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Nutrient Intake of Rural Households That Participated in a Farming System for Nutrition Study in India

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Abstract

Food based approach can prove effective in improving access and availability of nutrients from foods required for daily life where most of the people depend on agriculture for their livelihood. A study on feasibility of Farming Systems for Nutrition (FSN) approach was undertaken from 2013 to 2018 in a few villages of Koraput district, Odisha state and Wardha district, Maharashtra state in India. Interventions were done to increase crop diversity, intercropping of pulses and cereals, promotion of seasonal vegetables and fruits along with nutrition awareness. The endline survey showed increase in production diversity leading to improved household dietary diversity. This paper demonstrates the impact of FSN interventions on household nutrient intake. The results show that the intake of nutrients like protein, vitamin C, iron and calcium increased significantly in Koraput and all the nutrients including energy and vitamin A increased significantly in Wardha. The evidence shows that Farming System for Nutrition approach improves individual nutrient intake which in the long run can address the problem of undernutrition.

Keywords

Farming Systems for Nutrition, Nutrient Intake, Recommended Dietary Allowance, Nutrient Source

1. Introduction

Food insecurity and associated undernutrition affects health, particularly of women, infants, children, and adolescents. Poverty amplifies the risk of undernutrition and increases health care costs, reduces productivity, and slows economic growth, which can perpetuate a cycle of poverty and ill-health [1]. Low-income countries typically have large agricultural sectors and productivity increase in agriculture often serve as the catalyst for growth, as well as having strong effects on reducing poverty due to the high numbers of people involved in these sectors. This shows that there is a pathway for addressing food and nutrition security effectively by leveraging agriculture.

Link between agriculture and food security has long been established. Based on review of evidence on nutrition-sensitive agriculture research conducted since 2014, Ruel *et al.* [2] 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. Significant association between crop diversity and dietary diversity was reported in diets of smallholder farmers and was more closely related to home food consumption than to purchased food consumption [3]. National representative data for the early 2000s from eight developing countries showed that there is a positive association between the number of crops produced and the number of foods consumed by the rural households; ownership of livestock and ruminants are also associated with increase in dietary diversity [4]. A study in Nepal showed that production diversity is positively associated with maternal and child dietary diversity, and WHZ [5]. 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 [6].

Many intervention programmes use the UNICEF framework, which identifies three main determinants of good nutrition: availability and access to food; optimal quality of feeding and caring practices; and a healthy environment and adequate access to health care services. Johnson-Welch *et al.* [7] modified the UNICEF framework calling it the agriculture-nutrition advantage framework, and included agriculture, nutrition and food, with food as the common link between agriculture and nutrition. The framework proposes that agriculture helps ensure good nutrition, and good nutrition builds human capital, which is also an input for agricultural production, creating a circular pathway between agriculture and nutrition. However, the evidence is also that increased food production and/or increased income by itself does very little towards ensuring a balanced diet to the rural household [8] [9]. Following a review of 25 research studies, Pandey *et al.* [10] concluded that the production of targeted nutrition-rich crops, homestead gardens, and diversification of the agricultural production system towards fruits and vegetables and aquaculture can potentially improve nutrient intake and nutritional outcomes. Fiorella *et al.* [11] also reported that agricultural interventions to diversify production to improve nutrition status by supporting consumption of diverse nutritious foods, which are often vitamin A rich food, and/or dark green leafy vegetables. Nutrition security therefore has to be addressed by both availability and accessibility of nutrient rich foods at household level, and nutrition awareness. This is the central concept behind the Farming System for Nutrition (FSN) approach.

A feasibility study on a Farming System for Nutrition (FSN) approach to address the problem of undernutrition was undertaken in India by the M S Swaminathan Research Foundation (MSSRF), under a research consortium programme on "Leveraging Agriculture for Nutrition in South Asia" (LANSA), from 2013-18. LANSA was a multi country research programme consortium funded by Department for International Development, UK. 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 [12]. It is an interventional approach that includes a combination of sustainable measures including advanced crop production practices, biofortification, 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. At the end of the study, the uptake of FSN interventions had also expanded beyond the core group of villages by 2017, to 25 more villages in Wardha and 18 more villages in Koraput, reaching out to more households. Farm men and women emerged as spokespersons of the FSN approach within the community and at different stakeholder forums.

This paper shows changes in energy and protein intake and micronutrients (iron, calcium, vitamin A and C) per consumer unit per day among households that participated in FSN intervention. 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. Detailed results of the study were published as a working paper and can be found at Nithya *et al.* [13].

2. Materials and Methods

2.1. Study Location

The study on feasibility of FSN approach was conducted in seven villages (658 households with population of 2845) in Koraput district of Odisha state and five villages (556 households with population of 2254) in Wardha district of Maharashtra state in India. These locations were purposively selected due to the contrasting features with regard to agro-climate, landholding pattern, and farming practices. Majority of people in the selected villages belonged to indigenous communities, classified as scheduled tribes (ST) by the Constitution of India. Majority of them were cultivators with 80.7 percent marginal farmers with less than 1 hectare (ha) land in Koraput and 25.9 percent small (>1 to <2 ha land)

and 18.9 percent semi-medium (2 to <4 ha land) 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. Both the locations were districts declared as high burden districts of malnutrition by government of India. The baseline survey was conducted in 2014 and the endline survey was in 2017. Detailed information of the study locations and baseline nutrition and agriculture situation can be found in Bhaskar *et al.* [14] and Nithya *et al.* [15].

2.2. Study Design

The FSN interventions were carried out from 2014-2015 to 2016-17. Detailed information on FSN interventions in Koraput and Wardha is reported elsewhere [16] [17]. The main objective of the interventions was to improve household dietary diversity through widening the on-farm crop diversity. Farming interventions were introduced to improve intercrop diversity suitable to the local agro-climatic conditions. For instance, zinc and iron enriched wheat varieties were introduced for the first time in Rabi (November 2013 to February 2014) season in Wardha, in farms where irrigation was available [16], promotion of vegetable cultivation through household and community level gardens with naturally biofortified fruits and vegetables species and nutrient-dense varieties especially green leafy vegetables to address micronutrient malnutrition. Nutrition awareness was given on the nutritional importance of consuming fruits and vegetables. Orange fleshed sweet potato (OFSP) (vitamin A enriched (biofortified)) was newly introduced, to be grown in the Kharif (June to October) season. Promotion of animal based food interventions included fishery in community and individual ponds in Koraput and backyard poultry in Wardha. Nutrition awareness was focused mainly on improving household dietary diversity and promoting hygienic practices. The awareness was done with the help of "Community Hunger Fighters (CHF)" approach; villagers were selected and trained on nutrition security in general and educated them about the FSN pathway to improve nutrition. Further, awareness in schools was done by commemorating nutrition and health related days [18] [19].

2.3. Sample Size

In order to understand the feasibility of FSN interventions on household food consumption pattern, an endline survey was conducted in 2017. Subsample of 190 households each in Koraput and Wardha were purposively selected based on households that had at least one child below the age of five years in 2014. Among the 190 sample households in each location, 34 in Koraput and 32 in Wardha were households who did not partake in the intervention out of their own choice. The remaining 156 and 158 households in Koraput and Wardha respectively 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.

2.4. Calculation of Nutrient Intake and Data Analysis

One-month recall on consumption of foods was recorded using semi quantitative questionnaire. The nutrient content of foods was calculated using the nutritive values given in Nutritive Value of Indian Foods [20]. The recommended dietary allowance (RDA) for different nutrients given by the Indian Council for Medical Research (ICMR) was used for comparison of nutrient intake. The total nutrient consumed per day by the household was divided by the total household consumption unit to arrive at per CU/day (CU-values given for different age groups doing different types of physical activity and physiological status [19]). 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. Statistical analyses were performed using SPSS version 20.0 and STATA 14.0.

3. Results and Discussion

3.1. Socio-Economic Characteristic of the FSN Households

Table 1 gives the socio-demographic profile and land holding pattern of the FSN households at the time of the endline survey. In Koraput the households are largely from Other Backward Caste (OBC) or ST households and the education levels are lower, while the caste diversity is higher in Wardha. About 80 percent of participating households in Koraput and 75 percent in Wardha owned land.

Significant changes were observed in the socioeconomic characteristics of households like, house type, source of drinking water, sanitation and primary cooking fuel between the baseline (2014) and endline (2017). This is mainly due to government schemes, for instance, several Kuccha households were upgraded to semi pucca households possibly due to "Pradhan Mantri Awas Yojana" under which subsidies are given to build houses; subsidy is given for construction of toilets under "Total Sanitation Campaign" launched by Rajiv Gandhi National Drinking Water Mission, marginally bringing down open defecation; households using LPG for cooking increased in both locations due to "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 acre 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.

3.2. Nutrient Intakes

3.2.1. Energy Intake

Calorie intake is one of the commonly used food security indicators that measures food access in terms of quantity of energy consumed at household level. The average per CU per day intake of energy in Koraput was more than the recommended allowance (RDA 2320 kcal) in 2014, *i.e.*, before intervention and increased slightly in 2017, after intervention (**Table 2**). Before intervention, maximum energy (82%) was obtained from cereals and millets mainly rice and finger

Table 1. Socioeconomic characteristics of FSN households (2017).

Variable	Feature	Koraput	Wardha	Total
Sample size		154	154	308
Caste (%)	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 (%)	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 (%)	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 (%)	Landless	3.9	11.0	7.5
	<1 acres	20.9	0	10.4
	1 to 2.5 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
Family size (%)	1 to 4	23.5	46.1	34.9
	5 to 7	67.3	49.4	58.3
	≥8	9.2	4.5	6.8
House type (%)	Kuccha	35.3	11.0	23.1
	Semi Kuccha	60.1	80.5	70.4
	Pucca	4.6	8.4	6.5
Source of drinking water (%)	Dug well	15.7	17.5	16.6
	Piped water	7.2	76.6	42.0
	Bore well etc.	77.1	5.8	41.4
Sanitation (%)	Closed Toilet	16.3	59.1	37.8
	Open defecation	83.7	40.9	62.2
Cooking fuel (%)	Firewood	88.9	70.1	79.5
	LPG	11.1	29.9	20.5

Table 2. Changes in mean nutrient intakes (per CU per day) before and after intervention in FSN households (N = 154).

Year		Energy, kcal	Protein, g	Calcium, mg	Iron, mg	Vitamin A, g
				Koraput		
2014	Mean	2633.3	64.4	637.8	14.8	471.4
	Median (IQR)	2573.1 (692.8)	62.1 (16.2)	579.8 (188.0)	13.0 (4.3)	407.7 (244.5)
	Std. Deviation	727.4	17.7	251.0	7.1	259.6
	Std. Error	58.6	1.4	20.2	0.6	20.9
2017	Mean	2734.1	74.7	971.1	20.3	492.0
	Median (IQR)	2609.6 (846.2)	68.1 (29.6)	810.9 (508.1)	17.7 (10.3)	329.9 (420.4)
	Std. Deviation	726.3	27.8	533.1	8.0	404.1
	Std. Error	58.7	2.2	43.1	0.6	32.7
Change		100.9	10.4***	333.2***	5.5***	20.6
				Wardha		
2014	Mean	1854.1	58.7	417.6	20.5	341.9
	Median (IQR)	1786.6 (465.6)	56.4 (16.3)	394.8 (132.3)	19.6 (5.4)	315.9 (129.9)
	Std. Deviation	448.1	14.4	121.1	5.0	145.3
	Std. Error	36.1	1.2	9.8	0.4	11.7
2017	Mean	2480.5	83.9	838.6	30.1	675.4
	Median (IQR)	2411.7 (697.8)	81.0 (28.8)	781.2 (412.5)	28.9 (10.3)	642.1 (320.3)
	Std. Deviation	571.8	21.4	331.3	7.4	249.2
	Std. Error	46.1	1.7	26.7	0.6	20.1
Change		626.3***	25.3***	420.9***	9.6***	333.5***

IQR: Interquartile Range; *** indicates statistical significance @1%.

millet followed by vegetables in 2014. The contribution of cereals and millets to average total energy consumed per CU per day decreased to 73 percent followed by vegetables and pulses vegetables and pulses in 2017 (**Figure 1**). It was also found that the dispersion in energy intake is also lower in Koraput and also lower variance before and after the intervention. As Koraput is in hilly terrain, the average energy intake might be high due to higher physical activity. The per consumption unit energy distribution for Koraput remained the same between pre and post FSN and could be expected as the intervention was not targeted towards production of energy dense items. Similar results were reported by Adhiguru and Ramasamy [21] that the energy consumption remained non-significant across rice, vegetable and food and cash crop production systems. Holmboe-Ottesen *et al.* [22] also reported that raising the productivity of paddy cultivation recorded no significant difference in energy intake.

The average per CU per day intake of energy in Wardha was less than the recommended allowance in 2014 which increased significantly by 626 kcal/CU/day in 2017 and met the RDA (Table 2). About 62 percent of energy was obtained from cereals and millets mainly wheat and rice, followed by fats and oils and pulses (Figure 2). It was observed that only 68 percent of households were consuming more than 70 percent of RDA which after FSN increased to 97 percent. However, the source of this increase in energy intake 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? Demographic composition increased towards adults then in both places and the increased need for energy intakes seem to have been satisfied either from home consumption or from market.

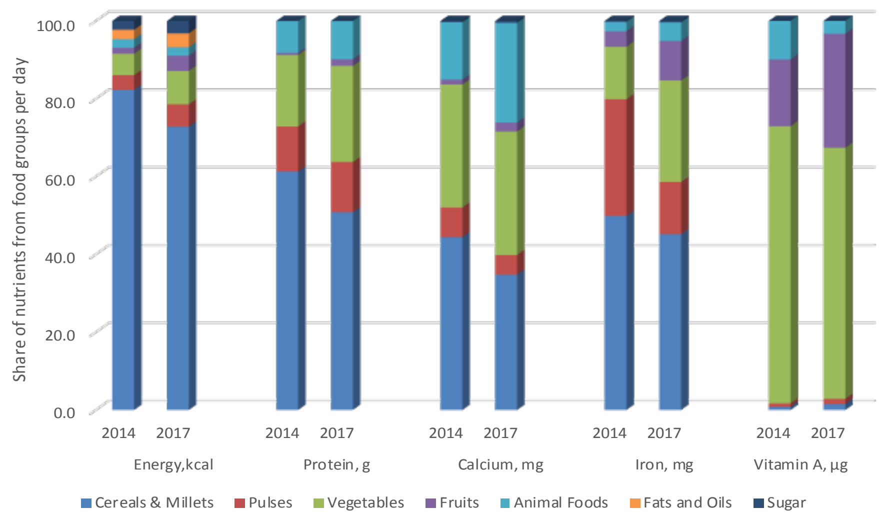

Figure 1. Percentage share of nutrients per day from different food groups before and after intervention in Koraput.

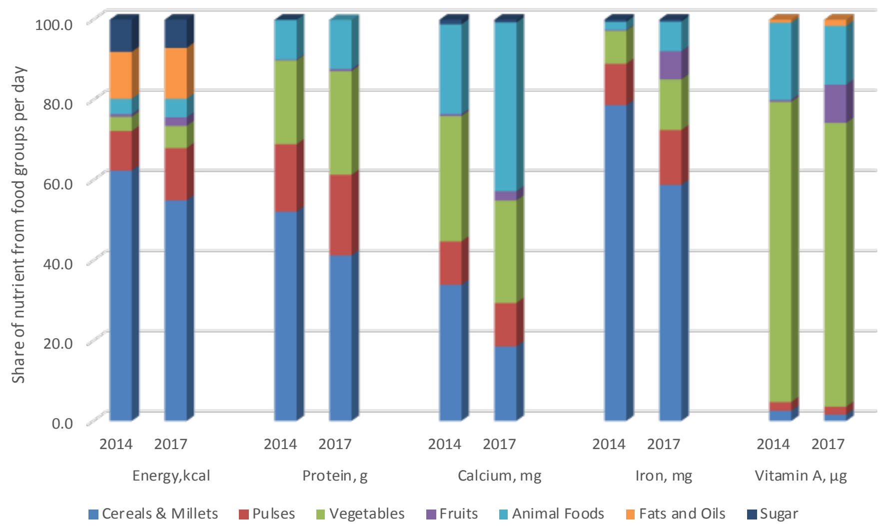

Figure 2. Percentage share of nutrients per day from different food groups before and after intervention in Wardha.

3.2.2. Protein Intake

The average intake of protein per CU per day increased significantly in both locations after FSN intervention (**Table 2**). The average protein intake was around the recommended dietary allowances (RDA 60 g) in 2014 which increased significantly by 10 g in Koraput and 25 g in Wardha in 2017. The quantity and frequency of consumption of pulses was more in Wardha than in Koraput. About 96 percent of the households in Koraput consumed protein more than 70 percent of RDA which remained the same after intervention. In Wardha, it was 94 percent households consumed more than 70 percent of RDA before intervention and by all the households after intervention.

In Koraput, 61 percent of protein was obtained from cereals and millets in 2014, which decreased to 51 percent in 2017; other major contributors of protein are vegetables, pulses and legumes and animal foods (**Figure 1**). In Wardha, 52 percent of protein was obtained from cereals and millets followed by vegetables and pulses and legumes in 2014. Following FSN interventions, in 2017, 41 percent of protein was obtained from cereals and millets and remaining share from vegetables, pulses and legumes increased. Rampal [23] reported that cereals and pulses are the major sources of protein in the Indian diet. Overall, protein obtained from animal foods increased by 2 percent after intervention in both locations. In Koraput, protein obtained from fishes and sea foods increased from 3 percent to 7 percent due after intervention.

3.2.3. Calcium Intake

The average calcium intake per CU per day in 2014 was more than the RDA (RDA 600 mg) in Koraput and increased significantly after intervention by 333 g. This increase may have been due to increase in consumption of finger millet (ragi) and green leafy vegetables sourced from home production and fish from market. Major share of calcium was obtained from cereals and millets (44%), vegetables (32%) and animal foods (15%) in 2014 which changed to 35 percent, 32 percent and 26 percent respectively in 2017. About 93 percent of the households in 2014 consumed calcium more than 70 percent of RDA which further increased to 97 percent in 2017. Puranik *et al.* [24] reported that for low-income households which mostly depend on starchy and bulky foods like rice for their calorie requirements, finger millet ensures a pragmatic solution. Bioavailability of calcium (28%) in finger millet is high when compared with other cereals like rice (24.7%), maize (25.4%) and sorghum (26%) [25].

In Wardha the average intake of calcium was less than RDA in 2014 and increased significantly by 421 g and met the RDA as most of the households consuming less than 70 percent of recommended allowance of calcium in 2014 were consuming more than 70 percent of RDA, in 2017 after FSN intervention. There was a notable increase in consumption of millets, leafy vegetables, animal foods, all of which are primary source of calcium. In 2014, calcium was obtained majorly from cereals and millets followed by vegetables and animal foods and after intervention in 2017, animal foods, mainly fishes and sea foods from market followed by vegetables mainly green leafy vegetables contributed major share of calcium to the diet (**Figure 2**). Similar results, calcium intake more than recommended level was reported by Adhiguru and Ramasamy [21] after vegetable production system intervention. Increased intake of calcium was reported due to consumption of vegetables and fruits from home garden by Alemu, *et al.* [26] and Kim and Park [27].

3.2.4. Iron Intake

The average per CU per day intake of iron in Koraput in 2014 was less than the RDA (RDA 17 mg) which significantly increased by 6 mg in 2017 after FSN intervention. About 71 percent of the households were consuming iron more than 70 percent of RDA in 2014 and in 2017, 92 percent of the households consumed iron more than 70 percent of RDA. In Wardha, in 2014 the intake was more than RDA, however it further significantly increased by 10 mg in 2017. The quantity of iron from home garden promoted as FSN activity increased in both the locations. Cereals and millets was the main source of iron in both the locations in 2014 and remained to be the higher source in 2017. Coarse cereals like sorghum, pearl millet and finger millet and whole wheat have relatively high iron and folate content [28]. Pulses and legumes was the second source of iron in 2014 which changed to vegetables in 2017 in Koraput and vegetables and pulses and legumes in Wardha. Adhiguru and Ramasamy [21] reported that the vegetable production system highly favoured the increased intake of iron, vitamin A and vitamin C.

3.2.5. Vitamin A Intake

The average intake per CU per day intake of vitamin A in Koraput was below RDA (RDA 600 μg) in 2014 and remained the same after FSN in 2017 while in Wardha it met RDA after FSN with significant increase. Only 47 percent of the households were consuming more than 70 percent of RDA and this decreased to 36 percent in 2017 while in Wardha, it increased from 18 percent of households in 2014 to 87 percent in 2017. In both the locations, the major source of vitamin A was vegetables in 2014 and 2017, followed by fruits in Koraput and animal foods in Wardha. Similar results were reported by Adhiguru and Ramasamy [21]. Dangura and Gebremedhin [29] documented that children of household's producing fruits and vegetables consumed vitamin A rich foods. Similarly, Girard *et al.* [30] reviewed eight studies and reported increased intake of macro and micronutrient intakes, particularly improvements in vitamin A intake, by the children from households with home garden interventions.

4. Conclusions

Policy makers and practitioners have long aimed to influence nutritional outcomes through agricultural programs. The relationship between agriculture and nutrition, or from food production to food consumption is direct, but complex. Strategies focused on the enhancement of a particular dietary nutrient provide a directed pathway to improve nutrient status via crop production, consumption, and nutrient absorption. This study focused on analysing the impact of FSN approach on mean per consumption unit intakes of nutrients like energy, protein, vitamin A, iron and calcium in two rural regions of India. The results show statistically significant increase and positive change following interventions during the three years between 2014 (baseline) and 2017 (endline). This indicates that the interventions are having a sustained impact.

The limitation of the study is that it does not indicate seasonal patterns of consumption which is important to understand the availability of vegetables and fruits and seasonal fluctuations in nutrition insecurity. Another limitation is that the dietary intake is measured at the household level and this may not be adequate to understand the pattern of intra-household distribution arising from the FSN intervention. 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.

This study has demonstrated the feasibility of a farming system of nutrition approach by providing inputs for farming activities as well as by creating awareness to improve dietary diversity, in two low rural regions of the country. Based on evidence from the study, the approach is being replicated in 47 villages (under 14 revenue villages) covering 1575 households in Boipariguda block of Koraput district, Odisha with support from Rashtriya Krishi Vikas Yojana, Government of Odisha, India. The FSN approach makes a case for promoting nutrition sensitive agriculture interventions and programmes among populations dependent on agriculture.

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Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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