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Impacts of Food Loss on the Cost of Cultivation: A Study on Agriculture Commodities of India

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Author's contributions

The sole author designed, analyzed, interpreted and prepared the manuscript.

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ABSTRACT

India is the respectable producer of most of the food grains in the world despite such a large production we are the 102nd rank in global hunger index 2019 and one of the most starving nations of the world. For a country like India production is not a problem anymore but the food available for human consumption is the problem as there is a huge amount of food loss in the marketing chain [1,2,3]. India losses a large amount of its production in post-harvest activities due to under established supply chains and poor infrastructure. So, this paper studies the effect of post-harvest losses on the cost of food production in the long-terms both empirically (Simple regression analysis) and theoretically (law of Scarcity by Lionel Robbins) from 1997 to 2017 and unravels that they are positively correlated i.e., post-harvest losses are one of major determining factor for actual price hike in the cost of cultivation of major agriculture commodities in India.

Keywords: Food loss; cost of cultivation; environmental impact; scarcity.

JEL Classification Code: Q5, Q51, Q01, Q21.

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1. INTRODUCTION

The world population is expected to reach 9.7 billion by 2050 [4] we need to produce anywhere near 25-75% more than now to feed such a large population [5]. One-third of the food produced in this world per year for human consumption is lost or wasted this food is enough to feed around 10 billion people, out of world population of 7.8 billion currently many don't have enough food to lead a healthy life or they are undernourished [6]. This is reducing the income of the farmers and increasing consumer expenses. An estimate of 230 cubic km of freshwater goes into producing food which is eventually wasted, this water is enough to quench the thirst of 10 crore people every year [7]. According to a CSR journal report "Indian's waste as much as the whole United Kingdom consumes". [8].

Food system losses, inefficiencies and waste is also creating large loss of Organic Carbons which in turn causes social, natural and environmental implication like global warming, hunger, etc [9]. According to research done in 2010 agriculture is contributing overall of 20% global greenhouse gas emission which is released during the entire production and waste management operation which act as major climate change driver [7]. FAO report of 2015 estimated that CO2 emission of 3.3 G tons equivalent for food that is produced but not consumed [10].

Developed countries food loss are generally low in the early and middle stage of the supply chain as there are more efficient farming system, better transport, better management, storage (cold chain system) and processing facilities which ensures a large proportion of output is delivered to the markets [11]. But in developing countries, the main food loss occurs in the early and middle of the supply chain and there is very little food wastage at the consumer level. In India, 75% of total post-harvest loss occurs at the farm level which includes 33-35% as storage loss and 25% at the market level [12]. It is estimated that 1.6 million tons of food are wasted in the United Kingdom because they don't meet the retailer standards [13]. Bangladesh is the fourth-largest producer of rice after China, India and Indonesia but it imports about 1 million tons of rice each year because of poor storage and supply chain infrastructure [14].

Food loss is also considered as a double waste of energy as chemical energy contained in food and productive energy of input both are wasted as food gets wasted [13]. Every year consumers in rich countries lose almost as much food (over 220 million tons) as the total net production in Sub- Saharan Africa (around 230 million tons) [15]. According to a report of FAO 2011 world average per capita production of food for human consumption is about 460 kg/year [16]. In India per capita, the availability of food grain is 176 kg/year (2015-2018) [17]. The Ministry of food processing industries (MFPI) of India estimate losses of 23 million tons of grain, 12 million tons of fruits and 21 million tons of vegetables for a total approximate value of 4.4 billion USD [18]. Another research which is done by ICAR AIRCP for post-harvest technology estimated that keeping the base year 2013-14 the quantitative loss of 45 crops/commodities was found to be approximate 92651 crores at an average price of 2014 [2]. 12-16 million tons of food wasted every year can meet the demand for food for one-third of India's poor population [19]. India targets of food grain were 270.10 million tons for 2016-17 and it achieved 275.11 million tons India has been progressively increasing its production for decades, [1] but still our country comes under serious in Global Hunger Index severity scale. [20]

Another important discussion to consider in food loss is subsidies because there is the main regulating factor by the government to control the price of the commodity, in India, there are two major subsidies for regulation of food prices i.e., Food and Fertilizer subsidy. Developed countries are giving a large number of subsidies for agriculture as compared to developing countries like India where subsidy is very low, but in countries like India, 70% of the population is dependent on agriculture. This creates one of the major issues in the global market as developing countries can never compete with the cultivation cost and product price of developed countries. In India fertilizer consumption of selected fertilizer like MOP, DAP and Urea have been in decreasing trend from 1990-2000 to 2010-13 but when we look into the amount of subsidy given by the government after removing inflation it is continuously increasing and growing at a faster rate (19.31%) as compared to a total subsidy (16.45%) [21]. This gives an important inference out of all the bigger picture that the cost of production of fertilizer is increasing continuously as it is a scarce resource. The agriculture subsidy of India has hiked to 247.24% from 1993-2001 and it is still increasing at a faster rate [22].

So, this paper studies the effect of post-harvest losses on the cost of food production in the long-terms both empirically (Simple regression analysis) and theoretically (law of Scarcity by Lionel Robbins) from 1997 to 2017. This research studies price hike of agricultural commodity and how it is kept in check by increasing the amount of subsidy on the production side e.g., fertilizer subsidy, electricity subsidy, etc., as well as output side e.g., food subsidy which makes food available for consumption at the feasible amount. Food wastage is causing various environmental effects like global warming, hunger etc [23]. So, it's important to analyse how food loss affects the cost of cultivation in long run.

1.1 Theoretical Understanding Behind Food Loss

The concept of food loss has been always an ambiguous concept to understand as its definition change from country to country and organization to organization based on the situation and objectives. For this research, definition which is accepted by the FAO for food loss is considered i.e., "Food losses take place at production, post-harvest and processing stages in the food supply chain. Food losses occurring at the end of the food chain (retail and final consumption) are rather called "food waste", which relates to retailers' and consumer's behaviour", while "food waste occurs at the end of the food chain" [24,16]. In countries like India which comes under developing countries, food wastage is minimum and food loss is more unlike developed countries where food loss is less but food wastage is very high [11]. Food that is produced, but never consumed, still cause environmental impacts to the atmosphere, water, land and biodiversity. These environmental costs must be paid by society and future generations. Furthermore, by contributing to environmental degradation and increasing the scarcity of natural resources, food wastage is associated with wider social costs that affect people's well-being and livelihoods.

For understanding this concept of food loss and how it may affect the cost of cultivation of crops ideal hypothetical situation. A framer produces 100kg of commodity A and incurred a cost of cultivation of $1000 and passes on the commodity forward in the marketing channel which goes to a wholesaler then a processer and then to a retailer.

1.2 Assumptions and Situations

1. Everyone in the marketing channel keeps a profit share of 10% over the investment amount.
2. The ideal price is the price of the commodity if there is no food loss in the marketing channel.
3. All market sub-ordinates incur some amount of quantity loss Farm level (5%), wholesaler level (1%), processer level (1%) and retailer level (1%).
4. The actual price is gross profit divided by produce available.

The above situation depicts that the cost of production is increasing and the quantity of produce is decreasing as the commodity moves in the marketing channel. Due to the loss at different levels, there is an uneven increase in the price of the commodity, for the above situation, there is a price increase of $3.57/kg. So, till the end of the marketing channel, there was a net loss of about 7.82kg and for producing 7.82kg of produce it required input which cost around $78.2(7.82kg × $10/kg). Therefore, input worth $78.2 was wasted by wasting 7.82 kg of produce in the marketing chain.

So, from the above example, there are two theoretical understandings, first food loss is affecting the price of the commodity directly in the present year as the amount of supply is reducing and the second is the cost of cultivation hike of the commodities in consecutive years. The effect of increasing the cost of cultivation in consecutive years is supported by the basic rule of economics by Lionel Robbins i.e., is the "law of scarcity of resources". The input used for the production of the particular commodity is scarce e.g., land, fertilizers, labour force, energy, etc., these are present in nature in non-renewable or exhaustible forms [13]. The commodity produced should give socio-economic benefits to the society but when it is wasted due to various reasons this wastage of commodity is ultimately causing wastage of the resources or inputs which was used for producing it and in turn causes scarcity of resources and hence hiking and affecting the cost of cultivation for several years from then on till its effect is nullified by real value change of the commodity.

2. METHODOLOGY

Food loss is one of the biggest problems of our socio-economic environment but this is given less importance as compared to production or

marketing constraints prevailing in agriculture. Food loss is causing various social and economic problems some of which are increasing food price, decreasing per capita food availability, less income for the farmer, in the long run, malnutrition, more hunger, production pressure and many more, as there are more mouths to feed every year.

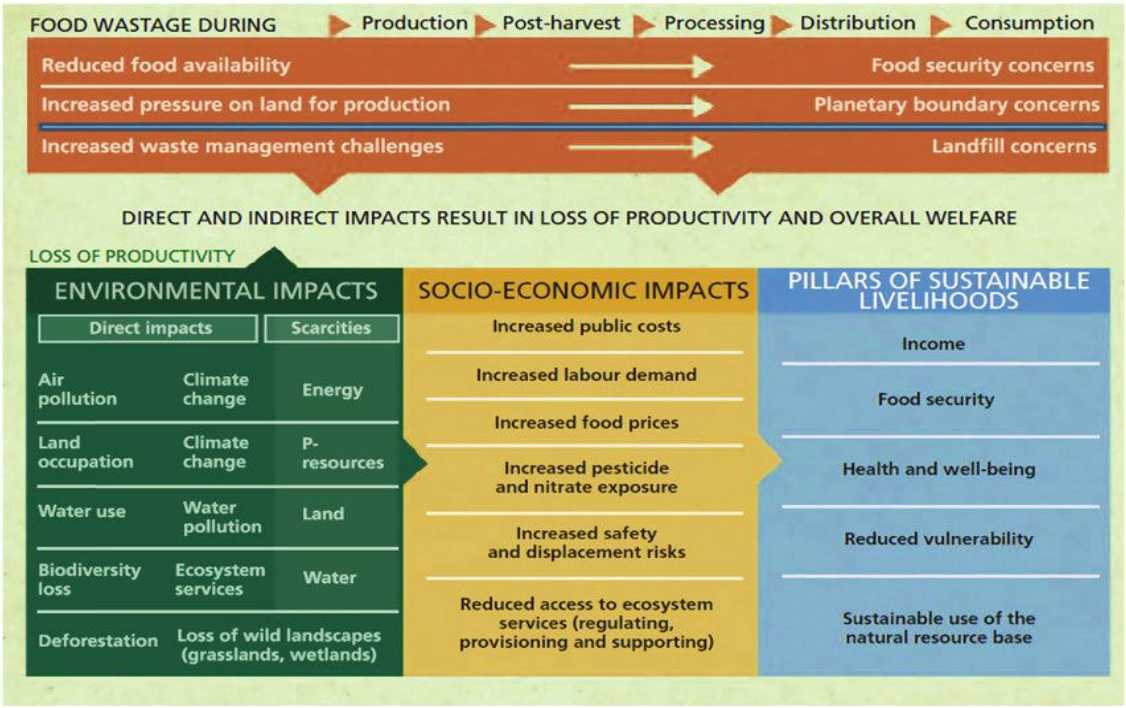


Fig. 1. Impact of food wastage
**Source: FAO [13]*

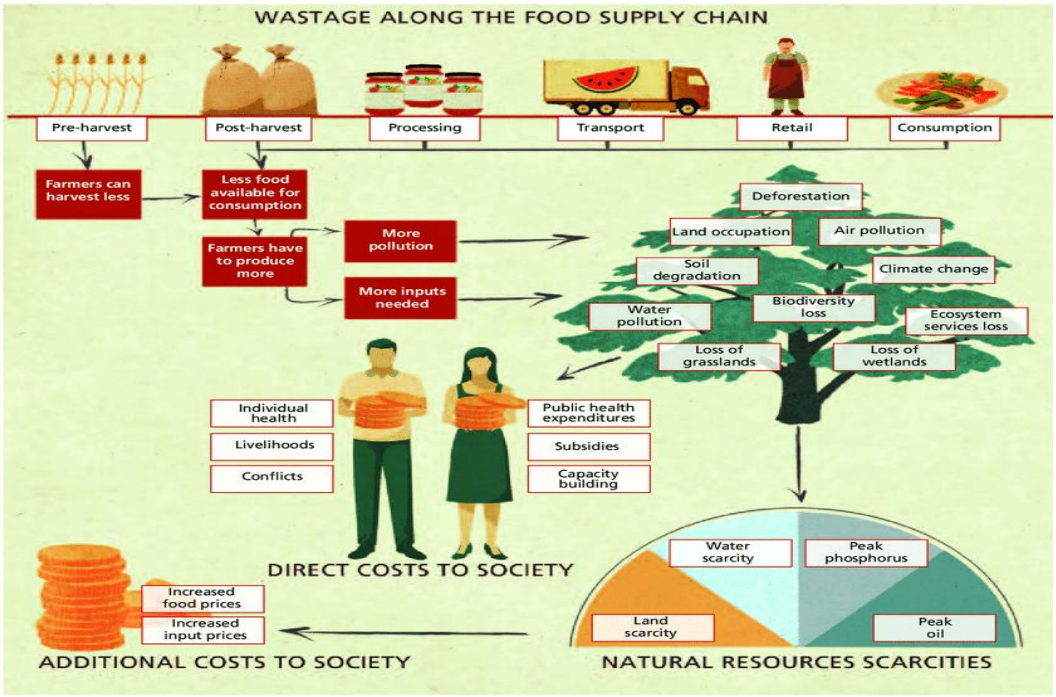


Fig. 2. Direct impacts of food wastage and additional security costs
**Source: FAO [13]*

Table 1. Marketing channel real v/s Ideal situation

Market subordinates	Produce available (in kg)	Gross profit	Loss (in kg)	Actual price ($/kg)	Ideal price ($/kg)	Price increase ($/kg)
INITAL	100	$1000	0	10	10	0
Farm level	95	$1100	5	11.58	11	0.58
Wholesaler level	94.05	$1210	0.95	12.87	12.10	0.77
Processer level	93.11	$1331	0.94	14.29	13.31	0.98
Retailer level	92.18	$1464.1	0.93	15.88	14.64	1.24

**Source: This data was created by the author of this paper as an example*

Table 2. Fertilizer subsidy (Rs. Crores) from 1997-2017

Years	Fertilizer Subsidy (Rs. Crore)
1997-98	9918.00
1998-99	11387.00
1999-00	13244.00
2000-01	13800.00
2001-02	12595.00
2002-03	11015.00
2003-04	11847.00
2004-05	16128.00
2005-06	19389.64
2006-07	28019.55
2007-08	43319.16
2008-09	99494.71
2009-10	64032.29
2010-11	65836.68
2011-12	73791.00
2012-13	70592.00
2013-14	71280.00
2014-15	75067.00
2015-16	72415.00
2016-17	66313.00

**source: Fertilizer association of India, 2020 [39]*

This research is time series data analysis research which proves and depicts that how food wastage did in the current year is affecting the cost of cultivation in consecutive years. For understanding and proving this paper, two different approaches are used which backs each other. First is the theoretical approach which gives an understanding based on basic economic principles that how the cost of cultivation is dependent on post-harvest losses using an ideal hypothetical example. The second approach is empirical, it uses various primary data from different authenticated sources and some of it were processed to get secondary data, with all the data available a system for processing it is created to get to a conclusion by statistical analysis using simple regression in MS Excel which proves and justifies both the approaches.

2.1 Assumptions and Reasons

1. Fertilizer subsidy is 50% of the total subsidy given to the farmer. Reason. Since the amount of power and irrigation subsidy used by the farmer is directly dependent on the fertilizer subsidy as more fertilizer needs more irrigation and more irrigation need more power. According to research done by Agro- Economic Research Centre for Madhya Pradesh and Chhattisgarh which showed that approx. 50% of subsidy which is incurred by the farmer is from fertilizer and other subsidy takes rest 50%. [25].
2. The actual cost of cultivation of 2008-09 is average of 2007-08 and 2009-10. Reason. According to the research done by Shah Deepak of Gokhale Institute of Politics and Economics which depicted that how the Economic and Financial Crisis of 2008 has affected the Agricultural Sector of India, one of the major effects was the inflated cost of cultivation. [26]
3. Effect of loss which is the X variable or the dependent variable is a hypothetical analysing system created to process the data and determine the effect caused by food loss as in this research it is considered that in the initial year when food loss is done there is no effect on the cost of cultivation of present year, as it is already incurred by the farmer but from the next year it affect will reduce from 100% in the first year, 50% in 2nd year, 25% in 3rd year, 12.5% in 4th year, 6.25% in 5th year, 3.12% in 6th year, and 1.6% in 7th year.

2.2 Empirical Data Analysis

This data analysis is conducted with the help of simple regression model i.e., $Y = \beta_0 + \beta_1 X^1 + \mu_0$. [27]. This econometrics model finds the relationship between the independent variable X i.e., the effect of food loss which empirically extracted from time-series data and create secondary data based on some assumptions which can be analysed and compared with dependent variable Y i.e., the actual cost of cultivation which is the cost of cultivation of a crop if there is no incentivise and support from government and inflation-free, and finds the correlation between this two variables.

3. RESULTS AND DISCUSSION

This analysis is done on some of the prominent crops which are grown in India for decades, these crops consume most of the subsidy amount and provide income for the majority of the farmers of India. The lists of selected crops for data analysis are as follows.

1. Wheat
2. Rice
3. Maize
4. Groundnut
5. Gram
6. Bajra

3.1 Fertilizer Subsidy (1)

There are two types of subsidy based on the availability of the economic benefits i.e., direct and indirect. Fertilizer subsidy is one of the direct subside which is given by the government of India. It is the difference between the price paid to fertilizer manufacturers and the price received by the farmers. [25].

3.2 Subsidy for Particular Crop (Rs. crores) (2)

Crop wise fertilizer subsidy is calculated based on their respective share in fertilizer consumption. Input survey data is released every 5 years [28]. So, subsidy percentage to a particular crop is assumed to be the same for the next 4 year till the next input survey data is released.

$$Fertilizer\ subsidy \times Fertilizer\ input\ \%$$

3.3 Cropping Area (million ha) (3)

The cropping area comes with two concept net cropping area and total cropped area. This

research is on the total cropped area as it gives the area under a particular crop annually.

3.4 Fertilizer Subsidy (□/ha) (4)

It is the value that is calculated by dividing the subsidy percentage to a particular crop to cropping area. As to get the actual cost of cultivation per hectare we have to include all the economic and financial benefits which are available, as this subsidy reduces the expenditure of the farmer.

$$\frac{Subsidy\ for\ particular\ crop\ (Rs.crores) \times 10\ (converstion\ factor)}{Cropping\ area\ (millions\ ha)}$$

3.5 Total Subsidy (□/ha) (5)

The total subsidy is twice the fertilizer subsidy. This subsidy includes major indirect subsidy like power subsidy, irrigation subsidy, credit subsidy and other incentives through different schemes [29]. Most states provide this subsidy under different strategies so it is not unified as fertilizer subsidy which is controlled by the central government but generally it is equal to fertilizer subsidy on an average basis.

$$Fertilizer\ subsidy\ \times 2$$

3.6 Cost of Cultivation (COC) (Rs. / ha) (6)

The cost of cultivation is the amount required to cultivate one hectare of land. This data is the average cost of cultivation for all the state which is leading producer of the particular crop to get whole countries average. This is the C2 cost of cost calculation.

3.7 Total Cost of Cultivation (t COC) (7)

It is the sum of total subsidy and cost of cultivation to get the total cost required for producing the particular commodity. This data gives the cost of cultivation of crop if there is no incentivise given by the government in the forms of subsidies and schemes as this relieves reduces the cost of cultivations to a large extend.

$$Cost\ of\ cultivation + total\ subsidy$$

3.8 Actual Cost of Cultivation (a COC) (Y) (8)

The actual cost of cultivation is the amount that is free from inflation hence it gives a clearer picture. For this experiment, the base year to calculate inflations is 2004-05 as it is considered an ideal year by the government of India and we are considering Wholesale's price index of India as it is a standard inflation projecting index considered by the government.

$$\frac{Cost\ of\ cultivation}{New\ WPI} \times 100$$

3.7 Average Food Loss Percentage (10)

Food loss data is collected from two pieces of research that have been recorded in different timeframes i.e., 2005-07 and 2012-15 [2] [3]. So, the food loss percentage is average of both the recorded data for 27 years as before 2002 there is no recorded data for estimation of food loss. Post-harvest and harvest loss are majorly categorized into operational and storage loss which includes all the market participant starting from the farm, wholesaler, processer and retailer.

3.8 Productivity (kg/ha) (11)

Productivity is the amount of agricultural commodity produced from one hectare of land with the given resources.

3.9 Food Loss (kg/ha) (12)

Productivity multiplied to average food loss per cent which gives food loss in kg/ha for the particular year.

$$Productivity\ \times Average\ food\ loss\ \%$$

3.10 Effect of Loss (X) (13)

Food loss has an effect on the scarcity of resources to measure this effect and its correlation to the cost of cultivation we considered that food loss is done in the present year has an effect on the cost of cultivation for the next 7 years as years pass its effects keeps reducing to 50% year on year. Present year food loss does not affect cost of cultivation of present year. Let's consider food loss for present year as x_0 and previous years as x_1, x_2, x_3....., x_7. So, the equation will be

$$x_1 + (x_2 \times 0.5) + (x_3 \times 0.25) + (x_4 \times 0.125) + (x_5 \times 0.063) + (x_6 \times 0.031) + (x_7 \times 0.016).$$

Table 3. Fertilizer input percentage for different crops

CROPS	1996-97(1997-98 to 2000-01)		2001-02(2001-02 to 2005-06)		2006-07(2006-07 to 2010-11)		2011-12 (2011-12 to 2016-17)	
	Subsidy	Percentage	Subsidy	Percentage	Subsidy	Percentage	Subsidy	Percentage
1.Wheat	2852644	21.52	3189675	18.74	4141271	22.21	5273897	20.3
2.Rice	4310472	32.52	5061724	29.73	5581259	29.93	7268091	27.98
3.Maize	266550	2.01	258434	1.52	515016	2.76	1201306	4.62
4.Groundnut	355277	2.68	465858	2.74	251421	1.35	338837	1.3
5.Gram	63564	0.48	96901	0.57	200585	1.08	200585	2
6.Bajra	302996	2.29	304253	1.79	231998	1.24	394262	1.52
Total Subsidy	13253740		17023240		18649380		25975600	

**Subsidy and total subsidy are in metric tonnes; *Total Subsidy of every 5-year plan is average of all fertilizer available during that period; * Since data for 2015-17 input survey is unavailable so it is considered under 2011 input survey; * Source: All India report on input survey, department of agriculture cooperation, GOI, 2016; Fertilizer association of India, 2020 [31]*

Table 4. Cropping Area (million ha)

Years	Crops (million ha)					
	Wheat	Rice	Maize	Groundnut	Gram	Bajra
1997-98	26.70	43.45	6.32	7.09	7.56	9.89
1998-99	27.52	44.80	6.20	7.40	8.47	9.30
1999-00	27.49	45.16	6.42	6.87	6.15	8.90
2000-01	25.73	44.71	6.61	6.56	5.19	9.83
2001-02	26.34	44.90	6.58	6.24	6.42	9.53
2002-03	25.20	41.18	6.64	5.94	5.91	7.74
2003-04	26.59	42.59	7.34	5.99	7.05	10.61
2004-05	26.38	41.91	7.43	6.64	6.71	9.23
2005-06	26.48	43.66	7.59	6.74	6.93	9.58
2006-07	27.99	43.81	7.89	5.62	7.49	9.51
2007-08	28.04	43.91	8.12	6.29	7.54	9.57
2008-09	27.75	45.54	8.17	6.16	7.89	8.75
2009-10	28.46	41.92	8.26	5.48	8.17	8.90
2010-11	29.07	42.86	8.55	5.86	9.19	9.61
2011-12	29.86	44.01	8.78	5.26	8.30	8.78
2012-13	30.00	42.75	8.67	4.72	8.52	7.30
2013-14	30.47	44.14	9.07	5.51	9.93	7.81
2014-15	31.47	44.11	9.19	4.77	8.25	7.32
2015-16	30.42	43.50	8.81	4.60	8.40	7.13
2016-17	30.79	43.99	9.63	5.34	9.63	7.46

**Source: Agricultural Statistics at a Glance 2018, DoE&S, GOI, [1]*

Table 5. Cost of Cultivation of crops (Rs. /ha)

Years	Crops (Rs. / ha)					
	Wheat	Rice	Maize	Groundnut	Gram	Bajra
1997-98	12862.68	15136.53	8263.76	13427.68	7681.55	6432.98
1998-99	14492.16	17319.94	9504.09	14889.49	7827.00	7874.94
1999-00	15960.18	19076.74	10898.60	15829.52	8185.20	8652.46
2000-01	16406.34	19436.16	10991.33	15290.27	10413.36	8826.70
2001-02	16863.36	20593.81	11264.06	16934.49	10900.06	9280.07
2002-03	16944.91	20937.11	12140.00	18849.92	9885.62	11562.68
2003-04	17346.60	21336.45	12869.47	19870.38	9804.42	9782.00
2004-05	18007.53	21980.40	12224.24	19220.25	9954.02	10132.34
2005-06	19588.50	21967.58	14090.99	19087.74	12077.39	10395.44
2006-07	21791.85	22842.24	14330.71	19179.51	13160.50	11798.59
2007-08	23531.92	24851.67	17184.89	23634.70	13373.66	13118.08
2008-09	26101.06	29935.70	20273.50	27700.92	16419.73	16205.57
2009-10	28858.37	34203.92	22095.93	30364.85	16909.61	18064.60
2010-11	30915.51	36043.38	25512.90	37079.54	18877.91	18634.88
2011-12	35653.71	41450.23	30127.87	47741.34	25184.73	22791.10
2012-13	38578.35	47644.51	36556.45	57718.70	29009.76	26359.97
2013-14	41660.28	51408.03	39990.51	58048.26	28436.08	32361.43
2014-15	43831.29	58667.96	48479.51	57857.49	31498.88	37208.54
2015-16	46466.88	60824.27	51809.06	66829.84	35266.88	37821.01
2016-17	48543.97	62290.61	52337.76	68606.77	41342.59	42134.51

**Source: Cost of Cultivation, DoE&S, GOI, [1] [32]*

Table 6. Inflation rate based on 2004-05 as base year

Year	Old WPI (1993-94)	New WPI (2004-05)	Inflation rate (base year 2004-05)
1997-98	132.80	70.90	-5.61478
1998-99	140.70	75.12	-3.16586
1999-00	145.30	77.58	-6.67951
2000-01	155.70	83.13	-3.47179
2001-02	161.30	86.12	-3.29736
2002-03	166.80	89.06	-5.17339
2003-04	175.90	93.91	-6.08646
2004-05	187.30	100.00	0
2005-06	195.60	104.47	4.47
2006-07	206.20	111.35	6.585623
2007-08	215.70	116.63	4.741805
2008-09	233.90	126.02	8.051102
2009-10	242.90	130.81	3.800984
2010-11		143.32	9.563489
2011-12		156.13	8.938041
2012-13		167.62	7.359252
2013-14		177.64	5.977807
2014-15		181.19	1.998424
2015-16		176.67	-2.49462
2016-17		183.20	3.696157

**Converting ratio between old (1993-94) and new WPI (2004-05) is 0.53; *Source: WPI, MoC&I, GOI, 2020 [33]*

Table 7. Average post- harvest loss percentage (ICAR report)

Crops	Post-harvest loss percent		Average loss percent
	2005-07	2012-15	
Wheat	5.93%	4.93%	5.43%
Rice	5.19%	5.53%	5.36%
Maize	4.10%	4.65%	4.38%
Groundnut	10.06%	6.03%	8.05%
Gram	4.28%	8.41%	6.35%
Bajra	4.80%	5.23%	5.02%

**Source:[2,3]*

Table 8. Productivity of Crops

Years	Crops (kg/ha)					
	Wheat	Rice	Maize	Groundnut	Gram	Bajra
1990-01	2281	1740	1518	904	712	658
1991-92	2394	1751	1376	818	739	465
1992-93	2327	1744	1676	1049	684	836
1993-94	2380	1888	1602	941	783	521
1994-95	2559	1911	1570	1027	853	700
1995-96	2483	1797	1595	1007	700	577
1996-97	2679	1882	1720	1138	813	788
1997-98	2485	1900	1711	1040	811	773
1998-99	2590	1921	1797	1214	803	748
1999-00	2778	1986	1792	764	833	650
2000-01	2708	1901	1822	977	744	688
2001-02	2762	2076	2000	1127	853	869
2002-03	2610	1744	1681	694	717	610
2003-04	2713	2079	2041	1357	811	1141
2004-05	2602	1984	1907	1020	815	859
2005-06	2619	2102	1938	1187	808	802
2006-07	2708	2131	1921	866	845	886
2007-08	2802	2202	2335	1459	762	1042
2008-09	2907	2178	2414	1163	895	1015
2009-10	2839	2125	2024	991	915	731
2010-11	2988	2239	2542	1411	894	1079
2011-12	3177	2393	2478	1323	928	1171
2012-13	3117	2461	2566	995	1036	1198
2013-14	3146	2461	2676	1764	960	1184
2014-15	2750	2391	2632	1552	889	1255
2015-16	3034	2400	2563	1465	840	1132
2016-17	3200	2494	2689	1398	974	1305

**Source: Agricultural Statistics at a Glance 2018, DoE&S, GOI, [1]*

Wheat

Table 9. Calculating the actual cost of cultivation in wheat

Year (1)	Fertilizer subsidy (corers.) (2)	Subsidyfor particular crop (3) (corers.)	Cropping area (million ha) (4)	Fertilizer subsidy (□/ha) (5)	Total subsidy (□/ha) (6)	Cost of cultivation (COC) (□/ha) (7)	Cost of cultivation (COC) (□/ha) (7)	Actual cost of cultivation (a COC) (□/ha) (Y) (9)
1997-98	9918.00	2132.37	26.70	798.64	1597.28	12862.68	14459.96	20394.20
1998-99	11387.00	2448.21	27.52	889.61	1779.22	14492.16	16271.38	21660.48
1999-00	13244.00	2847.46	27.49	1035.82	2071.63	15960.18	18031.81	23244.03
2000-01	13800.00	2967.00	25.73	1153.13	2306.26	16406.34	18712.60	22510.39
2001-02	12595.00	2355.27	26.34	894.18	1788.36	16863.36	18651.72	21658.19
2002-03	11015.00	2059.81	25.20	817.38	1634.77	16944.91	18579.68	20863.15
2003-04	11847.00	2215.39	26.59	833.17	1666.33	17346.60	19012.94	20245.15
2004-05	16128.00	3015.94	26.38	1143.27	2286.53	18007.53	20294.07	20294.07
2005-06	19389.64	3625.86	26.48	1369.28	2738.57	19588.50	22327.07	21371.75
2006-07	28019.55	6220.34	27.99	2222.34	4444.69	21791.85	26236.53	23562.22
2007-08	43319.16	9616.85	28.04	3429.69	6859.38	23531.92	30391.30	26057.87
2008-09	99494.71	22087.83	27.75	7959.58	15919.15	26101.06	42020.22	27877.94
2009-10	64032.29	14215.17	28.46	4994.79	9989.58	28858.37	38847.95	29698.00
2010-11	65836.68	14615.74	29.07	5027.78	10055.55	30915.51	40971.06	28587.12
2011-12	73791.00	14979.57	29.86	5016.60	10033.20	35653.71	45686.91	29262.10
2012-13	70592.00	14330.18	30.00	4776.73	9553.45	38578.35	48131.80	28714.83
2013-14	71280.00	14469.84	30.47	4748.88	9497.76	41660.28	51158.04	28798.71
2014-15	75067.00	15238.60	31.47	4842.26	9684.53	43831.29	53515.82	29535.75
2015-16	72415.00	14700.25	30.42	4832.43	9664.86	46466.88	56131.74	31772.08
2016-17	66313.00	13461.54	30.79	4372.05	8744.10	48543.97	57288.07	31270.78

**source: This table is calculated using MS Excel by processing data from table 2 to table 8*

Table 10. Calculating the effect of loss in wheat

Year	Productivity (kg/ha) (11)	Food loss (kg/ha) (12)	Effect of loss (13)(X)
1990-01	2281.00	123.86	
1991-92	2394.00	129.99	
1992-93	2327.00	126.36	
1993-94	2380.00	129.23	
1994-95	2559.00	138.95	
1995-96	2483.00	134.83	
1996-97	2679.00	145.47	
1997-98	2485.00	134.94	277.75
1998-99	2590.00	140.64	272.88
1999-00	2778.00	150.85	276.11
2000-01	2708.00	147.04	287.95
2001-02	2762.00	149.98	290.06
2002-03	2610.00	141.72	293.96
2003-04	2713.00	147.32	287.70
2004-05	2602.00	141.29	290.07
2005-06	2619.00	142.21	285.31
2006-07	2708.00	147.04	283.82
2007-08	2802.00	152.15	287.82
2008-09	2907.00	157.85	294.96
2009-10	2839.00	154.16	304.20
2010-11	2988.00	162.25	305.20
2011-12	3177.00	172.51	313.74
2012-13	3117.00	169.25	328.33
2013-14	3146.00	170.83	332.35
2014-15	2750.00	149.33	335.90
2015-16	3034.00	164.75	316.14
2016-17	3200.00	173.76	321.64

**source: This table is calculated using MS Excel by processing data from table 2 to table 8*

Rice

Table 11. Calculating the actual cost of cultivation in Rice

Year (1)	Fertilizer subsidy (corers.) (2)	Subsidy % for particular crop (3)	Cropping area (million ha) (4)	Fertilizer subsidy (□/ha) (5)	Total subsidy (□/ha) (6)	Cost of cultivation (COC) (□/ha) (7)	Total cost of cultivation (t COC) (□/ha) (8)	Actual cost of cultivation (a COC) (□/ha) (Y) (9)
1997-98	9918.00	3223.35	43.45	741.85	1483.71	15136.53	16620.23	23441.03
1998-99	11387.00	3700.78	44.80	826.07	1652.13	17319.94	18972.07	25255.63
1999-00	13244.00	4304.30	45.16	953.12	1906.24	19076.74	20982.99	27048.26
2000-01	13800.00	4485.00	44.71	1003.13	2006.26	19436.16	21442.42	25794.25
2001-02	12595.00	3740.72	44.90	833.12	1666.24	20593.81	22260.06	25848.15
2002-03	11015.00	3271.46	41.18	794.43	1588.86	20937.11	22525.96	25294.43
2003-04	11847.00	3518.56	42.59	826.15	1652.29	21336.45	22988.74	24478.63
2004-05	16128.00	4790.02	41.91	1142.93	2285.86	21980.40	24266.26	24266.26
2005-06	19389.64	5758.72	43.66	1318.99	2637.99	21967.58	24605.57	23552.76
2006-07	28019.55	8377.85	43.81	1912.31	3824.63	22842.24	26666.87	23948.69
2007-08	43319.16	12952.43	43.91	2949.77	5899.53	24851.67	30751.20	26366.46
2008-09	99494.71	29748.92	45.54	6532.48	13064.96	29935.70	43000.66	29748.59
2009-10	64032.29	19145.65	41.92	4567.19	9134.38	34203.92	43338.30	33130.72
2010-11	65836.68	19685.17	42.86	4592.90	9185.80	36043.38	45229.18	31558.18
2011-12	73791.00	20587.69	44.01	4677.96	9355.91	41450.23	50806.14	32540.92
2012-13	70592.00	19695.17	42.75	4607.06	9214.11	47644.51	56858.62	33921.14
2013-14	71280.00	19887.12	44.14	4505.46	9010.93	51408.03	60418.96	34012.02
2014-15	75067.00	20943.69	44.11	4748.06	9496.12	58667.96	68164.08	37620.22
2015-16	72415.00	20203.79	43.50	4644.55	9289.10	60824.27	70113.36	39686.06
2016-17	66313.00	18501.33	43.99	4205.80	8411.61	62290.61	70702.21	38592.91

**source: This table is calculated using MS Excel by processing data from table 2 to table 8*

Table 12. Calculating the effect of loss in Rice

Year	Productivity (kg/ha) (11)	Food loss (kg/ha) (12)	Effect of loss (13)(X)
1990-01	1740.00	93.26	
1991-92	1751.00	93.85	
1992-93	1744.00	93.48	
1993-94	1888.00	101.20	
1994-95	1911.00	102.43	
1995-96	1797.00	96.32	
1996-97	1882.00	100.88	
1997-98	1900.00	101.84	197.53
1998-99	1921.00	102.97	199.80
1999-00	1986.00	106.45	202.08
2000-01	1901.00	101.89	206.71
2001-02	2076.00	111.27	204.42
2002-03	1744.00	93.48	212.64
2003-04	2079.00	111.43	199.13
2004-05	1984.00	106.34	210.19
2005-06	2102.00	112.67	210.64
2006-07	2131.00	114.22	217.18
2007-08	2202.00	118.03	221.98
2008-09	2178.00	116.74	228.22
2009-10	2125.00	113.90	229.98
2010-11	2239.00	120.01	228.16
2011-12	2393.00	128.26	233.22
2012-13	2461.00	131.91	244.04
2013-14	2461.00	131.91	253.05
2014-15	2391.00	128.16	257.54
2015-16	2400.00	128.64	256.01
2016-17	2494.00	133.68	255.73

**source: This table is calculated using MS Excel by processing data from table 2 to table 8*

Maize

Table 13. Calculating the actual cost of cultivation in Maize

Year (1)	Fertilizer subsidy (corers.) (2)	Subsidy % for particular crop (3)	Cropping area (million ha) (4)	Fertilizer subsidy (□/ha) (5)	Total subsidy (□/ha) (6)	Cost of cultivation (COC) (□/ha) (7)	Total cost of cultivation (t COC) (□/ha) (8)	Actual cost of cultivation (a COC) (□/ha) (Y) (9)
1997-98	9918.00	199.35	6.32	315.43	630.86	8263.76	8894.62	12544.90
1998-99	11387.00	228.88	6.20	369.16	738.32	9504.09	10242.41	13634.70
1999-00	13244.00	266.20	6.42	414.65	829.30	10898.60	11727.89	15117.92
2000-01	13800.00	277.38	6.61	419.64	839.27	10991.33	11830.61	14231.68
2001-02	12595.00	191.44	6.58	290.95	581.90	11264.06	11845.96	13755.41
2002-03	11015.00	167.43	6.64	252.15	504.30	12140.00	12644.30	14198.31
2003-04	11847.00	180.07	7.34	245.33	490.67	12869.47	13360.13	14225.99
2004-05	16128.00	245.15	7.43	329.94	659.88	12224.24	12884.12	12884.12
2005-06	19389.64	294.72	7.59	388.30	776.61	14090.99	14867.60	14231.46
2006-07	28019.55	773.34	7.89	980.15	1960.30	14330.71	16291.01	14630.45
2007-08	43319.16	1195.61	8.12	1472.42	2944.85	17184.89	20129.74	17259.48
2008-09	99494.71	2746.05	8.17	3361.14	6722.29	20273.50	26995.79	18711.19
2009-10	64032.29	1767.29	8.26	2139.58	4279.16	22095.93	26375.08	20162.90
2010-11	65836.68	1817.09	8.55	2125.25	4250.51	25512.90	29763.40	20767.10
2011-12	73791.00	3409.14	8.78	3882.85	7765.70	30127.87	37893.57	24270.53
2012-13	70592.00	3261.35	8.67	3761.65	7523.30	36556.45	44079.75	26297.43
2013-14	71280.00	3293.14	9.07	3630.80	7261.60	39990.51	47252.11	26599.93
2014-15	75067.00	3468.10	9.19	3773.77	7547.54	48479.51	56027.05	30921.71
2015-16	72415.00	3345.57	8.81	3797.47	7594.94	51809.06	59404.00	33624.27
2016-17	66313.00	3063.66	9.63	3181.37	6362.74	52337.76	58700.50	32041.76

**source: This table is calculated using MS Excel by processing data from table 2 to table 8*

Table 14. Calculating the effect of loss in Maize

Year	Productivity (kg/ha) (11)	Food loss (kg/ha) (12)	Effect of loss (13)(X)
1990-01	1518	66.49	
1991-92	1376	60.27	
1992-93	1676	73.41	
1993-94	1602	70.17	
1994-95	1570	68.77	
1995-96	1595	69.86	
1996-97	1720	75.34	
1997-98	1711	74.94	178.72
1998-99	1797	78.71	184.00
1999-00	1792	78.49	188.90
2000-01	1822	79.80	193.01
2001-02	2000	87.60	195.35
2002-03	1681	73.63	205.04
2003-04	2041	89.40	199.48
2004-05	1907	83.53	203.48
2005-06	1938	84.88	211.00
2006-07	1921	84.14	209.21
2007-08	2335	102.27	209.71
2008-09	2414	105.73	227.39
2009-10	2024	88.65	248.86
2010-11	2542	111.34	239.84
2011-12	2478	108.54	248.48
2012-13	2566	112.39	265.67
2013-14	2676	117.21	271.02
2014-15	2632	115.28	281.15
2015-16	2563	112.26	285.61
2016-17	2689	117.78	282.60

**source: This table is calculated using MS Excel by processing data from table 2 to table 8.*

Groundnut

Table 15. Calculating the actual cost of cultivation in Groundnut

Year(1)	Fertilizer subsidy (corers.) (2)	Subsidy % for particular crop (3)	Cropping area (million ha) (4)	Fertilizer subsidy (□/ha) (5)	Total subsidy (□/ha) (6)	Cost of cultivation (COC) (□/ha) (7)	Total cost of cultivation (t COC) (□/ha) (8	Actual cost of cultivation (a COC) (□/ha) (Y) (9)
1997-98	9918.00	265.80	7.09	374.90	749.80	13427.68	14177.48	19995.79
1998-99	11387.00	305.17	7.40	412.39	824.79	14889.49	15714.27	20918.85
1999-00	13244.00	354.94	6.87	516.65	1033.30	15829.52	16862.82	21737.13
2000-01	13800.00	369.84	6.56	563.78	1127.56	15290.27	16417.83	19749.89
2001-02	12595.00	345.10	6.24	553.05	1106.10	16934.49	18040.59	20948.55
2002-03	11015.00	301.81	5.94	508.10	1016.20	18849.92	19866.12	22307.69
2003-04	11847.00	324.61	5.99	541.92	1083.83	19870.38	20954.22	22312.24
2004-05	16128.00	441.91	6.64	665.52	1331.05	19220.25	20551.29	20551.29
2005-06	19389.64	531.28	6.74	788.24	1576.49	19087.74	20664.22	19780.05
2006-07	28019.55	378.26	5.62	673.07	1346.13	19179.51	20525.65	18433.45
2007-08	43319.16	584.81	6.29	929.74	1859.49	23634.70	25494.19	21859.03
2008-09	99494.71	1343.18	6.16	2180.48	4360.97	27700.92	32061.89	23741.89
2009-10	64032.29	864.44	5.48	1577.44	3154.88	30364.85	33519.72	25624.74
2010-11	65836.68	888.80	5.86	1516.72	3033.43	37079.54	40112.97	27988.40
2011-12	73791.00	959.28	5.26	1823.73	3647.46	47741.34	51388.81	32914.11
2012-13	70592.00	917.70	4.72	1944.27	3888.54	57718.70	61607.24	36754.11
2013-14	71280.00	926.64	5.51	1681.74	3363.48	58048.26	61411.75	34570.90
2014-15	75067.00	975.87	4.77	2045.85	4091.70	57857.49	61949.19	34190.18
2015-16	72415.00	941.40	4.60	2046.51	4093.02	66829.84	70922.86	40144.26
2016-17	66313.00	862.07	5.34	1614.36	3228.72	68606.77	71835.50	39211.52

**source: This table is calculated using MS Excel by processing data from table 2 to table 8*

Table 16. Calculating the effect of loss in Groundnut

Year	Productivity (kg/ha) (11)	Food loss (kg/ha) (12)	Effect of loss (13) (X)
1990-01	904.00	72.77	
1991-92	818.00	65.85	
1992-93	1049.00	84.44	
1993-94	941.00	75.75	
1994-95	1027.00	82.67	
1995-96	1007.00	81.06	
1996-97	1138.00	91.61	
1997-98	1040.00	83.72	170.80
1998-99	1214.00	97.73	168.57
1999-00	764.00	61.50	181.53
2000-01	977.00	78.65	151.63
2001-02	1127.00	90.72	153.90
2002-03	694.00	55.87	167.05
2003-04	1357.00	109.24	138.80
2004-05	1020.00	82.11	177.93
2005-06	1187.00	95.55	170.46
2006-07	866.00	69.71	180.04
2007-08	1459.00	117.45	159.26
2008-09	1163.00	93.62	196.52
2009-10	991.00	79.78	191.17
2010-11	1411.00	113.59	174.98
2011-12	1323.00	106.50	200.23
2012-13	995.00	80.10	206.03
2013-14	1764.00	142.00	182.37
2014-15	1552.00	124.94	232.68
2015-16	1465.00	117.93	240.40
2016-17	1398.00	112.54	237.42

**source: This table is calculated using MS Excel by processing data from table 2 to table 8*

Gram

Table 17. Calculating the actual cost of cultivation in Gram

Year (1)	Fertilizer subsidy (corers.) (2)	Subsidy % for particular crop (3)	Cropping area (million ha) (4)	Fertilizer subsidy (□/ha) (5)	Total subsidy (□/ha) (6)	Cost of cultivation (COC) (□/ha) (7)	Total cost of cultivation (t COC) (□/ha) (8)	Actual cost of cultivation (a COC) (□/ha) (Y) (9)
1997-98	9918.00	47.61	7.56	62.97	125.94	7681.55	7807.49	11011.62
1998-99	11387.00	54.66	8.47	64.53	129.06	7827.00	7956.06	10591.12
1999-00	13244.00	63.57	6.15	103.37	206.74	8185.20	8391.94	10817.68
2000-01	13800.00	66.24	5.19	127.63	255.26	10413.36	10668.62	12833.86
2001-02	12595.00	71.79	6.42	111.82	223.65	10900.06	11123.71	12916.74
2002-03	11015.00	62.79	5.91	106.24	212.47	9885.62	10098.09	11339.16
2003-04	11847.00	67.53	7.05	95.78	191.57	9804.42	9995.99	10643.82
2004-05	16128.00	91.93	6.71	137.00	274.01	9954.02	10228.03	10228.03
2005-06	19389.64	110.52	6.93	159.48	318.96	12077.39	12396.36	11865.95
2006-07	28019.55	302.61	7.49	404.02	808.04	13160.50	13968.54	12544.72
2007-08	43319.16	467.85	7.54	620.49	1240.97	13373.66	14614.63	12530.77
2008-09	99494.71	1074.54	7.89	1361.90	2723.81	16419.73	19143.54	13375.89
2009-10	64032.29	691.55	8.17	846.45	1692.90	16909.61	18602.51	14221.02
2010-11	65836.68	711.04	9.19	773.71	1547.41	18877.91	20425.32	14251.55
2011-12	73791.00	1475.82	8.30	1778.10	3556.19	25184.73	28740.93	18408.33
2012-13	70592.00	1411.84	8.52	1657.09	3314.18	29009.76	32323.94	19284.06
2013-14	71280.00	1425.60	9.93	1435.65	2871.30	28436.08	31307.38	17624.06
2014-15	75067.00	1501.34	8.25	1819.81	3639.61	31498.88	35138.49	19393.17
2015-16	72415.00	1448.30	8.40	1724.17	3448.33	35266.88	38715.21	21913.86
2016-17	66313.00	1326.26	9.63	1377.22	2754.43	41342.59	44097.03	24070.43

**source: This table is calculated using MS Excel by processing data from table 2 to table 8*

Table 18. Calculating the effect of loss in Gram

Year	Productivity (kg/ha) (11)	Food loss (kg/ha) (12)	Effect of loss (13)
1990-01	712	45.18	
1991-92	739	46.89	
1992-93	684	43.40	
1993-94	783	49.68	
1994-95	853	54.12	
1995-96	700	44.42	
1996-97	813	51.58	
1997-98	811	51.46	98.44
1998-99	803	50.95	100.35
1999-00	833	52.85	100.77
2000-01	744	47.21	102.91
2001-02	853	54.12	98.30
2002-03	717	45.49	102.86
2003-04	811	51.46	96.59
2004-05	815	51.71	99.37
2005-06	808	51.27	101.01
2006-07	845	53.62	101.39
2007-08	762	48.35	103.91
2008-09	895	56.79	99.96
2009-10	915	58.06	106.36
2010-11	894	56.72	110.90
2011-12	928	58.88	111.79
2012-13	1036	65.73	114.38
2013-14	960	60.91	122.55
2014-15	889	56.41	121.78
2015-16	840	53.30	116.94
2016-17	974	61.80	111.34

**source: This table is calculated using MS Excel by processing data from table 2 to table 8*

Bajra

Table 19. Calculating the actual cost of cultivation in Bajra

Year (1)	Fertilizer subsidy (corers.) (2)	Subsidy % for particular crop (3)	Cropping area (million ha) (4)	Fertilizer subsidy (□/ha) (5)	Total subsidy (□/ha) (6)	Cost of cultivation (COC) (□/ha) (7)	Total cost of cultivation (t COC) (□/ha) (8)	Actual cost of cultivation (a COC) (□/ha) (Y) (9)
1997-98	9918.00	227.12	9.89	229.65	459.30	6432.98	6892.28	9720.81
1998-99	11387.00	260.76	9.30	280.39	560.78	7874.94	8435.72	11229.63
1999-00	13244.00	303.29	8.90	340.77	681.55	8652.46	9334.00	12032.06
2000-01	13800.00	316.02	9.83	321.49	642.97	8826.70	9469.67	11391.58
2001-02	12595.00	225.45	9.53	236.57	473.14	9280.07	9753.21	11325.33
2002-03	11015.00	197.17	7.74	254.74	509.48	11562.68	12072.16	13555.84
2003-04	11847.00	212.06	10.61	199.87	399.74	9782.00	10181.74	10841.61
2004-05	16128.00	288.69	9.23	312.77	625.55	10132.34	10757.89	10757.89
2005-06	19389.64	347.07	9.58	362.29	724.58	10395.44	11120.02	10644.22
2006-07	28019.55	347.44	9.51	365.34	730.69	11798.59	12529.28	11252.16
2007-08	43319.16	537.16	9.57	561.29	1122.59	13118.08	14240.66	12210.12
2008-09	99494.71	1233.73	8.75	1409.98	2819.96	16205.57	19025.53	13691.97
2009-10	64032.29	794.00	8.90	892.14	1784.27	18064.60	19848.87	15173.82
2010-11	65836.68	816.37	9.61	849.51	1699.01	18634.88	20333.89	14187.76
2011-12	73791.00	1121.62	8.78	1277.48	2554.95	22791.10	25346.05	16233.94
2012-13	70592.00	1073.00	7.30	1469.86	2939.72	26359.97	29299.69	17479.83
2013-14	71280.00	1083.46	7.81	1387.27	2774.54	32361.43	35135.96	19779.31
2014-15	75067.00	1141.02	7.32	1558.77	3117.54	37208.54	40326.07	22256.24
2015-16	72415.00	1100.71	7.13	1543.77	3087.54	37821.01	40908.55	23155.34
2016-17	66313.00	1007.96	7.46	1351.15	2702.30	42134.51	44836.81	24474.24

**source: This table is calculated using MS Excel by processing data from table 2 to table 8*

Table 20. Calculating the effect of loss in Bajra

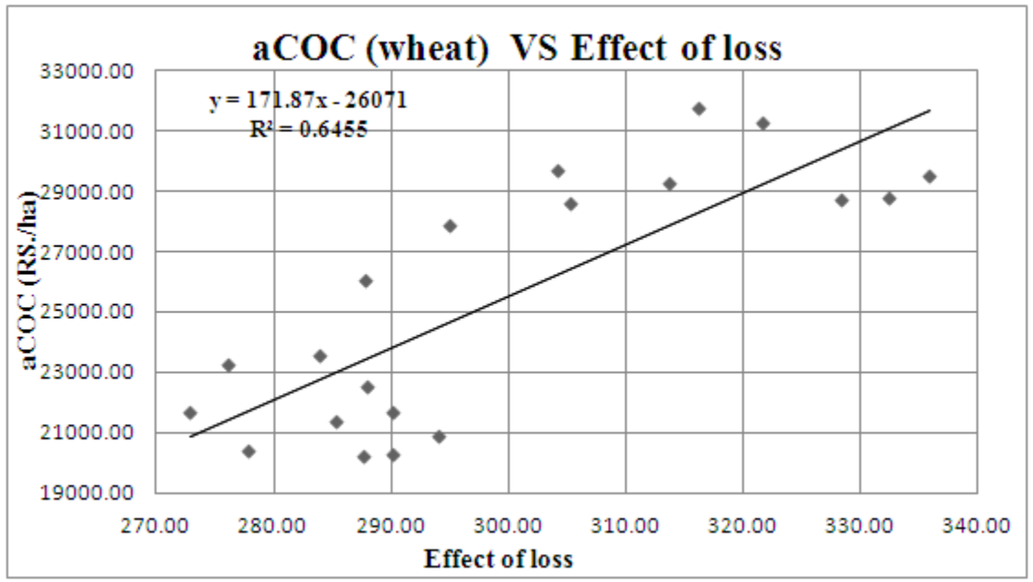
Year	Productivity (kg/ha) (11)	Food loss (kg/ha) (12)	Effect of loss (13)(X)
1990-01	658	33.00	
1991-92	465	23.32	
1992-93	836	41.93	
1993-94	521	26.13	
1994-95	700	35.11	
1995-96	577	28.94	
1996-97	788	39.52	
1997-98	773	38.77	69.92
1998-99	748	37.51	73.47
1999-00	650	32.60	74.08
2000-01	688	34.50	69.31
2001-02	869	43.58	68.97
2002-03	610	30.59	77.80
2003-04	1141	57.22	69.28
2004-05	859	43.08	91.56
2005-06	802	40.22	88.57
2006-07	886	44.43	84.23
2007-08	1042	52.26	86.30
2008-09	1015	50.90	95.16
2009-10	731	36.66	98.14
2010-11	1079	54.11	85.51
2011-12	1171	58.73	96.43
2012-13	1198	60.08	106.62
2013-14	1184	59.38	113.09
2014-15	1255	62.94	115.59
2015-16	1132	56.77	120.35
2016-17	1305	65.45	116.56

**source: This table is calculated using MS Excel by processing data from table 2 to table 8*

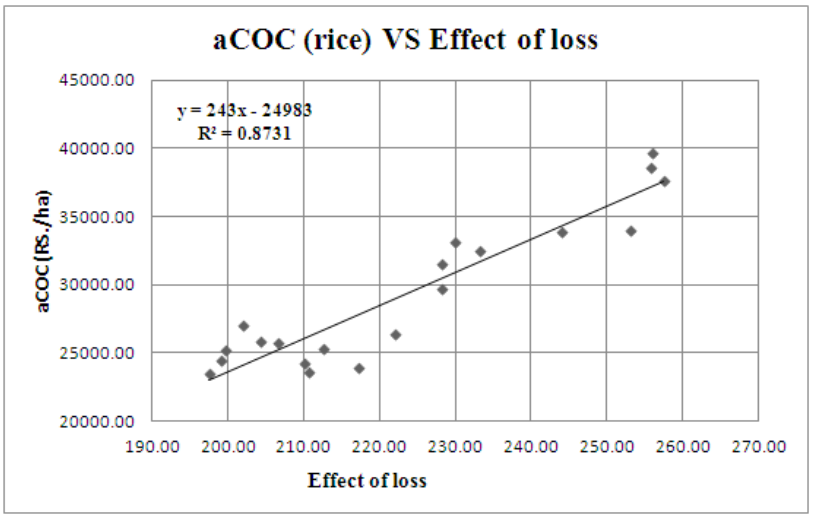
Table 21. Crop wise regression function

Crops	Regression function	R^2	Correlation	p value (regression)	p value (intercept)
Wheat	y = 171.87x - 26071	0.6455	Medium	$1.99e^{-5}$*	0.0096*
Rice	y = 243x - 24983	0.8731	High	$1.68e^{-9}$*	7.47E-05*
Maize	y = 187.98x – 23058	0.9305	High	$7.24e^{-12}$*	1.42E-07*
Groundnut	y = 212.7x - 12969	0.6773	Medium	$8.37e^{-6}$*	0.0593***
Grams	y = 424.6x - 30555	0.6755	Medium	$8.80e^{-6}$*	0.0006*
Bajra	y = 237.18x - 6787.6	0.8107	High	$6.35e^{-8}$*	0.0134**

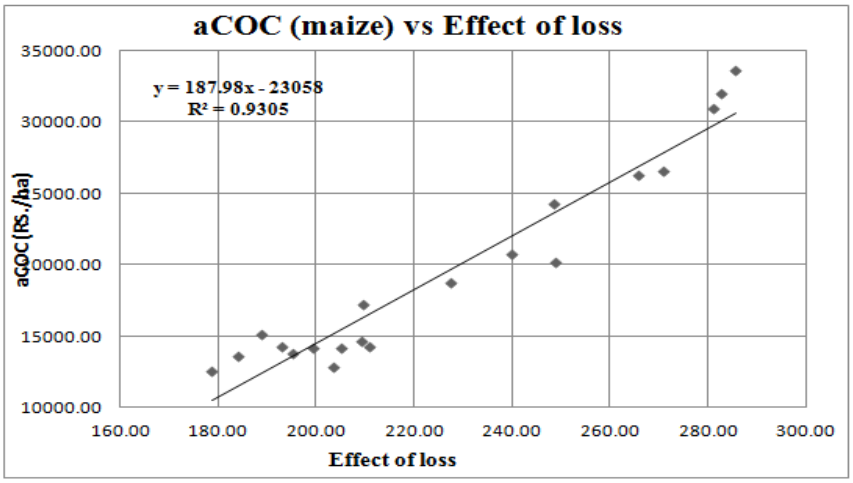
p value above 0.01 means 99% significance level;p value above 0.05 means 95% significance level;***p value above 0.10 means 90% significance level;# source: Appendix I to IV*



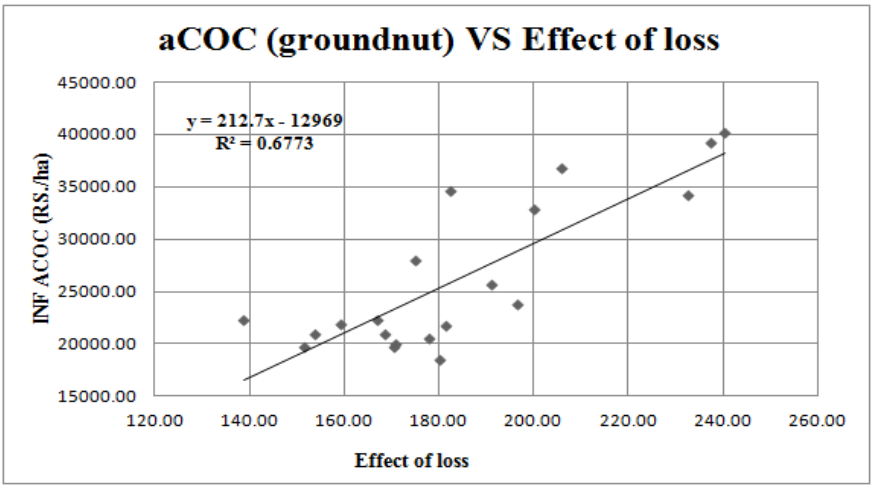
Graph 1. Simple regression analysis in wheat



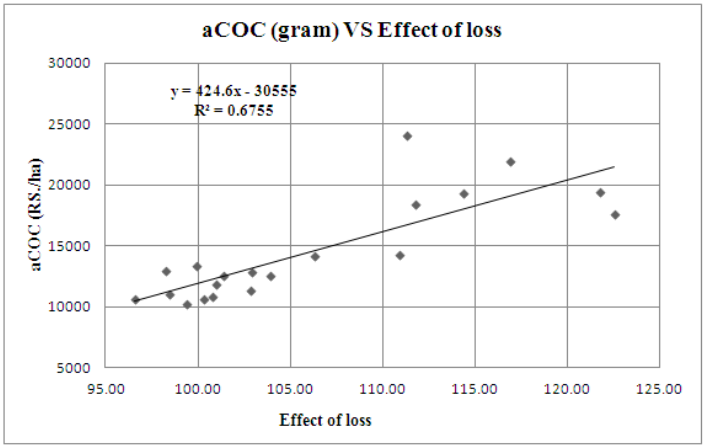
Graph 2. Simple regression analysis in Rice



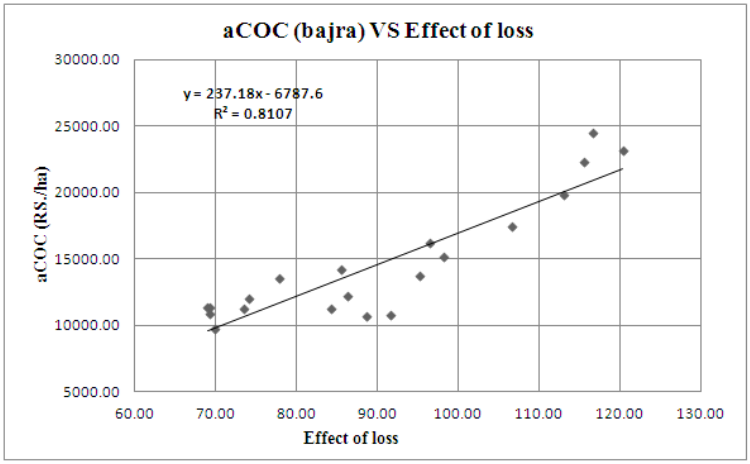
Graph 3. Simple regression analysis in Maize



Graph 4. Simple regression analysis in Groundnut



Graph 5. Simple regression analysis in Gram



Graph 6. Simple regression analysis in Bajra

Therefore, from the above analysis i.e., The oretically it clearing gives a crystal-clear understanding that how food loss is correlated with the cost of cultivation. Empirically studies done using simple regression function on the above six crops depicted various R2 and produced a different degree of correlation between the variables. For this data analysis R2 is categorised as follows; below 0.5 (low correlation), 0.5-0.7 (medium correlation) and above 0.7 (high correlation).

The regression function above shows a medium to high correlation i.e., around 0.6 to 0.9 which proves the fact that food loss is affecting the cost of cultivation of agriculture commodity at different levels to different crops. Hence, theoretical understanding is backed by statistical analysis which showed how the cost of cultivation of major agriculture commodities of India is affected by post-harvest food losses.

4. CONCLUSION

Various conclusions can be derived from the following results and there are various solutions to address this problem more efficiently. This research has been more concentrated on the cost of cultivation and food loss and it proves that it is significantly linked with each other and increase in food loss is somehow helping to increase of the cost of cultivation in long-term. Some of the major conclusions which can be derived from this paper are as follows:

1. The price of the inputs is increasing continuously after removing the inflation because of depletion of the resource year after year but by increasing the amount of food loss this increase in the price of input is accelerated as food loss is a double waste of resources.

2. Food loss should be addressed more seriously as it is increasing the real cost of a commodity in long run at both the consumer and farmer level.

Food that is produced, but never consumed, still causes environmental impacts to the atmosphere, water, land and biodiversity. These environmental costs must be paid by society and future generations. Furthermore, by contributing to environmental degradation and increasing the scarcity of natural resources, food wastage is associated with wider social costs that affect people's well-being and livelihoods [13].

Reducing post-harvest loss has to be the necessary step towards global food security in a sustainable manner given the challenge proposed by climate change and limited land, water and other resources, food security cannot be achieved by merely increasing agriculture productivity [12]. Food scarcity is a man-made problem as nature is pushing its level best to complete the ever-growing demand of humans [7]. Farm operation should be mechanized to reduce the amount of loss at harvesting, threshing, storage, packing etc. According to the research use of scientific storage, the method can reduce these losses by 1-2%. Cold storage is one of the best ways to reduce this food loss in our country as it is growing at a rate of 3.57 % with a capacity increase of 5.19% due to its advantages and the government should invest and popularize it more [30]. Value addition can be one of the ways to increase the shelf-life of the commodity and reduce its losses.

Since the paper is more concentrated on major agriculture commodities of India so various sectors have been left for a decision like horticulture crops losses. One of the major consents of our country, as we are one of the largest producers of fruits and vegetable and meat products, food loss is affecting its price and increasing its production cost, etc., are some of the areas of research which are still needed to be explored further.

CONFLICT OF INTEREST

I Mr. Sumit Sutradhar certify that I have no affiliations with or involvement in any organization or entity with any financial interest, or non-financial interest in the subject matter or materials discussed in this manuscript.

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COMPETING INTERESTS

Author has declared that no competing interests exist.

REFERENCES

1. Agricultural Statistics at a Glance 2018, Directorate of economics and statistics, ministry of agriculture, government of India. (n.d.). Retrieved April, 2020, from https://eands.dacnet.nic.in/ [In text; DoE&S, GOI, 2018] [In text; Agricultural Statistics at a Glance 2018, DoE&S, GOI, 2018].
2. Nanda SK, Vishwakarma RK, Bathla HVL, A Rai, Chnadra P. Harvest and Post-harvest losses of major crops and livestock produce in India. All India Coordinated Research Project on Post-Harvest Technology, (ICAR), Ludhiana; 2012.
3. Jha SN, Vishwakarma RK, Ahmad Tauqueer, Rai Anil, Dixit AK. Report on assessment of quantitative harvest and post- harvest losses of major crops and commodities in India. ICAR-All India Coordinated Research Project on Post-Harvest Technology, ICAR-CIPHET, P.O.-PAU, Ludhiana-141004; 2015.
4. World population to exceed 10 billion | UN DESA Department of economic and social affairs. (n.d.). In text; United Nation;2011. Available:https://www.un.org/en/development/desa/news/population/population-exceed-10-billion.html
5. Rezaei, Maryam, Liu, Bin. Food loss and waste in the food supply chain. Nutfruit. 2017;71:26-27.
6. Sawicka, Barbara. Post-harvest Losses of Agricultural Produce. Sustainable Development. 2019;1:1-16. DOI:10.1007/978-3-319-69626-3_40-1.

7. Nigam R, Sharma S. Food Waste Management. Amity journal of energy & environment studies 2017;3:1-8.
8. Mandla A. Food for thought: Our country does not provide nutritious food for all. the ramifications are huge;2019.
   Available:
   https://www.dailyo.in/variety/starvation-in-india-hunger-deaths-in-india-food-wastage-in-india/story/1/31921.html
9. The State of Food and Agriculture 2019. Moving forward on food loss and waste reduction. Rome. Licence: CC BY-NC-SA 3.0 IGO. [In text; FAO;2019]
10. FAO/LEI. 2015. Potential impacts on sub-Saharan Africa of reducing food loss and waste in the European Union – A focus on food prices and price transmission effects, by Rutten, M., Verma, M., Mhlanga, N. & Bucatariu, C. Rome, Italy [In text; FAO/LEI;2015]
11. Hodges, Rick & Buzby, Jean,Bennett, B. Postharvest losses and waste in developed and less developed countries: Opportunities to improve resource use. The Journal of Agricultural Science. 2011;149:37-45.
    DOI:10.1017/S0021859610000936.
12. Aulakh J, Regmi A. Post-Harvest Food Losses Estimation- Development of Consistent Methodology. Conference Paper. 2013;10.22004/ag.econ.150363
13. Scialabba, Nadia, Jan, Olivier, Tostivint, Clément & Turbé, Anne & O'Connor, Clémentine & Lavelle, Perrine & Flammini, Alessandro, Hoogeveen, Jippe, Iweins, Mathilde, Tubiello, Francesco, Peiser, Livia, Batello, Caterina. Food Wastage Footprint: Impacts on Natural Resources. Summary Report; 2013. [In text; FAO 2013]
14. Sawicka, Barbara. Post-harvest Losses of Agricultural Produce. Sustainable Development. 2019;1:1-16.
    DOI:10.1007/978-3-319-69626-3_40-1.
15. Alexander Pete, Brown, Calum & Arneth, Almut, Finnigan, John, Moran, Dominic, Rounsevell, Mark. Losses, inefficiencies and waste in the global food system. Agricultural Systems. 2017;153:190-200.
    DOI: 10.1016/j.agsy.2017.01.014.
16. FAO; 2011. Global food losses and food waste – Extent, causes and prevention. Rome [In text; FAO 2011]
17. Directorate of economics and statistics, Ministry of Agriculture, G. (2017, March 17). PER CAPITA NET AVAILABILITY OF FOODGRAINS. Retrieved June, 2020, from
    https://eands.dacnet.nic.in/PDF/PerCapita-FoodGrains.pdf [In text; Directorate of economics and statistics, Ministry of Agriculture, 2017]
18. NAAS. Saving the Harvest: Reducing the Food Loss and Waste. Policy Brief No. 5, National Academy of Agricultural Sciences, New Delhi. 2019;10. [In text; NAAS 2019]
19. Nagpal M, Kumar A. Grain losses in India and government policies. Quality Assurance and Safety of Crops & Foods. 2012;4(3):143-143.
    DOI: 10.1111/j.1757-837x.2012. 00150.x
20. GHI. Global hunger index scores by 2020 GHI RANK; 2020.
    Available:https://www.globalhungerindex.org/ranking.html
21. Praveen KV, Aditya KS, Nithyashree ML, Sharma, Akriti. Fertilizer subsidies in India: An insight to distribution and equity issues; 2018
22. Annual report, department of fertilizer, government of India; 2020.
    Available: https://fert.nic.in/publication-reports/annual-report [In text; DoF, GOI, 2020; Annual Reports, Dept. of Fertilizer, GOI]
23. Food losses and waste in the context of sustainable food systems. A report by the High Level Panel of Experts on Food Security and Nutrition of the Committee on World Food Security, Rome 2014. [In text; HLPE, 2014]
24. Parfitt J, Barthel M, Macnaughton S. Food waste within food supply chains: quantification and potential for change to 2050, Phil. Trans. R. Soc. 2010;365:3065-3081.
25. Sharma KG. Agricultural input subsidies in India: quantum of subsidies to SC/ ST farmers in Madhya Pradesh & Chhattisgarh. Agro - economic research Centre for Madhya Pradesh and Chhattisgarh j.n.k.v.v., Jabalpur (m.p.); 2004.
26. Shah, Deepak. Global Financial and Economic Crisis: Implications for Agricultural Sector in India. Indian Journal of Agricultural Economics. 2010;65:476-486.
27. Gujarati DN, Porter DC. Basic econometrics (4th ed.). USA: McGraw-Hill/Irwin; 2017.

28. All India reports on Input Survey, Agriculture census division, Department of Agriculture Cooperation. (n.d.). Retrieved February, 2020, from http://inputsurvey.dacnet.nic.in/ [In text; All India report on input survey, department of agriculture cooperation, GOI, 2016]
29. Sharma S, Moerenhout T, Tripathi S. Rationalizing Energy Subsidies in Agriculture: A scoping study of agricultural subsidies in Haryana, India. International Institute for Sustainable Development; 2015.
30. Sivaraman, Madhu. Government's Role in India's Ailing Cold Storage Sector; 2016. DOI:10.13140/RG.2.2.36370.45765.
31. Statistical database, Fertilizer Association of India; 2020. Available:https://www.faidelhi.org/statistics/statistical-database [In text; Fertilizer Association of India, 2020]
32. Cost of Cultivation, Directorate of economics and statistics, ministry of agriculture, government of India. (n.d.). Retrieved April, 2020, from https://eands.dacnet.nic.in/Cost_of_Cultivation.htm [In text; Cost of Cultivation, DoE&S, GOI, 2017]
33. Wholesale price Index, Office of economic adviser, ministry of commerce and industry, government of India. (n.d.). Available:https://eaindustry.nic.in/download_data_0405.asp [In text; WPI, MoC&I, GOI]

APPENDICES

APPENDIX I

Statical analysis of Bajra						
Regression Statistics						
Multiple R	0.900401					
R Square	0.810721					
Adjusted R Square	0.800206					
Standard Error	2034.762					
Observations	20					
ANOVA						
	df	*SS*	*MS*	*F*	*Significance F*	
Regression	1	3.19E+08	3.19E+08	77.0978084	6.35058E-08	
Residual	18	74524600	4140256			
Total	19	3.94E+08				
	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	-6787.6	2474.532	-2.74298	0.013371006	-11986.3936	-1588.796894
X	237.1778	27.01176	8.780536	6.35058E-08	180.4281424	293.9273584

*****source: MS Excel data analysis tool for calculating simple regression and ANOVA*

APPENDIX II

Statistical analysis of Gram						
Regression Statistics						
Multiple R	0.821885					
R Square	0.675495					
Adjusted R Square	0.657467					
Standard Error	2416.336					
Observations	20					
ANOVA						
	df	*SS*	*MS*	*F*	*Significance F*	
Regression	1	218770012.3	218770012.3	37.46909	8.80107E-06	
Residual	18	105096222.8	5838679.043			
Total	19	323866235.1				
	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	-30554.6	7379.136994	-4.140679103	0.000614	-46057.6299	-15051.6
X	424.6016	69.36573887	6.12120035	8.8E-06	278.8695754	570.3336

**source: MS Excel data analysis tool for calculating simple regression and ANOVA*

APPENDIX III

Statistical analysis of Groundnut						
Regression Statistics						
Multiple R	0.82296					
R Square	0.677263					
Adjusted R Square	0.659333					
Standard Error	4238.02					
Observations	20					
ANOVA						
	df	*SS*	*MS*	*F*	*Significance F*	
Regression	1	6.78E+08	6.78E+08	37.77291695	8.36938E-06	
Residual	18	3.23E+08	17960810			
Total	19	1E+09				
	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	-12968.6	6440.993	-2.01345	0.059266444	-26500.65555	563.3923
X	212.6982	34.60776	6.145968	8.36938E-06	139.9899714	285.4064

**source: MS Excel data analysis tool for calculating simple regression and ANOVA*

APPENDIX IV

Statistical analysis of Wheat						
Regression Statistics						
Multiple R	0.803421					
R Square	0.645486					
Adjusted R Square	0.62579					
Standard Error	2524.886					
Observations	20					
ANOVA						
	df	*SS*	*MS*	*F*	*Significance F*	
Regression	1	2.09E+08	2.09E+08	32.77369	1.99E-05	
Residual	18	1.15E+08	6375050			
Total	19	3.24E+08				
	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	-26070.5	9003.045	-2.89575	0.009633	-44985.2	-7155.83
X	171.8691	30.02168	5.724831	1.99E-05	108.7958	234.9423

**source: MS Excel data analysis tool for calculating simple regression and ANOVA*

APPENDIX V

Statistical analysis of Rice						
Regression Statistics						
Multiple R	0.934402549					
R Square	0.873108124					
Adjusted R Square	0.866058575					
Standard Error	1973.280919					
Observations	20					
ANOVA						
	df	*SS*	*MS*	*F*	*Significance F*	
Regression	1	482263670.7	482263670.7	123.8531	1.68E-09	
Residual	18	70089076.54	3893837.585			
Total	19	552352747.2				
	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	-24983.38508	4898.070931	-5.10065808	7.47E-05	-35273.9	-14692.9
X	242.9960432	21.83463038	11.12892863	1.68E-09	197.1232	288.8689

**source: MS Excel data analysis tool for calculating simple regression and ANOVA*

APPENDIX VI

Statistical analysis of Maize						
Regression Statistics						
Multiple R	0.964631					
R Square	0.930512					
Adjusted R Square	0.926652					
Standard Error	1892.948					
Observations	20					
ANOVA						
	df	*SS*	*MS*	*F*	*Significance F*	
Regression	1	863702523.4	863702523.4	241.0388459	7.2356E-12	
Residual	18	64498505.89	3583250.327			
Total	19	928201029.3				
	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	-23057.5	2773.991872	-8.31203743	1.42E-07	-28885.4649	-17229.6
x	187.9784	12.10777909	15.52542579	7.23559E-12	162.540926	213.4159

**source: MS Excel data analysis tool for calculating simple regression and ANOVA*

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