WORKING PAPER 202/2020

EFFECT OF FARMING SYSTEM FOR NUTRITION ON NUTRITIONAL INTAKES: A STUDY OF TWO REGIONS IN INDIA

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Price : Rs. 35

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Abstract

In nutrition insecure regions of rural India, farming system with focus on nutrition (or FSN) can prove effective in improving access and availability for nutrient intake. In 2017, a few villages in Koraput district, Odisha and Wardha district, Maharashtra were involved to increase their crop diversity, intercropping of pulses and cereals, promotion of seasonal fruits and vegetables and nutrition awareness. About 75-80 percent of households voluntarily agreed to involve, for whom the reported dietary habits were recorded in 2014, before the FSN interventions and in 2017, after the interventions. This study reports the findings from reported dietary changes for the two years. Household food consumption is converted into its nutrient content and normalized by the demographic composition of the households. The intake of micronutrients like vitamin A, vitamin C, iron and calcium show larger improvements compared to calories and proteins. This is partly because the intervention focused more on dietary quality than in improving energy dense food. The changes are more apparent in Wardha as their nutrient intakes and dietary diversity were low in 2014. Households in Koraput benefitted substantially from the newly introduced schemes for clean cooking fuel and sanitation thereby improving hygienic environment that would enable improved nutrient absorption.

Key words: *Rural, Household Survey, Crop Diversification, Home Garden, Nutrition*

JEL Codes: *D13, I15, Q12, Q18, R11*

Acknowledgement

This research is part of the data generated by the Leveraging Agriculture for Nutrition in South Asia Research (LANSA) research consortium, and is funded by UK Aid from the UK government. The views expressed do not necessarily reflect the UK Government's official policies. The results of the study were presented in the 3rd Agriculture, Nutrition and Health (ANH) Academy week from 25-29 June, 2018 at Accra, Ghana; Symposium on Leveraging Agriculture for Nutrition at Golden Jubilee Conference of Nutrition Society of India, November 2018 at National Institute of Nutrition, Hyderabad; Workshop on Agriculture and the Imperatives of Food and Nutrition Security organized by IIT Bombay, APAARI and NABARD 6-7 Dec 2018, Mumbai and International Consultation on Promoting Nutrition- Sensitive Approaches: Linking Agriculture, Health and Nutrition towards Malnutrition free Odisha organised by Dept. of Panchayati Raj and Drinking Water, Govt. of Odisha Supported by Azim Premji Philanthropic Initiatives (APPI) 18 Oct 2019, Bhubaneswar.

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INTRODUCTION

Poor nutritional status affects the productivity of the adults and the physical growth and cognitive abilities of the children impairing their economic mobility as an adult and hence generates a vicious cycle of poverty and undernutrition. Several production and consumption based interventions that were implemented over the years to reduce nutrition insecurity have been effective only in a limited manner. During the decades of higher economic growth, the better skilled in the organized services sector benefitted the most with least gains for those in the agricultural sector. The period of high economic growth in India was not able to absorb the surplus labour from rural areas. However, this period saw the implementation of schemes like National Rural Employment Guarantee Scheme and investment in rural roads through *Pradhan Mantri Gram Sadak Yojana* resulting in increased wages and consumption among the poorer sections of the rural population alongside a modest decline in poverty rates. Thus, there had been a decline in undernutrition rates during this period but the reduction was not commensurate with the high economic growth and India still accounted for large numbers of stunted and underweight children and neonatal mortality rates. The irony is in the fact that those involved with food production system are among the highly nutrition insecure.

One of the major limitations of many of the earlier interventions in the Indian context has been its inability to connect farming activities with the household member's nutritional security. The farming system for nutrition (FSN) approach (Das *et. al.*, 2014; Nagarajan *et. al.*, 2014) gives the scope to introduce location specific agricultural activities to address food and nutrition security of small holder farmers. The systemic approach emphasizes strongly on creating awareness (by the intervention team) not only on farming and home gardens but also on diets, hygiene and access to public programs that could subsidise cost of production, or of basic commodities or of health care. Thus, FSN gives scope for involvement of different stakeholders around a cluster of villages aiming

at sustainability of the agriculture-nutrition linkage and gives equal priority to behavioural change among both food producers and food consumers. This is different from nutrition-sensitive agriculture, where food based approach to agriculture is at the core and other features mentioned under FSN were included later (Ruel *et. al.*, 2018).

A feasibility study on a Farming System for Nutrition (FSN) approach to address the problem of undernutrition was undertaken in India under a research consortium programme on 'Leveraging Agriculture for Nutrition in South Asia' (LANSA). LANSA was a multi country research programme consortium funded by Department for International Development, UK. The core research question underlying the study was: *How strong is the evidence that agricultural interventions can be pro-nutrition*? FSN as defined by Professor M S Swaminathan, envisages the introduction of location-specific agricultural remedies for nutritional maladies by mainstreaming nutritional criteria in the selection of farming system components involving crops, animals and wherever feasible fish (Nagarajan *et. al.*, 2014). It is an interventional approach that includes a combination of sustainable measures including advanced crop production practices, bio-fortification, promotion of nutrition gardens of fruits and vegetables, livestock and poultry development, and setting up of small-scale fisheries, combined with nutrition awareness, as stimulant for rendering consistent output of higher income and better nutrition. The objective is to address malnutrition in all its forms, viz. calorie deprivation, protein deficiency and hidden hunger (i.e. micronutrient deficiencies).

This study documents the findings on changes in per consumer unit energy and protein intake and intake of four micronutrients among households that participated in FSN intervention in a few villages belonging to two different agro-climatic regions of India. The findings are based on a feasibility study and not an experimental study. The interventions involved an increase in production of some of the existing crops, as well as diversification and nutrition awareness, and thus have

four components. The crop based interventions focused not just on increasing output of the existing ones but also on diversification so that improving soil quality becomes an added feature. Home garden intervention focused on increasing availability of fruit, leafy and other vegetables, roots and tubers to specifically improve micronutrient intake. Poultry and fisheries intervention focused on improving protein intakes. Nutrition awareness interventions focused on generating awareness about nutrient content in different foods and the importance of balanced diet. Thus, in this study comparison is on the household nutrient intakes, adjusted for age-sex composition of the household (i.e. intake of per consumer unit of different nutrients), as reported by the households, before and after the introduction of FSN interventions. The baseline survey was conducted in 2014 and the endline survey was in 2017.

INTEGRATION OF FOOD AND NUTRITION SECURITY: AN OVERVIEW

In 2017-18, about 50 percent of households are involved with agriculture as the main activity with 56 percent of rural males and 73 percent of rural women involved with agriculture as the main source of employment (GoI, 2019). The share of agriculture in GDP declining to about 13 percent in 2019 and undernutrition rates among children less than five years of age, for stunting (41 percent) and wasting (38 percent) being ten percentage points higher in rural than in urban areas in 2015. Those in rural areas and more likely to be involved with agriculture tend to share burden of nutrition insecurity in India. Shetty (2009) discusses the opportunity that agriculture and agricultural biotechnology offers for increasing food and nutrition security. The increased availability of food with higher nutrient content from biofortification as well as increased crop yields and crop diversification ensure both food and nutrition security. Since the non-availability of nutritious food has been one of the important reasons for high undernutrition in several regions of the world, interventions that increase the supply become imminent.

In most of the undernourished regions of the world, agriculture is the main occupation of the people. Nutrition-sensitive agriculture (NSA) that gives the scope to enhance production, productivity and crop diversification is the food based approach to increase availability of nutritionally rich food for overcoming undernutrition and micronutrient deficiencies. The pathway for increased and a more smoothened consumption is from either own produce (in the absence of markets) or from market purchases or in some instances from both (Ruel *et. al.*, 2018). The monetized part of consumption arises from increase in incomes due to sale of agricultural produce in the markets. This results in improved accessibility and affordability towards purchase of more diversified food items.

A smoothened consumption of diverse diets is only one aspect to improve nutrition security. Supply of health care and clean environment (which includes clean water, sanitation and clean cooking fuel) is also an important input to maintain good health. In the absence of these, the absorption of nutrients is weak and impairs cognitive development of young children and hence affects their long term productivity as adults. In the short run, timely intervention to health setbacks as well as a disease free environment ensures lower morbidity and mortality of children and adults. Infrequent illness of adults has positive implications for smooth flow of incomes as well as the care time that mothers give towards the upbringing of healthy children *in-utero* and beyond. Education and women's empowerment are two key demand side factors that strongly influence food and nutrition security as they play a strong role in reducing the adverse influence of cultural factors like gender discrimination, or adverse dietary and health practices. The inclusion of a strong behavior change communication (BCC) component in any intervention becomes imperative for enhancing the potential impacts of agriculture on diets and other nutrition outcomes.

The role of the state in regulating the market that benefits both net producers and net consumers of food and provision of services like

transportation, storage, health and education are very relevant. In order to improve nutrition security, government intervention alone will not succeed and the role of the community of individuals involved with agriculture and related non-governmental organizations is very important. As a country develops, it is now increasingly envisaged that the state will be more of a regulator so that the synergies between market and community (the other two stakeholders) will result in minimizing the trade-off between efficiency and equity.

Clearly, a nutrition sensitive agriculture intervention should have all these features and farming system for nutrition has been envisaged keeping these aspects in mind and hence is unique to the nature of interventions. As agriculture is primarily a rural activity, the studies focus mainly on rural areas and that too among the farming households as they possess the land and are the target for agricultural intervention. However, this gives a partial assessment as agricultural labour households are also a part of the farming system but as they do not possess land hence get excluded from direct participation in the crop intervention programs. However, such households can participate in FSN interventions like poultry or home-garden interventions. Besides, farming system interventions are expected to have an overall impact on the local food systems. On the one hand there will be an increase in diversified availability of food in the local market. On the other hand, in order that net producers benefit from the surplus production the net consumers should also have enhanced purchasing power to buy from the market. This may be possible for instance, when agricultural labour households could benefit through increased demand for labour due to the FSN intervention and hence increased returns to labour which makes diversified diets affordable. Studies rarely discuss this aspect of the entire rural economy benefitting from crop diversification. Such features as well as the effect on nutrient outcomes are not discussed in this study and this study highlights only the impact of crop diversification on nutrient intakes.

Agriculture and Nutrition Linkages

The overall objective of nutrition-sensitive agriculture as given by FAO (2014) is to make the global food system better equipped to produce good nutritional outcomes. FAO has reported that nutrition-sensitive agricultural approach can be implemented by increasing agricultural production which makes more food available and affordable and improves both the health and the economic status of the community. Family farming, home gardens and homestead food production can make a wider variety of crops available at the local level.

Ruel *et. al.*, (2018) reviewed the evidence from research on nutrition–sensitive agriculture published since 2014 and reported that agricultural development programs that promote production diversity, micronutrient-rich crops (including biofortified crops), dairy, or small animal rearing, can improve the production and consumption of targeted commodities, and that such improvements lead to increase in dietary diversity at the household level. Herforth (2010) found that crop diversity in smallholder farmers' diet was significantly associated with dietary diversity and was more closely related to home food consumption than to purchased food consumption; farmers used many varieties of the same crop for different purposes, and within-crop diversity was correlated with increased consumption of that crop. Empirical results from both the dynamic and linear models using panel data covering 41 countries from 1980-2009, showed that agricultural productivity have a significant positive effect on all food security measures (Ogundari and Awokuse, 2016).

Pellegrini and Tasciotti (2014) show based on nationally representative data for early 2000s from eight developing countries, that there is a positive association between the number of crops produced and the number of foods consumed by the rural households. The study also shows that ownership of livestock and ruminants are also associated with increase in dietary diversity. The access channel seems to be the key pathway. The landless households are not separately analysed but

the land area and crop diversification does not seem to show a strong association. In the econometric specification, once crop diversification is controlled for, land area is not statistically significant indicating that land size and number of crops could be correlated. However, crop specialization could be more prevalent in large farm area due to scale economies and the higher income that this may fetch compared to small farms where the scope for interspersed vegetables could improve crop diversification. Smallholder farmers are likely to diversify in production and they are also the ones at the lower end of dietary diversity.

A study by Hazel *et. al.* (2015) in Nepal showed that production diversity is positively associated with maternal and child dietary diversity, and WHZ; women's group membership, control over income, reduced workload, and overall empowerment are positively associated with better maternal nutrition. Control over income is positively associated with HAZ; Women's empowerment mitigates the negative effect of low production diversity on maternal and child dietary diversity and HAZ. Headey and Hoddinott (2016) reported that rice yields predict the earlier introduction of complementary foods to young children (most frequently rice) as well as increases in their weight-for-height, but no improvements in their dietary diversity or height-for-age. For improvement in an adult woman's BMI, dietary diversity matters, and equal importance must be given to environmental conditions like better quality of drinking water, good sanitation, smoke-free cooking area and better access to healthcare facilities (Viswanathan *et. al.*, 2015).

STUDY LOCATION

The FSN study under LANSA was conducted in seven villages of Koraput district in the state of Odisha and five villages of Wardha district in the Vidarbha region of Maharashtra. These locations were purposively selected due to the contrasting features with regard to agro-climatic and socio-economic conditions, land holding status, agricultural practices and food consumption pattern. The villages were chosen on the basis of their

contrasting agro-climatic and socio-economic characteristics, agricultural practices and food consumption pattern. Both the locations, Wardha district in Maharashtra and Koraput district in Odisha were districts declared as high burden districts of malnutrition by government of India. Though both sites are rain-fed farming areas, Koraput is characterised by subsistence farming, while Wardha is dominated by commercial crop cultivation (Das *et. al.*, 2014). The harvested agriculture produce were mostly sold in markets and very less or no produce was retained for household consumption. The food consumption pattern was cereal based as most of energy was from cereals. Agrarian crises and farmer suicide has been extensively documented in Wardha while Koraput is an agro-biodiversity hotspot, threatened by erosion of natural resources and food insecurity (Bhaskar *et. al.*, 2017).

The child (age 0-71 months) underweight rate in 2002-04 (IIPS, 2006) was 52.5 percent in Wardha and 43.5 percent in Koraput. In a decade's time by 2015-16, this decreased to 36.1 percent in Wardha and 44.4 percent in Koraput, according to NFHS-4 (IIPS and ICF, 2017 and 2018). Further, the prevalence of anemia in Wardha district was 48.5 percent among 6-59 months children, 42.4 percent among 15-49 years women and 43.4 percent among pregnant women in the same age group; in Koraput district, 71.4 percent of 6-59 months children, 63.4 percent of 15-49 years women and 60.5 percent of pregnant women were anaemic.

Majority of people in the selected villages belonged to scheduled tribes and lived in *kutcha* houses. Wood was used as a major source of cooking fuel. In Wardha, half of the population sourced water from piped water while in Koraput, it was sourced from tube well. Open defecation was practiced by majority of the households in both the locations. More than half of the head of the households did not have formal education in Koraput and in Wardha, 77 percent of the heads of households had formal education. Majority of them were cultivators followed by agricultural wage laborers with 80.7 percent as marginal farmers in

Koraput and 25.9 percent as small and 18.9 percent medium farmers in Wardha. Nearly half of the households in Koraput had backyard kitchen garden while in Wardha only 15 percent of households had backyard garden. The detailed baseline demographical profile of the study population, agriculture pattern, household food consumption pattern and nutritional status of the population based on baseline survey in 2014, are given in detail in Bhaskar *et. al.* (2017). Endline survey was conducted in 2017; Table 1 lists different aspects of the survey conducted and the timeline.

Table 1: Timeline of the Surveys

S.no	Particulars	Period of data collection	
		Baseline	**Endline**
1	Household survey on demography, agriculture and socio-economic aspects	Wardha and Koraput: January to February 2014	Koraput: June to July 2017; Wardha: July to August 2017
2	Agriculture, animal husbandry and home garden	Wardha and Koraput: January to March 2014	Koraput: June to July 2017; Wardha: July to August 2017
3	Food consumption frequency survey	Wardha and Koraput: 2014 (3 rounds) 1. January to March, 2. April to June 3. October to December	Koraput: October 2017 Wardha: September-October 2017*
5	Nutrition survey (anthropometry)	Wardha: January to March 2014; Koraput: April to May 2014	Koraput: June to July 2017; Wardha: July to August 2017

Note: *Food frequency survey was conducted once at endline and compared with the same season at the baseline

STUDY DESIGN

The FSN interventions were carried out in 2015 and 2016 with baseline survey conducted in 2014 and endline survey conducted in 2017. Baseline description of the villages is in Bhaskar et al (2017) and Nithya *et. al.* (2018). Detailed information on FSN intervention in Koraput and Wardha is reported elsewhere (Pradhan *et. al.*, 2017a and b). Once the villages were identified as discussed in Das et al (2014), baseline survey and on farm demonstration of the farm based interventions were conducted simultaneously (Nagarajan *et. al.*, 2014; Pradhan *et. al.*, 2017a and b).

The core strategies of the farming system to address nutritional concerns in the two locations were focused on increasing the availability of cereals, millets and pulses for household food requirement by enhancing production at the farm level, and of fruits and vegetables through promotion of nutrition gardens. The main objectives of the intervention and a broad summary of the improvements in farming related outcomes are given below:

1. To improve the dietary diversity from home consumption through widening the on-farm crop diversity. The farming intervention were introduced to improve inter crop diversity as was suitable to the local agro-climatic conditions (Pradhan *et. al.*, 2017a and b).

2. Among the irrigated land of the villages of Wardha, zinc and iron enriched wheat varieties were introduced for the first time in *rabi* season (Pradhan *et. al.*, 2017b). As shown in Table 2 (below) the 16 percent of the households who were earlier growing the normal variety of wheat were given the biofortified seeds and awareness about managing the crop was also introduced to them. The production increased from 1500kg/ha in 2014 to 3200 kg/ha in 2017 and the standard deviation declined from 157 to 48.

3. Promotion of vegetable cultivation through household and community level gardens with naturally bio-fortified fruits and vegetables species and nutri-dense varieties especially green leafy vegetables to address micronutrient malnutrition. The households were given seeds and saplings for growing additional varieties and also larger in numbers to better utilise the space and the seasonal varieties. Papaya and drumstick trees were given special emphasis for growing in the garden as they could be maintained easily for a range vitamin and minerals that they consume as vegetable, fruit, leaves and flowers (for drumstick). More importantly, the adult member of the households and middle school children were given special awareness session to consume the fruits and vegetables. It was observed that in Wardha even though drumstick was growing in that region, there was no preference for consumption. Hence, special culinary sessions were conducted to give the recipes for its consumption and awareness about the nutrition aspects was emphasized. In the endline survey it was observed that the households reported consumption and hence seemed to have shown an acceptance to the drumstick and its leaves (Pradhan *et. al.*, 2018).

4. One of the crops for the nutrition garden, newly introduced was orange fleshed sweet potato (OFSP) which is vitamin A enriched (biofortified) sweet potato to be grown in the *kharif* season. In Koraput however some households took to growing it on their farmland also. Among the 22 percent of the households that produced this crop there, the production was 6300kg/ha with 22kg as the standard deviation).

5. Promotion of animal based food interventions included fishery (community and individual) in Koraput and backyard poultry in Wardha.

6. In Koraput, with the help of district fishery department, interventions like, renovation of the pond for greater water

retention, packages of practices involving pre and post stock management to improve the fish harvest[1]. Due to the intervention the number of ponds for fishery increased from 23 in 2014 in 4 villages to 64 ponds in 16 villages. As the irrigation of the pond was from rainwater during the *kharif* season, the data on output showed an increase from 142 kgs in 2015 to 1829 kgs in 2017 during this season. As the output of fish increased, the proportion sold to the market increased from 7 percent to 50 percent. Interestingly, as the number of ponds and hence the output of fish increased, the home consumption share declined from 68 percent to 32 percent as the storage and consumption of a huge harvest would have been difficult in a very short span of time. Thus, the availability of fish in the local market during this production season had increased leading to a possible increase in protein and calcium content of the food intake in Koraput.

7. In Wardha the backyard poultry intervention was given to landless households. Improved quality of chick breeds was given so that increased home consumption of eggs and later on for meat would be possible. This intervention was assisted by the Maharashtra Animal and Fishery Science University. Since these were only 25 households a case study of these households is reported describing their production and consumption pattern in 2016[2].

8. Nutrition awareness was focussed mainly on improving household dietary diversity and promoting hygienic practices. The awareness campaign was done with the help of "Community Hunger Fighters (CHF)". In this approach villagers are selected by the intervention team and trained on nutrition security in general and educating them about the FSN pathway to improve nutrition (Narayanan and Rao, 2019). MSSRF has been practicing

[1] http://59.160.153.187/sites/default/files/Fishery%20Case%20study-Koraput.pdf

[2] http://59.160.153.187/sites/default/files/Poultry%20case%20study-Wardha%20-%20final.pdf

this methodology considered as sustainable as the selected CHFs are from the village and hence will find it easy to communicate and interact with the local population. Further, community level awareness in schools was done by commemorating nutrition and health related days (Narayanan *et. al.*, 2018).

In order to understand the changes in the household's production and consumption pattern after the FSN intervention, an endline survey of 190 households each in Koraput and Wardha were conducted. The inclusion criterion of the households was purposive with focus on households that had at least one child below the age of five years in 2014[3]. Among the 190 sample households in each location, 34 in Koraput and 32 in Wardha were those who did not partake in the intervention out of their own choice. The remaining 156 and 158 households respectively in Koraput and Wardha had at least one intervention. They are hereinafter referred to as FSN households. Two FSN households in Koraput and four households in Wardha were not taken for the analysis in the present paper as they were found to be outliers with regard to reported food consumption.

Table 2 below shows the distribution of households across different types of FSN intervention. The variation in the number and type of interventions across households got determined by how the households perceived their land holding pattern and household labour availability.

[3]One of the aims of the intervention was to see improvements in children's nutritional status after the intervention. Hence households with at least one child below 5 years were considered. In Koraput the sample households were about 190 that had such a demographic composition. In Wardha the number of such households were little lower than 190 so the next inclusion criterion was to include household with an adolescent girl at the time of baseline survey. Between 2014 and 2017, the demographic composition of Koraput changed with about 40 newborn babies and the age increased from less than five years to older age group. However, in Wardha the age specific demographic composition remained more or less the same.

Table 2: Cropping Pattern by Households (percent) that Participated in the Intervention

Koraput (N=156)			Wardha (N=158)		
Crops	**Baseline**	**Endline**	**Crops**	**Baseline**	**Endline**
Finger millet	29 (45)	50 (78)	Sorghum	6 (9)	26 (41)
Pigeon pea	0	21 (33)	Pigeon pea	65 (103)	41 (65)
OFSP	0	22 (34)	Green gram	0	25 (40)
Green gram	14 (22)	37(58)	Black gram	0	19 (30)
Black gram	5 (7)	29 (45)	Wheat	16 (25)	16 (25)
Fishery	0	13 (21)	Bengal gram	11 (17)	21 (33)
Nutrition garden	77 (120)	63 (98*)	Poultry	0	15 (24)
			Nutrition garden	20 (32)	88 (138)

Note: *remaining households followed traditional gardening; Figures in parenthesis denotes number

RESULTS AND DISCUSSION

As indicated in the previous section, that FSN intervention was designed as a feasibility study. In such studies the procedure for assessing the impact is by associations and correlations between the intervention and outcomes. In the broader literature this study is comparable to an observation study (Ruel *et al.*, 2018). In this study we use dietary diversity as the focus and convert the intakes into the nutrient content that may be derived from different types of intervention. Table 3 below gives the socio-demographic profile and land holding pattern of the households in the two regions. In Koraput the households are largely from OBC or ST households and the education levels are lower while the caste diversity is higher in Wardha. 80 percent of participating households in Koraput owned land compared to 75 percent in Wardha.

Table 3: Socioeconomic Characteristics of FSN Households

Variable	Feature	Koraput	Wardha	Total
Sample size		154	154	308
Caste (percent)	OBC	58.2	24.7	41.4
	Others		14.3	7.2
	SC	5.2	13.6	9.4
	ST	36.6	47.4	42.0
Education of head of the family (percent)	Illiterate	45.1	13.6	29.3
	Primary school	45.8	50.6	48.2
	Middle school	5.9	18.8	12.4
	Higher secondary	3.3	14.9	9.1
	Graduate		1.9	1.0
Occupation of head of the family (percent)	Not in labour force	1.3	5.2	3.3
	Cultivation	79.7	76.0	77.9
	Allied activities	5.2	1.9	3.6
	Agricultural Wage labour	3.3	13.0	8.1
	Non Agri. Activities	3.9	1.9	2.9
	Service	0	1.9	1.0
	Other Activities	6.5	0	3.3
Land class (percent)	Landless	3.9	11.0	7.5
	<1 acres	20.9	0	10.4
	1 to 205 acres	45.1	9.1	27.0
	2.6 to 4.5 acres	20.3	35.1	27.7
	>=4.6	9.8	44.8	27.4

Significant changes are observed in the household characteristics between 2014 and 2017 as seen from Table 4 below. For instance, several *kuccha* households upgraded to semi *pucca* households possibly due to the government scheme "Pradhan Mantri Awas Yojana" under which subsidies are given to build houses. Similar changes were observed in sanitation facility also due to a government scheme. A nominal subsidy in the form of incentive is given to rural poor households for construction of toilets under a comprehensive programme called 'Total Sanitation Campaign' launched by Rajiv Gandhi National Drinking Water Mission, Government of India. The households using LPG for cooking increased in both locations due to the government scheme "Ujjawala Yojana" where

LPG connections were provided at subsidised rates. The number of landless households decreased and there was increase in households having less than 1 hectare of land. The reasons were mainly due to cultivation of fallow lands and shift in leased in and leased out land. Other socio demographic variables remained the same in baseline and endline.

Table 4: Household Characteristics of the Study Population that Participation in FSN Intervention (percent)

Variable	Feature	2014			2017		
		Koraput	Wardha	Total	Koraput	Wardha	Total
Sample size	No. of households	154	154	308	154	154	308
Family Size	1 to 4	40.3	46.1	43.2	23.5	46.1	34.9
	5 to 7	53.2	48.7	51.0	67.3	49.4	58.3
	>=8	6.5	5.2	5.8	9.2	4.5	6.8
House type	Kuccha	39.6	39.6	39.6	35.3	11.0	23.1
	Semi Kuccha	57.8	53.9	55.8	60.1	80.5	70.4
	Pucca	2.6	6.5	4.5	4.6	8.4	6.5
Source of drinking water	Dug well	10.4	24.7	17.5	15.7	17.5	16.6
	Piped water	24.0	59.1	41.6	7.2	76.6	42.0
	Bore well etc.	65.6	16.2	40.9	77.1	5.8	41.4
Sanitation	Closed Toilet	0.6	32.5	16.6	16.3	59.1	37.8
	Open defecation	99.4	67.5	83.4	83.7	40.9	62.2
Cooking fuel	Firewood	100	95.5	97.7	88.9	70.1	79.5
	LPG	0	4.5	2.3	11.1	29.9	20.5

Source: Primary Survey.

Nutrient Intakes: Comparing 2014 and 2017

This section discusses the pattern of distribution of different nutrient intakes, compares the changes in mean intakes and the changes in intakes compared to recommended dietary allowance (RDA), wherever applicable, before and after intervention. The RDA for different nutrients is prescribed by the Indian Council for Medical Research (ICMR) and the

reference is given in Table 5. All these comparisons are analysed separately for Koraput and Wardha.

Table 5: RDA for Nutrients for A Reference Man Doing Sedentary Activity

Nutrients	RDA/CU/day
Protein (g)	60
Energy (Kcal)	2320
Calcium (mg)	600
Iron (mg)	17
Vitamin A (µg)	600
Vitamin C (mg)	40

The total nutrient consumed per day by the household was divided by the total household consumer unit (CU - values given for different age group doing different type of physical activity and physiological status in ICMR (2012) to arrive at per CU/day). CU for a reference man is 1 and this varies for women (who requires lesser than the reference man) and different age group. Detailed explanation is given in ICMR (2012) page 9.

Energy Intakes

The average per CU per day (pcu-pd) energy intake was higher for Koraput than Wardha in the year 2014, prior to the intervention (Table 6). The average cereal intakes have not changed in Koraput while in Wardha it has increased on an average by about 33 percent. However in Wardha, the changes are substantial as noted from Figure 1. The test for equality of means shown in Table 6 confirms further that mean energy intakes have not changed in Koraput while in Wardha it has gone up by an average of 626 kcal per consumer unit per day. The dispersion in energy intakes is also lower in Koraput as observed from the spread of the density function in Figure 1 and also the lower variance as seen in Table 6 compared to Wardha for both the years.

The improvements in energy intake in Wardha in 2017 have ensured that 97 percent of the people now have intakes above 70 percent of RDA (Table 7). It is to be noted that to ensure average pcu-pd intakes are closer to the ICMR norms, almost all the population should be consuming more than 70 percent of RDA. For Koraput the average intake values are closer to the ICMR norm in both the years. On the whole it appears that in Koraput as the intakes were close to the RDA in 2014, perhaps the households also did not feel the need to increase intakes. However, in Wardha the increased consumption is very welcome but the source of this change is not clear. Is it due to a better awareness program given that average intakes were low? Or has there been a demographic shift towards more adult population?

Table 6: Tests for Equality of Mean Per Consumer Unit Per Day Energy (kcal) Intake, Prior to and Post Intervention in FSN Households

	Koraput			Wardha		
	2014	2017	Change	2014	2017	Change
Mean	2633.3	2734.1	100.9	1854.1	2480.5	626.3
Standard Error	58.61	58.72	82.96	36.11	46.08	58.54
Standard Deviation	727.36	726.30		448.06	571.81	
Sample Size	154	154		154	154	
t-statistics			1.22			10.69***
p-value			0.1125			0.0000

Note: *** indicates statistical significance at 1 percent.

Table 7: Distribution of FSN households by energy intake as per RDA (percent)

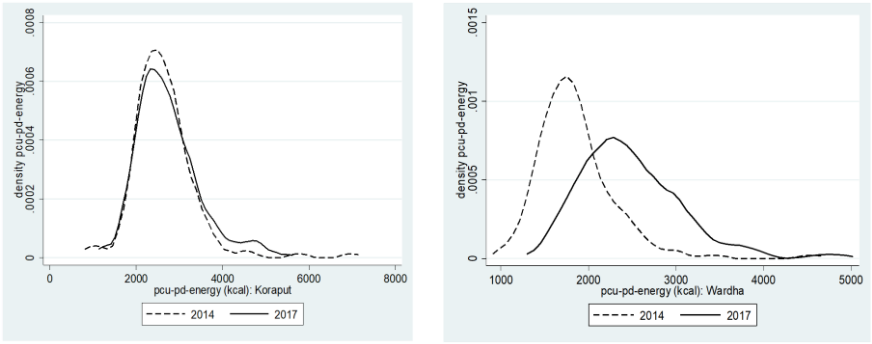
	2014		2017	
RDA	Koraput	Wardha	Koraput	Wardha
<50 percent	1.90	1.90		
50 percent- 70 percent	1.30	29.90	2.60	2.60
≥70 percent	96.80	68.20	97.40	97.40

Note: RDA-Recommended Dietary Allowance, based on table 5

The higher average intake and a lower variance among Koraput households is a positive feature. The higher average intake could be justified as the physical activity in a hilly terrain and in a tribal setting is expected to be higher and to that extent there is access to adequate calories on an average for these households. The variability in consumption among households being lower shows that between households it appears like a more equitable access and availability for consumption but within household variability cannot be ascertained with this information.

The plot of probability density function of per consumer unit per day energy intake helps us to understand the inter-household distribution in a better manner. The energy intake in Wardha has been far lower in the pre FSN year and that seems to have increased rightward for a correction. The per consumer unit energy distribution for Koraput remains the same between pre and post FSN and could be expected as the intervention was not targeted towards production of energy dense items.

Figure 1: Changes in Per Consumer Unit Per Day Energy Intake Distribution for Koraput and Wardha from 2014 to 2017 for FSN Households



The seasonal variability in nutrition intake and outcome would be location specific. In Koraput if the people are more likely to be dependent

on home consumption or neighbourhood markets then there is a possibility that there may be seasonal variability in consumption and physical activity due to seasonal variation in produce. In comparison Wardha being situated closer to an urban center, the access to markets may be easier provided affordability is not an issue. In this sense, the households in Wardha may prefer to sell a larger part of their agricultural produce in the market and use the cash income to buy food and non-food items to their preference. However, here also there could be seasonal variability in consumption if the cash flow of the income varies with agricultural season. Another issue of concern with purchase on the basis of one's choice is whether the income would be spent on nutritious food items.

The seasonal variability in consumption would be an important aspect to focus upon when there is seasonal variability both in physical activity and availability/affordability of food. This raises two issues. First, would be related to storage of surplus production so that consumption is smoothened during lean season. The second would be the sale of the produce in the market and the cash income should be sufficient to purchase the commodity and equally importantly is the availability and affordability of the commodity in the markets during all seasons. This would require a more detailed and longitudinal study of the households to understand the channels of supply of commodities, physical activity patterns and an assessment of nutrition outcomes like BMI of the adults and height and weight of the children (Rao and Raju, 2019). The anthropometric measures are a net of intakes and energy expenditures and hence useful in making these assessments.

The awareness program introduced the households to improved storage and healthy eating habits. In Koraput, before intervention 83 percent of the energy was obtained from cereals and millet. In Wardha, at baseline 63 percent of energy was obtained from cereals and millets followed by fats and oils. Remaining energy was obtained from pulses and legumes and other vegetables like cauliflower, brinjal, cowpea pods,

etc in Wardha and beans, ivy gourd, kankoda, bitter gourd etc in Koraput. But at endline, energy from cereals and millets declined to 73 percent in Koraput while majority of energy in Wardha was supplied by cereals and millets followed by pulses and legumes due to pulses intervention.

The endline survey shows that the number of households that increased finger millet cultivation increased from 29 percent to 50 percent in Koraput with yield increasing from 400 kg per hectare to 2500 kg per hectare. This increase in more households using this crop is from using upland left fallow and that was part of intervention to educate people on how to do so. This also increased consumption from home produce from 21 percent to about 40 percent. In Wardha sorghum cultivation was already low at about 6 percent in 2014 with 9 households cultivating it. In 2017 this increased to about 40 households, accounting for 26 percent of the households as shown in Table 2 above.

Once again here also if the demographic composition increased towards adults then in both places the increased need for energy intakes seem to have been satisfied either from home consumption or from market. So even though iron fortified sorghum was a component of FSN intervention in Wardha, its uptake for crop production has been lower though the average yield per hectare has doubled from 1000 kg/ha to 2000 kg/ha. The report shows that pulses have been intercropped with sorghum.

Protein Intake

Table 8 below gives comparison of mean and standard deviation of per consumer unit protein values for FSN households before and after the interventions. Koraput has a higher mean protein intake compared to Wardha. Post intervention, the protein intakes increased by 10gms per consumer unit per day in Koraput, while in Wardha the 25 gms average increase was about 40 percent higher than the pre-intervention average and thus, making the mean intake to be higher than in Koraput. The

results in Table 8 and the test for equality of means show that the increase in average pcu-pd protein intake is statistically significant in Koraput and Wardha.

Table 8: Tests for Equality of Mean Per Consumer Unit Per Day Protein (gm) Intake, Prior to and Post Intervention in FSN Households

	Koraput			Wardha		
	2014	2017	Change	2014	2017	Change
Mean	64.4	74.7	10.4	58.7	83.9	25.3
Standard Error	1.43	2.25	2.66	1.16	1.73	2.08
Standard Deviation	17.73	27.79		14.42	21.43	
Sample Size	154	154		154	154	
t-statistics			3.89***			12.13***
p-value			0.0001			0.0000

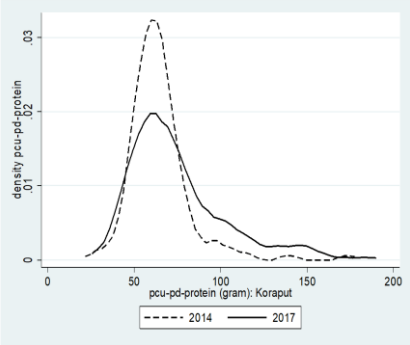
Note: The null hypothesis is H_0: Mean(prior)-Mean(post)=0 and the alternative hypothesis is H_1: Mean(prior)-Mean(post)<0.

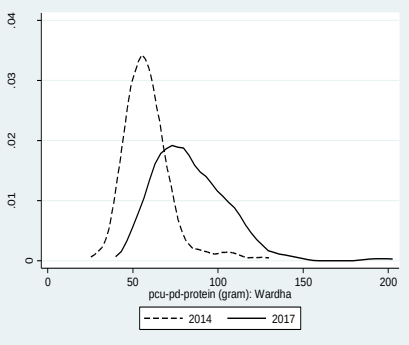
About 96 percent of households in Koraput consumed more than 70 percent of recommended allowance of protein, before and after FSN intervention and in Wardha, almost all the households consumed more than the 70 percent of recommended allowance of protein after FSN intervention (Table 9).

Table 9: Distribution of FSN households by Protein Intake as per RDA (percent)

	2014		2017	
RDA	Koraput	Wardha	Koraput	Wardha
<50 percent	0.6	0.6		
50 percent- 70 percent	3.2	5.2	3.9	
≥70 percent	96.1	94.2	96.1	100.0

Figure 2: Changes in Per Consumer Unit Per Day Protein Intake Distributions for Koraput and Wardha from 2014 to 2017 for FSN households





The protein intake is expected to have gone up from home consumption based on the food sources like pulses in both locations and meat and poultry in Wardha and fish in Koraput, that could largely be from consumption from own production after FSN intervention. In Koraput, the distribution of pcu-pd protein intake shows that the right tail has increased after FSN shifting the density away from values around 60 gms to more than 100 gms (Figure 2). In Wardha there has been substantial rightward shift of the distribution of pcu-pd protein intake where initially the mode was at about 59 gms and average at 58 gms but now the minimum intake starts at about 50 gms.

Compared to Koraput, the changes are more visible in Wardha as the quantity and frequency of consumption of pulses was more in Wardha than in Koraput, for the FSN households, where there is a rightward shift in the entire distribution. Thus, with FSN intervention those at the lower end of the distribution and all others seem to have improved the intakes. Before intervention, 68 percent of protein was obtained from cereals and millets followed by pulses and legumes (12.6 percent) which changed to 57 percent and 14.3 percent respectively due to the pulse intervention. Protein obtained from fishes and sea foods

increased from 3 percent to 7 percent after intervention in Koraput. In Wardha, 63 percent of protein was obtained from cereals and millets at baseline, decreased to 50 percent and the protein from pulses increased from 20 percent to 25 percent. The percentage share of meat and poultry (7 percent) remained the same while the share from fishes and sea foods increased from 2 percent to 6 percent.

Calcium Intake

Table 10 shows that the mean intake of calcium increased in Koraput and Wardha in 2017 compared to 2014. As shown in Figure 3, the mean value in Wardha was lower for calcium prior to intervention and increased more after FSN; yet the gap did not close up with that in Koraput as values increased here as well in 2017.

Table 10: Tests for Equality of Mean Per Consumer Unit Per Day Calcium (mg), Prior to and Post Intervention in FSN Households

	Koraput			Wardha		
	2014	2017	Change	2014	2017	Change
Mean	637.8	971.1	333.2	417.6	838.6	420.9
Standard Error	20.22	43.10	47.61	9.76	26.70	28.42
Standard Deviation	250.97	533.10		121.14	331.28	
Sample Size	154	154		154	154	
t-statistics			7.00***			14.81***
p-value			0.000			0.000

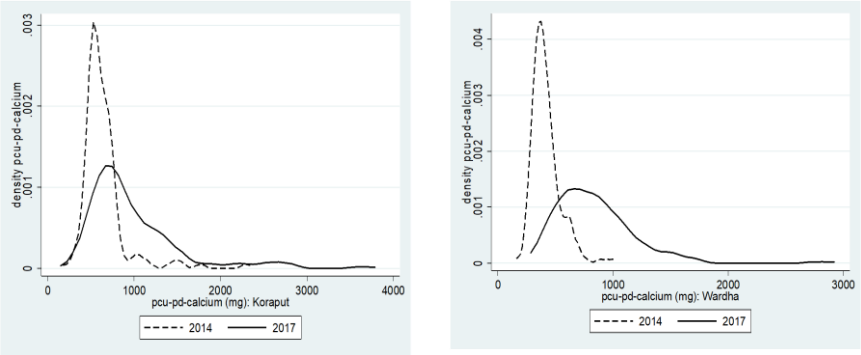
In Koraput, about 94 percent of the households consumed more than 70 percent of recommended calcium in 2014, which increased to 97 percent in 2017 (Table 11). There was drastic change in the case of Wardha as most of the households consuming less than 70 percent of recommended allowance of calcium were consuming more than 70 percent of RDA after FSN intervention. There was a notable increase in consumption of millets, leafy vegetables, fishes and sea foods and milk, all of which are primary source of calcium.

Table 11 Distribution of FSN households by calcium intake as per RDA (percent)

	2014		2017	
RDA	Koraput	Wardha	Koraput	Wardha
<50 percent	0.6	11.7	0.7	0.0
50 percent- 70 percent	5.8	50.6	2.0	1.9
≥70 percent	93.5	37.7	97.4	98.1

The large rightward shift in the distribution of pcu-pd calcium intake as shown in Figure 3 is expected given that mean intake increased by 300 to 400 gms pcu-pd. In 2014 the lower intake shows low spread of the distribution and is substantiated by the lower standard deviation in Table 10 above. The increase in mean intakes in 2017 has resulted in a large variance between households.

Figure 3: Changes in Per Consumer Unit Per Day Calcium Intakes Distributions for Koraput and Wardha from 2014 to 2017 for FSN Households



The calcium increase in Koraput may have been due to increased consumption of ragi (finger millet) and green leafy vegetables sourced from home production and fish from market. In Wardha, leafy vegetables and fishes sourced from market are the likely sources. Majority of calcium consumed in Koraput at baseline was from cereals and millets, mainly from finger millet followed by leafy vegetables which remained the same

after intervention. But the calcium from fish and sea foods increased from 9 percent to 25 percent. In Wardha, at baseline, majority of calcium was obtained from cereals and millets followed by leafy vegetables and milk and milk products, this changed after intervention, i.e., most of the calcium consumed was from fish and seas foods followed by cereals and millets, leafy vegetables and milk and milk products.

Iron Intake

The average pcu-pd iron intake in Koraput was seen to have been lower among all households in 2014 compared to Wardha (Table 12). In 2017, there has been an overall increase in intake but the gaps in intakes between the two regions have been maintained. The increase in mean intake results in a marginal increase in variance.

Table 12: Tests for Equality of Mean Per Consumer Unit Per Day Iron intake (mg), Prior to and Post Intervention in FSN Households

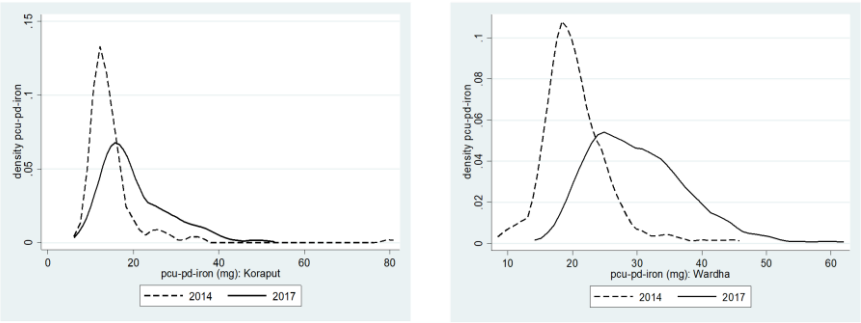
	Koraput			Wardha		
	2014	2017	Change	2014	2017	Change
Mean	14.79	20.32	5.53	20.50	30.13	9.63
Standard Error	0.575	0.644	0.86	0.405	0.598	0.72
Standard Deviation	7.140	7.965		5.027	7.424	
Sample Size	154	154		154	154	
t-statistics			6.40^{***}			13.33^{***}
p-value			0.0000			0.0000

The average consumption of iron in Wardha meets the recommended level of iron and after intervention all households were consuming more than 70 percent of recommended allowance (Table 13). In Koraput, the percentage of households consuming more than 70 percent of recommended allowances increased from 71 percent to 92 percent. This could mainly be due to the increased consumption of millets, pulses and other vegetables in both locations after FSN intervention. Figure 4 shows the distributional change in iron intakes with larger change in Wardha than Koraput.

Table 13: Distribution of FSN households by Iron intake as per RDS (percent)

RDA	2014		2017	
	Koraput	Wardha	Koraput	Wardha
<50 percent	1.9	0.0	0.0	0.0
50 percent- 70 percent	27.3	2.6	8.5	0.0
≥70 percent	70.8	97.4	91.5	100.0

Figure 4: Changes in Per Consumer Unit Per Day Iron Intakes Distribution for Koraput and Wardha from 2014 to 2017 for FSN Households



Although most of iron consumed was sourced from market, the quantity of iron obtained from nutrition garden produce has increased in both the locations. In Koraput, iron was obtained from cereals and millets followed by pulses and legumes and other vegetables at baseline. This changed after intervention, as iron was obtained from cereals and millets, followed by other vegetables (17 percent) and pulses and legumes (13 percent). Iron obtained from leafy vegetables increased from 0.4 percent to 5.2 percent. Similar pattern was observed in Wardha.

Vitamin A Intake

The change in mean pcu-pd intake of Vitamin A in Koraput is not significantly different between 2014 and 2017 but the variance (standard error) has increased substantially (Table 14). In Wardha both mean and

variance in pcu-pd Vitamin A values have increased. The increased average intake in Wardha in 2017 is statistically significant but the small increase in mean intakes in Koraput is not statistically significant.

Table 14: Tests for Equality of Mean Per Consumer Unit Per Day Vitamin A (µg) intake Prior to and Post -Intervention in FSN Households

	Koraput			Wardha		
	2014	2017	Change	2014	2017	Change
Mean	471.4	492.0	20.6	341.9	675.4	333.5
Standard Error	20.92	32.67	38.80	11.71	20.08	23.25
Standard Deviation	259.64	404.14		145.26	249.25	
Sample Size	154	154		154	154	
t-statistics			0.53			14.35***
p-value			0.2979			0.0000

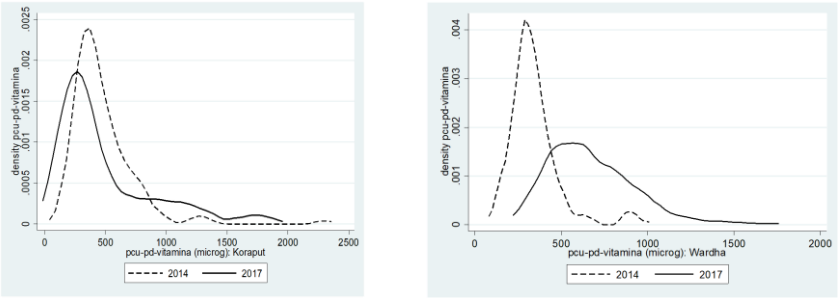
In Koraput the increase in variance seems to have an adverse effect when pcu-pd RDA values are considered in 2017. About 44 percent have pcu-pd RDA values below 50 percent in 2017 in Wardha and increased from about 20 percent of the households in 2014. Although there was slight increase in the mean intake in Koraput 2017, the percentage of households consuming less than 50 percent increased and above 70 percent of RDA decreased (Table 15). Wardha shows a large decline in <50 percent and 50-70 percent so that about 87 percent are in >70 percent RDA values. In Wardha, due to the increase in the consumption of vegetables, the percentage of households consuming more than 70 percent of recommended allowance increased.

Table 15: Distribution of FSN Households by Vitamin A Intake as per RDA (percent)

RDA	2014		2017	
	Koraput	Wardha	Koraput	Wardha
<50 percent	19.5	42.2	44.4	0.6
50 percent- 70 percent	33.0	39.6	19.6	12.3
≥70 percent	46.8	18.2	35.9	87.0

Given the change in pattern of distribution with respect to RDA, the distribution in Koraput shows a leftward shift in 2017 compared to 2014 (Figure 5). The distributional shift for Vitamin A in Wardha is substantial with a large proportion in the higher end values but with a marked increase in variance when the mean is also high.

Figure 5: Changes in Per Consumer Unit Per Day Vitamin A Intake Distribution for Koraput and Wardha from 2014 to 2017 for FSN Households



Vitamin A was obtained majorly from leafy vegetables followed by fruits and other vegetables in 2014 in Koraput which remained the same in 2017 also but the percentage share increased. In Wardha, vitamin A was obtained from leafy vegetables (65 percent) followed by meat and poultry (13 percent) at baseline while the percentage share of vitamin A from leafy vegetables was 55 percent and 10 percent from other vegetables and meat and poultry followed by fruits.

Vitamin C Intake

Intake of vitamin C estimated in 2014 have high average values and in 2017 the reported values more than doubled in Koraput and almost doubled in Wardha. The large increase in mean values in Koraput has also resulted in a large increase in variance (standard error) but such large increase in variance is not noted in Wardha.

Table 16: Tests for Equality of Mean Per Consumer Unit Per Day Vitamin C (mg) intake Prior to and Post Intervention in FSN Households

	Koraput			Wardha		
	2014	2017	Change	2014	2017	Change
Mean	63.2	170.2	107.0	61.2	107.0	45.8
Standard Error	2.82	11.71	12.05	2.25	2.57	3.42
Standard Deviation	34.95	144.91		27.95	31.94	
Sample Size	154	154		154	154	
t-statistics			8.89***			13.40***
p-value			0.0000			0.0000

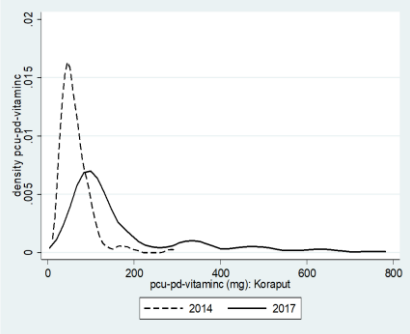
Before intervention, almost all the households in both locations were consuming more than 70 percent of the recommended level of vitamin C which remained the same after intervention as show in Table 17 below.

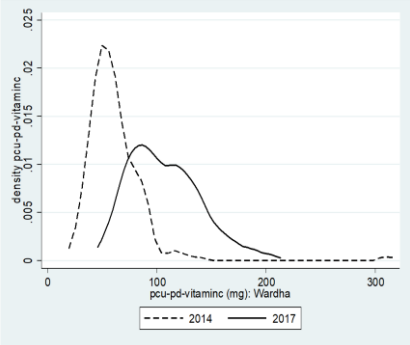
Table 17: Distribution of FSN Households by Vitamin C Intake as per RDA (percent)

	2014		2017	
RDA	Koraput	Wardha	Koraput	Wardha
<50 percent	0.6	0.0	0.0	0.0
50 percent- 70 percent	4.5	1.9	0.7	0.0
≥70 percent	94.8	98.1	99.3	100.0

As the mean intakes, variances and RDA values show, the distribution has shifted rightward for a large number of households (Figure 6). The long right tail for Koraput is the reason for high variance while in Wardha also we see the spread having increased with an increase in modal value.

Figure 6: Changes in Per Consumer Unit Per Day Vitamin C Intake Distributions for Koraput and Wardha from 2014 to 2017 for FSN Households





The percentage share of vitamin C from leafy vegetables, fruits and other vegetables before intervention in Koraput was 27 percent which increased to 40 percent after intervention. Similarly in Wardha, leafy vegetables and other vegetables were the major foods from which vitamin C was obtained before intervention. After intervention, in addition to vegetables, the percentage share from fruits increased from 4 percent to 16 percent.

Overall it is observed that the mean values of most of the micronutrients had gone up post intervention while energy intakes did not change when compared to protein intakes. This could partly be due to the fact that interventions perhaps focused more on improving diet quality than on improving intake of energy dense food.

CONCLUSION

South Asia in general and India in particular contributes to a large percentage of nutrition related morbidity and mortality (Harding *et. al.*, 2017, GBD 2017, von Grebmer *et. al.*, 2018). This affects children, adolescents, adults and elderly in varied ways and is pervasive among the poor and the rich, of course, due to different reasons.

Malnourishment among the better privileged arises from larger intake of energy dense food and lower intake of fruits and vegetables alongside rapid changes in lifestyles. The less privileged are undernourished due to inadequate quantity and quality of diets. Consequently, countries like India face triple burden of malnutrition across different segments of the population: low intake of macronutrients and widespread inadequacy of micronutrient intake among the lower income groups and micronutrient deficiency and high intake of macronutrients specifically lipids among higher income groups (Meenakshi, 2016; Agrawal, *et. al.*, 2014). All this adds to a huge burden of disease affecting the economic prosperity and health of individuals and hence the nation.

In this context it is important that diverse diets are affordable along with its sustainable availability for both rural and urban consumers in India and along withnutrition awareness. This would not only improve nutrition security for the undernourished but also among the richer segments of the population whose diets are not healthy and who are prone to overweight and obesity. This study focused on two less developed rural regions of India, to improve nutrition security using the FSN approach. The impact is analysed based on the change in mean per consumer unit per day intakes of energy, protein, vitamin A, vitamin C, iron and calcium. In most instances we find a statistically significant increase in these values. In spite of a time gap of nearly three years between 2014 (baseline) and 2017 (endline) measurements, the results show a positive change indicating that the interventions are having a sustained impact.

The method of assessment for household composition adjusted nutrient intakes does not indicate seasonal patterns of consumption. This may be very important to understand as agricultural harvests and availability of fruits and vegetables are largely seasonal in nature. Surplus output and good storage facilities for the semi-perishables and diversity in different fruits and vegetables all through the year need to be ensured. If it was possible to collect such data then understanding seasonal

fluctuations in nutrition insecurity if any is crucial to address through some forms of intervention. Another limitation is that the dietary intake is measured at the household level and reported as per consumer unit to take into account the demographic composition of the household. This may not be adequate to make any comment about changes in the pattern of intra-household distribution arising from the FSN intervention. Although reviewing these parameters periodically would also be challenging unlike the anthropometric indicators which could be collected more frequently particularly for children. However, while assessing nutrition outcomes, morbidity patterns and hygienic conditions become relevant given that absorption of nutrients and hence the anthropometry would depend on an individual's health condition.

With a declining share of agriculture in GDP and volatile growth rate of sub-sectors within agriculture and allied sectors, undernutrition rates will decline only when public policies improve land and labour productivity, access to clean water, sanitation and clean cooking fuel, and primary health care. The slowing down of the Indian economy in the last two years would mean that investment in infrastructure and such public policies would decline with detrimental effects on nutrition security among the vulnerable sections of the rural population. At the same time, the discussion on what should be the extent of involvement of the government and the community for nutrition security by improving access, availability, affordability and awareness remains valid. This study has demonstrated the role of a non-governmental organization in demonstrating the feasibility of a farming system of nutrition approach by providing inputs for farming activities as well as in creating awareness and optimally using the public provisioning of services to the extent accessible to the population in improving dietary diversity in two low income regions of the country. The approach can be seen as a case for nutrition sensitive agriculture interventions and programmes among populations dependent on agriculture.

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