Food Loss Foot Print: Implications for Food Security and Environment in India

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Abstract:

It is projected that, India's population would reach1.69 billion by 2050 and the demand for cereals is estimated to be around 390 to 465 mt. Presently 14.5 per cent of India's population is undernourished, thus posing a serious question on food security? On the other hand, food is lost due to various harvest and post harvest losses. The food lost serves as opportunity cost for the economy as well environment. Hence, this study focuses on food loss, its impact on food security and environment. The food loss footprint was calculated using the methodology developed by FAO. Results revealed that, carbon foot print was more in case of cereals (13.37 mt of CO2 equivalent). Of the total blue water that was utilized in producing the lost food, 59 per cent of the lost blue water was used for cereal production. The land and water saved by reducing the food loss could be used more efficiently in producing extra food. Lost food can be used to achieve food security. Timely harvesting and use of mechanization in harvesting is needed. There is a need to develop efficient supply chain network. Aerobic rice cultivation needs to be promoted to reduce GHG emission.

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Abstract:

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Keywords: *Food loss, Carbon foot print, Blue water foot print, Supply chain and GHG emission*

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1. Introduction:

It is projected that the world's population would reach 9.1 billion which is 34 per cent higher than present population and this increase in population will be noticed in the developing countries. Currently 49 per cent of the world's population leave in urban areas and is expected to be around 70 per cent by 2050. This increase in population calls for a need to rise in cereal production to about 3 billion tonnes as against 2.1 billion tonnes of current production[1].

As most of the increase in population will be noticed in developing countries, India is also not an exception to this. India is an agrarian economy with more than 50 per cent of the population depends upon agriculture for their livelihood.

India, with a population of over 1.3 billion, has seen tremendous growth in agriculture sector. The euphoria of "Green Revolution" in India has given way to many growing concerns in the recent years and the major among them is the agricultural productivity in the country reaching a plateau. Despite of all these achievements in transforming the country from a food deficit to surplus, it is unable to provide access to food to a large number of people (Anonymous, 2016).

India ranks 100th out of 119 countries in Global Hunger Index, 190.7 million people are undernourished in India representing 14.5 per cent of the population is undernourished in India and 38.4 per cent of the children aged fewer than five in India are stunted (Anonymous (b), 2017) By 2050, India's population is likely to reach 1.69 billion (Nikos and Jelle, 2012). India's total cereals consumption demand in 2050 is estimated to be around 390 to 465 million metric tonnes (Bale and Jennifer, 2014). To meet the increased demand of food grains, investment on agriculture sector is necessary. Climate change may directly impact food production all over the world. Increase in the temperature can reduce the duration of many crops and hence reduce the yield (Anupama, 2014). Around 76 per cent of the youth belonging to farmer households reported that, they would prefer to work some other work rather than in farming (Anonymous, 2014). Under changing climatic conditions, increase in urbanization, dominance of small and marginal farmers, youth willing to quit agriculture, prevalence of under nourishment and increase in population; the main question that comes into picture is “Fate of Food Security for the Future India?”

The most significant, feasible factor the policy makers should focus to achieve food security is reducing food loss and food waste. Food loss is defined as decrease in mass (dry matter) or nutritional value (quality) of food that was originally intended for human consumption. These losses are mainly caused by inefficiencies in the food supply chains. Whereas, the term food waste most commonly means food that was purchased but not consumed and ends up in the garbage. FAO estimates that each year, approximately one-third of all food produced (1.3 billion tonnes amounting to about 940 million USD) for human consumption in the world is lost or wasted.

The food lost or waste represents a missed opportunity to improve global food availability, to mitigate environmental impacts and resources use along the food chain. The environmental footprint of food wastage is assessed through four different model components viz., carbon foot print, water footprint, land occupation and potential biodiversity impact (Anonymous, 2013).

Identifying the hotspots along the food supply chain helps in reducing the food loss. In case of developed countries, food waste is more where as in case of developing countries, food loss is quite common (Anonymous, 2013). The present study focuses on identifying such hotspots where sustainability can be brought in so as to achieve food security and also to feed the increasing population. Estimating the environmental impacts due to food loss forms another important component of the study.

2. Data sources and Methodology:

2.1 Data Sources:

The analysis of food loss was calculated for different group of commodities.

1. Cereals (Rice, Wheat, Maize and Millets)
2. Pulses (overall)
3. Oilseeds (Overall)
4. Fruits (Apple, Banana, Citrus and Grapes)
5. Vegetables (Overall)

6. Milk.
7. Egg.
8. Meat (Poultry, Bovine, Goat and Pig).

The data for the present study was collected from different secondary sources. Data pertaining to production for the year 2014-15 was collected from Anonymous (a) 2017 and Anonymous, 2015. The data on production, loss over the years (2000-2013) for the selected groups was collected from FAO, stat[2].

Data regarding the per cent of loss was taken from "Report on Assessment of Quantitative Harvest and Post-Harvest Losses of Major Crops and Commodities in India" (Jha *et al*., 2015). For the per cent loss of food under different harvest and post harvest activities were averaged to get the total loss under each group. For pulses, loss in different stages of pigeon pea, chick pea, black gram and green gram were averaged. Similarly for oilseeds mustard, soybean, safflower, sunflower and ground nut were considered. For vegetables, cabbage, cauliflower, green pea, onion, potato and tomato were considered. For the rest of groups, per cent losses under selected crops were averaged to get the per cent of loss.

Food loss foot print was calculated under three categories viz., carbon foot print and water foot print. Potential biodiversity impact was not calculated because of the non-availability of data. To find out the foot prints, impact factors provided by Food and Agriculture Organization (FAO) for South Asian countries was taken as proxy for India. This is because India is a part of South Asia and no data was available in FAO for individual countries. For cereals, fruits four crops were chosen, as the impact factors to calculate the environmental impact due to food loss was given separately and these were averaged to get the group impact factors, where as impact factors for remaining group was available in general (overall).

2.2 Methodologies:

2.2.1 Compound growth rate analysis:

In order to assess the trend in total food loss of the selected groups among South Asian countries, the compound growth rate analysis was employed. Compound growth rates were computed using the exponential function of the form,

$Y_t = ab^t u_t$…………………………………. (1)

Where,

Y_t: Dependent variable for which growth rate was estimated (Total Food loss)

a: Intercept (constant)

b: Regression coefficient

t: Years which take values, 1, 2, …,n

u_t: Disturbance term for the year t

For the purpose of estimation, equation (1) was transformed into log linear form and was estimated using Ordinary Least Square (OLS) technique. The compound growth rate (g) in percentage was then computed from the following relationship,

g = (Antilog of ln b-1)*100.

The significance of the regression coefficient was tested by using, 't' test which was defined as,

$t=b_i/se(b_i)$

where,

b_i= Regression coefficient

$se(b_i)$=Standard error of the regression coefficient

2.2.2 Food loss foot print: Food loss foot print was calculated based on the methodology proposed by FAO.

For all quantifiable components, the environmental footprint (EF) of a product "i" can be expressed with the following generic equation, as a multiplication of an activity data (AD) and an impact factor (IF). This equation is valid at each phase of the life cycle.

$EF_i=AD_i*IF_i$ ....(2)

2.2.2.1 Carbon Foot Print:

The carbon footprint (CF) of a food product is the total amount of greenhouse gases (GHG) emitted throughout the life cycle of that product, expressed in kilograms of CO_2 equivalents. This encompasses all GHG emissions of the agricultural phase – including the emissions related to the production and transport of all inputs, as well as the emissions due to on-farm energy use and non-energy related emissions (such as CH_4 and N_2O) from soils and livestock.

2.2.2.2 Water foot print

The Global standard on water footprint assessment developed by the Water Footprint Network (WFN) defines the water footprint of a product as the total volume of freshwater that is used directly or indirectly to produce the product. There are two different types of water foot prints. The **blue water footprint** refers to consumption of surface and groundwater resources along the supply chain of a product. The **green water footprint** is an indicator of the human use of so-called "green water". Green water refers to the precipitation on land that does not run off or recharge the groundwater but is stored in the soil or vegetation. Sooner or later, this part of precipitation evaporates or transpires through plants.

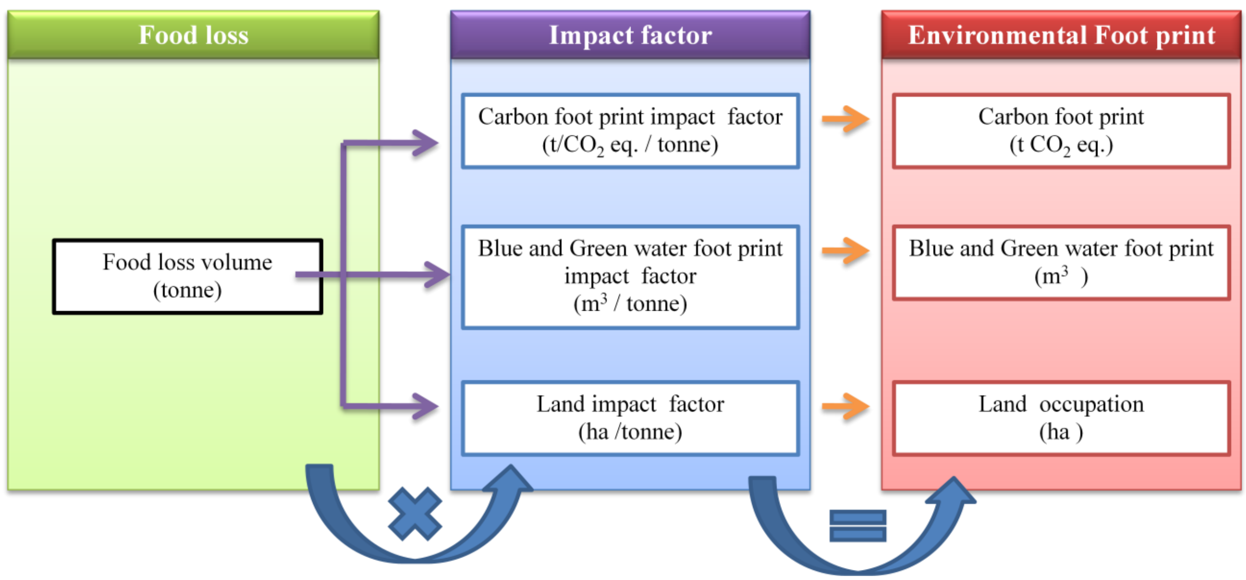

Fig 1: Activity data and impact factors used for quantifiable environmental components

Source: Food wastage footprint impacts on natural resources, Technical Report, FAO.

2.2.2.3 Land foot print

Land foot print refers to the area that is required to produce the total amount of loss. The land occupation component is further divided in this study in two sub-components: Arable land occupation (ha of cropland for human consumption or for livestock feed) and Non-arable land occupation (ha of pastures or meadows).

3 Results and Discussion:

Table 1: Per cent of food loss of selected commodities among South Asian countries

Year	Afghanistan	Bangladesh	India	Iran	Nepal	Pakistan	Sri Lanka
2000	7.16	5.96	5.08	8.83	9.25	5.71	5.44
2001	7.77	6.05	5.26	8.68	9.20	5.89	5.84
2002	7.64	6.00	5.26	8.03	9.16	5.98	6.12
2003	12.00	6.27	5.32	7.75	9.20	5.94	5.89
2004	9.24	6.37	5.35	7.66	9.25	5.85	6.01
2005	10.69	6.32	5.39	7.87	9.26	5.80	6.47
2006	10.48	6.35	5.71	7.84	9.07	5.80	5.99
2007	10.90	6.40	5.70	7.81	9.06	5.76	5.96
2008	9.90	6.26	5.96	8.78	9.12	5.86	5.68
2009	11.22	6.49	5.95	8.47	9.05	5.84	5.64
2010	10.87	6.53	6.02	8.21	9.07	5.92	5.88
2011	10.40	6.42	6.04	8.25	9.03	5.80	5.92
2012	10.93	6.31	5.88	8.73	9.10	5.95	5.68
2013	10.98	6.39	5.93	8.50	9.19	5.92	5.57
CAGR (%)	7.72**	4.42**	5.07**	1.83**	3.31**	2.83**	2.34**

Note: ** indicates significant at 1 per cent

CAGR = Compound Annual Growth Rate. CAGR was worked for total loss of selected commodities.

Total per cent food loss among South Asian countries for cereals, pulses, oilseeds, vegetables, fruits, milk and egg are presented in Table 1. Among the selected groups, meat is not considered here because of non availability of data regarding the loss of meat. The results revealed that, among South Asian countries, highest per cent of total food loss for the selected commodities during the year 2013 was more in Afghanistan (10.98 %) followed by Nepal (9.09 %) and Iran (8.50 %).

Nevertheless, the Compound Annual Growth Rate (CAGR) analysis indicated that, total food loss was significantly increasing at one per cent in all the South Asian countries. CAGR was 7.72 per cent for Afghanistan indicating that, total food loss increased at a rate of 7.72 per cent annually. When compound annual growth rates were considered, India stood at second place with 5.07 per cent increase in food loss over the year which was followed by Bangladesh (4.42 %). Fig. 2 clearly indicates that there is an increasing linear trend of food loss in India. This calls for the attention of the policy makers to address the issue of food loss which is increasing significantly in India over the years. The main factor contributing to the food loss in India is lack of infrastructure facilities and poor harvesting measures.

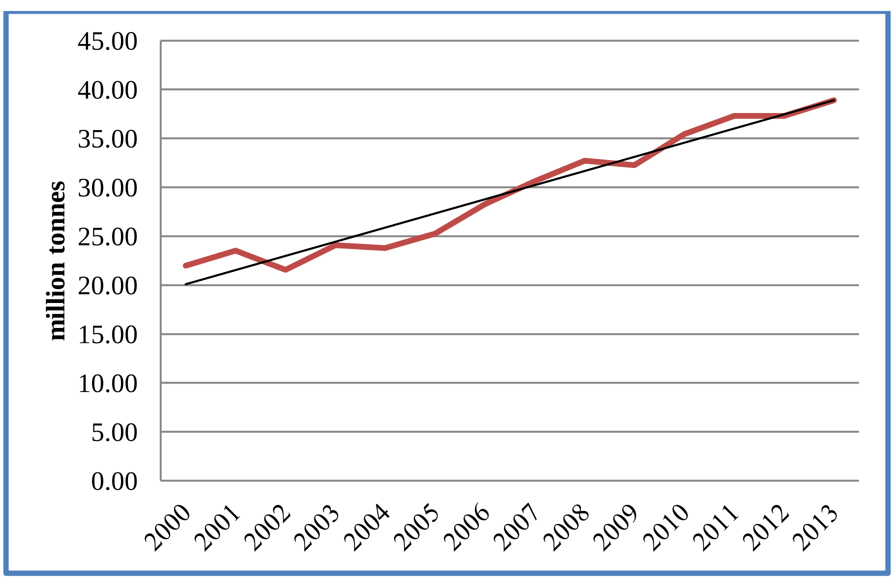

Fig 2: Food loss of selected groups in India over the years.

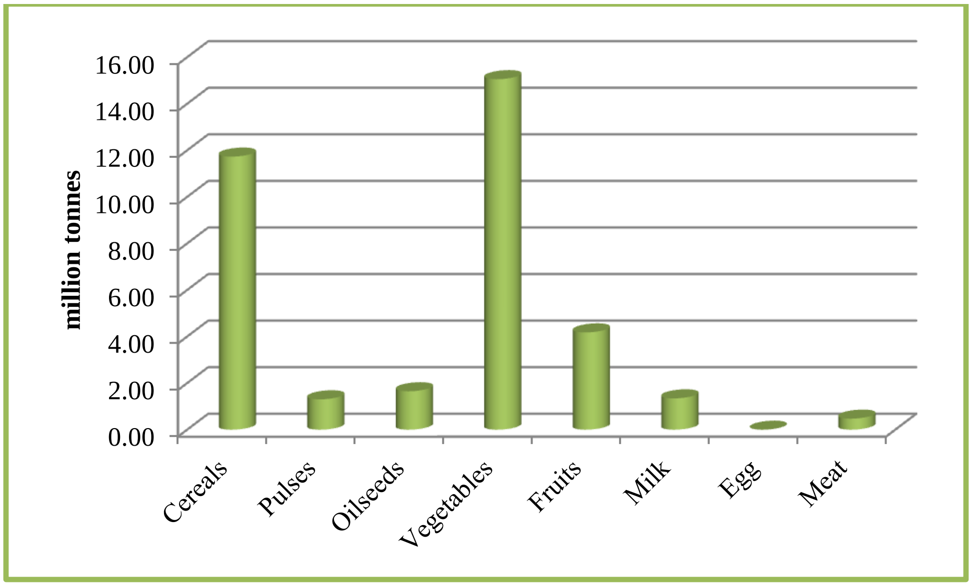

Fig 3: Food loss volumes in India during 2014-15.

Food losses in India during the year 2014-15 for the selected group of commodities are represented in Fig 3. The results revealed that, loss of vegetables was around 15 million tonnes. India is the second largest producer of vegetables in the world next to China (FAOSTAT data set, 2013), yet there exists an imbalance between the demand and supply of vegetables. Consequently, it is not only important to grow more, but also to save what is grown at higher cost. This huge loss is because of short shelf life, improper bagging without crating, lack of transportation facilities with controlled conditions and lack of cold storage facility (Rais and Sheoran, 2015). Great emphasis is required to develop advanced and improved post harvest technologies for vegetables which pave a way for achieving food security (Vishal *et al.*, 2014).

The total food loss of cereals in India was 11.73 million tonnes. Study conducted by Raveesh *et al.*, 2014 reported that, the total food lost and wasted every year is sufficient enough to solve the four times hunger crises of population. The total food loss of fruits was 4.18 million tonnes. Loss of fruits is because of lack of cold storage facilities and poor processing activities. Cost of preventing losses is less than the cost involved in producing the same (Sreenivasa *et al.*, 2009) indicating the importance of reducing the loss.

Total loss of pulses and oilseeds are 1.31 and 1.65 million tonnes whereas the production was 17.15 and 27.51 million tonnes, respectively. The total loss of pulses and oilseeds seems to be lower when compared to cereals, vegetables and fruits but when the total per cent of loss is considered, it is about 7.61 per cent in pulses and 6 per cent in oil seeds which is more than cereals (5.08 %). India has imported 45.85 lakh tonnes of pulses during the year 2014-15 (Tiwari and Shivhare, 2016). But when you look at the loss, it is around 13.1 lakh tonnes. Hence reducing the loss helps in reducing the imports of pulses. Similar is the case of oilseeds.

The loss of milk is less (1.35 million tonnes) when compared to cereals, pulses, oilseeds, vegetables and fruits. This is because of well established co-operative supply chain, improved processing technologies and value addition.

Hence, it is quite evident from the analysis that, India needs to focus more on reducing food loss which acts as an essential pre-requisite to achieve hunger free India and also to feed the increasing population.

Food loss acts as an opportunity cost to the economy as well as environment. Opportunity cost to economy because it is the return forgone for having loss which accrues as a dead weight cost on the economy. It acts as opportunity cost to the environment as it represents the reduction in the environmental foot print if the lost quantity had not been produced at all. Hence, an attempt was made to analyze the environmental impact due to food loss in India. Environmental impact consists of carbon foot print, water foot print and land occupation as defined in the methodology.

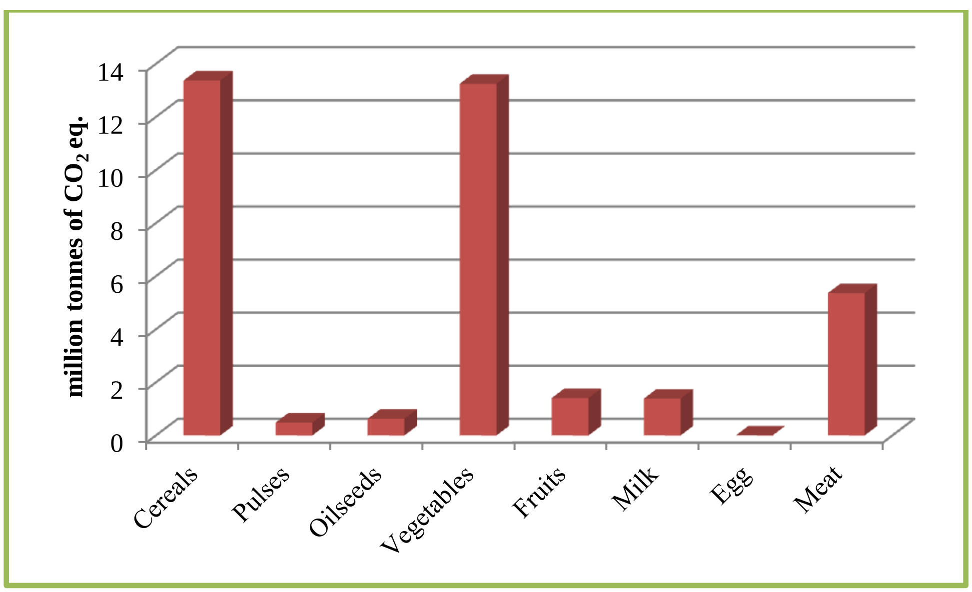

Fig 4: Carbon footprint of food loss by commodity in India during 2014-15

The carbon foot print due to food loss is presented in Fig 4. The results revealed that, carbon foot print was more in case of cereals (13.37 million tonnees of CO_2 equivalent) followed by vegetables and meat with 13.25 and 5.63 million tonnes of CO_2 equivalent, respectively. The carbon foot print for cereals is more because of the wet land paddy cultivation in India, which releases methane to the atmosphere and the energy needed for pumping water (Hardy, 2013). Paddy cultivation is a key source of employment for the 60 per cent of Indian workers still dependent on agriculture for work. Moreover rice is the one of the staple foods of India. Since it is a staple food, altering the mindset of the consumers to reduce the consumption makes no sense. Hence, there is a need to adopt aerobic method of paddy cultivation where, the CH_4 emission is 13.18 mg plant^{-1} day^{-1} as against 24.57 mg plant^{-1} day^{-1} in case of wet land paddy cultivation (Jayadeva *et al*., 2009). System of Rice Intensification (CH_4 emission is 22.01 mg plant^{-1} day^{-1}) should also be encouraged to reduce the methane emissions (Jayadeva *et al*., 2009).

In vegetable production improper nutrient management is a problem where farmers use more of fertilizers to maximize their yield. Hence, proper nutrient management in vegetable production may provide a greater opportunity for mitigating climate change (Yan *et al*., 2012).

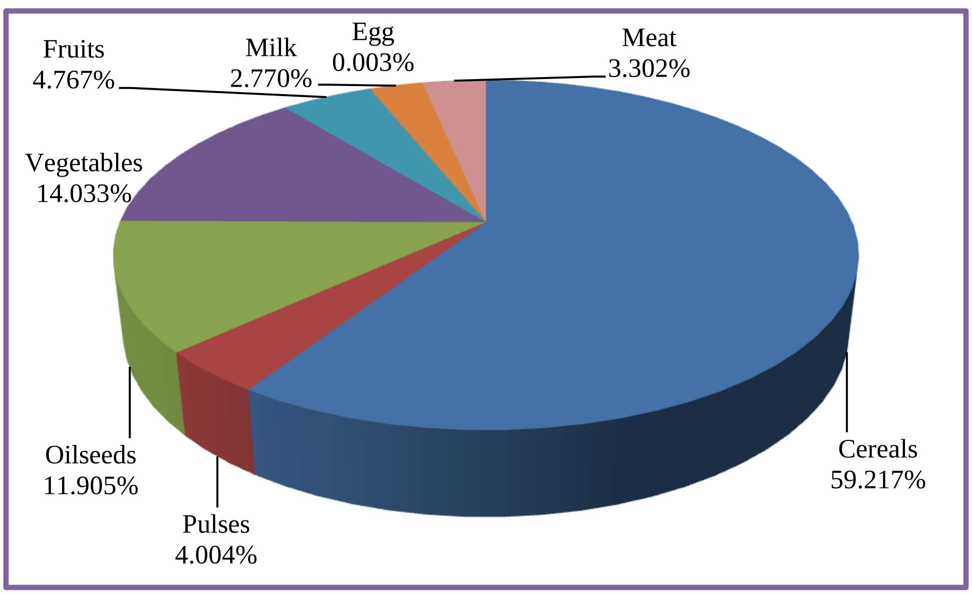

Fig 5: Blue water foot print of food loss by commodity in India during 2014-15

Blue water foot print results revealed that, of the total blue water i.e. surface and ground water that was utilized in producing the lost food, 59 per cent of the lost blue water was used for cereal production followed by 14 per cent in vegetable production and 11 per cent in oil seeds production (Fig 5). Blue water foot print was more for cereals because of wet land paddy cultivation where water will be stagnated throughout the crop period. Yet another reason is more area under cereal production as against other groups. Vegetable production occupied second place and the possible reasons may be because of use of more ground water in vegetable production during rabi and summer seasons as vegetables are required for consumption at all time. In India, the ground water table is decreasing over the years and the farmers often quote the reason of low availability of water for agriculture, it is necessary to avoid the food loss. Food loss is eventually wasting the precious water resources.

But when we consider the green water foot print, highest water was utilized in producing cereals (52.7 %) followed by pulses (13.48 %) and oil seeds (12.82 %). Most of the cereals, pulses and oilseeds are grown in kharif season in India and Indian agriculture is mainly dependent on the kharif rainfall. Thus, higher green water foot print was noticed for cereals, pulses and oilseeds. Food loss prevention helps in the use of the soil moisture more efficiently.

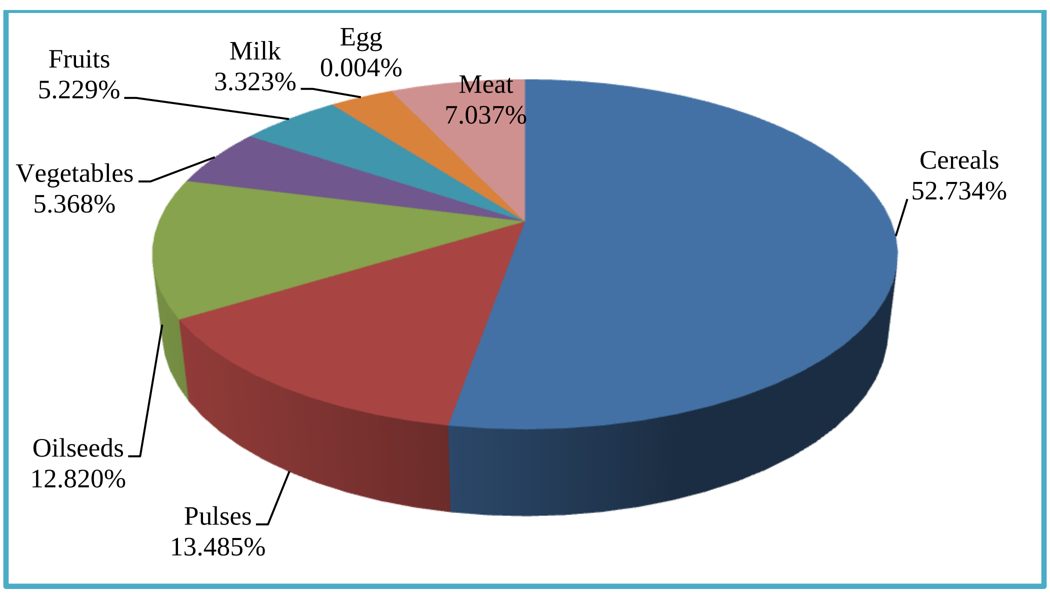

Fig 6: Green water foot print of food loss by commodity in India during 2014-15

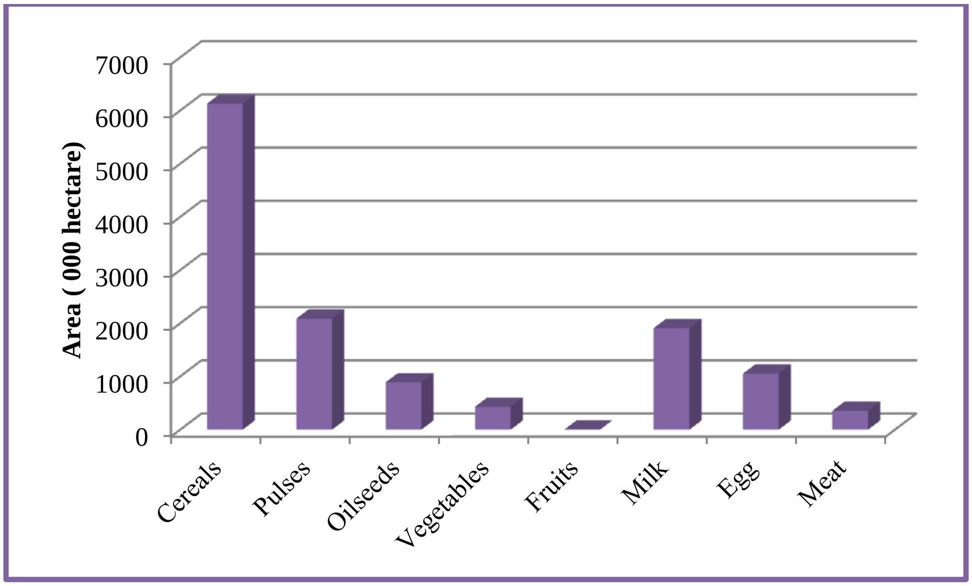

Fig 7: Arable land occupation of food loss by commodity in India during 2014-15

The land that has been wasted in producing the food that has been wasted is represented in Fig 7. The results revealed that, more arable land was used in cultivating cereals (6129000 ha) followed by pulse production (2088000 ha). The possible reason for higher land occupation for cereals and pulses may be due to lower productivity which intern leads to more area under that group. From this analysis, it is clearer that, we are wasting huge land in producing the lost food. Hence, if we save the loss (land), the land saved can be used in producing more to feed the hungry people so as to achieve food security. Or it can also be diverted in producing the crops where there is more demand – supply gap and thus reducing the imports.

Most of the non-arable land was used in meat production (17366387 ha). This is due to the fact that in India most of the meat production is from open grazing of animals. Stall feeding is very less in case of livestock.

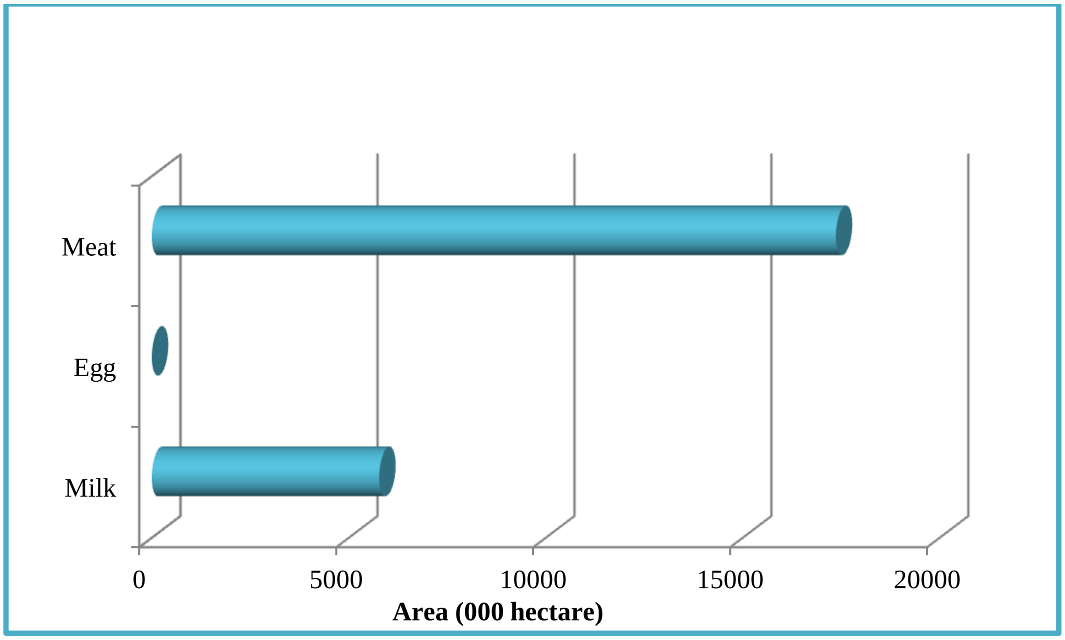

Fig 8: Non-Arable land occupation of food loss by commodity in India during 2014-15

It is also essential to identify the hotspots of food loss in the food supply chain system in order to find out the mitigation strategies. Hence, an attempt for identifying the hotspot was done and the results of carbon foot print of food loss by commodity across different harvest and post harvest loss are presented in Table 2. The results revealed that, for cereals, pulses and oilseeds harvesting & collection and threshing & winnowing/grading were the major hotspots. Mechanization in harvesting, timely harvesting can be the coping measures to reduce the carbon foot print. Whereas in case of vegetables, fruits and meat, threshing & winnowing/grading resulted in 4079724, 505437 and 253266 thousand tonnes of CO_2 equivalent, respectively was the major hot spot. Nonetheless, transportation and storage also has a major impact indicating the relative importance of creating the infrastructure facilities like storage structures specially cold storages for fruits and vegetables and also improving the road connectivity, improved transportation facility and so on.

The results of water foot print (blue+green) indicated that, 3154 thousand hectare meter was lost in cereal production, which is followed by oilseeds and pulse cultivation (Table 3). Thus indicating the importance of reducing the loss in cereals, pulses and oilseeds would result in greater water conservation. In addition to preventing food loss, advanced micro irrigation methods, precision farming should be adopted to reduce the water print.

Table 2: Carbon footprint of food loss by commodity across different harvest and post harvest loss in India during 2014-15

(000 tonnes of CO_2 eq.)

Particulars	Harvesting & collection	Threshing& Winnowing/ Grading	Drying & Packing	Transportation	Storage	Total
Cereals	5170374.81	5071703.54	690698.93	296013.83	2144455.71	13373246.81
Pulses	162444.80	151022.90	32996.60	52667.65	83760.60	482892.55
Oilseeds	303160.20	192349.92	30316.02	13589.94	87811.92	627228.00
Milk	587687.10	0.00	452067.00	30137.80	316446.90	1386338.80
Egg	584.34	426.08	368.26	109.56	703.04	2191.29
Meat	1285231.60	253266.23	0.00	249486.13	3575967.93	5363951.90
Vegetables	4079724.26	4518666.50	314575.27	1348528.10	2989684.37	13251178.51
Fruits	409145.46	505437.73	22429.52	191811.11	281529.20	1410353.02

Table 3: Water footprint (Blue+Green) of food loss by commodity across different harvest and post harvest loss in India during 2014-15

(000 ha meter)

Particulars	Harvesting & collection	Threshing & Winnowing/ Grading	Drying & Packing	Transportation	Storage	Total
Cereals	1219.46	1196.19	162.90	69.82	505.78	3154.15
Pulses	232.74	216.37	47.27	75.46	120.00	691.84
Oilseeds	358.21	227.28	35.82	16.06	103.76	741.12
Milk	80.05	0.00	61.58	4.11	43.10	188.84
Egg	0.05	0.04	0.03	0.01	0.07	0.20
Meat	89.49	17.64	0.00	17.37	249.00	373.51
Vegetables	124.25	137.61	9.58	41.07	91.05	403.56
Fruits	87.44	108.01	4.79	40.99	60.16	301.40

Conclusion and recommendations:

It is evident that the food loss in India is increasing over the years. At the same time, the population is also increasing and India stands at 100th position in Global Hunger Index. It is important to feed the needy instead of wasting it. When we have more number of people without food, it is alarming for all of us to take initiatives in reducing the food loss. Food loss occurs at different stages of food supply chain. Identifying these hotspots helps in reducing the food loss. It was noticed that, harvesting and threshing/grading were the major hotspots for most of the groups chosen. Harvesting at correct time, use of mechanization to reduce labour problem serves as the measures. The next hotspot was storage loss. Thus, it is important for the policy makers to take initiatives in increasing the cold storages, store houses, improving supply chain network and encourage public private partnership. Food loss also has many environmental impacts. Climate change is one of the major problems, the globe is facing. Reducing the food loss also helps in reducing the green house gas emission. Water being a scare resource and a major input for agriculture using this scare resource efficiently matters a lot. Therefore, reducing food loss helps in achieving zero hunger, mitigating climate change and also efficient use of natural resources.

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[1](http://www.fao.org/fileadmin/templates/wsfs/docs/expert_paper/How_to_Feed_the_World_in_2050.pdf)

[2]http://www.fao.org/faostat/en/#data/FBS