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Pathways for Enhancing Farmers' Income, Nutritional Security and Sustainable Food Systems

Thematic Session: DIETARY DIVERSITY, NUTRITION AND FOOD SAFETY

Discussion Paper: Dietary Diversification, Nutrition and Food Safety

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1. INTRODUCTION

India is faced with a triple burden of malnutrition, viz., under-nutrition, micronutrient deficiency and over-nutrition. In 2017 about 68.2 percent of the total death of children under-5, was due to malnutrition in India (LANCET, 2019). The prevalence of stunting among children under-5 was high at 34.7 percent during 2016-18. (CNNS, 2019). The body mass index of 23 percent of women aged 14-49 was below normal in 2015-16 (NFHS, 2016). Moreover, two-thirds of India's population is estimated to be micronutrient deficient (Rao et al., 2018). The deficiency of micronutrients exists despite impressive economic growth (6 percent in 2018-19), a high level of food grain production, and an increase in per capita net availability of total food grains (MoAFW, 2020). There has also been a significant decline in the percentage of the population below the poverty line (Tendulkar method) from 37.2 percent in 2004-05 to 21.9 percent in 2011-12 (GoI, 2013)[1].

Along with undernutrition, overweight and obesity have emerged as severe public health problems leading to non-communicable diseases (NCD). In 2017 about 63 percent of deaths in India were attributable to NCDs (WHO, 2018). It is vital to address malnutrition challenges, especially in children and women, to ensure proper cognitive growth, overall health, and productivity.

Sustainable Development Goal (SDG) – 2 aims to end hunger, achieve food security, improve nutrition, and promote sustainable agriculture. Dietary patterns interact with food systems and may subsequently lead to environmental degradation. Food production is one of the major causes of global environmental change (Lancet, 2019). Therefore, interventions are needed to secure a sustainable diet that delivers food and nutrition security for all in a manner that does not compromise future generations' ability to ensure food and nutrition security (HLPE, 2014).

With this background, the present paper aims to study dietary pattern and malnutrition trends, impact of different food and nutrition security interventions. The issues related to healthy diets and food safety are discussed and pathways for a safe and healthy diet to achieve nutritional security in India are suggested.

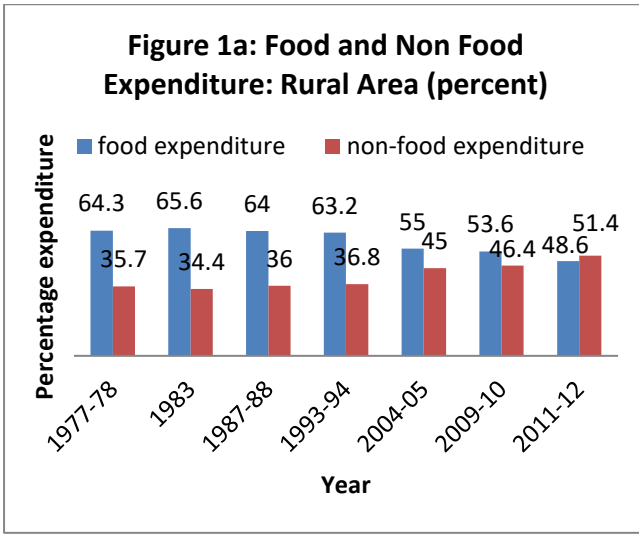
[1] The government has not released the latest 2017-18 consumer expenditure data due to comparison problems.

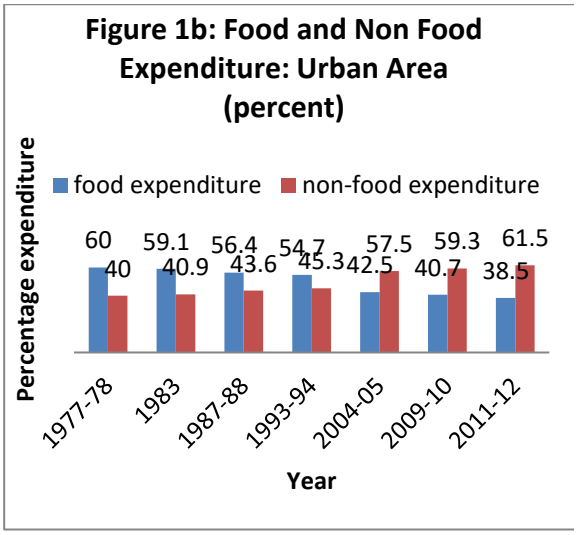
2. CHANGING DIETARY PATTERN

Consumption expenditure on different food groups and intake of calorie, protein and fat is studied using the National Sample Survey (NSS) 50th, 61th, and 68th rounds[2]. National Family Health Survey (NFHS) second, third and fourth rounds are used for understanding the trend in micronutrient consumption. A recent Comprehensive National Nutritional Survey for the period 2016-18 (CNNS, 2019), has also been referred for the latest available data on consumption pattern and nutritional status among the children and adolescents.

2.1 CONSUMPTION EXPENDITURE ON FOOD AND NON-FOOD GROUPS

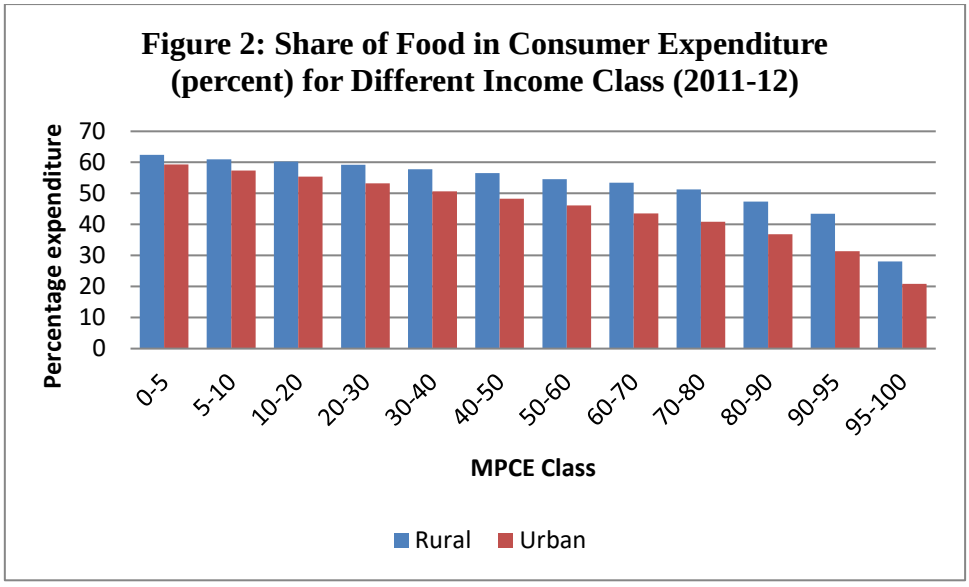
The monthly per capita consumption expenditure (MPCE) has increased (in real terms) from Rs 943 to Rs 1287 in rural areas and from Rs 1608 to Rs 2477 in urban areas during 1993-94 to 2011-12. The share of food expenditure in the total budget is higher in rural areas than in urban areas. A steady decline in the percentage of food consumption expenditure in rural and urban areas was observed with steeper decline in urban areas than the rural areas (Figure 1a and Figure 1b). This decline is in line with Engel's Law, that the proportional share of food expenditure declines in the household budget with income growth.





Source: NSSO, 2013

[2] As National Statistical Office (NSO) has not released the 2017-18 consumer expenditure survey results because of data quality issues, we could analyze consumption expenditure data only up to 2011-12. The uniform reporting period is being used from NSS reports of these rounds.

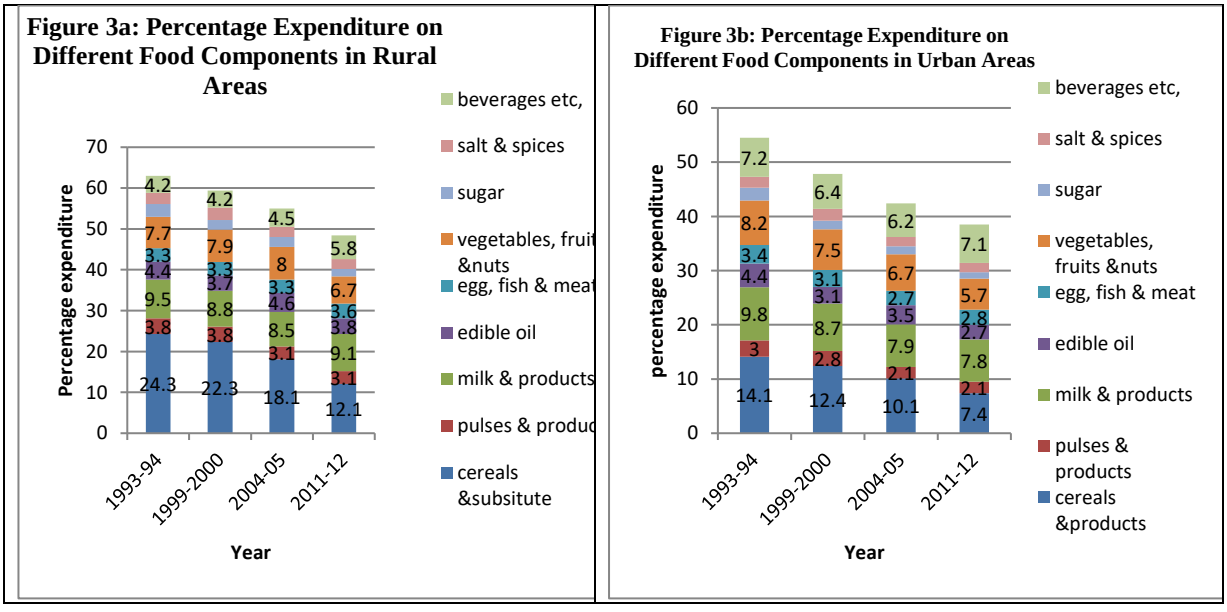


Source: NSSO, 2013

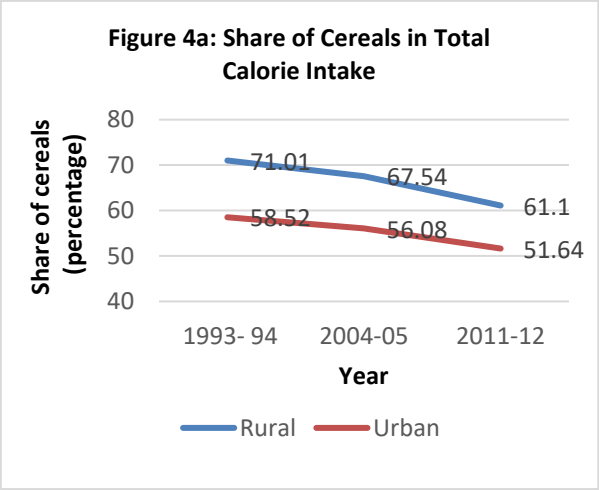
Table 1: Per Capita per Month Consumption of Different Food Components

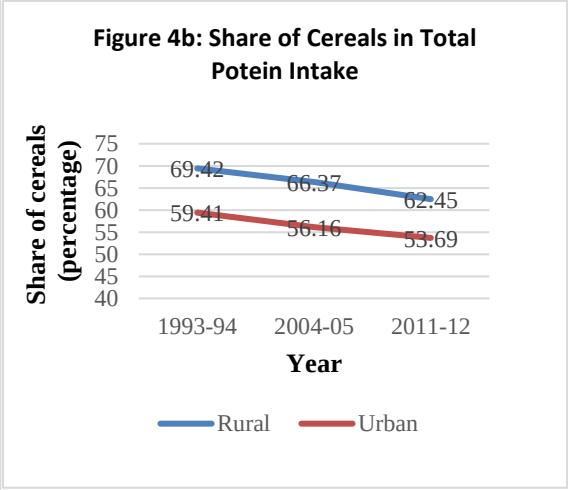
Year	Cereals (kg)	Pulses (kg)	Edible oils (kg)	Vegetables (kg)	Milk(litre)	Egg (No.)	Fish & meat (kg)
Rural areas							
1993-94	13.40	0.76	0.37	2.71	3.94	0.64	0.26
2004-05	12.12	0.71	0.48	2.92	3.87	1.01	0.30
2011-12	11.22	0.78	0.67	4.33	4.33	1.94	0.50
Urban areas							
1993-94	10.60	0.86	0.56	2.91	4.89	1.48	0.34
2004-05	9.94	0.82	0.66	3.17	5.11	1.72	0.37
2011-12	9.28	0.90	0.85	4.32	5.42	3.18	0.57

Source: NSSO reports



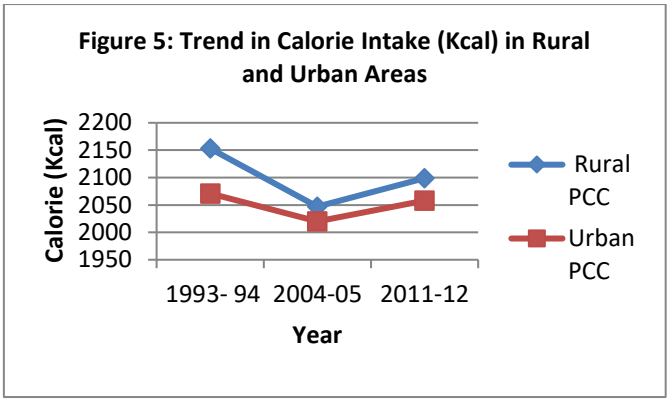
Over time, along with broader categories of food and non-food expenditure, India's food basket has also got transformed. There are changes in the dietary pattern in rural and urban areas as per capita monthly consumption of edible oils, vegetables, egg, fish and meat has almost doubled from 1993-94 to 2011-12. Consumption of pulses remained stagnant while cereals consumption reduced in the same period (Table 1). The dominance of cereals in total expenditure has also significantly decreased even among the poorest (lowest 10 percent of MPCE class) in rural and urban areas (Figure 3a and 3b). A decline in expenditure towards cereals reflects Bennett's Law, which suggests that with the increase in income, diets get more diversified and move away from staple grains. However, in the same period, the share of expenditure on non-staples such as vegetables, fruits and nuts, pulses and pulses products, milk and milk products also decreased in both the areas. The spending on meat, egg and fish increased from 3.3 percent to 3.6 percent, and on beverages risen from 4.2 percent to 5.8 percent in the rural areas from 1993-94 to 2011-12 (Figure 3a).



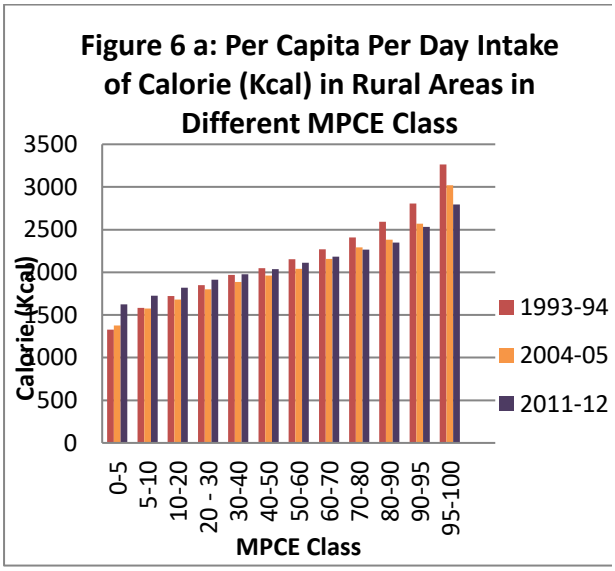


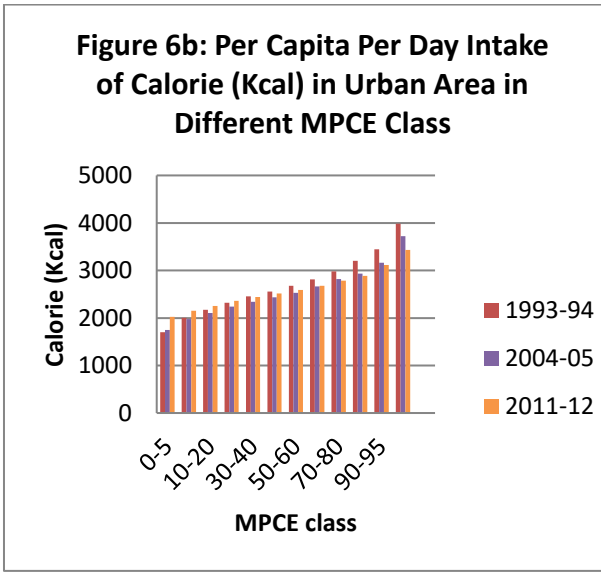
2.2 Calorie intake trends

Cereals are the main constituents of the Indian diet and a major source of energy (Figure 4a). A significant decline in the share of expenditure on cereals in the food budget is observed and evidence shows that it is possibly due to lifestyle changes, urbanization, mechanization, dietary diversification, etc., leading to fewer requirements of the staples (Pingali et al., 2019; Deaton, 2009).



The calorie intake was lower than the recommended guideline of 2100 Kcal in urban and 2400 Kcal in rural areas in 1993-94, and there is a further decline in the same by 2011-12 (Figure 5). An improvement in calorie intake in both the areas are observed in 2011-12, compared with 2004-05 due to better coverage of the public distribution system (Srivastava and Chand, 2017) and increased income. Recently recommended calorie intake guidelines were revised and lowered to 2090 Kcal per person per day in urban areas and 2155 Kcal per person per day in rural areas by Indian Council for Medical Research. Even with the revised guidelines, average calorie consumption was below the norms in rural and urban areas. However, it was above the revised norms in the highest 50 percent and 60 percent of the MPCE classes in rural and urban areas, respectively (Figure 6a and 6b).





There is a significant difference in the average calorie consumption of the poorest (lowest 5 percent of MPCE) and the richest (highest 5 percent of MPCE) class in rural and urban areas. However, this gap has been narrowed in both rural and urban areas (Figure 6a and Figure 6b)

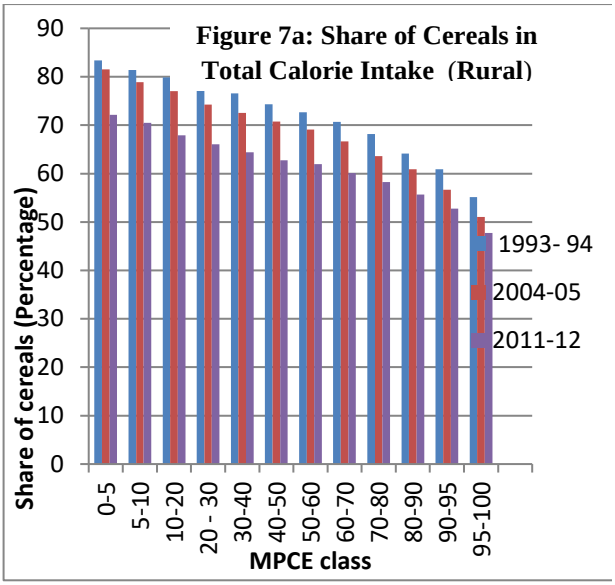
and the Gini coefficients of inequality in calorie intake reduced from 0.16 to 0.13 in rural areas and 0.18 to 0.14 in urban areas (Srivastava and Chand, 2017). Improvement in calorie intake of poor households might be attributed to better food access because of increased income and better coverage of government food subsidy programme. However, in the higher decile classes (5^{th} decile class and above), there is a reduction in calorie intake in both the areas, and the highest decline is observed in the richest decile. According to Deaton and Dreze (2009), the calorie *Engel* curve's downward shift is due to lower calorie requirements, mainly associated with better health and lower activity levels. The decrease in calorie consumption is observed even when there is undernutrition. However, it is being noticed that there is an increase in the number of meals taken outside the house (Table 2), and calorie consumption calculations ignore these consumed calories.

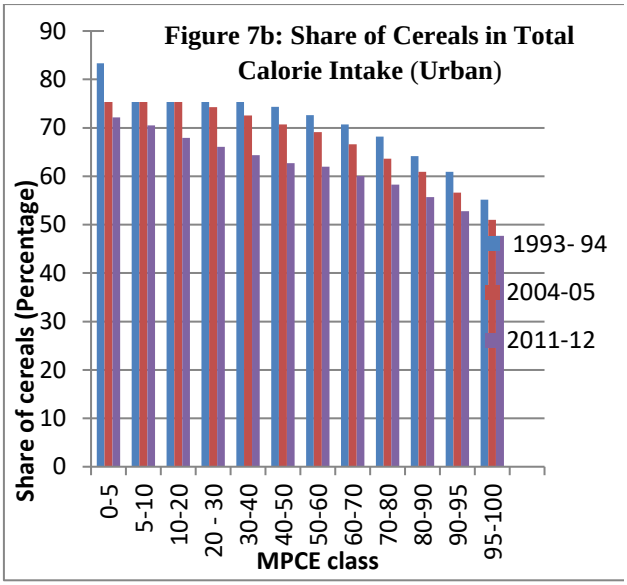
Table 2: Average Number of Meals Consumed by the Households outside the House in Last 30 Days

Year	Free Meals		Meals on Payment	
	Rural	Urban	Rural	Urban
1993-94	6	7	1	4
2004-05	11	8	1	3
2011-12	13.7	8.05	1.44	5.45

Source: NSS reports

The share of cereals in total energy intake is highest, 70.5 percent in rural areas and 63.6 percent in urban areas, for lowest decile class whereas for the richest this percentage is 52.8 percent and 40.3 percent in rural and urban areas respectively in 2011-12 (Figure 7a and 7b). This indicates poor dietary quality of households in lower decile classes than the higher decile classes. According to dietary guidelines, balanced diet should have 50-60 percent of total calories from carbohydrates, about 10-15 percent from proteins and 20-30 percent from fats (NIN, 2011). EAT-LANCET norms suggest that total calories from cereals should be about 32.44 percent for a healthy diet (Willett, et al. 2019) and therefore, Indian diets are unhealthy across all the income classes as contribution of cereals in calorie intake is quite high.





The highest contribution in calorie intake after cereals was oil and fats, with 9.01 percent in rural areas and 12.2 percent in urban areas in 2011-12 (Table 3). The increase in the share of oils and fats from 1993-94 to 2011-12 was 3.7 percentage point in rural areas and a 3.4 percentage point in urban areas. However, the share of vegetables and fruits in total calorie intake has declined despite its increased consumption, both in rural and urban areas. The highest percentage point increase was observed in miscellaneous food, mostly fast food, processed food, sugary beverages etc. (Table 3). This diversion of calorie sources towards unhealthy foods might be the cause of increasing overweight in India.

Table 3: Percentage of Calorie Consumption from Food Groups Other than Cereals

	Roots & Tubers	Sugar & Honey	Pulses, Nuts & Oilseeds	Veg & Fruits	Meat Eggs & Fish	Milk & Milk Products	Oils & Fats	Misc Food, Food Products and Beverages
Rural								
1993-94	2.65	4.8	4.92	2.02	0.68	6.15	5.34	2.41
2004-05	2.95	4.78	4.98	2.23	0.76	6.42	7.36	2.98
2011-12	3.01	4.9	5.2	1.85	0.82	7.07	9.01	7.04
Change (1993-94 to 2011-12)	0.36	0.10	0.28	-0.17	0.14	0.92	3.67	4.63
Urban								

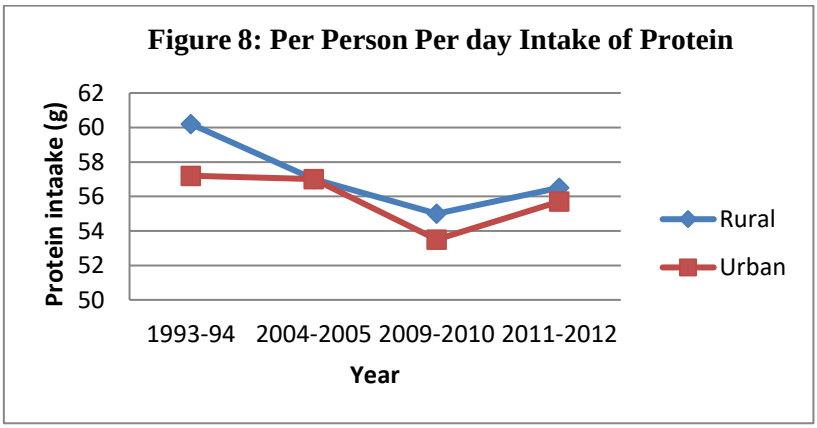
1993-94	2.54	6.21	6.05	3.26	1.02	8	8.79	5.6
2004-05	2.82	5.69	6.68	3.17	1.05	8.61	10.58	5.32
2011-12	2.73	5.62	6.41	2.62	1.13	9.07	12.17	8.61
Change (1993-94 to 2011-12)	0.19	-0.59	0.36	-0.64	0.11	1.07	3.38	3.01

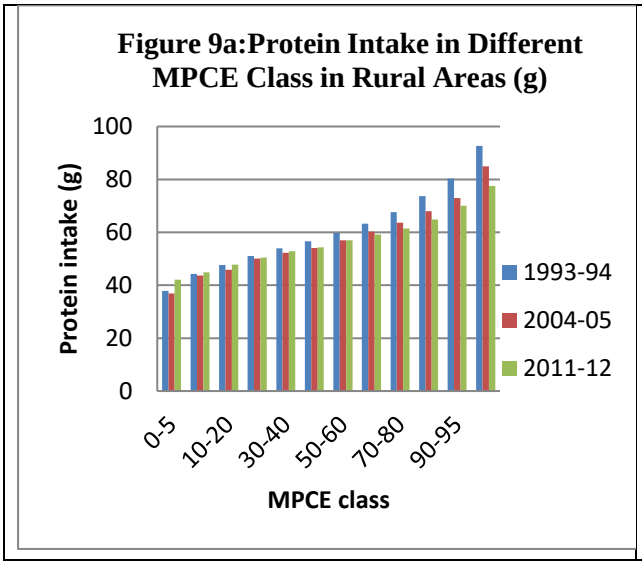
Source: NSS reports

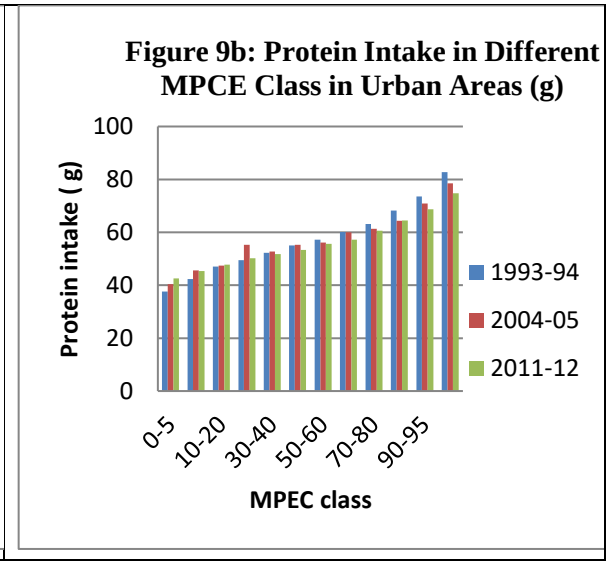
2.3 PROTEIN INTAKE TRENDS

The average consumption of protein has declined in rural and urban areas (Figure 8) in 2011-12 compared to 1993-94. The average intake of protein is above the norms in both rural and urban areas. The recommended dietary allowance (RDA) norms for protein consumption are 48 g and 50 g per person per day in urban and rural areas, respectively (Expert Group on Poverty Measurement, 2014). However, there is a vast gap in protein intake among the MPCE classes. Wealthier households consume higher than RDA norms. The average consumption of the poorest households (bottom 20 percent of MPCE class) is below the RDA norms in rural and urban areas (Figure 9a and 9b). Though protein consumption in the lowest decile classes (first and second) has improved from 1993-94 to 2011-12, there is a need to increase the protein intake by the poor households.

Figure 8: Per Person Per day Intake of Protein







Grams

Cereals are also the primary source of protein in the Indian diet (Figure 4b), followed by other miscellaneous foods, pulses, milk and milk products and egg, fish and meat (Table 4). Though cereals are a moderate source of protein (NIN, 2017), they become the major source of protein due to their large quantity of consumption. The percentage point increase for other food products covering fast food, processed food, etc., is highest (3.34 percent) in rural areas. Protein-rich foods such as milk and milk products and egg, fish, and meat have recorded a modest increase in the share of total protein intake.

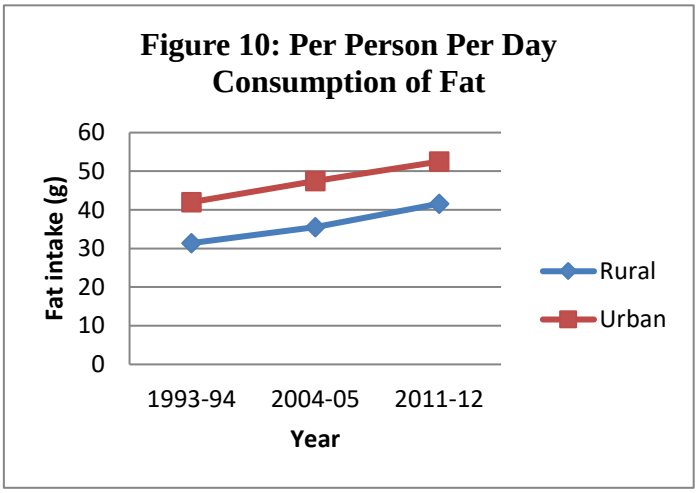
Table 4: Percentage of Protein intake from Different Food Groups

	Cereals	Pulses	Milk & Milk Products	Egg, Fish & Meat	Other Food
Rural					
1993-94	69.42	9.76	8.81	3.66	8.35
2004-05	66.37	9.47	9.28	3.98	10.84
2011-12	62.45	10.57	10.56	4.73	11.69
Change (1993-94 to 2012)	-6.97	0.81	1.75	1.07	3.34
Urban					
1993-94	59.41	11.54	11.66	5.29	12.1
2004-05	56.16	11	12.33	5.47	14.98
2011-12	53.69	12.41	13.57	6.39	13.94
Change (1993-94 to 2011-12)	-5.72	0.87	1.91	1.10	1.84

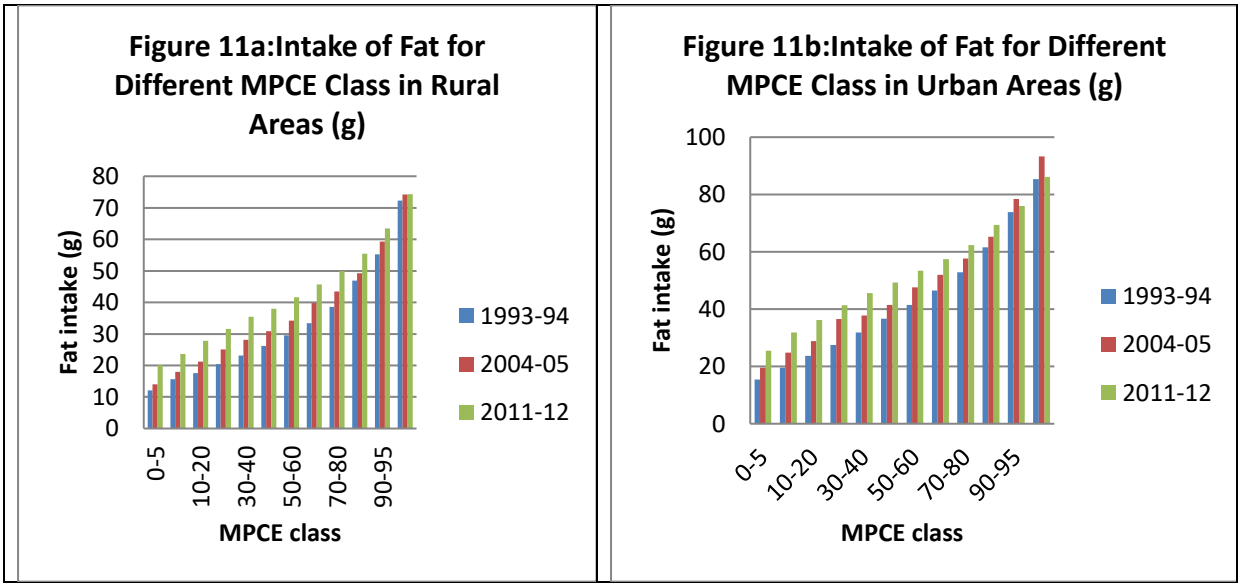
Source: NSS reports

2.4 FAT INTAKE TRENDS

The consumption of fat has an increasing trend in rural and urban areas. In rural and urban areas, per capita per day consumption of fat has increased significantly by 32.5 percent and 25 percent, respectively during 1993-94 to 2011-12 (Figure 10). The intake is much higher, in urban areas (52.5 g), than the RDA norms of 26 g (RDA for rural areas is 28 g).



There is a considerable gap in fat intake among the MPCE classes. The average consumption of the poorest households is below the RDA in rural areas (Figure 11a and 11b). However, fat consumption in the urban areas is above the RDA (25 g) across all the MPCE classes.

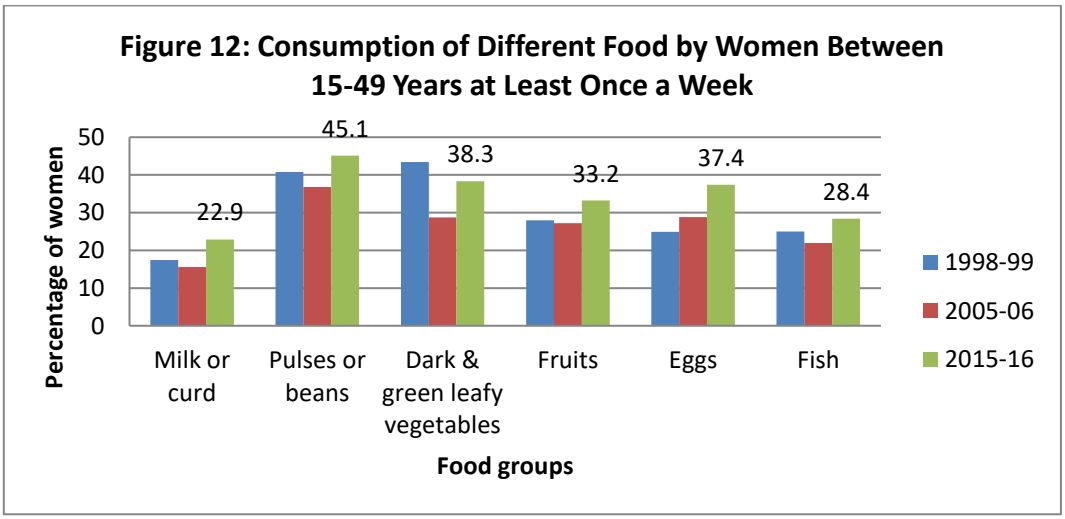


2.5 MICRONUTRIENTS INTAKE

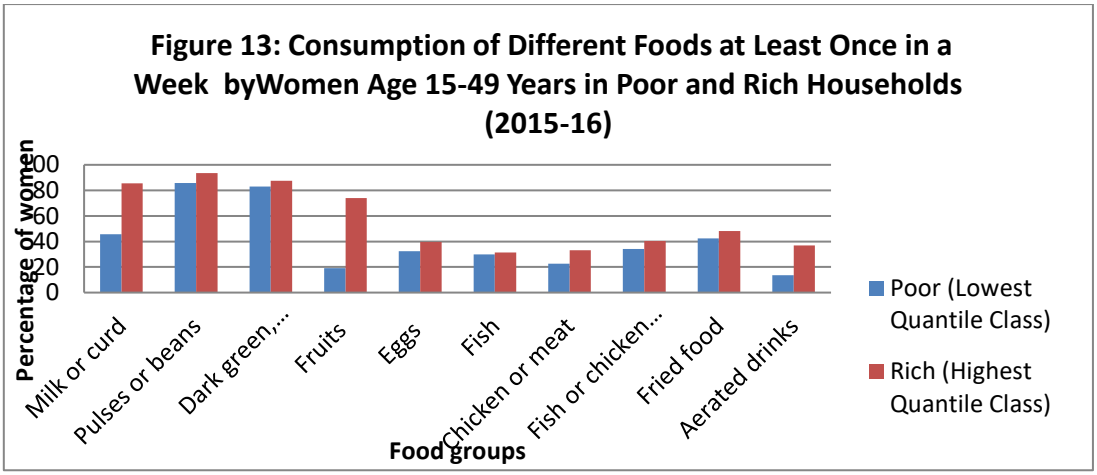
An adequate amount of intake of micronutrients is necessary for good health. The problem of chronic micronutrient deficiency (hidden hunger) is relatively severe (George & McKay,

2019). Milk and milk products, dark and green leafy vegetables, fruits, pulses, fish, egg and meat, are considered rich sources of micronutrients. The micronutrient content of each food is different; therefore, various foods are required to get sufficient vitamins and minerals. The NFHS-4 data show that only 45 percent and 38 percent of women between the age 15-49 years consumed pulses and dark and green leafy vegetables, respectively, at least once a week in 2015-16. There is an increase in the percentage of women in the age group 15 - 49 years consuming milk and curd, pulses, egg, fish and fruits at least once a week from 1998-99 to 2015-16 (Figure 12). This percentage has reduced for leafy vegetables in the same period. There is a significant difference in the consumption of milk, curd and fruits between rich and poor households (Figure 13).

Recent Comprehensive National Nutritional Survey 2016-18 (CNNS) shows that among school-age children (5-9 years) and adolescents (10-19 Years), consumption of dairy products was less frequent (61 percent among school-age children and 60 percent among adolescent). Consumption of fruits, eggs, and fish or chicken or meat was even less regular. The report shows that mothers' education and household wealth significantly impact the consumption of these food groups. Though the intake of unhealthy foods such as fried food and aerated drinks also increased with higher levels of maternal schooling and economic status (Figure 14a & 14b; Figure 15a & 15b).

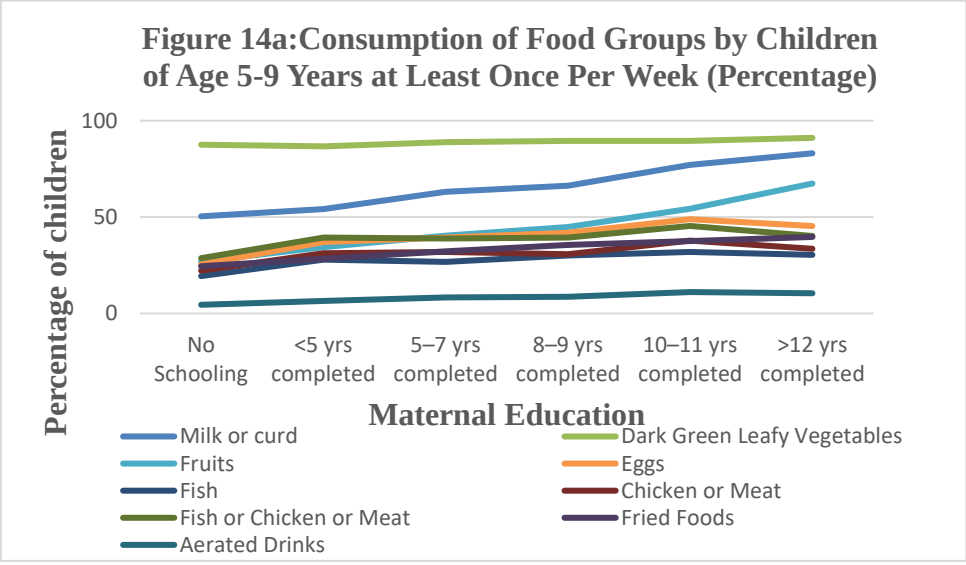


Source: NFHS II, III and IV

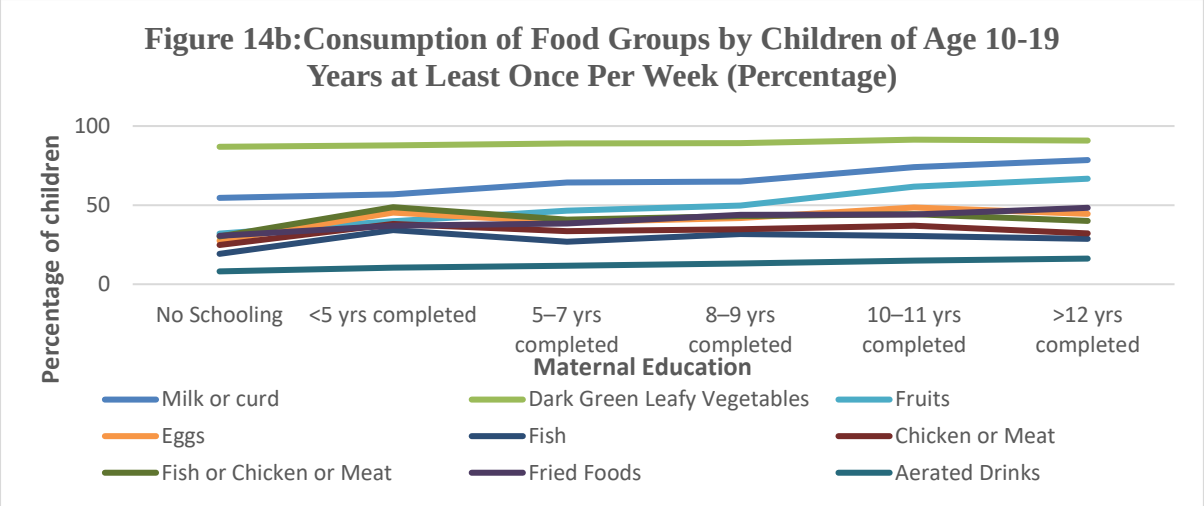


Source: NFHS IV

The mean level of consumption of various micronutrients among the adult women **(**≥ 18 years of age and involved in sedentary work), show a decline in intake of almost all the micronutrients except for thiamine and niacin between 1996-97 and 2011-12 in the rural areas (Table 5). The intake of calcium, vitamin A and vitamin C is much below the RDA. The gap from RDA in iron intake may be the primary cause of anaemia in women of reproductive age. According to CNNS-2019, in 2016-18, about 28 percent and 22 percent of adolescents had anaemia and iron deficiency, respectively. Iron deficiency was much higher in adolescent women (31 percent) than men adolescents (12 percent). The CNNS also reported that children and adolescents in urban areas had a higher prevalence of iron deficiency than their rural counterparts. Prevalence of deficiency of vitamin A (16 percent) and vitamin zinc (32 percent) was also considerably high among adolescents (CNNS 2019).



Source: CNNS 2019



Source: CNNS 2019

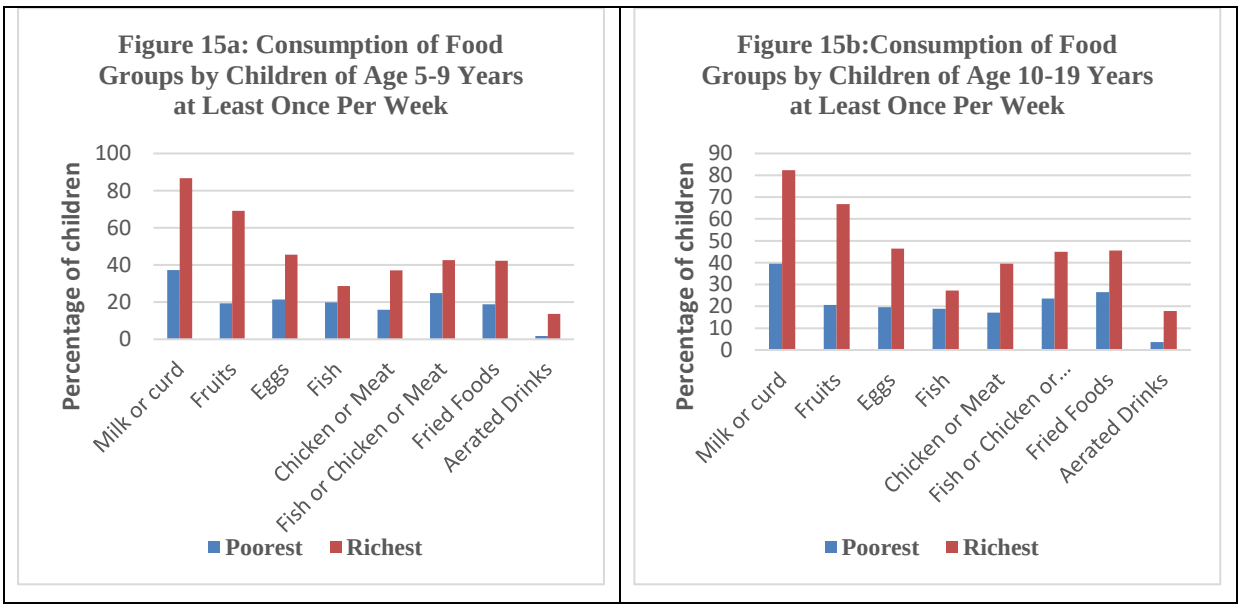


Table 5: Mean Intake of Micronutrients (per day) among Adult Women (≥18 years of age) for (Sedentary Worker)

Non Pregnant Non Lactating Women							
Micronutrients	Calcium (mg)	Iron (mg)	Vitamin A (µg)	Thiamine (mg)	Riboflavin (mg)	Niacin (mg)	Vitamin C (mg)
1996-97	593	24.1	311	1.1	1	12	44
2005-06	443	13.8	254	1.1	0.6	14.2	47
2011-12	372	14.4	251	1.3	0.8	14	39
RDA	600	21	600	1.1	1.3	14	40

Pregnant Women							
	Calcium	Iron	Vit A	Thiamin	Riboflavin	Niacin	Vit.-C

	(mg)	(mg)	(µg)	(mg)	(mg)	(mg)	(mg)
1996-97	575	24.3	269	1.1	0.9	12	39
2005-06	456	14	261	1.1	0.6	13.7	42
2011-12	418	13.7	291	1.3	0.8	13.8	43
RDA	1200	35	800	1.2	1.4	14	60
Lactating Women							
	Calcium	Iron	Vit A	Thiamin	Riboflavin	Niacin	Vit.-C
	(mg)	(mg)	(µg)	(mg)	(mg)	(mg)	(mg)
1996-97	553	26.7	277	1.3	1	14	40
2005-06	447	14.7	249	1.2	0.6	15.5	46
2011-12	411	15.8	304	1.4	0.8	15.5	47
RDA	1200	21	950	1.2	1.45	15.5	80

Source: NNMB reports

There is a structural shift in the dietary pattern and points towards India's nutrition transition (Drewnowski and Popkin, 1997). A dietary shift towards high-value food commodities such as vegetables and animal-sourced foods would significantly impact the agricultural production system and environment. The intake of calorie and protein has reduced, and deficiency in the intake of micronutrients is still very high. Though the average consumption of protein is above the RDA, in the poorest households, it is below the RDA. The contribution of non-cereals items in calories and proteins is increasing in both rural and urban areas. At the same time, there is an increase in the consumption of unhealthy foods such as processed and fast foods, beverages, etc. (Table 3).

Availability of a variety of food products increases with urbanization and trade liberalization and influences household's dietary pattern and preferences. In India, rising income, demographic transition, and the spread of retail chains have transformed households' dietary habits (Shetty, 2002; Pingali et al., 2019). Food expenditure elasticities have also changed over time, contributing to nutrition transition. Kumar et al. (2016) have shown that consumers prefer to spend additional income on spices and beverages, followed by animal products. Cereals are losing their importance in Indian diets. The demand for cereals has become more income inelastic and price elastic representing that cereals are a substitute rather than a complement to animal products in the household diet (Law et al., 2019). Both price and non-price factors were responsible for changes in consumption patterns.

3. MALNUTRITION TRENDS

Malnourished children and adolescents are at increased risk of impaired growth, poor cognitive development, low immunity, and mortality (Black & Dewey, 2014). In India, stunting among children under five declined from 48 percent in 2005-06 to 38.4 percent in 2015-16 at an average rate of one percentage point per year (Table 6). Underweight among children under five have also declined from 42.5 percent to 35.7 percent representing only a 0.7 percent decline per year during this period. According to CNNS (2019), stunting and underweight among children under-5 was 35 percent and 33 percent, respectively, during 2016-18. On the other hand, wasting has slightly increased (19.8 percent to 21 percent during 2005-06 to 2015-16) as per NFHS-4 data; however, CNNS (2019) shows that wasting was 17 percent during 2016-18. Malnutrition and anaemia for children and women is higher in rural areas than urban areas (CNNS, 2019). Although there is some improvement in anaemia for children and women and BMI for women, the levels are still high. Around 58 percent of children and 53 percent of women were anaemic in 2015-16 (Table 6).

Table 6: Nutritional Status of Children Under Five Years and Women (15-49): All India

	Total (Rural+Urban)		2015-16 (NFHS 4)	
Children under 5 years	2005-06 (NFHS 3)	2015-16 (NFHS 4)	Rural	Urban
Stunting (height for age)	48.0	38.4	41.2	31.0
Underweight (weight for age)	42.5	35.7	38.3	29.1
Wasting (weight for height)	19.8	21.0	21.5	20.0
Anaemia among children	69.4	58.4	59.4	55.9
Women (15-49 years)				
Anaemia among women	55.3	53.0	54.2	50.8
BMI below normal (women)	35.5	22.9	26.7	15.5

Sources: NFHS 3 and NFHS 4

Malnutrition is very high at 51 percent in the lowest wealth quintile in 2015-16. It has nearly 2.5 times of malnutrition levels than the highest quintile (Table 7). Scheduled castes and Scheduled tribes have 10 percentage points higher malnutrition than other castes. No education category has 20 percentage points higher malnutrition than the category with secondary or more (Table 7). It is shown that maternal education impacts nutrient intake and reduces malnutrition in children under-5 (Figure 14a, Figure 16, Pandey 2018, Jose et al., 2020).

Table 7: Nutrition Status of Children under-5 years, stunting (height for age): All India, 2015-16

Wealth Quintile	Stunting (percent)	Social Groups	Stunting(percent)	Education	Stunting (percent)
Lowest	51	Scheduled Caste	43	No education	51
Second	44	Scheduled Tribe	44	Primary complete	44
Middle	36	OBCs	39	Secondary or more complete	31
Fourth	29	None of them	31		
Highest	22				

Source: NFHS IV

Table 8: Comparing Status of Child Feeding, Nutritional Outcome, and Prevalence of Diseases in Children Under-5 (NFHS -5 (2019-20) and NFHS-4 (2015-16))

	AP		**Bihar**		**Gujarat**		**Karnataka**		**Maharashtra**		**WB**	
Characteristics	NFHS-5	NFHS-4	NFHS-5	NFHS-4	NFHS-5	NFHS-4	NFHS-5	NFHS-4	NFHS-5	NFHS-4	NFHS-5	NFHS-4
Women with 10 or more years of schooling (%)	39.6	34.3	28.8	22.8	33.8	33	50.2	45.5	50.4	42	32.9	26.5
Population with an improved drinking-water source (%)	96.7	95.6	99.2	98.4	97.2	95.9	95.3	95.3	93.5	92.5	97.5	97.2
Population that uses an improved sanitation facility (%)	77.3	54.4	49.4	26.5	74	63.6	74.8	57.8	72	52.3	68	52.8
Households using clean cooking fuel (%)	83.6	62	37.8	17.8	66.9	52.6	79.7	54.7	79.7	59.9	40.2	27.8
Child Feeding												
Children under age 6 months exclusively breastfed (%)	68	70.2	58.9	53.4	65	55.8	61	54.2	71	56.6	53.3	52.3
Children age 6-23 months receiving an adequate diet (%)	9.3	7.6	10.9	7.5	5.9	5.2	12.8	8.2	9	6.5	23.4	19.6
Nutritional Status and Diahorrea Among Children Under-5												
Stunted (%)	31.2	31.4	42.9	48.3	39	38.5	35.4	36.2	35.2	34.4	33.8	32.5
Wasted (%)	16.1	17.2	22.9	20.8	25.1	26.4	19.5	26.1	25.6	25.6	20.3	20.3
Severely wasted (below-3 standard deviations)	6	4.5	8.8	7	10.6	9.5	8.4	10.5	10.9	9.4	7.1	6.5
Underweight	29.6	31.9	41	43.9	39.7	39.3	32.9	35.2	36.1	36	32.2	31.6
Overweight	2.7	1.2	2.4	1.2	3.9	1.9	3.2	2.6	4.1	1.9	4.3	2.1

Prevalence of diarrhoea in the 2 weeks preceding the survey (%)	7.2	6.6	13.7	10.4	8.2	8.4	5.3	4.5	8.9	8.5	6.5	5.9
Prevalence of symptoms of acute respiratory infection in the 2 weeks preceding the survey (%)	2.4	0.5	3.5	2.5	1	1.4	1.5	1.2	3.2	2.4	2.8	3.3
Anaemia Among Children and Adults												
Children age 6-59 months who are anaemic (<11.0 g/dl) (%)	63.2	58.6	69.4	63.5	79.7	62.6	65.5	60.9	68.9	53.8	69	54.2
Non-pregnant women age 15-49 years who are anaemic (<12.0 g/dl) (%)	59	60.2	63.6	60.4	65.1	55.1	47.8	44.8	54.5	47.9	71.7	62.8
Pregnant women age 15-49 years who are anaemic (<11.0 g/dl) (%)	53.7	52.9	63.1	58.3	62.6	51.3	45.7	45.4	45.7	49.3	62.3	53.6
All women age 15-49 years who are anaemic (%)	58.8	60	63.5	60.3	65	54.9	47.8	44.8	54.2	48	71.4	62.5

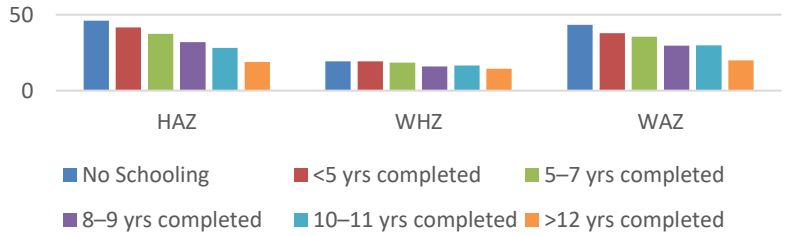
Source: NFHS -5, 2019-20

However, compared to the period 1998-99 to 2005-06, the decline in malnutrition is much higher during 2005-06 to 2015-16. Despite the non-improvement of diet quality in terms of protein and quantity of micronutrients at the aggregate level, the nutritional outcomes are getting better. The decline in malnutrition depends on several multidimensional factors. The increased protein intake in the lowest 20 percent of the MPCE class might be a reason. The drop could also be attributed to the expansion and improvement of several programmes that have targeted a mix of undernutrition's direct and indirect causes. The increasing efficiency in these programs' delivery systems might have improved children's nutrition status. Besides, improvements in drinking water, sanitation, hygiene (WASH), and women's literacy might have also helped enhance nutrition. Studies have shown that hygiene and sanitation are strongly associated with nutritional status, especially for children (Pandey et al., 2020; Kumar et al. 2015; Shivley 2015, Jose et al., 2020).

The NFHS-5 fact sheets of key indicators had released on 10th December 2020 for 22 States and UT. Table 8 presents the comparison of NFHS-5 with NFHS-4 for six major states and shows that despite the improvement in children's dietary adequacy, drinking water, sanitation facilities, clean cooking fuels, women's education and women's empowerment; stunting in children under-5 has increased in Gujarat, Maharashtra and West Bengal (WB). The proportion of children under-5 severely wasted has increased in all the states except Karnataka. Diarrhoea in children has increased in all the five states except Gujrat. Prevalence of underweight in children under-5 has grown in Gujarat, Maharashtra and WB however, the percentage of overweight children has increased in all six states. The percentage of overweight children is above two percent in the face of the high prevalence of severely wasted children. Anaemia among the children between age 6-59 months has increased in all the states, and among women age 15-49 years, it has increased in all the states except Andhra Pradesh (Table 8).

Along with undernutrition and micronutrient deficiency, India is suffering from the problem of an increase in overweight and obesity in the population that poses more significant risks for NCDs (CNNS, 2019). The prevalence of overweight and obesity has increased by 8.1 percentage point (12.6 to 20.7 percent) among the women during 2005-06 to 2015-16. It increased by 9.3 percentage points (9.3 to 18.6 percent) among the men during the same period. Undernutrition in utero and early childhood can affect individuals to become overweight and develop NCD in adulthood (WHO, 2018). According to CNNS (2019), overall, two percent of children under-5 were overweight or obese during 2016-18. In the well-nourished population, it is normal. But in India, as almost 20 percent of under-5 children were wasted, with the mean WHZ score for the population -1.0, the prevalence of overweight or obese at two percent was considered significantly higher and could represent the rise of overweight and obesity in the country (CNNS, 2019).

Figure 16:Maternal Education and Anthropometry of Children (0-4 Years)



Source: CNNS 2019

4. DIFFERENT INTERVENTIONS AND IMPACT

Responding to the shocks and vulnerabilities of the poor and marginalized through social policy has been one of the major functions of the governments all over the world. Policies related to social protection assume importance in this context, as they would directly deliver support to the needy. An important justification for public interventions in social protection programmes has been improvement in welfare of the poor and equity. Recent research has shown risk and vulnerability justification should be added since the poor do not have formal instruments for risk mitigation and coping (Devereux, 2006).

In order to alleviate poverty and achieving food security, India has adopted two-fold strategy of letting the economy grow fast and attacking poverty directly through poverty alleviation programmes. We first examine here the trends in poverty and the role of direct social protection programmes before going to the individual schemes.

4.1 POVERTY TRENDS

Based on NSS Consumer Expenditure data there are two conclusions on the trends in poverty. First a study by Datt et al (2016) shows that poverty declined by 1.36 percentage points per annum in post-1991 compared to that of 0.44 percentage points per annum prior to 1991. This study shows that among other things, urban growth is the most important contributor to the rapid reduction in poverty even in rural areas in post-1991 period. Second conclusion is that within post-reform period, poverty declined faster in 2000s than in 1990s. The official estimates based on Tendulkar poverty lines show that poverty declined much faster during 2004-05 to 2011-12 as compared to the period 1993-94 to 2004-05. In fact, the number of poor came down by 137 million during 2004-05 to 2011-12 while it increased by 3.4 million during 1993-94 to 2004-05. According to Rangarajan Committee methodology, the decline between 2009-10 to 2011-12 is 92 million[3].

Faster reduction in poverty is true even if we take multidimensional poverty index (MPI). According to the Report of the Global MPI, 2019 (Oxford and UNDP, 2019), India has made momentous progress in reducing multidimensional poverty. The incidence of multidimensional poverty was almost halved between 2005-06 and 2015-16, climbing down to 27.5 percent. Thus, if we look at consumption based poverty or MPI, poverty declined

[3] Rangarajan Committee estimates only for the years 2009-10 and 2011-12.

faster during the high growth period. It may be noted that GDP growth was 8.5 percent per annum during 2004-05 to 2011-12 as compared to 6.3 percent per annum during 1993-94 to 2004-05. During the period 2004-05 to 2011-12, several poverty alleviation programmes like MGNREGA (Mahatma Gandhi National Rural Employment Guarantee Act) NFSA (National Food Security Act) were introduced. Effectiveness of the programmes also increased. These factors could be responsible for faster decline in poverty in India. We do not have data for the recent period after 2011-12.

We now examine the importance of individual programmes in reducing poverty and improving nutrition.

4.2 MGNREGA

Public works programme is an important component of social protection policies. In India, the provision of employment has been extensively used as a tool of entitlement protection for many centuries. After independence in 1947, many schemes were sponsored by the central government, beginning with the Rural Manpower programme in 1960. However, the most important programme at the state level is the Maharashtra Employment Guarantee Scheme (EGS), introduced in 1972.

The National Rural Employment Guarantee Act (NREGA) was notified in September, 2005. It is now called Mahatma Gandhi National Rural Employment Guarantee Act (MGNREGA). The objective of the scheme is to enhance livelihood security in rural areas by providing at least 100 days of guaranteed wage employment in a financial year to every household. MGNREGA has been subject to much scrutiny, and assessment in terms of its effectiveness as a social protection intervention[4]. These assessments have yielded mixed findings, in terms of the effectiveness of the programme's design and objectives, its impact on the socially disadvantaged, especially children and women.

There are several pathways that lead to better outcomes in nutrition, health and education of children due to social protection programme like MGNREGA. One can group them into three heads (1) indirect effects of reduction in risks and vulnerabilities and increase in livelihoods

[4] For example, see Dreze and Khera (2009), Khera (2008), Dev (2011) Narayanan and Gerber (2017) Narayanan (2020),

and incomes of households (2) women's well-being and intra-household decisions (3) direct effects of child care facilities and linkages with school education and ICDS.

Based on the available literature, Dev (2011) examined the impact of MGNREGA on the well-being of children and the impact of the scheme on women. The study reported positive impact of MGNREGA on child well-being[5] along with positive impacts on household incomes, empowerment and well-being of women that has helped in improving nutrition, health and education of children and reduction in child labour[6]. Related to the issue of children in agriculture especially girls is the gender aspect of recognizing women as producers and farmers and its links to household food security. Strengthening extension training curriculum on gender and child protection issues in agriculture can help in reducing child labour.

Narayanan and Gerber (2017) and Narayanan (2020) also show positive impact of MGNREGA on women and children. MGNREGA benefits the poor and the marginalized who generally are more undernourished and have poor health[7]. MGNREGA can have links to nutrition and health at the micro level in two ways. (a) first through rise in earnings and expenditures that seem to have a positive impact on calories, proteins and micronutrient intake in Andhra Pradesh, Rajasthan and Maharashtra[8]; (b) The second pathway is through the assets created under MGNREGA (Narayanan and Gerber, 2017). A study by Indira Gandhi Institute of Development Research, Mumbai on assets created in Maharashtra under MGNREGA shows 87 percent of works exist and function and over 75 percent of these are directly or indirectly related to agriculture (Narayanan et al, 2014).

MGNREGA is the most important social protection programme in India. Apart from direct benefits, it has secondary benefits such as creation of assets for agriculture and rural development; more participation of women (more than 50 percent of workers are females); helping marginalized sections like SCs and STs; reducing distress migration; involvement of

[5] Child well being indicators are child labour, nutrition and education.
[6] Studies showed a positive relationship between MGNREGA and child nutrition indicators. Also it is shown that access to food also increased for the households including children.
[7] MGNREGA provided employment to 55 million rural households in 2019-20. Majority of them belong to poorer households as they are self selected for doing manual unskilled work.
[8] This is based on Jha et al (2011)

panchayats etc[9]. The programme has demonstrated varying degrees of success across the country. The achievements are still short of potential. This potential can be harnessed in order to strengthen the right to employment, which in turn can enhance the rights of women and children.

4.3 NFSA

The Public Distribution System (PDS) is one of the instruments for improving food security at the household level in India. The PDS ensures availability of essential commodities like rice, wheat, edible oils and kerosene to the consumers through a network of outlets or fair price shops. These are supplied at below market prices to consumers. The National Food Security Act (NFSA), 2013 is an Act of the Parliament which aims to provide subsidized food grains to approximately two thirds of India. It includes the Midday Meal Scheme (MDM), Integrated Child Development Services scheme (ICDS) and Targeted Public Distribution System (TPDS). Further, the NFSA 2013 recognizes maternity entitlements. The MDM and the ICDS are universal in nature whereas the TPDS will reach about two-thirds of the population (75 percent in rural areas and 50 percent in urban areas).

Under the provisions of the bill, beneficiaries of the PDS are entitled to 5 kg per person per month of cereals at INR 3 per kg of rice, INR 2 per kg of wheat and INR 1 per kg of coarse grains (millets). Pregnant women, lactating mothers, and certain categories of children are eligible for daily free cereals. In 2019-20, the offtake under TPDS was 50 million tonnes while it was 1.2 million tonnes and 2.1 million tonnes for ICDS and MDM respectively (Table 9).

Table 9: Allocation and Offtake under NFSA, 2019-20 (in million tonnes)

	TPDS	ICDS	Mid day meals	Total
Allocation	52.2	2.2	2.5	56.9
Offtake	50.1	1.2	2.1	53.4

Source: Food Bulletin, Department of Food and Public Distribution System (GOI)

[9] On benefits of employment guarantee schemes, see Dev (1995) and Dev (2011).

4.3.1 WHAT IS THE IMPACT OF PDS ON FOOD AND NUTRITION SECURITY?

In general, the poor and the vulnerable groups benefited from the PDS although the impact varies across states. Based on the available literature, Narayanan and Gerber (2017) show a range of limited to modest positive impact on calorie intake[10]. The study also indicates that most of the studies are limited to assessing the intermediary outcomes than on undernutrition. Krishnamurthy et al (2014) reveal an increase in consumption of protein, calcium and iron due to use of PDS (12.9 percent, 26.4 percent and 14.2 percent respectively).

In the case of PDS, we do have information on the MPCE of households using PDS and the quantities of grains etc. bought. One could, therefore, analyse the impact of PDS on measured poverty. Himanshu and Sen (2013) estimated that the value of PDS transfer was 2.4 percent of MPCE for the population as a whole and 5.2 percent of MPCE for the bottom 40 percent. In other words, poor benefited more than others due to these in-kind food transfers. Their study also shows that with PDS transfers, total poverty ratio (Tendulkar methodology) was 30.68 percent and without it, poverty ratio was higher at 33.85 percent in 2009-10.

One issue of NFSA is the adverse impact on diversification of cropping pattern. The policies in India support rice and wheat in a big way in the form of minimum support prices, buffer stock and PDS. These policies provide incentives for farmers to produce more of rice and wheat which are water incentive. They act as disincentives to undertake diversified farming.

Related criticism is that NFSA is not going to solve the problem of malnutrition as they give mainly calories. It is possible that savings from subsidized food items indirectly helps in consuming protein and micronutrient related foods. It is true that the poor and vulnerable spend more on cereals. It is known that health is determined by calorie, proteins, micronutrients, health, sanitation, safe drinking water etc. NFSB mainly provides rice, wheat, coarse cereals. It, however, has some provision for nutritious food for women and children.

[10] This is based on literature survey by Narayanan and Gerber (2017)

4.4. CHILD NUTRITION SCHEMES

4.4.1 ICDS

The Integrated Child Development Services (ICDS), launched in 1975, aims at the holistic development of children up to six years of age with a special focus on children up to two years, besides expectant and nursing mothers. This is done through a package of six services - health check-ups, immunisation, referral services, supplementary feeding, non-formal pre-school education and advice on health and nutrition.

The scheme has to focus more on 0–3 year children as malnutrition sets in utero and is likely to intensify during the 0–3 year period, if not addressed. In fact, this window of opportunity never returns in the lifetime of the child. A child malnourished during 0–3 years will be marred physically and mentally for life. The design of the scheme has to address this problem frontally.

Mother's malnutrition has knock-on effects on child malnutrition. Exclusive breastfeeding for six months is necessary to avoid unnecessary infections to the baby, develop the baby's immunity, and ensure growth. The baby must begin to receive solid, mushy food at 6 months (i.e. together with breastfeeds) for the baby to continue to grow in the way nature intended her to grow. The ICDS scheme accordingly needs to be restructured in a manner that addresses some of the weaknesses that have emerged and is suitable for universalization. The programme must effectively integrate the different elements that affect nutrition and reflect the different needs of children in different age groups (GOI, 2008).

Apart from the above, preliminary findings of FOCUS (Focus on children under six) survey conducted in May-June 2004 in six states brings out some of the problems and regional disparities in the working of ICDS (Dreze, 2006). This study shows that Tamil Nadu scores over Northern states in infrastructure, quality of pre-school education, immunization rates, mother's perceptions and, quality of anganwadi workers.

According to a study by Saxena (2008), ICDS is reaching only 12.5 percent of children in the age group 6 months to 6 years. The 11th Five Year Plan document aimed at halving the incidence of malnutrition by the end of the Eleventh Plan and reduce anaemia among

pregnant women and children to under 10 percent. To achieve these objectives, ICDS has to be restructured with higher allocations of funds and effective implementation.

The above studies were done more than a decade back. Jain (2015) uses NFHS 2005-06 shows that the supplementary feeding component of ICDS had sizable positive effects on heights of 0-2 year olds in 2005-06. The study finds that 0-2-year-old girls who received ICDS food daily were at least 1 cm taller than those who did not. It also indicates that the supplementary nutrition could potentially bridge height gap between the richest and poorest girls by at least 28 percent and for boys by 19 percent at adulthood. However, the study warns that one can have all these benefits only if the programme is targeted toward 0-2-year-old children. Restructuring of ICDS has been done in recent years including focus on supplementary feeding on children below three years of age and pregnant and lactating mothers. Apart from other factors, ICDS restructuring helped in decline in stunting in recent years.

A study by Chudasama et al (2016) evaluates ICDS programme during 2012 to 2015. Some of the findings are the following:

(a) A majority of pregnant (94.7 percent) and lactating (74.4 percent) mothers, and adolescent girls (86.6 percent) were availing ICDS services. (b) Two-third (66.2 percent) children were covered by supplementary nutrition (SN). (c) Only 14.6 percent of the AWCs (Anganwadi Centres) reported 100 percent preschool education (PSE) coverage among children; (d) More than half (55.4 percent) of the AWCs reported an interruption in supply during the last 6 months; (e)Various issues were reported by AWWs (Anganwadi Workers) related to the ICD. The study has reported gaps in terms of infrastructure facility, different trainings, coverage, supply, and provision of SN, status of PSE activities in AWCs, and provision of different services to the beneficiaries. These gaps have to be addressed in order to improve the impact of ICDS on nutrition

4.4.2 MID-DAY MEALS SCHEME

The MDM in India is a program covering primary school children to improve nutrition as well as increase educational enrolment, retention and attendance. Using Young Lives project data, Porter et al (2010) examines the effect of the scheme on children's nutrition and on their

learning. Among the children surveyed by Young Lives in Andhra Pradesh the scheme appears to deliver significant nutritional benefits for children aged 4 to 5 years, which can be seen in better height-for-age and weight-for-age than would otherwise be expected, suggesting that MDM helps reduce malnutrition. For older children (aged 11 to 12 years) there is evidence of significant positive impacts on children's learning, although it is not clear if these effects are generated by less hunger or by improved school attendance. The school meals have most impact in areas affected by drought. For younger children, there are large and significant gains in height-for-age and weight-for-age, which more than compensate for the negative effects of the drought. The success of Tamil Nadu MDM scheme on nutrition and education is well known.

4.5 Cash Transfers

Some argue unconditional cash transfers (CTs) to reduce poverty and undernutrition. It is advocated that we should move towards direct benefits transfer in place of present social protection programmes. There has been a lot of discussion on universal basic income (UBI) in both developed and developing countries. Rangarajan and Dev (2017) say introducing UBI is unrealistic. In fact, the concept of basic income must be turned essentially into a supplemental income.

A study on Bangladesh (Ahmed et al., 2019) showed positive relationship between cash transfers and nutrition. They implemented two, linked randomized control trials in rural Bangladesh, with (a) treatment arms including cash transfers, a food ration, or a mixed food and cash transfer, and (b) treatments where cash and nutrition behavior change communication (BCC) or where food and nutrition BCC were provided. The study reveals only cash plus nutrition BCC had a significant impact on nutritional status, but its effect on height-for-age z scores was large. Improved diets – including increased intake of animal source foods – along with reductions in illness in the cash plus BCC treatment seem to be responsible for improvement in children's nutrition.

4.6 COVID-19 AND SAFETY NET PROGRAMMES

COVID-19 has created health and economic crisis in India similar to many other countries. the complete shutdown of all economic activities except essential services have created an economic crisis and misery for the poor, with massive job losses and rising food insecurity.

The central and state governments and the RBI have recognized the economic crisis and responded using fiscal and monetary policies. The Central government announced *Atmanirbhar package* with INR 21 trillion (around 10 percent of GDP). But most of the package relates to liquidity measures. The real fiscal stimulus seems to be around 2 per cent of GDP. It also includes food transfers and cash transfers for the informal poor workers including migrants. Government has allocated more funds for MGNREGA.

India has nearly 56 million tonnes of excess stock of grains and cereals compared to the usual norms. In March, the government declared 5 kg free rations in addition to the present entitlement of buying 5 kg at subsidized prices. In June, the Prime Minister announced extension of the Pradhan Mantri Garib Kalyan Anna Yojana (PMGKAY), a programme to provide free ration for over 80 crore people, mostly poor, by five more months till November end. This will help the informal sector workers in both rural and urban areas. However, government has to make sure that no one is excluded as we still have exclusion errors in the PDS. State governments have also announced free basic and enhanced rations. The Central government also announced One Nation-One Ration card. The nutrition levels of informal workers and unemployed poor were low even before the crisis. It will decline further due to lack of jobs and incomes during lockdown and beyond. Therefore, there is a need to have pulses, oils, etc. in the provision to ensure a diversified diet for them. *Anganwadis* and schools can provide rations at home. Eggs can be added to improve nutrition for children and women. Government has to make sure that the prices of essential food items are under control. Otherwise, high prices would have adverse impact on the food and nutrition security of the poor.

4.6.1. MINIMUM BASIC INCOME FOR THE POOR IN THE POST-COVID PERIOD.

There has been a considerable discussion on UBI during pandemic times. It is true that a universal scheme is easy to implement. Feasibility is the critical question. Targeted program is another option. The issue with targeted programmes is the problem of identification.

Narrowly targeted programmes will run into complex problems of identification and give rise to exclusion and inclusion errors.

In order to avoid the identification problem, Rangarajan and Dev (2020) suggested three proposals to meet the objective of providing minimum basic income to poor and vulnerable groups in both rural and urban areas. These are:

(a) give cash transfer to all women in both rural and urban areas above the age of 20 years;

(b) expand the number of days provided under MGNREGA;

(c) launch National Employment Guarantee Scheme in urban areas.

In all the three proposals, there is no problem of identification. A combination of cash transfer and an expanded MGNREGA can provide minimum basic income.

a. Total cost of the three proposals.

The proposal of providing cash transfers to women above 20 years costs INR 1.72 lakh crore (0.84 percent of GDP). The total cost of the expenditure on MGNREGA for providing 150 days employment and 150 days for urban employment guarantee scheme would cost INR 3.21 lakh crore in a year (1.58 percent of GDP). The total cost of the three proposals would be INR 4.9 lakh crores or 2.4 percent of GDP. A person working in MGNREGA and urban programme can get an additional INR 30,000 if 150 days are provided.

It may be noted, however, that the total expenditure of the proposals could be lower due to two reasons. First, the number of days availed of by the employment guarantee programmes could be lower as it is a demand based programme. This is happening even now. Second, on cash transfers, some women particularly from richer classes may voluntarily drop out of the scheme or alternatively we can provide that everyone receiving cash transfer must declare that her total monthly income is less than INR 6,000 per month. In addition, it may be noted that the government is already incurring a total expenditure of INR 67,873 crore on MGNREGA.

In the post-COVID-19 situation, we need to institute schemes to provide minimum income for the poor and vulnerable groups. For this purpose, it is proposed here cash transfers for women, increasing MGNREGA from present 100 days to 150 days of work in rural areas and introduce 150 days of work as urban employment guarantee scheme. This will cost around 2

percent of GDP and will help the poor, informal workers including migrant workers and poverty and food and nutritional insecurity can be reduced significantly.

4.7 PROGRAMMES AND SDGS

In order to achieve SDG 1 of removing poverty and SDG 2 of reducing hunger and malnutrition by 2030, these programmes are important and can contribute significantly in attaining the targets. They have to be strengthened further in financial allocations and effective implementation. A synergistic approach across programmes is needed.

5. HEALTHY DIETS AND FOOD SAFETY CONCERNS

Healthy diets are required to avoid malnutrition, viz., under-nutrition, micronutrient deficiencies and over-nutrition. According to Rome Declaration of Second International Conference on Nutrition, "*nutrition improvement requires healthy, balanced, diversified diets, including traditional diets where appropriate, meeting nutrient requirements of all age groups and all groups with special nutrition needs, while avoiding the excessive intake of saturated fat, sugars and salt/sodium, and virtually eliminating trans fats, among others*" (FAO/WHO, 2014). Thus, the healthy diet varies with individuals' needs based on age, gender, level of physical activity, and local availability of foods and dietary customs (WHO, 2015b).

Recommendations for healthy and balanced diets for adults to prevent malnutrition include consuming diverse food groups by increasing intake of fruits, vegetables and legumes; consuming animal-sourced food in moderation; decreasing consumption of refined sugar; and substituting unsaturated fats over saturated fats (WHO, 2015b). Annexure 1 gives Guidelines on balanced diet for Indian adults recommended by NIN, Hyderabad.

Agricultural production can avert malnutrition by improving access to diverse foods that meet various dietary and micronutrient requirements (Blasbalg et al., 2011; Tontisirin et al., 2002). In terms of effective price incentives such as minimum support price and PDS, India's key agricultural policies have aimed to increase the production and distribution of energy-dense staple grains to address under-nutrition. Recently pulses are also included in PDS. The starchy staple grains are energy-dense and lack essential nutrients to tackle micronutrient inadequacies. Therefore, there is a need to diversify production towards nutrient-dense foods

to improve dietary diversity and nutritional status (Powell et al., 2015; Burlingame and Dernini, 2012; Hunter et al., 2013). Dietary diversity is a proxy for the nutrient adequacy of the diet. Obtaining multiple micronutrients from few food groups is difficult; therefore, consumption of an adequate quantity of diverse food groups can improve intake of micronutrients of household members (Carletto et al., 2015; Shively and Sununtnasuk, 2015; Fiorella et al., 2016; Jones, 2014; Jones, 2017; Dev et al., 2020). Insufficient dietary diversity and meal frequency lead to increased morbidity and mortality risks among the children (Arimond, 2004; Black, 2014). For children under-2 a nutritionally balanced diet is critical for proper growth and development. To assess the quality of complementary feeding practices for children aged 6-23 months the WHO has recommended three core indicators: minimum dietary diversity (MDD), minimum meal frequency, and minimum acceptable diet (MAD) (Annexure 2).

It is observed that only 21 percent of children aged 6-23 months were having required MDD, and 42 percent were fed minimum number of times per day for their age (Table 9). The minimum acceptable diet was observed only in 6 percent of children in this age group. The level of maternal education and household wealth has a positive influence on the prevalence of MDD and MAD but negatively affects minimum meal frequency (Table 10). The reason could be that mothers with no or less schooling might perceive that frequently feeding the child with high-value food be better than feeding diverse food groups. Further, the poor household might not be able to afford to feed high-value foods to adequately address dietary diversity and acceptable diet; therefore, they would try to compensate it by feeding more frequently. However, there is a need to explore this issue further.

Table 10: Minimum Dietary Diversity, Minimum Meal Frequency and Minimum Acceptable Diet for Children Aged 6–23 Months (Percentage)

	Minimum dietary diversity	Minimum meal frequency	Minimum acceptable diet
Total	20.9	41.9	6.4
Residence			
Urban	26.9	36.7	7.6
Rural	19	43.6	6.1
Sex			
Male	20.6	43.2	6.4
Female	21.4	40.5	6.5
Maternal Education			
No Schooling	11.4	50.4	3.9
<5 yrs completed	14.8	45.3	6
5–7 yrs completed	20	43.2	6.1
8–9 yrs completed	21.6	38.5	5.4
10–11yrs completed	25.2	34.3	8.2
>12 yrs completed	31.8	36.2	9.6
Wealth Index			
Poorest	9.3	51	2.5
Poor	16.1	50	6.4
Middle	20.5	41.4	6.1
Rich	22.6	36.7	8
Richest	34.7	31.9	8.9

Source: CNNS, 2019

Malnutrition is more prevalent in rural areas than in urban areas (Table 6) and requires addressing the issue on a priority basis. There are mixed pieces of evidence concerning crop production diversity and household dietary diversity (HDD) in India. Bhagowalia et al. (2012) and Kataki (2002) have shown that crop diversity leads to improvement in HDD. A strong and positive association of agricultural production diversity and HDD at the state level is reported by Venkatesh et al. (2017). Kachwaha et al. (2020) assessed the economic

feasibility of assuring nutritionally adequate diets for vulnerable populations in Uttar Pradesh and reported that home production of food items had the highest potential for reducing the cost of nutritious diets. However, Kavitha et al. (2016) have found no significant association between HDD and crop diversity in Telangana and Maharashtra states. Further, production diversity of non-staples did not associate with women's dietary diversity in the states of Uttar Pradesh, Bihar and Odisha (Gupta et al., 2019). Therefore, we carried out an analysis to understand the linkage between production diversity and HDD in Bihar and Odisha using SPANDAN data (Annexure 3).

5.1 LINKAGE BETWEEN PRODUCTION DIVERSITY AND DIETARY DIVERSITY

A. EMPIRICAL STRATEGY

The outcome variable used is household diet diversity. The ordinary least square model was used to understand the association between agricultural diversity and dietary diversity based on the following specifications:

$$D_i = \alpha + \beta A_i + \varphi H_i + \omega Com_i + \varepsilon_i$$

where D_i is the diet diversity score of the household. Household dietary diversity score is a qualitative measure of the count of diverse food groups consumed by the household over the preceding 24-hour recall period and takes a value between 1 and 11. Following 11 food groups were considered, (1) cereals (2) roots and tubers (3) vegetables (4) fruits (5) meat, poultry, and eggs (6) fish (7) milk and milk products (8) oil and fat (9) pulses and nuts (10) sugar and honey (11) miscellaneous.

A_i represents agricultural diversity variables and consumption from various sources of food. H_i and Com_i represents household and community characteristics, respectively. Multiple measures of agricultural diversity were used, viz., crop group diversity (count of the number of food groups grown), livestock diversity (count of different livestock groups reared), kitchen garden diversity (count of food crops grown in kitchen garden - mostly fruits and vegetables), and common property resources (CPR) food diversity (count of food items sourced from CPR). In-kind wage is a binary variable, taking value '1' if a household has got any or '0' otherwise. The consumption of food groups from home production as dichotomous indicators was also used to analyse its influence on household dietary diversity.

Household socio-economic characteristics such as wealth index, caste, type of ration card were used. Hygiene and sanitation are important factors for food safety; therefore, access to toilets, clean drinking water and cooking fuels were used as proxy variables for WASH. The indicators for agricultural production characteristics, i.e., land size and percentage area irrigated, were also included. Used access to agricultural markets and other infrastructural variables, such as access to Public Distribution System (PDS) and Aganwadi Centres (AWC) at the community level. The literacy status of the head and adult women of the household were also employed. Two models were used, in the first model, agriculture diversity variables were used as control variables, and in the second model, household consumption from home production was used as control variables. Each model was computed both without the socio-economic variables and with socio-economic variables.

B. Results of regression analysis

The results of the regression analysis are given in Annexure 4, and the summary of the results is as follows:

a) Crop diversity and kitchen garden diversity has positive and significant association with household dietary diversity.
b) The Square of crop diversity variable has a negative and significant association representing that relationship is not linear, and the magnitude of the effect decreases at higher levels of production diversity.
c) Counter-intuitively, livestock diversity has a negative and significant association with dietary diversity when socio-economic variables are included. However, in the absence of socio-economic variables, it is not having a significant association. This behaviour may be due to the reasons as reported by Parvathi (2017), which suggest that a mixed crop-livestock farming system reduces household dietary diversity in subsistence farming.
d) It is evident from the results that consumption from livestock production has a significant influence on household dietary diversity. The results suggest that the production of livestock products need not necessarily lead to higher consumption at the household level.
e) Household consumption expenditure and wealth are strongly associated with an increase in household dietary diversity.
f) Compared to households with no toilets, those with access to pit/flush toilets have improved dietary diversity.

g) The literacy status of the head and adult women was associated with better household dietary diversity.
h) Access to PDS has positive and significant association with dietary diversity.

5.2 Food Safety Concerns

Food safety refers to ways to prevent food-borne diseases (FBD) in the entire food system due to food contamination during production, processing, storage, transport, food distribution, and household level. It also refers to the standards and controls that are in place to protect consumers from unsafe foods. Food Safety and Standards Authority of India (FSSAI) was established to lay down science-based quality and safety standards for food and regulate the manufacturing, storage, distribution, sale, and import to ensure safe and healthy food (FSSAI, 2006). However, several shortcomings in FSSAI functioning are being reported (Siruguri, 2018). Food safety, security and nutrition (FSN) are closely linked, with unsafe food creating a vicious circle of diseases and malnutrition, affecting the more vulnerable groups (WHO, 2015a). However, nutritional and food safety objectives generally contradict, as the most nutritious foods are usually the riskiest ones (FAO, 2016).

Economic growth, improved literacy rates, rising incomes, urbanization, and liberalization have not only influenced Indians' dietary pattern but also made them more aware of food safety. Food safety is the key to achieving SDGs and are interlinked to SDG 6 and SDG 12 (Grace, 2017), focusing on various dimensions of food security recognized along the pathways from agriculture to nutrition. Food safety is determined not only by how food is produced and delivered but also by how consumers procure, handle, cook, store, and consume food. Access to safe water, toilets, and washing the hand with soap is required for proper utilization of the consumed food.

Food contaminations also affect the export of fresh and processed food commodities. In January 2020, the USA rejected 112 consignments of food and beverages from India. Major Indian products rejected by USFDA include spices, shrimps and prawns, vitamins and proteins, honey, sweets, biscuits and flavoured snacks (USFDA Rejection Data). In 2009-10 European Union (EU) rejected around 1,200 of total 3,400 containers of grape consignments from India, citing the presence of pesticide residue on the fruit. The EU banned the import of Indian mangoes in 2014 because they were infected with pests that could harm indigenous

crops. However, in 2015, the ban was lifted. EU has also banned eggplant, bitter gourd and snake gourd after consignments of these items were found infested with fruit flies. The Indian basmati rice was also subjected to import restrictions because London's Pesticide Safety Directorate stated that it contained a high level of fumigants.

Spain, Italy and Germany detained the import of spices from India due to the presence of aflatoxin and pesticide residue. Aflatoxins are produced by fungi when they infect crops and are highly toxic and cancer-causing. Indian marine products were also banned by the EU because antibiotic residues were more than the prescribed level. Likewise, shrimp import by Japan was restricted on the ground of non-freshness, foreign bodies, and unhygienic practices.

Kohli and Garg (2015) reported that the FBD is infrequent and often not reported in India and referred to a study conducted in 2006 that showed only 13.2 percent of households reported FBD. The FBD outbreaks, together with acute diarrhoeal diseases, and measles, constitute a majority of all reported outbreaks of diseases in India (GoI, 2020). To increase the productivity, farmers use a range of fertilizers and pesticides. These agrochemicals are often found in trace quantities in the final product and enter the food chain. Similarly, in animal farming, veterinary drugs/antibiotics are commonly used, and which, by entering the food chain, become injurious to human health. It is estimated that FBD costs stood at around 0.5 percent of the country’s GDP in 2011 (Kristkova et al., 2017). Kristkova et al. (2017) projected that there would be a higher consumption of food between the period 2011 and 2030, mainly fruits, vegetables, and meat, which will result in a significant increase of FBD cases to 150 - 177 million in 2030 compared to 100 million in 2011.

Most cases of FBD illnesses are preventable by following food protection principles. WHO promotes five keys to food safety viz., **keep clean; separate raw and cooked; cook thoroughly; keep food at safe temperatures; use safe water and raw materials**. There is a need to have sensitization at the household level, especially for the women, as they are generally custodians of food preparation and handling. In India, diverse food habits, cultural practices, and the changes brought in by globalization and scarcity of resources, especially clean water, money, appliances, etc., at the household level, make food safety promotion a difficult task (Subbarao, 2019). According to World Water State in 2018, around 19.33

percent of the population do not have access to clean water in India, which has implications for food safety.

Clean water, sanitation, and hygiene (WASH) are essential for reducing malnutrition and mortality rates (Heady and Palloni, 2019). The inadequate WASH leads to diarrhoea, undernutrition, helminthiases, and vector-borne diseases. Interventions to address water and sanitation simultaneously have been shown to positively affect child health (WHO, 2006; Checkley et al., 200; Duflo et al., 2015). Spears (2013) has studied India's Total Sanitation Campaign and has reported a decrease in infant mortality by 4 per 1,000 and an increase in children's height by 0.2 standard deviations at the mean programme intensity. The NFHS-4 reports that handwashing places with soap and water availability are present in 78.4 percent of households. Around 3.31 percent of households have handwashing places with no water or soap arrangements in India's urban areas. The situation of the rural areas is even worse. Under such circumstances, food safety issues at the household level become crucial for good health and require interventions focusing on improved practices at the point of consumption.

Proper cooking is needed, as inadequate cooking or not thoroughly reheating leads to food safety risks. But in situations where cooking fuel is difficult to get or inconvenient to use, households may try to save energy, effort, or time and may not thoroughly reheat before consumption. Therefore, WASH (water, sanitation, and hygiene) and access to clean and convenient cooking fuel are necessary for food safety. However, the recent fact sheets of NFHS-5 for 22 states and UTs released by the Ministry of Health and Family Welfare show that despite improvements in WASH and access to cleaning cooking fuels, children and women's nutritional status has worsened in most of the states. The reasons could be decline in household income, poor maintenance of sanitation facility, increase in environmental pollution, etc. However, there is a need to explore further the factors behind the worsening of the nutritional status once full data is made available.

6. SUSTAINABILITY IN CONSUMPTION

Presently, India is self-sufficient in addressing calorie intake requirements by producing staple crops (rice and wheat). Based on the review of 11 studies projecting the consumption of foods in India up to 2050, Alae-Carew et al. (2019) have reported an increase in per capita consumption of meat, vegetables, fruits and dairy products, and consumption of cereals and pulses to remain constant. It is being projected by Kumar et al. (2016) for 2030 that demand

for cereals is likely to be met with domestic production in India. However, pulses, edible oils, sugar, vegetables, and fruits would be short in supply (Annexure 5). Though the production of fruits and vegetables is sufficient to meet the demand, supply reduces due to very high postharvest losses. Therefore, the issue is to target hidden hunger by using micronutrient-rich products for food and nutrition security and sustainable food systems.

There is a change in India's dietary patterns, and this trend is likely to continue (Alae-Carew et al., 2019). These changes in dietary habits, together with a growing population, will have consequences on food systems. They might have potential implications for environmental sustainability through GHG emissions, ground and surface water depletion, soil pollution, etc. (Foley et al., 2005) and subsequently, lead to unsustainable agricultural production. Green et al. (2018) have quantified GHG emissions, associated with five distinct dietary patterns, based on the life cycle assessment approach. They have combined estimates of emissions from food production, storage, processing, transport, cooking, packaging, and food wastage for each food group. The results show substantial variability in the environmental impact between diets. The rice-based dietary patterns had higher associated GHG emissions and green water (precipitation) footprints (WFs), but wheat-based diets had lower GHG and higher blue (irrigation) WFs. The rice and meat patterns had the highest environmental impacts. Thus, the increased consumption of animal-sourced foods would significantly increase GHG emissions from Indian agriculture.

In a different study, Aleksandrowicz et al. (2019) using NSSO 2011-12 data have calculated the potential changes in GHG emissions, blue and green WFs, and land use (LU) that would result from shifting current national food consumption patterns in India to healthy diets that meet dietary guidelines (RDA) and also moving to diets currently consumed by the wealthiest quartile of the population. They modelled the changes in consumption of 34 food groups necessary to meet Indian dietary guidelines. The analysis shows that shifting to healthy guidelines at the national level will require increased dietary energy by 3 percent, fruit intake by 18 percent, and vegetable intake by 72 percent. Meeting healthy guidelines would slightly increase environmental footprints (3–5 percent). However, shifting to healthy diets among those with dietary energy intake below RDA would increase 28 percent in GHG emissions, 18 and 34 percent in blue and green WFs, respectively, and 41 percent in LU. Decreased environmental impacts were shown for those who currently consume above RDA energy (−6 to −16 percent across footprints).

Thus, in India, widespread adoption of healthy diets may lead to small increases in the environmental impact relative to the current status. For attaining healthy diets and the sustainability of the food production system, it is required to increase resource use efficiency in food production and reduce postharvest losses.

6.1 REDUCING POSTHARVEST LOSSES

Postharvest losses (PHL) add to food insecurity, wastage of natural resources, and wastage of labour and energy used to produce the food (UNEP 2016). A reduction in food waste will affect the total demand for food production while simultaneously reducing pressure on natural resources and the environment (FAO, 2019). In India, postharvest losses are as high as around 40 percent in fruits and vegetables produced every year (NAAS, 2019). The Ministry of Food Processing Industries estimated losses of 23 million tons of grains, 12 million tons of fruits, and 21 million tons of vegetables for a total approximate value of 4.4 billion USD in 2018-19. According to Fen et al. (2008), rural infrastructure is one of the three most effective public-spending items for promoting agricultural growth and reducing poverty. Therefore, proper transportation and storage facilities are must for reducing PHL.

Food processing and packaging can preserve the available nutrients and even enhance the shelf life and nutrient content of foods. Thus, proper processing and packaging can help make nutritious foods to reach those vulnerable groups who cannot access or afford fresh products. In the case of unhealthy ingredients presents in the food, product reformulation can be carried out, e.g., reducing sodium and trans-fats (HLPE, 2017).

There is also a need to regulate and monitor food processing by setting standards and labelling processed food products. Enforcement of standards is required to ensure food safety and reducing FBD. Thus, it is necessary to make the functioning of FSSAI more effective by removing the shortcomings (Siruguri, 2018).

7. FORTIFICATION AND BIO-FORTIFICATION

Though malnutrition can be tackled through dietary diversity, implementing it may not always be feasible among poor households. It is being shown that the diet that meets all the recommended nutrient requirements in vulnerable populations of Uttar Pradesh was over

twice more expensive than the diet that meets only the calorie requirements. A nutritious diet was unaffordable by 75 percent of the households (Kachwaha et al., 2020). Agricultural research has focused on increasing the production and productivity of calorie-dense staple crops. The prices of nutrient-dense non-staple foods have increased because of high demand and relatively low supply (Bouis et al., 2011). The effectiveness of dietary diversity may also be impacted by the seasonality of the crops and the low bioavailability of specific micronutrients. Nutrient deficiency in food can be tackled either by providing supplements or by food fortification such as iron and folate-fortified flour, iodized salts, etc. There was an increased focus on food fortification in the Union Budget-2019-20. However, these approaches may not be sustainable because they rely on a robust distribution, good infrastructure, and consumer compliance (Yadava et al., 2018). Generally, fortification is done with synthetic minerals, which are lower in bio-availability than bio-fortification (Mitra-Ganguli, 2019). Therefore, bio-fortification may be one of the more cost-effective solutions to provide the desired levels of nutrients, e.g., rice bio-fortified with zinc, iron-rich pearl millet, etc. (Pfeiffer, 2007).

Studies have demonstrated the positive effects of bio-fortified crops on human health. Meenakshi et al. (2010) have reported that the bio-fortification of staples may be more cost-effective in reducing the burden of diseases than fortification and supplementation. Stein et al. (2007) estimated that zinc bio-fortification of rice and wheat might reduce loss of Disability Adjusted Life Years (DALYs) burden by 20 –51 percent and save 0.6–1.4 million DALYs each year. Scott et al. (2018) have shown that consumption of bio-fortified pearl millet twice daily for six months by 12–16-year-olds from economically-disadvantaged classes in Maharashtra, India, had significantly improved their cognitive skills.

Distribution of bio-fortified cereals through PDS will ensure its reach to nutrition-deficient groups at a subsidized price. The incorporation of bio-fortified staples in welfare schemes, such as ICDS and MDM, might reduce children's malnutrition levels. There is a need to intensify efforts by public sector institutions for the adoption and acceptance of bio-fortified crops. To popularize the bio-fortified varieties, the seeds' genetic purity and vigour need to be retained (Yadava, 2017). Farmers should be encouraged and given incentives to grow bio-fortified crops with assured markets and minimum support prices for bio-fortified crops. Effective extension services are needed to increase the awareness of the production and consumption of bio-fortified crops.

For the successful adoption of bio-fortified crops by the consumer, food industry participation is also vital to bring bio-fortified crops into the food system for Indian consumers. The food industry can participate via food product development and innovations that fit into the consumers' growing demand due to increasing concerns for plant-based protein, reduced food additives, lower genetically modified ingredients, and more natural foods (Walton, 2019). Thus, bio-fortification has value to the food industry and food manufacturers by developing innovative products and suitable recipes and formulations for bio-fortified foods such that targeted nutrients are retained.

For this purpose, the identification of sustainable routes to market is required (Mitra-Ganguly 2019). A HarvestPlus workshop to discuss ways to increase the scale, reach and impact of bio-fortified foods in India highlighted a significant demand from the food industry and a lack of awareness as a major barrier to scale. The critical factors identified are meeting manufacturing product standards, more research on impact assessment, and consumer research (Mitra-Ganguly 2019).

8. PATHWAYS FOR SAFE AND HEALTHY DIETS FOR NUTRITIONAL SECURITY

The pathways for safe and healthy diets that ensure nutritional security requires meeting food demand for 18.1 percent of the world population whose share in total global DALYs attributable to the child and maternal malnutrition was 25.4 percent in 2017 (Lancet, 2020). India's population is projected to reach 1.5 billion by 2030, peaking at 1.6 billion by 2048 (Lancet, 2020). This will require sustainable food systems by increasing the production efficiency of agricultural systems that is faced with small landholdings, fragmentation of farmland, climate change impacts, and degradation of natural resources.

Based on our discussions in the earlier sections, the pathways for safe and healthy diets for nutritional security in India consist of the following a) improving dietary diversity, b) reducing postharvest losses, c) bio-fortification of staples, d) empowerment of women, e) enforcing standards of foods safety, packaging, and labelling, f) improving WASH (g) Food safety awareness and nutrition education (h) Implementation of food safety and nutrition programmes (i) Use of ICT.

a) Improving dietary diversity

Availability and access to adequate amounts of diverse food groups are required to address undernutrition and micronutrient deficiency. The household dietary diversity can be improved by increasing crop diversity and having access to kitchen gardens, including diverse food groups in the safety net programmes such as PDS, MDM, and THR (take-home ration).

The Government of India has programmes for diversifying the cropping system such as Crop Diversification Programme (CDP), National Horticulture Mission, National Food Security Mission- Pulses. There is a need to improve the coverage of these programmes and increase the production of fruits and vegetables rich in micronutrients. It is required to integrate these programmes with resource conservation technologies like micro-irrigation, precision agriculture, postharvest management infrastructure, and marketing infrastructure (Manjunatha et al., 2017).

The studies show that home production of diverse food increases affordability and accessibility of nutritious diet. Improving access to kitchen garden have shown to have a strong association with household dietary diversity and child nutrition (Dev et al., 2020; Pandey, 2020). The local food and nutrition security can dampen the adverse effects of food supply shocks and food price volatility (Galhena et al., 2013). The food supply shocks can immediately impact children's nutritional status and persist in their adult lives (Hoddinott, 2013). Many such non-government and government initiatives of kitchen gardens have helped people achieve nutritional security. Few such initiatives are as follows-

An initiative ‘Gardens of Hope - Emergency Kitchen Gardens’ by Utthan, a Gujrat based NGO, helps vulnerable rural communities in four districts of Gujarat to grow their own chemical-free vegetables at home. Despite the financial crunch during the COVID-19 induced lockdown and the consequent livelihood crisis, the beneficiaries' nutritional needs were met. There is a unique sharing mechanism under which each family growing vegetables share the produce with three other families who do not have land, water resources, or currently not growing vegetables. It has been estimated that each person will get nutritional security of around 700 g/day from these kitchen gardens (Karelia, 2020).

A community-based malnutrition management programme by Vikas Samvad, a non-profit organization, in Madhya Pradesh, developed kitchen gardens in the backyards of 232 families across six districts. This initiative gave people self-sustenance and helped them during the

COVID-19 lockdown when the anganwadis were closed. Under this initiative, a network was created through which around 37 quintals of vegetables grown were shared among 425 families. The beneficiaries included 217 malnourished children, 140 pregnant, and lactating mothers, and 68 elderly persons (Sushma, 2020).

Realizing the importance of kitchen gardens, the Government of India has initiated a scheme of School Nutrition (Kitchen) Garden (SNG) that aims to address the malnutrition and micronutrient deficiencies and enhance the knowledge of children for nutritional traits of vegetables. It has been reported that after the introduction of SNG, consumption of fresh vegetables in the daily diet among the children increased in fourteen selected Higher Primary School and High schools of Raichur and Bagalkot districts of Karnataka (Kammar et al. 2017). Many state governments have also taken the initiative to promote the kitchen gardens. Odisha Livelihood Mission, as part of the farm livelihood/promotion of Nutrition-sensitive Agriculture, is promoting kitchen gardens. The Karnataka Horticulture department, with funds from MGNREGA is developing kitchen gardens called 'Akshara Kaitoota' in government schools. The vegetable gardens already existing in many schools to promote the consumption of vegetables and fruits. In Chhattisgarh, kitchen gardens are encouraged to secure livelihood for rural households by converging MGNREGA with the Panchayat and Rural development departments. To create awareness of the significance of vegetables and fruits, Tamil Nadu Horticulture Department has tied up with the School Education Department to establish roof gardens. Maharashtra, a joint initiative of Rajmata Jijau Nutrition Mission under the Department of Women and Child Development and Reliance Foundation, has developed kitchen gardens at anganwadi centres to grow fruits and vegetables (Suri, 2020).

Thus, households should be encouraged to have kitchen gardens with more diverse vegetables and fruits to take seasonality into account. Perennial vegetables and fruits depending on the agro-climatic conditions, should be encouraged. The role played by information and communication technologies (ICT) is very important in providing information regarding new crop varieties, seeds, fertilizers, weather, raising awareness about nutrition, etc.

b) Reducing postharvest losses

Another important pathway for ensuring food and nutrition security is to reduce PHL. India is the second-largest producer of food next to China. However, in India, only 2.2 percent of the farm produce is processed against around 23 percent in China. A high level of PHL in India is unacceptable when a large section of the population is undernourished. More than half of women suffer from anaemia, which is one reason for the high rate of low-birth-weight babies (CNNS, 2019). These high levels of losses are mostly due to improper handling, inadequate transportation and packaging, low storage, and poor postharvest management.

It is being reported that the use of postharvest technologies like storage bags and drums and the application of postharvest loss management practices have positive outcomes on farmers' price realization (Boss & Pradhan, 2020). New and innovative methods are required to reduce the PHL and manage the harvest properly. At Tamil Nadu Agricultural University, researchers have developed a method to control losses in package houses, transportation, and retail shops by spraying Enhanced Freshness Formulation (EFF) on trees before the harvest and dipping fruits in EFF solution. The method slows down ripening and controls losses at the farm level (ToI, 2018). Such technologies should be encouraged after assessment of environmental and health impacts.

Strong farm-firm linkages might also facilitate in reducing PHL by providing assured markets. These institutional services and reducing PHL can also help smallholders raise their productivity and income and mitigate the risks involved in participating in the markets for high-value crops, livestock, and fishery products. However, achieving these goals will require new institutions and innovations to develop supply chains and facilitate linkages between farmers, wholesalers, processors, and retailers. These institutions and innovations may include various contract farming models, including those by farmer groups and private-sector resource intermediation (Gulati et al., 2008).

Thus, a holistic approach engaging proper postharvest storage and management technologies, institutions for efficient marketing of the products, and food processing and packaging technologies is required to reach to end consumer with its original nutritional value, intact or enhanced.

c. Bio-fortification of staples and improving awareness

Bio-fortification may be one of the more cost-effective solutions to provide the desired levels of nutrients. Indian diets are shifting towards high-value crops, and more emphasis should be given to bio-fortifying vegetables and fruits along with staples in India. The initiative of distributing bio-fortified staples grains through PDS will help in reducing hidden hunger. There is a need to develop the supply chain for bio-fortified crops. ICT initiatives of both public and private sectors can improve awareness among the farmers to adopt bio-fortified crops and among consumers for safe and natural nutrient-rich primary and processed produce. The involvement of food business firms is required along the supply chain for broader adoption by the consumers. However, food businesses require guidance for food product development and marketing of bio-fortified food products (Walton, 2019).

d) Empowerment of women

Empowering women has been shown to positively impact dietary diversity (Malapit et al., 2015; Pandey et al., 2016). As discussed, women's education has a significant role in improving children's dietary diversity and nutritional status. Hence, there is a need for targeted policies to increase women's education and empower them for a healthy diet.

According to NSSO, India’s female literacy rate was 70.3 percent in 2017-18, which has improved from 65.5 percent in 2011 (Census 2011). GoI has taken many initiatives to empower women. The Right to Education Act (RTE) came into force in 2010 for free and compulsory education for children between 6 and 14. The central government introduced the Beti Bachao Beti Padhao (BBBP) campaign in 2015 to address the declining sex ratio and improve girls' education level. The Samagra Shiksha scheme was launched in 2018-19 to make good quality education accessible and affordable to all. This scheme subsumes the three Schemes of Sarva Shiksha Abhiyan, Rashtriya Madhyamik Shiksha Abhiyan, and Teacher Education. To empower the adolescent ‘SABLA’ scheme was launched in 2010 to improve their nutritional and health status and promote awareness about health, hygiene, and nutrition.

The role of women in Indian agriculture is increasing. Nearly 77% of the total rural women workforce is employed in this sector (Labour Bureau, 2011). Conditions under which women are engaged (for example, prolonged exposure to fertilizers, pesticides, long working hours) and the support systems to strengthen women's capacity to care for themselves and their

children are of utmost importance. Easy access to maternity entitlements (JSY, THR), optimum quality daycare facilities for children within the community and at the place of work is critical to strengthen caring capacity and translate higher incomes.

A greater emphasis on women's collectives[11] Based on primary surveys, Agarwal (2018) examines the impact of group farming by women on productivity and profitability in Kerala and Telangana. The farms of women's groups under Kudumbashree (also called joint liability groups) in Kerala performed much better than the predominantly male-managed individual farms in their annual value of output per hectare and annual net returns per farm. In the case of Telangana group, farms (Samatha Dharani Groups) perform much worse than individual farms in annual output but are equivalent in net returns. The study finds that groups do much better in commercial crops in both states than in traditional food grains (Agarwal, 2018). The study demonstrates that group farming can provide an effective alternative, subject to specified conditions, and adapt the model to the local context.

e) Enforcing Standards of Foods Safety, Packaging, and Labelling

Food safety has become a serious issue with its public health implications. In response to the increasing number of FBD, GoI has intensified the efforts to improve food safety by supply and demand-side interventions. FSSAI is in the process of revising Food Safety and Standards (Packaging and Labelling) Regulations 2011, with having three different regulations dealing with packaging, labelling, and Advertisement & claims requirements.

Food processing and packaging can preserve the available nutrients and even enhance the shelf life and nutrient content of foods. Thus, proper processing and packaging can help make nutritious foods to reach those vulnerable groups who cannot access or afford fresh products. The micronutrients can be added to less nutrient-dense foods by food fortification during food processing. However, fortifications have some limitations, as discussed in section 5. In the case of unhealthy ingredients present in the food, product reformulation can be carried out, e.g., reducing sodium and trans-fats (HLPE, 2017).

[11] has shown positive results. The NGO Deccan Development Society (DDS), for example, enables women from landless families to access various government programs to establish land claims, through purchase and lease.

There is also a need to regulate and monitor the labelling of processed food products. The processed foods can contain high amounts of certain ingredients that are not healthy, such as "hidden" salt, which consumers may not be aware of and maybe desensitize to those amounts (HLPE, 2017). The evidence shows that food label information of quality and nutrition, production and storage processes influence informed decision-making by the consumers (Ali and Kapoor, 2009). A study in the village of South Delhi by Bhilwar et al. (2018) reported that about 64.1 percent of the consumers read food labels. Still, a majority of them (86 percent) only check for the manufacture and expiry dates. Generating awareness would be required to improve this behaviour. The factors that influence reading labels are associated with the study participants' educational status, socioeconomic status, and body mass index (Bhilwar et al., 2018). Therefore, in the areas with lower education levels, regulatory policies need to be followed strongly for promoting and marketing healthy foods.

FSSAI is in the process of overhauling the labelling regulations for packaged food products. The draft regulations propose colour-coded front-of-pack nutrition labelling to enable consumers to identify high fat, salt, and sugar products. Accordingly, the product will have a red colour if the total amounts of calories, fats, trans fats, sugar, and sodium per serving exceed the recommendations. However, there are some concerns from people and food industries related to the proposed labelling regulation, such as it is intended for individuals who are literate and nutritionally aware, the colour red is a danger sign and might deter consumers from the products, etc. (Pande et al, 2020)

Indian food regulation lays more emphasis on food adulteration due to its being an important issue. However, there is a need to focus on other food safety issues, also together with food adulteration. A study by Sudershan et al. (2008) in South India has reported that the food regulators' knowledge of basic food microbiology was limited. These regulators were not equipped to check newer adulterations. Their knowledge of health/nutrition claims on food labels, too, was almost nil.

It is being reported that the effectiveness of the FSSAI is not very satisfactory, and there are several shortcomings in its functioning (Siruguri, 2018). Thus, it is required to enforce the standards and regulations more effectively by removing the deficiencies and considering people and industries' concerns. FASSI is in the process of fixing some of its shortcomings for a safe and sustainable diet.

f) Improving WASH

Access to adequate WASH and clean cooking fuel is crucial for nutritional security, as discussed in section 5.2. GoI has taken many initiatives towards improving WASH, such as Jal Jeevan Mission (JJM) and Swacch Bharat Mission (SBM) (Clean India Mission). JJM aims to provide Functional Household Tap Connection to every rural household by 2024. Under SBM, around 10.28 crores of toilets were built, and the coverage of rural sanitation increased from 34 percent in 2014 to 100 percent in 2019. The usage of these toilets is reported to be around 95 percent (GoI, 2019). SBM is now moving towards Phase II of SBM-Grameen to ensure that the open defecation free behaviours are sustained, no one is left behind, and that solid and liquid waste management facilities are accessible. These programmes will help in reducing FBD.

(g) Implementation of food safety and nutrition programmes

Pathways for a sustainable diet that is safe and healthy need sustainable food systems and require better implementation and synergy between different policies and programmes. To achieve SDG 2 of reducing hunger and malnutrition by 2030, effective implementation of programmes can contribute significantly in attaining the targets. The MGNREGA positively impacted child and woman well-being. It has also been shown to positively impact household income, empowerment, and well-being of women and improve children's nutrition and health and education and reduce child labour. Apart from its direct benefits, it has secondary benefits such as creating assets for agriculture and rural development, more women's participation, helping marginalized sections like SCs and STs reducing distress migration, and involvement of panchayats, etc.

The Public Distribution System (PDS) is a critical instrument towards improving food security at the household level in India. The impact of ICDS on child nutrition and protecting children's rights is quite limited. There is a need to increase its coverage to ensure rapid universalization, change the design, and restructure it with higher allocations of funds and effective implementation. The ICDS programme must effectively integrate the various elements that affect nutrition and reflect children's different needs in different age groups. The midday meal has helped reduce serious malnutrition, and for older children (aged 11-12), there is evidence of significant positive impacts on children's learning. Supplemental income can be started with old age populations by enhancing the amount of old-age pensions scheme and making it nearly universal.

(h) Nutrition education and food safety awareness

It has been recognized that education, especially for women, is associated with a reduction in the mortality rate, dietary diversity, and improved nutrition (Pandey, 2020; Gillespie and Haddad, 2003; Alderman and Headey, 2017; Spears, et al., 2013; Gulati et al., 2012).

There is a need to make nutrition education and nutrition information part of the education system and be integrated with other community programmes to improve the intake of nutritious food in a safe and hygienic manner. It is shown that when nutrition information is provided, consumer acceptance and willingness to pay increases for healthy food (Banerji et al. 2016).

i) Use of ICT

ICT can play a vital role in providing useful information such as nutrition-sensitive messages, healthy meal menus, recipes, etc. and educating people about lifestyle recommendations. ICT can also be used for real-time monitoring, data management, and convergence of schemes. Radio broadcasting can be a medium for comprehensive coverage in a less expensive manner related to food safety measures, labelling, etc. Penetration of mobile phones has rapidly increased in India. It can be used to disseminate different information related to food safety, food handling, processing, etc., such as information about ways to preserve food, the requirement of products at various stages of the food supply chain to avoid wastage. The information can be sent in the local language and can also engage symbols and digital pictures, as smartphone users have increased.

Identification and traceability issues have gained prominence in food systems. A food traceability system is an essential tool for managing food quality and safety risks and developing effective supply chain management. The traceability techniques used in India are radio-frequency identification (RFID) tags to track inventories, Holograms, Barcode, Nuclear techniques, and other tracking media to monitor the production process. Dandage et al., (2017) have reported that the development of an effective food traceability system is adversely affected by factors like restrictive government marketing standardization, uncertain policies, and unstable actions for food safety. Inefficient infrastructure in the market area and the supply chains, and inadequate agricultural practices with many small and medium players further make the system difficult to work.

Thus, for achieving food and nutrition security, sustainable food systems are required through multi-pronged strategies with better targeting and coordination between different policies and programmes. In India, these strategies need to focus on improving dietary diversity, kitchen gardens, reducing postharvest losses, bio-fortification of staples with its inclusion in safety net programmes, women's empowerment, enforcement of standards and regulations, improving WASH, nutrition education, and effective use of digital technology in more innovative ways in food systems. The recent fact sheets of NFHF-5 indicate that besides WASH, women empowerment, and education status, other factors like household income, personal hygiene, health information, and nutrition knowledge might be critical for sustainability in improving nutritional outcomes. In the future, food and nutrition security initiatives will have to be tuned in keeping with changing demographic structure, livelihood patterns, climate change, and health-specific needs. They also have to be linked with the overall development activities of the country.

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Annexure 1: Balanced Diet for Indian Adults - Sedentary/ Moderate/ Heavy Activity (Number of portions)

		Type of work					
	g/portion	Sedentary		Moderate		Heavy	
		Man	Woman	Man	Woman	Man	Woman
		No. of portions					
Cereals & millets	30	12.5	9	15	11	20	16
Pulses	30	2.5	2	3	2.5	4	3
Milk & milk products	100 ml	3	3	3	3	3	3
Roots & tubers	100	2	2	2	2	2	2
Green leafy vegetables	100	1	1	1	1	1	1
Other vegetables	100	2	2	2	2	2	2
Fruits	100	1	1	1	1	1	1
Sugar	5	4	4	6	6	11	9
Fat	5	5	4	6	5	8	6

Source: NIN, (2011)

Note: The number of portions to be consumed varies according to the level of activity in the guidelines.

Annexure 2: WHO recommendation for the quality of complementary feeding practices for children aged 6 to 23

Children received foods from four or more of the following food groups: a) infant formula, milk other than breastmilk, or other milk products; b) grains or roots, c) vitamin A-rich fruits and vegetables; d) other fruits and vegetables; e) eggs; f) meat, poultry, fish, shellfish, or organ meats; g) beans, peas, lentils, or nuts; h) fat.

Minimum meal frequency is receiving solid or semi-solid food at least twice a day for infants 6–8 months and at least three times a day for children 9–23 months for breastfed children. For non-breastfed children aged 6–23 months, minimum meal frequency is receiving solid or semi-solid food or milk feeds at least four times a day.

Breastfed children aged 6–23 months are considered to be fed a minimum acceptable diet if they are fed the minimum dietary diversity and the minimum meal frequency. Non-breastfed children aged 6–23 months are considered to be fed a minimum acceptable diet if they receive other milk or milk products at least twice a day, receive the minimum meal frequency and receive solid or semi-solid foods from at least four food groups not including the milk or milk products (dairy) food group.

Annexure 3: SPANDAN survey

The analysis is based on the integrated survey of agriculture and nutrition undertaken jointly by Indira Gandhi Institute of Development Research, Mumbai and National Institute of Nutrition (NIN), Hyderabad, in the rural areas of selected districts of Bihar and Odisha. The data was collected from October 2014 to December 2015 as part of the Bill and Melinda Gates initiative of 'System of Promoting Appropriate National Dynamism for Agriculture and Nutrition' (SPANDAN) (www.SPANDAN-India.org). The survey covered a total of 4100 households of which 2047 households from eight districts of Bihar and 2053 households were from ten districts of Odisha (See Dev et al.(2020) for survey design).

Annexure 4: Association between agriculture diversity and household dietary diversity (OLS)

	(1)	(2)	(3)	(4)
	HDDS (without socio-economic)	HDDS (with socio-economic)	HDDS (without socio-economic)	HDDS (with socio-economic)
	Production diversity		Consumption from home produce	
	b/se	b/se	b/se	b/se
Agricultural diversity				
Crop group diversity	0.541***	0.524***		
	(0.19)	(0.19)		
Crop group diversity square	-0.103**	-0.104**		
	(0.04)	(0.04)		
Kitchen garden diversity	0.023**	0.010		
	(0.01)	(0.01)		
Livestock diversity	-0.053*	-0.021		
	(0.03)	(0.03)		
Forest collection-food	-0.047	-0.017		
	(0.03)	(0.03)		
Consumption crop prod=0			0.000	0.000
			(.)	(.)
Consumption crop prod=1			0.145	0.154
			(0.11)	(0.11)
Consumption livestock prod=0			0.000	0.000
			(.)	(.)
Consumption livestock prod=1			0.256***	0.224***
			(0.05)	(0.05)
Consumption CPR prod=0			0.000	0.000
			(.)	(.)
Consumption CPR prod=1			-0.264***	-0.153*
			(0.08)	(0.08)
Consumption Kitchen garden prod=0			0.000	0.000
			(.)	(.)
Consumption Kitchen garden prod=1			-0.030	-0.068
			(0.05)	(0.05)
Household characteristics				
Consumption expenditure	0.328***	0.217***	0.325***	0.215***
	(0.06)	(0.06)	(0.06)	(0.06)
Landless	0.000	0.000	0.000	0.000
	(.)	(.)	(.)	(.)
Less than 1 acre	-0.133	-0.175**	-0.160	-0.203*
	(0.08)	(0.08)	(0.10)	(0.10)
1-2 acres	0.038	-0.075	0.034	-0.084

	(0.09)	(0.09)	(0.10)	(0.10)
Greater than 2 acres	0.248***	0.050	0.255**	0.049
	(0.09)	(0.09)	(0.11)	(0.11)
Irrigated percentage	0.001	0.001*	-0.000	0.000
	(0.00)	(0.00)	(0.00)	(0.00)
Family size	-0.063***	-0.066***	-0.069***	-0.069***
	(0.02)	(0.02)	(0.02)	(0.02)
Number of children	-0.032	-0.004	-0.034	-0.008
	(0.05)	(0.05)	(0.05)	(0.05)
Age of the head of the household	0.011***	0.007***	0.010***	0.006***
	(0.00)	(0.00)	(0.00)	(0.00)
Adult female lit=0	0.000	0.000	0.000	0.000
	(.)	(.)	(.)	(.)
Adult female lit=1	0.312***	0.091*	0.327***	0.096**
	(0.05)	(0.05)	(0.05)	(0.05)
Head lit =0	0.000	0.000	0.000	0.000
	(.)	(.)	(.)	(.)
Head lit = 1	0.321***	0.187***	0.312***	0.177***
	(0.05)	(0.05)	(0.05)	(0.05)
Religion: Hindu		0.000		0.000
		(.)		(.)
Muslims		0.140		0.110
		(0.10)		(0.10)
Others		-0.382		-0.384
		(0.26)		(0.27)
Caste: SC		0.000		0.000
		(.)		(.)
ST		0.059		0.053
		(0.10)		(0.10)
OBC		0.327***		0.318***
		(0.07)		(0.07)
General		0.429***		0.417***
		(0.09)		(0.09)
Others		0.101		0.081
		(0.17)		(0.18)
Toilet: Open Defecation		0.000		0.000
		(.)		(.)
Pit/Flush Toilet		0.326***		0.313***
		(0.08)		(0.07)
LPG no = 0		0.000		0.000
		(.)		(.)
yes		-0.056		-0.032
		(0.07)		(0.07)
Drinking water: Unclean		0.000		0.000
		(.)		(.)
Clean		0.224**		0.234**
		(0.10)		(0.10)

Wealth: 1st quantile		0.000		0.000
		(.)		(.)
2nd quantile		0.149**		0.146**
		(0.06)		(0.06)
3rd quantile		0.301***		0.322***
		(0.07)		(0.07)
4th quantile		0.421***		0.433***
		(0.09)		(0.09)
5th quantile		0.693***		0.687***
		(0.09)		(0.09)
No Ration Card		0.000		0.000
		(.)		(.)
BPL & Others		0.104*		0.101*
		(0.06)		(0.06)
Community characteristics				
PDS: No	0.000	0.000	0.000	0.000
	(.)	(.)	(.)	(.)
Yes	0.171*	0.092	0.183*	0.102
	(0.10)	(0.08)	(0.10)	(0.08)
Aganwadi: No	0.000	0.000	0.000	0.000
	(.)	(.)	(.)	(.)
Yes	0.115	0.173	0.113	0.162
	(0.15)	(0.15)	(0.15)	(0.15)
APMC: No	0.000	0.000	0.000	0.000
	(.)	(.)	(.)	(.)
Yes	0.020	-0.002	0.026	0.004
	(0.13)	(0.13)	(0.13)	(0.13)
Metalled road: no	0.000	0.000	0.000	0.000
	(.)	(.)	(.)	(.)
yes	0.036	0.034	0.048	0.037
	(0.12)	(0.11)	(0.11)	(0.11)
ACZ: NC Plateau	0.000	0.000	0.000	0.000
	(.)	(.)	(.)	(.)
E&SE Coastal Plain	0.190	-0.064	0.252	-0.020
	(0.24)	(0.24)	(0.24)	(0.24)
MC Table Land	0.650**	0.407	0.730***	0.476*
	(0.28)	(0.28)	(0.27)	(0.26)
E Ghat Highland	0.601***	0.417**	0.657***	0.459**
	(0.20)	(0.19)	(0.21)	(0.19)
W Undulating Zone	0.931***	0.748***	0.998***	0.806***
	(0.17)	(0.17)	(0.17)	(0.16)
NE alluvial plain	0.848***	0.523***	0.848***	0.536***
	(0.19)	(0.20)	(0.20)	(0.20)
NW alluvial plain	0.854***	0.470**	0.914***	0.528***
	(0.19)	(0.20)	(0.20)	(0.19)
1SBihar alluvial plain	0.277	-0.076	0.273	-0.076
	(0.22)	(0.21)	(0.22)	(0.21)

2SBihar alluvial plain	0.544**	0.189	0.556**	0.200
	(0.21)	(0.21)	(0.22)	(0.21)
Constant	2.825***	3.511***	3.293***	3.965***
	(0.48)	(0.49)	(0.46)	(0.47)
N	3802.000	3799.000	3802.000	3799.000
r2	0.124	0.172	0.128	0.174

Note: ***,**,* represents significance at 1 percent, 5 percent and 10 percent level respectively. The standard errors are in parentheses.

Annexure 5: Demand-supply projections and gaps (Million tons)

Commodities	Year	Supply projection	Demand projection	Demand- supply gap
Rice	2020	108.1	111.8	-3.7
	2030	122.1	122.4	-0.3
Wheat	2010	104.2	98.3	5.9
	2030	128.8	114.6	14.2
Coarse cereals	2020	50.4	42.5	7.9
	2030	64.2	47.2	17.0
Total cereals	2020	262.6	252.6	10.0
	2030	315.1	284.2	30.9
Pulses	2020	20.7	21.9	-1.3
	2030	26.4	26.6	-0.2
Food grains	2020	281.2	274.4	6.8
	2030	338.8	310.8	28.0
Edible oils	2020	12.5	17.0	-4.5
	2030	19.1	21.3	-2.1
Sugar	2020	33.4	33.1	0.3
	2030	40.3	39.2	1.1
Vegetables	2020	186.4	155	-13.1 (Post harvest losses (PHL) 23.99 percent)
	2030	210	192	-32.0
Fruits	2020	97.7	81	-2.7 (PHL 20 percent)
	2030	116.4	103	-9.9
Milk	2020	156.6	138	10.4 (PHL 5.03 percent)
	2030	188.7	170	8.8
Eggs	2020	4.7	4.4	0.1 (PHL 5.02 percent)
	2030	6.2	5.8	0.1

Source: Kumar et al., 2016

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