0.09 ±0.02	-	**0.09** ±0.02	**5.01** ±0.12
Poultry meat	0.46 ±0.33	-	0.62 ±0.12	-	-	-	0.00 ±0.00	0.00 ±0.00	**1.08** ±0.29	-	-	-	-	-	-	**1.08** ±0.29
Tomato	5.73 ±0.97	-	3.23 ±0.21	-	-	-	0.19 ±0.01	1.76 ±0.53	**10.92** ±0.56	-	-	-	-	-	-	**10.92** ±0.56
Wheat	2.36 ±0.26	0.03 ±0.00	-	0.32 ±0.01	0.25 ±0.08	-	0.02 ±0.01	0.02 ±0.00	**2.99** ±0.14	0.88 ±0.13	0.00 ±0.02	0.00 ±0.00	-	0.08 ±0.03	**0.96** ±0.12	**3.95** ±0.13

7. Eastern Plateau and Hills Region (Chattisgarh: 5 districts; Jharkhand: 2; M.P.: 1; Maharashtra: 1; Odisha: 2; W.B.:1)

Crop	Farm Operations								Total loss in farm operations	Storage in Channels					Total loss in storage	Overall Total Loss
	Harvest	Collect-ion	Sorting/ Grading	Thresh-ing	Winnow-ing	Drying	Packag-ing	Trans-port		Farm	Godown /cold store	Whole-saler	Retailer	Process-ing unit		
Black gram	2.70 ±0.59	0.31 ±0.23	-	2.29 ±1.70	0.09 ±0.15	0.14 ±0.17	0.05 ±0.01	0.03 ±0.00	**5.60** ±0.76	2.02 ±0.22	0.04 ±0.01	0.25 ±0.01	0.29 ±0.03	0.00 ±0.00	**2.61** ±0.18	**8.21** ±0.49
Cabbage	2.02 ±0.07	0.67 ±0.06	3.06 ±0.41	-	-	-	0.94 ±0.18	1.33 ±0.32	**8.01** ±0.27	0.09 ±0.01	0.06 ±0.03	1.92 ±0.07	2.70 ±0.12	0.02 ±0.01	**4.79** ±0.09	**12.81** ±0.21
Cashew	2.00 ±0.34	0.76 ±0.01	-	1.50 ±0.39	0.12 ±0.38	0.00 ±0.00	0.00 ±0.00	0.00 ±0.00	**4.38** ±0.26	0.00 ±0.00	-	0.27 ±0.12	0.03 ±0.02	-	**0.30** ±0.11	**4.68** ±0.19
Cauliflower	1.52 ±0.26	0.41 ±0.22	2.10 ±0.59	-	-	-	0.91 ±0.21	1.41 ±0.57	**6.36** ±0.43	0.10 ±0.07	-	0.49 ±0.20	0.67 ±0.16	-	**1.25** ±0.13	**7.61** ±0.36
Chick pea	1.27 ±0.77	0.43 ±0.57	-	0.51 ±0.82	0.02 ±0.11	1.89 ±0.38	0.04 ±0.10	0.83 ±0.06	**4.99** ±0.55	0.56 ±0.04	-	0.17 ±0.04	0.53 ±0.05	-	**1.26** ±0.04	**6.24** ±0.30
Coriander	2.32 ±0.26	0.43 ±0.09	-	1.60 ±0.25	0.35 ±0.09	0.06 ±0.02	0.08 ±0.02	0.10 ±0.03	**4.93** ±0.14	-	-	0.02 ±0.03	0.01 ±0.00	-	**0.02** ±0.03	**4.96** ±0.13
Green gram	2.32 ±0.33	0.63 ±0.48	-	1.81 ±0.14	0.04 ±0.65	0.45 ±0.01	0.11 ±0.01	0.10 ±0.01	**5.46** ±0.36	1.07 ±0.32	-	0.58 ±0.04	0.54 ±0.06	0.06 ±0.03	**2.26** ±0.20	**7.71** ±0.26
Groundnut	2.84 ±0.19	1.67 ±0.33	-	1.68 ±0.32	1.09 ±0.20	0.14 ±0.21	0.00 ±0.00	0.00 ±0.00	**7.42** ±0.23	0.14 ±0.19	-	-	0.07 ±0.04	-	**0.21** ±0.13	**7.62** ±0.22
Guava	6.47 ±0.56	0.13 ±0.02	7.45 ±2.84	-	-	-	0.07 ±0.33	1.16 ±0.70	**15.28** ±1.30	-	-	1.34 ±0.49	2.82 ±0.75	0.04 ±0.03	**4.20** ±0.70	**19.48** ±1.12
Maize	0.01 ±0.27	0.59 ±0.17	-	0.94 ±0.20	0.01 ±0.15	0.05 ±0.03	0.10 ±0.08	0.03 ±0.07	**1.73** ±0.18	0.28 ±0.44	-	-	-	-	**0.28** ±0.44	**2.00** ±0.33
Mustard	0.68 ±1.78	0.68 ±1.81	-	5.45 ±3.15	0.46 ±0.49	0.00 ±0.00	0.00 ±0.00	0.00 ±0.00	**7.26** ±1.57	0.00 ±0.00	-	-	-	-	**0.00** ±0.00	**7.26** ±1.27
Onion	2.74 ±0.22	0.17 ±0.15	3.05 ±0.35	-	-	-	0.08 ±0.40	0.32 ±0.17	**6.37** ±0.27	0.76 ±0.24	0.09 ±0.02	1.17 ±0.08	0.81 ±0.15	0.02 ±0.01	**2.84** ±0.19	**9.22** ±0.23
Paddy	1.11 ±0.71	0.41 ±0.40	-	1.28 ±0.40	0.22 ±0.42	0.10 ±0.21	0.08 ±0.03	0.22 ±0.08	**3.41** ±0.41	1.35 ±0.12	0.25 ±0.01	0.47 ±0.05	0.04 ±0.01	0.43 ±0.03	**2.55** ±0.12	**5.96** ±0.29
Pigeon pea	1.56 ±0.35	0.64 ±0.40	-	5.08 ±0.89	0.13 ±0.98	0.25 ±0.23	0.31 ±0.44	0.32 ±0.54	**8.30** ±0.61	1.84 ±0.03	-	0.03 ±0.01	0.43 ±0.01	0.04 ±0.01	**2.34** ±0.03	**10.65** ±0.35

Crop	Farm Operations								Total loss in farm operations	Storage in Channels					Total loss in storage	Overall Total Loss
	Harvest	Collect-ion	Sorting/ Grading	Thresh-ing	Winnow-ing	Drying	Packag-ing	Trans-port		Farm	Godown /cold store	Whole-saler	Retailer	Process-ing unit		
Potato	2.18 ±0.83	0.60 ±0.21	2.72 ±0.38	-	-	-	0.21 ±0.08	0.17 ±0.11	**5.88** ±0.47	0.29 ±0.03	0.00 ±0.00	-	0.12 ±0.08	0.04 ±0.00	**0.44** ±0.04	**6.32** ±0.30
Soybean	2.54 ±0.43	0.52 ±0.17	-	1.77 ±0.26	0.46 ±0.14	0.10 ±0.05	0.11 ±0.02	0.12 ±0.03	**5.63** ±0.21	0.17 ±0.02	-	0.22 ±0.08	0.24 ±0.01	-	**0.63** ±0.03	**6.25** ±0.13
Tomato	4.15 ±0.43	0.36 ±0.16	3.10 ±0.40	-	-	-	0.23 ±0.18	1.73 ±0.32	**9.57** ±0.34	0.08 ±0.02	-	1.33 ±0.12	1.79 ±0.13	0.04 ±0.00	**3.24** ±0.11	**12.81** ±0.29
Wheat	1.09 ±0.41	0.49 ±0.06	-	1.80 ±0.21	0.11 ±0.06	0.15 ±0.08	0.07 ±0.03	0.04 ±0.01	**3.75** ±0.21	2.17 ±0.12	0.00 ±0.01	0.19 ±0.02	0.07 ±0.01	0.21 ±0.01	**2.64** ±0.11	**6.39** ±0.15

8. Central Plateau and Hills Region (M.P:3 districts; Rajasthan: 7)

Crop	Farm Operations								Total loss in farm operations	Storage in Channels					Total loss in storage	Overall Total Loss
	Harvest	Collect-ion	Sorting/ Grading	Thresh-ing	Winnow-ing	Drying	Packag-ing	Trans-port		Farm	Godown /cold store	Whole-saler	Retailer	Process-ing unit		
Bajra	0.93 ±0.10	0.35 ±0.14	-	1.88 ±0.23	0.12 ±0.01	0.17 ±0.15	0.11 ±0.04	0.15 ±0.11	**3.70** ±0.14	0.31 ±0.01	0.01 ±0.01	0.16 ±0.08	0.02 ±0.01	-	**0.50** ±0.03	**4.20** ±0.11
Black gram	2.88 ±1.25	1.98 ±0.84	-	3.17 ±0.85	0.92 ±0.27	0.39 ±0.31	0.36 ±0.16	0.39 ±0.26	**10.11** ±0.68	-	-	-	-	-	-	**10.11** ±0.68
Chick pea	2.37 ±0.43	2.07 ±0.41	-	3.75 ±0.61	1.09 ±0.30	0.44 ±0.10	0.47 ±0.10	0.54 ±0.16	**10.75** ±0.35	0.14 ±0.01	0.03 ±0.01	0.18 ±0.17	0.05 ±0.04	0.00 ±0.00	**0.40** ±0.10	**11.15** ±0.27
Cottonseed	5.60 ±1.52	0.33 ±0.04	-	-	-	0.10 ±0.01	0.21 ±0.09	0.54 ±0.26	**6.77** ±0.79	0.01 ±0.00	-	0.16 ±0.16	0.00 ±0.00	0.00 ±0.00	**0.16** ±0.06	**6.94** ±0.65
Groundnut	4.22 ±0.89	0.07 ±0.15	-	2.70 ±0.88	1.76 ±0.76	-	0.36 ±0.16	0.36 ±0.16	**9.47** ±0.61	0.02 ±0.01	-	0.03 ±0.02	0.00 ±0.00	0.02 ±0.01	**0.07** ±0.01	**9.54** ±0.26
Maize	2.02 ±0.46	0.87 ±0.23	-	1.89 ±0.68	0.67 ±0.20	0.45 ±0.10	0.28 ±0.06	0.20 ±0.03	**6.37** ±0.34	0.21 ±0.11	0.03 ±0.02	0.20 ±0.16	0.08 ±0.06	-	**0.52** ±0.11	**6.89** ±0.27
Mustard	1.43 ±0.42	0.65 ±0.33	-	1.75 ±0.66	0.77 ±0.27	0.29 ±0.08	0.27 ±0.08	0.25 ±0.09	**5.41** ±0.35	0.09 ±0.03	0.00 ±0.00	0.02 ±0.02	0.00 ±0.00	0.01 ±0.01	**0.13** ±0.03	**5.54** ±0.22
Pigeon pea	1.34 ±1.47	0.23 ±0.92	-	2.37 ±0.65	0.72 ±0.19	0.30 ±0.16	0.19 ±0.42	0.31 ±0.38	**5.46** ±0.74	-	-	-	0.13 ±0.05	-	**0.13** ±0.05	**5.59** ±0.59
Sorghum	1.69 ±1.05	0.01 ±0.00	-	3.31 ±0.68	0.14 ±0.30	0.00 ±0.00	0.23 ±0.24	0.00 ±0.00	**5.39** ±0.52	0.09 ±0.01	0.03 ±0.01	0.04 ±0.02	-	-	**0.16** ±0.01	**5.55** ±0.35
Soybean	7.63 ±0.68	1.40 ±0.32	-	2.51 ±0.58	0.77 ±0.38	0.14 ±0.08	0.19 ±0.09	0.21 ±0.08	**12.86** ±0.42	0.02 ±0.01	0.00 ±0.00	0.23 ±0.22	0.03 ±0.04	0.02 ±0.01	**0.30** ±0.07	**13.16** ±0.34
Wheat	1.48 ±0.22	1.48 ±0.16	-	1.78 ±0.19	0.83 ±0.14	0.06 ±0.02	0.20 ±0.03	0.21 ±0.03	**6.03** ±0.14	0.43 ±0.01	-	0.10 ±0.03	-	-	**0.53** ±0.01	**6.56** ±0.11

9. Western Plateau and Hills Region (M.P.: 3 districts; Maharashtra: 5)

Crop	Farm Operations								Total loss in farm operations	Storage in Channels					Total loss in storage	Overall Total Loss
	Harvest	Collect-ion	Sorting/ Grading	Thresh-ing	Winnow-ing	Drying	Packag-ing	Trans-port		Farm	Godown /cold store	Whole-saler	Retailer	Process-ing unit		
Bajra	0.99 ±0.14	0.00 ±0.00	-	2.85 ±0.38	0.31 ±0.16	0.00 ±0.00	0.00 ±0.00	0.00 ±0.00	**4.14** ±0.18	0.21 ±0.03	0.03 ±0.02	0.40 ±0.15	0.22 ±0.12	-	**0.85** ±0.11	**4.99** ±0.13
Banana	1.54 ±0.50	0.61 ±0.25	3.92 ±1.04	-	-	-	0.02 ±0.00	2.41 ±0.80	**8.51** ±0.68	-	-	1.50 ±0.31	0.59 ±0.04	0.00 ±0.00	**2.10** ±0.16	**10.60** ±0.42
Black gram	2.24 ±0.22	0.39 ±0.12	-	2.69 ±0.19	0.08 ±0.19	0.04 ±0.26	0.19 ±0.11	0.09 ±0.12	**5.72** ±0.18	0.44 ±0.15	0.04 ±0.03	0.59 ±0.10	0.34 ±0.08	0.47 ±0.01	**1.88** ±0.11	**7.61** ±0.14
Cabbage	2.14 ±0.33	0.59 ±0.24	3.82 ±1.34	-	-	-	0.18 ±0.12	0.64 ±0.11	**7.38** ±0.71	-	-	-	2.23 ±0.18	-	**2.23** ±0.18	**9.61** ±0.50
Chick pea	1.97 ±0.29	0.65 ±0.21	-	2.38 ±0.35	0.08 ±0.16	0.02 ±0.03	0.06 ±0.06	0.08 ±0.03	**5.24** ±0.21	1.13 ±0.42	0.05 ±0.01	1.17 ±0.06	0.05 ±0.02	0.55 ±0.02	**2.94** ±0.21	**8.17** ±0.21
Citrus	1.07 ±0.23	0.24 ±0.23	5.26 ±0.22	-	-	-	0.21 ±0.22	3.59 ±0.09	**10.36** ±0.20	-	-	0.84 ±0.13	1.77 ±0.08	-	**2.61** ±0.10	**12.97** ±0.17
Coriander	2.50 ±0.04	0.97 ±0.01	-	1.02 ±0.19	0.46 ±0.01	0.00 ±0.00	0.09 ±0.01	0.33 ±0.01	**5.36** ±0.08	-	-	0.52 ±0.08	0.51 ±0.06	-	**1.02** ±0.07	**6.38** ±0.08
Grapes	1.93 ±0.36	0.29 ±0.06	3.40 ±0.59	-	-	-	0.01 ±0.02	0.98 ±0.06	**6.60** ±0.33	0.01 ±0.00	-	0.31 ±0.14	0.87 ±0.09	-	**1.19** ±0.11	**7.79** ±0.27
Green gram	1.97 ±0.17	0.74 ±0.14	-	1.65 ±0.26	0.61 ±0.05	0.31 ±0.47	0.20 ±0.10	0.16 ±0.13	**5.65** ±0.23	0.73 ±0.21	0.01 ±0.01	1.09 ±0.12	0.21 ±0.08	0.35 ±0.01	**2.38** ±0.15	**8.03** ±0.18
Groundnut	2.00 ±0.29	0.81 ±0.16	-	1.94 ±0.37	0.44 ±0.45	0.05 ±0.06	0.51 ±0.14	0.02 ±0.02	**5.78** ±0.25	0.03 ±0.06	0.02 ±0.01	0.77 ±0.25	0.11 ±0.06	-	**0.92** ±0.10	**6.71** ±0.20
Maize	1.90 ±0.56	0.52 ±0.17	-	0.75 ±0.15	0.01 ±0.08	0.03 ±0.05	0.14 ±0.08	0.07 ±0.18	**3.42** ±0.26	-	-	-	-	-	**-**	**3.42** ±0.26
Mango	1.71 ±0.37	0.00 ±0.00	1.64 ±0.57	-	-	-	0.27 ±0.00	0.20 ±0.30	**3.82** ±0.39	-	0.00 ±0.00	0.31 ±0.26	0.79 ±0.27	-	**1.10** ±0.25	**4.91** ±0.34
Mustard	3.23 ±0.36	0.33 ±0.09	-	0.68 ±0.17	0.50 ±0.04	0.05 ±0.08	0.20 ±0.03	0.18 ±0.12	**5.17** ±0.17	-	-	-	-	-	**-**	**5.17** ±0.17
Onion	2.74 ±0.10	0.59 ±0.23	3.04 ±0.19	-	-	-	0.15 ±0.07	0.64 ±0.09	**7.17** ±0.15	0.41 ±0.06	0.70 ±0.30	2.35 ±0.26	2.09 ±0.11	-	**5.55** ±0.19	**12.72** ±0.18
Paddy	1.39 ±0.12	0.43 ±0.14	-	1.02 ±0.18	0.48 ±0.10	0.01 ±0.01	0.25 ±0.08	0.02 ±0.01	**3.60** ±0.11	0.03 ±0.21	0.01 ±0.10	0.31 ±0.24	0.02 ±0.01	0.00 ±0.00	**0.36** ±0.19	**3.96** ±0.15
Papaya	1.48 ±0.61	0.63 ±0.37	3.71 ±0.90	-	-	-	0.37 ±0.11	0.42 ±0.55	**6.62** ±0.61	-	-	0.85 ±0.16	3.17 ±0.13	-	**4.02** ±0.14	**10.64** ±0.31
Pigeon pea	1.11 ±0.42	0.23 ±0.21	-	1.59 ±0.54	0.50 ±0.18	0.16 ±0.06	0.15 ±0.04	0.15 ±0.08	**3.90** ±0.32	1.74 ±0.38	0.15 ±0.03	0.08 ±0.02	0.16 ±0.08	0.66 ±0.01	**2.80** ±0.19	**6.70** ±0.26

Crop	Farm Operations								Total loss in farm operations	Storage in Channels					Total loss in storage	Overall Total Loss
	Harvest	Collection	Sorting/ Grading	Threshing	Winnowing	Drying	Packaging	Transport		Farm	Godown /cold store	Wholesaler	Retailer	Processing unit		
Safflower	0.63 ±0.61	0.54 ±0.41	-	0.52 ±0.37	-	-	0.33 ±0.10	0.23 ±0.14	**2.25** ±0.38	0.03 ±0.00	-	-	-	-	**0.03** ±0.00	**2.28** ±0.35
Sapota	3.03 ±0.09	0.85 ±0.18	4.12 ±0.55	-	-	-	0.41 ±0.23	0.50 ±0.52	**8.91** ±0.38	-	-	0.70 ±0.16	2.36 ±0.11	-	**3.06** ±0.13	**11.98** ±0.24
Sorghum	0.73 ±0.21	0.54 ±0.09	-	2.52 ±0.21	0.59 ±0.13	0.01 ±0.04	0.35 ±0.13	0.07 ±0.03	**4.81** ±0.15	0.36 ±0.10	0.17 ±0.02	1.99 ±0.16	0.11 ±0.05	0.01 ±0.00	**2.64** ±0.10	**7.45** ±0.12
Soybean	4.23 ±0.45	1.05 ±0.72	-	0.79 ±0.16	0.37 ±0.38	0.02 ±0.04	0.13 ±0.12	0.10 ±0.11	**6.69** ±0.37	0.18 ±0.08	0.28 ±0.05	0.58 ±0.30	0.18 ±0.09	0.48 ±0.01	**1.69** ±0.08	**8.39** ±0.31
Sugarcane	1.45 ±0.17	0.42 ±0.25	0.43 ±0.11	-	-	2.00 ±0.32	0.05 ±0.02	0.28 ±0.13	**4.63** ±0.18	0.00 ±0.00	-	-	0.21 ±0.09	0.07 ±0.05	**0.28** ±0.06	**4.91** ±0.17
Sunflower	1.83 ±0.32	0.19 ±0.09	-	2.16 ±0.24	0.26 ±0.07	0.01 ±0.05	0.04 ±0.04	0.01 ±0.02	**4.48** ±0.20	0.03 ±0.03	-	-	-	-	**0.03** ±0.03	**4.51** ±0.19
Tomato	3.79 ±0.94	0.59 ±0.44	3.26 ±0.71	-	-	-	0.76 ±0.30	2.41 ±0.34	**10.81** ±0.62	0.27 ±0.01	-	3.68 ±0.14	3.59 ±0.49	-	**7.54** ±0.32	**18.34** ±0.50
Wheat	1.73 ±0.69	0.36 ±0.11	-	0.42 ±0.08	0.33 ±0.10	0.00 ±0.00	0.03 ±0.03	0.08 ±0.03	**2.96** ±0.31	0.31 ±0.01	0.00 ±0.00	0.07 ±0.04	0.02 ±0.03	-	**0.40** ±0.02	**3.36** ±0.23

10. Southern Plateau and Hills Region (Karnataka: 6; Tamil Nadu: 3)

Crop	Farm Operations								Total loss in farm operations	Storage in Channels					Total loss in storage	Overall Total Loss
	Harvest	Collect-ion	Sorting/ Grading	Thresh-ing	Winnow-ing	Drying	Packag-ing	Trans-port		Farm	Godown /cold store	Whole-saler	Retailer	Process-ing unit		
Arecanut	0.87 ±1.22	0.47 ±0.01	-	1.64 ±1.14	-	0.10 ±0.00	0.12 ±0.01	0.13 ±0.18	**3.33** ±0.79	0.04 ±0.01	-	-	0.07 ±0.06	0.36 ±0.50	**0.47** ±0.24	**3.80** ±0.57
Bajra	1.25 ±0.45	0.37 ±0.51	-	1.38 ±0.49	0.21 ±0.14	0.31 ±0.03	0.35 ±0.03	0.22 ±0.02	**4.08** ±0.35	0.81 ±0.01	0.02 ±0.01	-	0.12 ±0.05	0.01 ±0.02	**0.97** ±0.03	**5.04** ±0.27
Banana	1.77 ±0.57	0.19 ±0.01	0.98 ±0.49	-	-	-	0.06 ±0.01	1.96 ±0.02	**4.97** ±0.40	0.02 ±0.01	-	0.96 ±0.54	0.31 ±0.12	0.00 ±0.00	**1.29** ±0.24	**6.26** ±0.31
Black gram	0.51 ±0.01	-	-	0.51 ±0.01	0.38 ±0.01	-	-	0.00 ±0.00	**1.40** ±0.01	0.43 ±0.01	-	0.34 ±0.20	0.19 ±0.04	-	**0.96** ±0.18	**2.37** ±0.16
Chick pea	1.33 ±0.01	0.22 ±0.01	-	2.02 ±0.01	0.25 ±0.02	0.12 ±0.00	0.14 ±0.01	0.11 ±0.01	**4.19** ±0.01	-	-	-	-	-	-	**4.19** ±0.01
Chilli	2.38 ±0.31	0.51 ±0.14	1.41 ±0.22	-	-	0.01 ±0.17	0.30 ±0.08	0.60 ±0.11	**5.22** ±0.20	0.05 ±0.01	-	1.66 ±0.38	0.43 ±0.30	0.12 ±0.07	**2.26** ±0.22	**7.48** ±0.21
Coconut	1.31 ±0.45	0.31 ±0.05	-	1.15 ±0.50	-	0.47 ±0.66	0.16 ±0.14	0.09 ±0.27	**3.49** ±0.35	0.07 ±0.01	-	0.78 ±0.24	0.27 ±0.12	-	**1.12** ±0.08	**4.61** ±0.28
Cottonseed	2.24 ±0.35	0.43 ±0.04	-	-	-	-	0.33 ±0.07	0.27 ±0.05	**3.27** ±0.18	0.01 ±0.00	-	-	-	-	**0.01** ±0.00	**3.28** ±0.16
Egg	-	2.25 ±0.09	1.42 ±0.18	-	-	-	0.82 ±0.35	0.28 ±0.06	**4.76** ±0.22	0.03 ±0.01	-	0.09 ±1.43	-	-	**0.12** ±0.91	**4.88** ±0.40
Grapes	1.35 ±0.15	0.34 ±0.01	3.26 ±0.02	-	-	-	0.35 ±0.08	1.00 ±0.25	**6.30** ±0.15	-	-	0.87 ±0.50	1.21 ±0.25	0.09 ±0.03	**2.17** ±0.27	**8.47** ±0.17
Groundnut	1.64 ±0.29	0.38 ±0.08	-	1.00 ±0.29	0.25 ±0.11	0.13 ±0.01	0.19 ±0.02	0.12 ±0.19	**3.71** ±0.20	0.22 ±0.03	0.05 ±0.01	0.18 ±0.10	0.15 ±0.05	0.23 ±0.09	**0.83** ±0.06	**4.54** ±0.16
Guava	2.90 ±0.61	0.60 ±0.94	3.96 ±0.35	-	-	-	0.17 ±0.01	1.37 ±0.47	**9.00** ±0.50	-	-	-	-	-	-	**9.00** ±0.50
Maize	1.83 ±0.24	0.31 ±0.14	-	0.87 ±0.24	0.28 ±0.08	0.14 ±0.05	0.18 ±0.07	0.18 ±0.15	**3.80** ±0.17	0.41 ±0.04	0.05 ±0.03	0.56 ±0.15	-	0.15 ±0.07	**1.17** ±0.07	**4.97** ±0.15

Crop	Farm Operations								Total loss in farm operations	Storage in Channels					Total loss in storage	Overall Total Loss
	Harvest	Collect-ion	Sorting/ Grading	Thresh-ing	Winnow-ing	Drying	Packag-ing	Trans-port		Farm	Godown /cold store	Whole-saler	Retailer	Process-ing unit		
Mango	1.50 ±0.12	0.39 ±0.03	2.82 ±0.53	-	-	-	0.22 ±0.12	1.83 ±0.24	**6.75** ±0.29	0.02 ±0.00	-	1.09 ±0.30	0.99 ±0.32	0.15 ±0.08	**2.26** ±0.21	**9.01** ±0.28
Marine fish	8.25 ±0.05	0.78 ±0.02	0.33 ±0.16	-	-	-	-	0.92 ±0.12	**10.28** ±0.12	-	-	0.82 ±0.54	0.32 ±0.28	-	**1.14** ±0.38	**11.41** ±0.28
Meat	1.08 ±0.32	-	-	-	-	-	-	-	**1.08** ±0.32	-	-	-	-	-	-	**1.08** ±0.32
Milk	0.23 ±0.06	0.12 ±0.06	-	-	-	-	-	-	**0.35** ±0.06	0.00 ±0.00	-	-	-	-	**0.00** ±0.00	**0.35** ±0.05
Onion	2.64 ±0.18	0.35 ±0.07	0.96 ±0.08	-	-	-	0.11 ±0.01	0.49 ±0.04	**4.54** ±0.10	0.17 ±0.01	-	0.40 ±0.34	0.55 ±0.12	-	**1.12** ±0.17	**5.66** ±0.13
Paddy	3.00 ±0.79	0.49 ±0.15	-	0.73 ±0.27	0.12 ±0.08	0.11 ±0.06	0.19 ±0.12	0.15 ±0.15	**4.81** ±0.38	0.91 ±0.23	0.01 ±0.01	0.54 ±0.05	0.03 ±0.02	-	**1.50** ±0.20	**6.30** ±0.34
Papaya	0.84 ±1.75	0.75 ±0.04	0.73 ±0.05	-	-	-	0.35 ±0.01	0.71 ±0.03	**3.39** ±0.88	-	-	1.16 ±0.47	1.19 ±0.22	0.03 ±0.01	**2.38** ±0.28	**5.77** ±0.64
Pigeon pea	1.03 ±0.07	0.59 ±0.21	-	0.65 ±0.13	0.38 ±0.03	0.20 ±0.05	0.19 ±0.02	0.19 ±0.01	**3.23** ±0.09	0.89 ±0.03	0.05 ±0.02	0.14 ±0.04	0.23 ±0.02	0.36 ±0.12	**1.67** ±0.05	**4.90** ±0.08
Poultry meat	3.09 ±0.37	-	-	-	-	-	-	1.32 ±0.36	**4.41** ±0.37	-	-	-	-	-	-	**4.41** ±0.37
Safflower	1.52 ±0.10	0.44 ±0.14	-	0.46 ±0.68	0.25 ±0.14	0.11 ±0.02	0.07 ±0.12	0.12 ±0.04	**2.97** ±0.27	0.00 ±0.00	0.02 ±0.01	0.30 ±0.13	-	-	**0.32** ±0.10	**3.29** ±0.18
Sapota	2.02 ±0.27	0.22 ±0.08	2.38 ±0.68	-	-	-	0.35 ±0.30	2.04 ±0.33	**7.01** ±0.44	-	-	1.62 ±0.14	0.98 ±0.21	0.05 ±0.02	**2.64** ±0.18	**9.65** ±0.43
Sorghum	2.20 ±0.47	0.27 ±0.05	-	1.01 ±0.27	0.42 ±0.24	0.18 ±0.06	0.24 ±0.09	0.18 ±0.05	**4.51** ±0.26	0.33 ±0.05	0.03 ±0.01	0.36 ±0.32	0.19 ±0.06	0.03 ±0.01	**0.93** ±0.14	**5.44** ±0.23
Sugarcane	0.68 ±0.08	0.06 ±0.00	0.42 ±0.03	-	-	4.38 ±0.58	0.06 ±0.00	0.22 ±0.02	**5.82** ±0.08	0.00 ±0.00	-	-	-	-	**0.00** ±0.00	**5.82** ±0.07

Crop	Farm Operations								Total loss in farm operations	Storage in Channels					Total loss in storage	Overall Total Loss
	Harvest	Collect-ion	Sorting/ Grading	Thresh-ing	Winnow-ing	Drying	Packag-ing	Trans-port		Farm	Godown /cold store	Whole-saler	Retailer	Process-ing unit		
Sunflower	0.52 ±0.13	0.51 ±0.06	-	1.56 ±0.33	0.25 ±0.20	0.17 ±0.08	0.13 ±0.12	0.10 ±0.06	**3.23** ±0.17	0.05 ±0.00	0.02 ±0.01	0.06 ±0.07	-	1.34 ±0.49	**1.46** ±0.26	**4.69** ±0.20
Tapioca	0.97 ±0.04	0.09 ±0.01	1.65 ±0.05	-	-	-	0.02 ±0.00	0.12 ±0.00	**2.86** ±0.02	0.00 ±0.00	-	-	-	-	**0.00** ±0.00	**2.86** ±0.01
Tomato	1.51 ±0.67	0.31 ±0.05	3.09 ±0.51	-	-	-	0.20 ±0.08	2.46 ±0.11	**7.58** ±0.45	0.10 ±0.01	-	1.07 ±0.37	1.08 ±0.52	-	**2.25** ±0.39	**9.83** ±0.44
Turmeric	2.79 ±0.21	-	1.00 ±0.52	-	-	0.14 ±0.01	0.11 ±0.01	0.05 ±1.25	**4.10** ±0.65	0.09 ±0.00	-	0.22 ±0.09	0.04 ±0.02	-	**0.36** ±0.05	**4.46** ±0.44
Wheat	1.02 ±0.29	0.55 ±0.22	-	1.86 ±0.33	0.37 ±0.22	0.15 ±0.03	0.33 ±0.14	0.23 ±0.13	**4.52** ±0.24	0.14 ±0.11	-	-	-	-	**0.14** ±0.11	**4.66** ±0.23

11. East Coast Plains and Hills Region (Odisa: 4; Tamil Nadu: 3; A.P.:2)

Crop	Farm Operations								Total loss in farm operations	Storage in Channels					Total loss in storage	Overall Total Loss
	Harvest	Collect-ion	Sorting/ Grading	Thresh-ing	Winnow-ing	Drying	Packag-ing	Trans-port		Farm	Godown /cold store	Whole-saler	Retailer	Process-ing unit		
Banana	2.07 ±0.03	0.03 ±0.00	1.37 ±0.17	-	-	-	0.68 ±0.38	1.80 ±0.59	**5.94** ±0.34	0.02 ±0.00	-	1.46 ±0.26	0.38 ±0.08	-	**1.85** ±0.15	**7.79** ±0.28
Black gram	0.72 ±0.20	0.44 ±0.99	-	0.61 ±0.46	0.31 ±0.02	0.36 ±0.43	0.08 ±0.01	0.02 ±0.02	**2.54** ±0.44	0.52 ±0.16	-	0.02 ±0.01	0.09 ±0.03	0.01 ±0.01	**0.64** ±0.10	**3.18** ±0.32
Cashew	2.54 ±2.77	2.37 ±3.97	-	1.24 ±0.35	0.88 ±0.97	0.00 ±0.00	0.00 ±0.00	0.55 ±0.07	**7.59** ±1.83	0.00 ±0.00	0.00 ±0.00	0.01 ±0.01	0.03 ±0.02	0.08 ±0.04	**0.12** ±0.02	**7.72** ±1.24
Chick pea	0.40 ±0.22	0.42 ±0.01	-	0.85 ±0.04	0.24 ±0.01	0.15 ±0.02	0.02 ±0.00	0.00 ±0.00	**2.08** ±0.09	0.08 ±0.01	-	0.10 ±0.04	0.17 ±0.08	0.07 ±0.09	**0.42** ±0.06	**2.50** ±0.07
Chilli	0.63 ±0.39	1.34 ±0.04	2.75 ±0.03	-	-	0.04 ±0.00	0.02 ±0.00	0.03 ±0.29	**4.81** ±0.23	0.02 ±0.00	-	0.94 ±0.23	0.29 ±0.08	0.01 ±0.00	**1.27** ±0.12	**6.08** ±0.17
Citrus	1.56 ±0.19	0.48 ±0.02	1.94 ±0.14	-	-	-	0.00 ±0.00	0.00 ±0.00	**3.98** ±0.12	-	-	1.11 ±0.08	1.08 ±0.12	-	**2.19** ±0.11	**6.17** ±0.11
Coconut	2.94 ±0.38	0.04 ±0.03	-	2.31 ±0.53	-	0.15 ±0.01	0.03 ±0.00	0.04 ±0.10	**5.50** ±0.30	0.20 ±0.03	-	0.77 ±0.22	0.41 ±0.11	-	**1.38** ±0.13	**6.87** ±0.24
Cottonseed	3.48 ±0.13	0.25 ±0.02	-	-	-	0.65 ±0.01	0.08 ±0.00	0.13 ±0.03	**4.59** ±0.07	0.07 ±0.05	-	0.05 ±0.07	0.02 ±0.01	-	**0.14** ±0.05	**4.74** ±0.06
Egg	-	2.05 ±0.16	1.45 ±0.02	-	-	-	1.46 ±0.02	0.38 ±0.03	**5.34** ±0.10	-	-	1.86 ±0.30	1.15 ±0.37	-	**3.00** ±0.35	**8.34** ±0.22
Green gram	2.05 ±0.54	0.91 ±0.21	-	1.30 ±1.49	0.12 ±0.82	0.25 ±0.49	0.10 ±0.03	0.05 ±0.02	**4.77** ±0.76	0.26 ±0.10	-	0.06 ±0.10	0.05 ±0.13	0.01 ±0.01	**0.38** ±0.10	**5.15** ±0.63
Groundnut	2.24 ±1.07	0.39 ±0.33	-	1.67 ±0.87	0.22 ±0.11	0.08 ±0.22	0.06 ±0.01	0.03 ±0.00	**4.70** ±0.61	0.03 ±0.02	-	0.01 ±0.05	0.00 ±0.04	0.01 ±0.16	**0.05** ±0.08	**4.75** ±0.46
Inland fish	1.71 ±0.60	0.62 ±0.03	1.65 ±0.05	-	-	-	0.30 ±0.01	0.21 ±0.02	**4.49** ±0.37	0.08 ±0.01	-	0.49 ±0.34	0.95 ±0.47	-	**1.52** ±0.36	**6.01** ±0.36
Mango	2.92 ±0.22	0.29 ±0.03	3.14 ±0.16	-	-	-	0.02 ±0.00	0.81 ±0.11	**7.18** ±0.15	0.03 ±0.00	-	0.81 ±0.36	1.35 ±0.49	0.36 ±0.04	**2.55** ±0.32	**9.72** ±0.20

Crop	Farm Operations								Total loss in farm operations	Storage in Channels					Total loss in storage	Overall Total Loss
	Harvest	Collection	Sorting/ Grading	Threshing	Winnowing	Drying	Packaging	Transport		Farm	Godown /cold store	Wholesaler	Retailer	Processing unit		
Marine fish	-	1.94 ±0.07	0.20 ±0.02	-	-	-	-	0.11 ±0.12	**2.25** ±0.08	-	-	1.24 ±0.07	0.33 ±0.15	-	**1.57** ±0.12	**3.83** ±0.08
Meat	2.41 ±0.16	-	-	-	-	-	-	-	**2.41** ±0.16	-	-	-	-	-	-	**2.41** ±0.16
Mushroom	1.06 ±0.04	-	5.07 ±0.10	-	-	-	-	0.18 ±0.01	**6.31** ±0.08	-	-	-	-	-	-	**6.31** ±0.08
Onion	2.52 ±0.12	0.97 ±1.68	3.02 ±3.26	-	-	-	0.08 ±0.21	0.33 ±0.27	**6.91** ±1.66	0.06 ±0.07	-	0.85 ±0.09	0.67 ±0.13	-	**1.58** ±0.12	**8.49** ±0.67
Paddy	2.43 ±0.43	0.36 ±0.19	-	1.00 ±0.13	0.30 ±0.08	0.15 ±0.15	0.04 ±0.03	0.02 ±0.03	**4.30** ±0.22	0.25 ±0.25	0.07 ±0.01	0.13 ±0.01	0.05 ±0.00	0.04 ±0.01	**0.53** ±0.21	**4.83** ±0.22
Papaya	1.00 ±0.62	0.19 ±0.01	0.06 ±0.56	-	-	-	0.00 ±0.00	0.05 ±0.31	**1.30** ±0.41	0.01 ±0.00	-	0.55 ±0.12	1.30 ±0.51	-	**1.86** ±0.35	**3.16** ±0.39
Poultry meat	1.80 ±0.40	-	0.25 ±0.15	-	-	-	-	1.44 ±1.01	**3.48** ±0.47	-	-	3.02 ±0.65	1.68 ±0.56	-	**4.70** ±0.60	**8.18** ±0.52
Sorghum	2.39 ±0.24	0.00 ±0.00	-	1.12 ±0.74	0.82 ±0.09	0.22 ±0.10	0.14 ±0.18	0.00 ±0.00	**4.70** ±0.34	0.07 ±0.03	-	0.91 ±0.14	-	-	**0.98** ±0.04	**5.67** ±0.29
Sugarcane	2.43 ±0.21	0.13 ±0.09	0.22 ±0.02	-	-	3.67 ±0.30	0.05 ±0.01	0.53 ±0.23	**7.03** ±0.19	0.03 ±0.00	-	-	0.00 ±0.00	0.00 ±0.00	**0.04** ±0.01	**7.07** ±0.18
Tapioca	0.70 ±0.09	0.12 ±0.01	0.30 ±0.15	-	-	-	0.00 ±0.00	0.00 ±0.00	**1.11** ±0.08	0.19 ±0.01	-	0.21 ±0.05	0.98 ±0.33	-	**1.39** ±0.23	**2.50** ±0.16
Tomato	2.68 ±0.73	1.37 ±0.04	5.15 ±0.39	-	-	-	0.24 ±0.01	0.39 ±0.22	**9.84** ±0.42	0.04 ±0.02	-	0.75 ±0.18	0.99 ±0.37	0.00 ±0.00	**1.78** ±0.26	**11.61** ±0.33
Turmeric	1.49 ±0.19	0.13 ±0.15	0.12 ±0.10	-	-	0.20 ±0.05	0.00 ±0.00	0.00 ±0.03	**1.95** ±0.11	0.03 ±0.01	-	0.23 ±0.03	0.11 ±0.06	0.06 ±0.01	**0.42** ±0.04	**2.37** ±0.08

12. West Coast Plains and Ghats Region (Kerala: 5 districts; Karnataka: 3; Tamil Nadu: 3)

Crop	Farm Operations								Total loss in farm operations	Storage in Channels					Total loss in storage	Overall Total Loss
	Harvest	Collect-ion	Sorting/ Grading	Thresh-ing	Winnow-ing	Drying	Packag-ing	Trans-port		Farm	Godown /cold store	Whole-saler	Retailer	Process-ing unit		
Arecanut	1.30 ±0.29	0.39 ±0.10	-	0.53 ±0.22	1.12 ±0.39	0.22 ±0.15	0.04 ±0.01	0.17 ±0.05	**3.77** ±0.21	0.01 ±0.00	-	0.69 ±0.11	0.23 ±0.07	-	**0.92** ±0.05	**4.69** ±0.20
Bajra	2.22 ±0.05	0.11 ±0.01	-	0.91 ±0.03	0.76 ±0.02	0.11 ±0.01	0.54 ±0.03	0.31 ±0.04	**4.96** ±0.04	0.61 ±0.01	-	-	-	-	**0.61** ±0.01	**5.57** ±0.04
Banana	1.10 ±0.39	0.23 ±0.16	1.22 ±0.36	-	-	-	0.21 ±0.33	0.81 ±0.28	**3.58** ±0.32	0.05 ±0.02	-	0.41 ±0.15	0.32 ±0.04	0.01 ±0.00	**0.79** ±0.05	**4.36** ±0.30
Black pepper	0.47 ±0.19	0.21 ±0.10	-	0.23 ±0.11	0.02 ±0.10	0.04 ±0.04	0.01 ±0.00	0.00 ±0.00	**0.99** ±0.11	0.01 ±0.00	-	0.00 ±0.00	0.18 ±0.14	-	**0.20** ±0.07	**1.18** ±0.11
Cashew	0.78 ±0.18	0.00 ±0.00	-	1.25 ±0.75	-	0.15 ±0.12	0.00 ±0.00	0.00 ±0.00	**2.18** ±0.28	0.01 ±0.00	-	-	0.04 ±0.05	0.26 ±0.14	**0.31** ±0.07	**2.49** ±0.26
Coconut	1.10 ±0.24	0.16 ±0.16	-	0.61 ±0.31	0.26 ±0.10	0.32 ±0.08	0.04 ±0.04	0.02 ±0.09	**2.51** ±0.22	0.04 ±0.00	-	0.72 ±0.24	0.14 ±0.05	0.38 ±0.05	**1.27** ±0.05	**3.78** ±0.19
Cottonseed	3.33 ±0.02	0.00 ±0.00	-	-	-	-	0.72 ±0.02	0.10 ±0.00	**4.15** ±0.02	0.07 ±0.01	-	1.44 ±0.72	-	-	**1.51** ±0.31	**5.66** ±0.19
Egg	-	0.80 ±0.52	1.00 ±1.25	-	-	-	1.71 ±0.80	0.67 ±1.17	**4.18** ±0.91	-	-	0.37 ±0.12	0.39 ±0.09	-	**0.75** ±0.11	**4.93** ±0.49
Green gram	2.83 ±0.05	-	-	1.17 ±0.03	0.94 ±0.04	0.20 ±0.01	0.64 ±0.01	0.00 ±0.00	**5.77** ±0.03	0.02 ±0.00	-	-	-	-	**0.02** ±0.00	**5.80** ±0.03
Groundnut	2.31 ±0.13	0.52 ±0.03	-	2.14 ±0.05	-	0.18 ±0.01	0.20 ±0.01	0.13 ±0.01	**5.47** ±0.08	0.10 ±0.03	-	0.93 ±0.27	-	-	**1.03** ±0.11	**6.50** ±0.10
Inland fish	2.12 ±0.71	-	-	-	-	-	-	1.03 ±0.02	**3.15** ±0.55	-	-	-	1.34 ±0.22	-	**1.34** ±0.22	**4.49** ±0.43
Mango	3.22 ±0.06	0.11 ±0.01	2.83 ±0.05	-	-	-	0.85 ±0.02	1.10 ±0.04	**8.11** ±0.04	0.18 ±0.01	-	1.00 ±0.33	0.54 ±0.41	-	**1.72** ±0.31	**9.83** ±0.26
Marine fish	7.42 ±0.01	0.22 ±0.04	0.14 ±0.02	-	-	0.13 ±0.01	-	1.37 ±0.09	**9.28** ±0.05	-	-	0.28 ±0.16	0.19 ±0.06	-	**0.47** ±0.10	**9.75** ±0.07

Crop	Farm Operations								Total loss in farm operations	Storage in Channels					Total loss in storage	Overall Total Loss
	Harvest	Collect-ion	Sorting/ Grading	Thresh-ing	Winnow-ing	Drying	Packag-ing	Trans-port		Farm	Godown /cold store	Whole-saler	Retailer	Process-ing unit		
Meat	1.36 ±0.10	-	-	-	-	-	-	-	**1.36** ±0.10	-	-	-	-	-	-	**1.36** ±0.10
Milk	0.17 ±0.03	0.00 ±0.00	-	-	-	-	-	-	**0.17** ±0.02	-	-	-	-	-	-	**0.17** ±0.02
Mushroom	1.57 ±0.32	-	3.61 ±0.52	-	-	-	0.19 ±0.01	2.66 ±0.02	**8.02** ±0.32	-	-	-	-	-	-	**8.02** ±0.32
Paddy	2.14 ±0.16	0.57 ±0.12	-	1.18 ±0.25	0.37 ±0.12	0.09 ±0.03	0.13 ±0.02	0.12 ±0.04	**4.61** ±0.14	0.20 ±0.09	0.02 ±0.00	0.08 ±0.02	0.01 ±0.01	-	**0.31** ±0.08	**4.92** ±0.13
Potato	3.18 ±0.67	-	2.32 ±0.36	-	-	-	0.17 ±0.01	0.46 ±0.10	**6.13** ±0.42	0.20 ±0.01	-	0.32 ±0.06	-	-	**0.52** ±0.05	**6.64** ±0.27
Poultry meat	2.51 ±0.71	-	-	-	-	-	-	0.10 ±0.23	**2.61** ±0.60	-	-	-	-	-	-	**2.61** ±0.60
Sorghum	1.63 ±0.06	0.00 ±0.00	-	0.66 ±0.02	0.19 ±0.01	0.36 ±0.03	0.41 ±0.04	0.17 ±0.01	**3.41** ±0.05	0.34 ±0.01	-	-	-	-	**0.34** ±0.01	**3.76** ±0.04
Sugarcane	1.03 ±0.78	-	0.12 ±0.01	-	-	2.24 ±1.42	0.21 ±0.00	0.13 ±0.03	**3.73** ±0.65	0.07 ±0.01	-	-	-	-	**0.07** ±0.01	**3.80** ±0.53
Tapioca	1.48 ±0.51	0.44 ±0.08	0.98 ±0.17	-	-	-	0.13 ±0.01	1.02 ±0.04	**4.05** ±0.28	0.54 ±0.01	-	0.25 ±0.06	0.28 ±0.08	0.17 ±0.02	**1.25** ±0.05	**5.30** ±0.26
Tomato	3.15 ±0.10	-	4.62 ±0.16	-	-	-	-	2.30 ±0.06	**10.08** ±0.14	0.09 ±0.01	-	0.96 ±0.19	1.39 ±0.36	-	**2.44** ±0.29	**12.52** ±0.28
Turmeric	0.54 ±0.27	0.01 ±0.00	0.20 ±0.00	-	-	0.21 ±0.50	0.14 ±0.17	0.01 ±0.00	**1.11** ±0.28	0.16 ±0.09	-	1.42 ±0.22	-	-	**1.58** ±0.12	**2.68** ±0.22

13. Gujarat Plains and Hills Region (Gujarat: 6 districts)

Crop	Farm Operations								Total loss in farm operations	Storage in Channels					Total loss in storage	Overall Total Loss
	Harvest	Collect-ion	Sorting/ Grading	Thresh-ing	Winnow-ing	Drying	Packag-ing	Trans-port		Farm	Godown /cold store	Whole-saler	Retailer	Process-ing unit		
Bajra	3.04 ±0.64	0.71 ±0.63	-	3.16 ±0.30	0.07 ±0.12	0.00 ±0.00	0.19 ±0.08	0.37 ±0.36	**7.54** ±0.39	0.22 ±0.17	0.03 ±0.03	0.12 ±0.08	0.11 ±0.02	-	**0.48** ±0.12	**8.01** ±0.32
Banana	1.46 ±0.04	0.03 ±0.01	1.75 ±0.04	-	-	-	0.31 ±0.17	1.64 ±0.10	**5.19** ±0.09	0.03 ±0.01	0.08 ±0.04	0.68 ±0.29	0.22 ±0.04	-	**1.01** ±0.07	**6.20** ±0.08
Black gram	1.89 ±0.05	0.85 ±0.01	-	0.85 ±0.16	0.65 ±0.01	0.00 ±0.00	0.53 ±0.02	0.00 ±0.00	**4.77** ±0.08	0.00 ±0.00	-	-	0.13 ±0.07	-	**0.13** ±0.06	**4.90** ±0.07
Cottonseed	1.61 ±0.26	0.31 ±0.41	-	-	-	0.01 ±0.01	0.00 ±0.00	0.08 ±0.08	**2.01** ±0.27	0.04 ±0.03	0.01 ±0.01	0.24 ±0.09	-	-	**0.29** ±0.03	**2.30** ±0.19
Green gram	1.45 ±0.04	0.84 ±0.05	-	1.38 ±0.14	0.93 ±0.02	0.37 ±0.01	0.74 ±0.02	0.37 ±0.01	**6.10** ±0.07	0.18 ±0.04	0.00 ±0.00	0.09 ±0.08	0.28 ±0.09	-	**0.56** ±0.06	**6.65** ±0.07
Groundnut	1.85 ±0.10	0.52 ±0.36	-	3.00 ±0.25	0.01 ±0.05	0.17 ±0.01	0.21 ±0.01	0.16 ±0.03	**5.91** ±0.18	0.08 ±0.03	0.10 ±0.01	0.78 ±0.52	0.09 ±0.33	0.94 ±0.34	**2.00** ±0.18	**7.91** ±0.18
Mango	2.30 ±0.10	0.68 ±0.36	2.02 ±0.03	-	-	-	0.59 ±0.16	1.96 ±0.04	**7.53** ±0.16	0.13 ±0.01	0.02 ±0.03	0.41 ±0.22	0.45 ±0.11	-	**1.02** ±0.05	**8.55** ±0.14
Milk	0.16 ±0.08	0.78 ±0.04	-	-	-	-	0.30 ±0.01	0.03 ±0.01	**1.28** ±0.06	-	-	-	-	-	**-**	**1.28** ±0.06
Mustard	3.82 ±0.51	0.69 ±0.05	-	2.07 ±0.16	0.01 ±0.16	0.00 ±0.00	0.33 ±0.06	0.01 ±0.04	**6.92** ±0.23	0.32 ±0.11	0.03 ±0.03	0.14 ±0.14	0.06 ±0.04	-	**0.55** ±0.08	**7.47** ±0.19
Onion	1.93 ±0.05	0.86 ±0.01	1.28 ±0.07	-	-	-	0.20 ±0.01	0.23 ±0.06	**4.50** ±0.05	0.21 ±0.01	0.12 ±0.03	0.24 ±0.06	0.41 ±0.11	0.01 ±0.00	**0.99** ±0.07	**5.49** ±0.07
Papaya	0.68 ±0.09	0.02 ±0.01	1.84 ±0.18	-	-	-	0.45 ±0.02	1.49 ±0.17	**4.49** ±0.13	0.04 ±0.01	0.02 ±0.00	0.78 ±0.16	0.75 ±0.25	-	**1.59** ±0.06	**6.08** ±0.10
Pigeon pea	1.06 ±0.09	0.14 ±0.01	-	1.54 ±0.63	0.25 ±0.01	0.00 ±0.00	0.48 ±0.02	0.03 ±0.00	**3.49** ±0.26	-	-	-	0.03 ±0.03	-	**0.03** ±0.03	**3.52** ±0.17
Potato	2.60 ±0.11	0.02 ±0.01	2.47 ±0.02	-	-	-	0.01 ±0.00	1.11 ±0.15	**6.22** ±0.09	0.00 ±0.00	0.21 ±0.07	-	0.16 ±0.02	-	**0.37** ±0.02	**6.59** ±0.07
Sapota	2.75 ±1.34	0.18 ±0.06	1.80 ±0.54	-	-	-	0.14 ±0.15	2.06 ±0.50	**6.94** ±0.72	0.01 ±0.01	0.41 ±0.09	0.58 ±0.13	0.62 ±0.09	0.02 ±0.00	**1.63** ±0.03	**8.57** ±0.50
Wheat	2.35 ±0.45	0.64 ±0.15	-	2.37 ±0.44	0.06 ±0.04	0.00 ±0.00	0.24 ±0.02	0.02 ±0.02	**5.68** ±0.26	0.18 ±0.01	0.08 ±0.02	0.37 ±0.23	0.02 ±0.01	0.71 ±0.22	**1.36** ±0.06	**7.04** ±0.20

14. Western Dry Region (Rajasthan: 2 districts)

Crop	Farm Operations								Total loss in farm operations	Storage in Channels					Total loss in storage	Overall Total Loss
	Harvest	Collect-ion	Sorting/ Grading	Thresh-ing	Winnow-ing	Drying	Packag-ing	Trans-port		Farm	Godown /cold store	Whole-saler	Retailer	Process-ing unit		
Bajra	1.17 ±0.78	0.65 ±0.58	-	2.49 ±0.43	0.26 ±0.04	0.27 ±0.33	0.18 ±0.20	0.12 ±0.08	**5.15** ±0.45	0.33 ±0.01	-	0.15 ±0.05	0.05 ±0.03	-	**0.52** ±0.02	**5.68** ±0.34
Chick pea	0.58 ±0.26	0.49 ±0.12	-	0.88 ±0.14	0.75 ±0.06	0.27 ±0.12	0.14 ±0.02	0.08 ±0.01	**3.18** ±0.13	0.17 ±0.01	-	0.15 ±0.04	0.06 ±0.05	-	**0.38** ±0.03	**3.56** ±0.10
Groundnut	1.11 ±0.54	0.63 ±0.19	-	0.65 ±0.09	0.33 ±0.01	0.14 ±0.12	0.10 ±0.07	0.10 ±0.02	**3.05** ±0.23	0.11 ±0.03	-	0.37 ±0.09	0.01 ±0.01	-	**0.49** ±0.04	**3.54** ±0.16
Mustard	0.81 ±0.01	0.42 ±0.02	-	1.33 ±0.05	0.22 ±0.01	0.23 ±0.02	0.13 ±0.01	0.07 ±0.00	**3.22** ±0.04	0.23 ±0.01	-	0.11 ±0.03	0.01 ±0.00	-	**0.35** ±0.02	**3.56** ±0.04

A grain saved is a grain produced

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