“Agri-Nutri Connect” for promoting dietary diversity and addressing malnutrition among tribal populations in Telangana

RESEARCH AND INNOVATION CIRCLE OF HYDERABAD (RICH)
3rd Floor, T hub, Catalyst Building, IIIT-H, Gachibowli, Hyderabad-500032

Table of Contents

1. Introduction

Researchers have been particularly concerned with undernutrition and the ability of agriculture to make food available and meet the nutritional needs of the population. Globally, 821 million people were undernourished in 2017, signifying an upward trend since 2014 where 462 million adults were reported to be underweight. Current evidence indicates an increase in global hunger and a shift of trends after a protracted decline.

Though there has been progress in reducing childhood stunting (low height-for-age), yet, 150.8 million children are stunted, often associated with a high risk of mortality. Besides, 50.5 and 38.3 million children are wasted (low weight-for-height) and overweight respectively. In 2017, more than half of the stunted children under five lived in Asia. Also, more than one quarter and more than two-thirds of children who were wasted came from Africa and Asia respectively. Out of the nine global nutrition targets, less than half of the countries are on course to meet at least one of them with only five countries on course to meet four.

Food safety and other food-related hazards and risks remain a prominent source of concern in the food system. The global burden of foodborne illness and infections is substantial. Each year 420,000 lives are lost due to foodborne illnesses globally. In many parts of the semi-arid tropics, aflatoxin remains an unresolved food safety challenge.

As low and middle-income countries are in transition, their economies and livelihoods are in transition too. Also, their diets are in the midst of a rapid change from traditional to modern diets. The increasing availability and consumption of energy dense processed foods and increasing low activity lifestyles are leading to escalating rates in overweight and obesity. Contemporary food systems are not well prepared to provide consumers with safe, nutritious and sustainable diets.

2. Problem Statement

India has made progress in food security but the problem of chronic household food insecurity is still prevalent. India experiences malnutrition burden among its under-five population. As of 2015, the national prevalence of under-five overweight is 2.4%, which has increased slightly from 1.9% in 2006. The national prevalence of under-five stunting is 37.9%, which is greater than the developing country average of 25%. India's under-five wasting prevalence of 20.8% is also greater than the developing country average of 8.9%. About 47 million or 4 out of 10 children in India are facing chronic undernutrition or stunting mainly in vulnerable regions and communities.

As per the recent National Family Health Survey-4 (2015-16), about 58% children (6-59 months), 53% women (15-49 y) and 23% men were suffering from various degrees of anaemia. In fact, the prevalence of among women (15-49y) increased from 52% in 1998-99 (NFHS-2) to 55% in 2005-6 (NFHS-3) and has only slightly reduced to 53% in 2015-16 (NFHS-4). India is off course to meet the global targets for all indicators analysed with adequate data. There is insufficient target data to assess India's progress for under-five overweight, infant exclusive breastfeeding, and low birth weight.

Telangana is no exception. According to statistics made available by the Union Ministry of Health and Family Welfare, the number of pregnant women detected with anemia in the Telangana State was 6.77 lakh in 2018-19. In 2017-18, it was 5.92 lakh and just two years down the line in 2016-17, the number was 4.29 lakh. It may be mentioned here that a recent study on anemia trends in India over a decade, from 2008-18, by an Indian Council of Medical Research (ICMR) researcher, has reported that Telangana has the highest percentage of women suffering with severe anemia, wherein haemoglobin levels are less than 7g/dL.

Vikarabad district in Telangana has high population of scheduled tribes (13.01% of total population). About 83.87% of the land are owned by small and marginal farmers and primarily drylands. Maize, red gram and cotton occupy 19%, 28.8% and 28.6% of the gross cropped area respectively.

The diet of tribal population in Telangana mainly consists of sorghum porridge (or roti) for breakfast, sorghum roti for lunch, and rice with an accompaniment of a minimum amount of *dhal* in most cases, for dinner. Forest tubers available during certain times of the year are also consumed. Milk, eggs, fish, meat, fruits and vegetables are consumed occasionally or minimally due to the lack of purchasing power. There are no home-based special diets for tribal children and pregnant women, other than the supplementary nutrition that they may be receiving from the ICDS program and mid-day meal scheme.

Our preliminary ex-ante assessment of the current situation of crop–livestock systems in Vikarabad revealed that capital availability for investment in technology and inputs was very low and the situation was aggravated by erratic rainfall. Additionally, we found that low productivity and profitability of food crops pushed the farmers to adopt cash crops like cotton and soybean. Many of the households own cattle with very low productivity (1-2 L of milk/day/herd of typically ~5 animals) which results in low consumption of dairy products and low nutritional status of the population over the years. Preliminary discussion with these farmers during recent scoping studies indicated that farmers are willing to experiment with crop and livestock innovations to increase the productivity of crops and dairy productivity.

3. Proposed Solution and Partners

RICH along with partners like ICRISAT, Dept. of Agriculture and Dept. of Women Development and Child Welfare, Govt. of Telangana, central institutions such as NIN, the start-up ecosystem in Hyderabad and other national level institutions will work on addressing the issues related to improved nutrition and food safety though a holistic approach ranging from basic research to behavior change and communication to improving diets and nutrition. We propose to integrate crop–livestock technologies and management practices to build resilience into existing food systems to be more sustainable, profitable and acceptable.

We hypothesize that nutritional and socio-economic wellbeing of tribal farming communities can be improved by integrating nutrition sensitive and climate smart crops and livestock technologies. The team proposes to develop a holistic, sustainable nutritional program and demonstrate in Vikarabad district of Telangana. This program is expected to be a model which could be replicated across the country.

To achieve the above objective, specific interventions are planned.

a. **Studying the nutritional status of target groups**
   Partners Responsible: RICH, ICRISAT, NIN, NICE, Grameen, NutrifyU8, Millet Bank
   Blood samples will be collected from 2600 subjects and tested for Anaemia. Other parameters including Stunting and Body Mass Index (BMI) will be estimated at three stages (baseline, mid-term and end-line)

b. **Nutrition-sensitive agriculture** – Agricultural (including vegetables, horticulture and livestock) production to encourage healthy and sustainable diets.
   Partners Responsible: RICH, ICRISAT, World Veg, Grameen, NRCM

c. **Seed to Market support** for producing, consuming and marketing the excess.
   Partners Responsible: RICH, ICRISAT, Kheyti

d. **Creating sustainable production systems** for food and fodder, ultimately turning all the interventions sustainable.
   Partners Responsible: RICH, ICRISAT, World Veg, Grameen, Millet Bank

e. **Product development and food sciences –** Enhancing product functionality, product profile, consumer satisfaction and acceptability. (eg: fortification and flour blending for improved nutrition and sustainable food supply).
Partners Responsible: NIN, ICRISAT, RICH, NutrifyU8

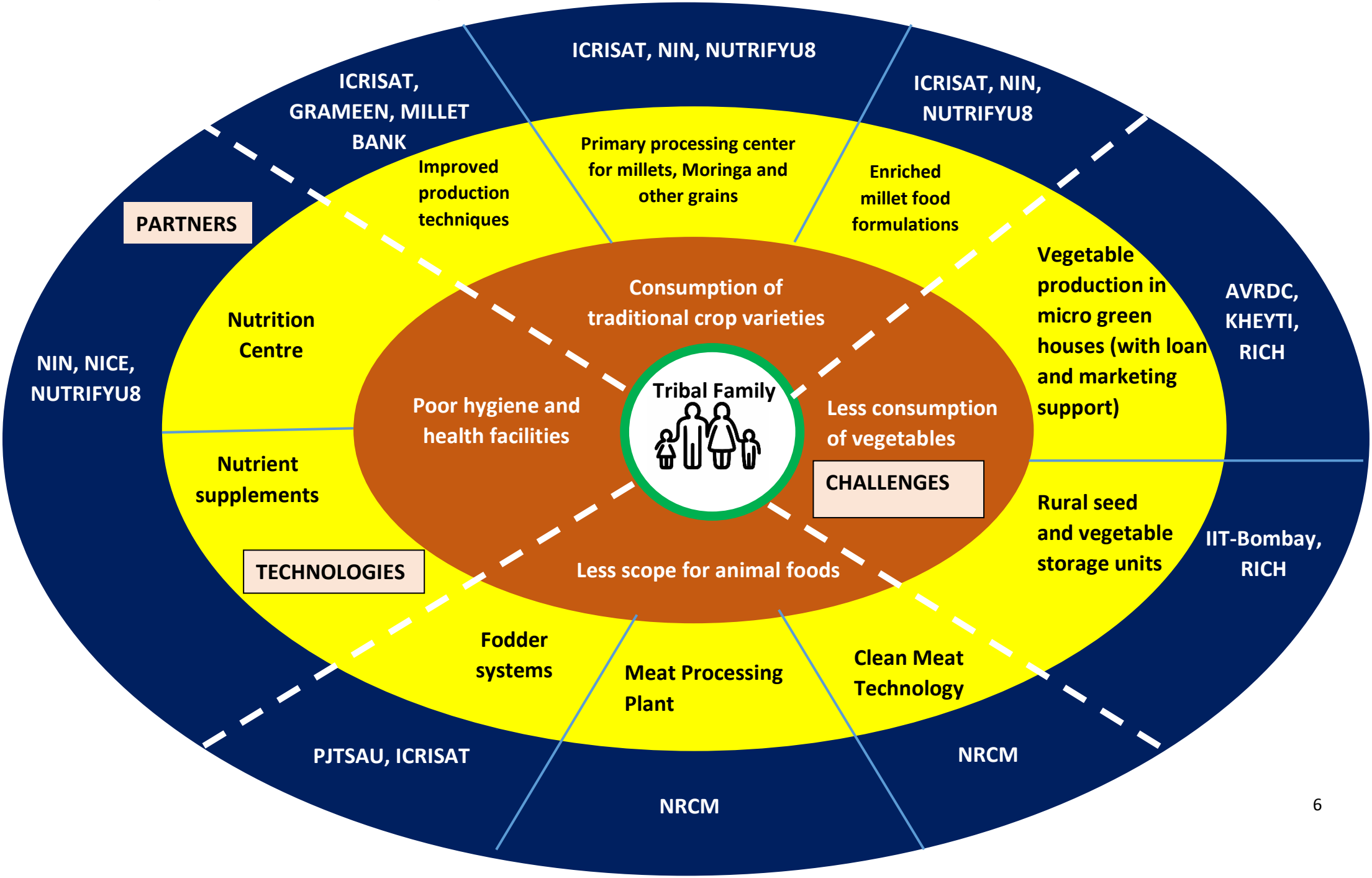
f. **Agri-business and value chains -** Identifying entry points for innovative interventions to improve nutrition-sensitivity along the value chain and enhancing the demand for Nutri-rich crops.
Partners Responsible: RICH, ICRISAT, NutrifyU8

g. **Infrastructure for sustained production:** Market research for health products, establishment of processing units and capacity building of farmers for sustainable business model.
Partners Responsible:
Crop Processing facility: ICRISAT, RICH, Grameen, NutrifyU8
Animal Processing facility: RICH, NRCM

h. **Dietary behavior change determinants** – Investigating the role of social and cultural norms leading to gender inequalities in nutrition and how this can be reversed – gender transformative approaches.
Partners Responsible: RICH, NIN, NICE

i. **Capacity building and livelihood promotion:** Selected beneficiaries will be trained on managing the infra structure and spread the word about the project impact to so as to contribute in replicating this model across other districts/states.
Partners Responsible: RICH, NIN, NICE, ICRISAT, World Veg, NRCM, Grameen, Millet Bank, NutrifyU8

Combating Malnutrition in tribal regions of Telangana



4. Key Activities and Partners

1. Assessing the current agricultural production practices and household nutrition status and identifying potential opportunities and challenges. Details of the nutrition study is given in appendix-1.
2. Promotion of nutrition sensitive agricultural (biofortified crops, vegetables and livestock) production in target districts through modern agricultural technologies
3. Designing and promotion of consumer preferred energy dense micronutrient rich with enhanced bioavailability (SMART) foods and dietary diversity
4. Validation of food products on consumer preferred traits and health claims. Details of the analysis to be conducted while formulating nutrient rich foods is given in appendix-2
5. Promoting agricultural value-chains and agri-business for enhancing nutri-sensitive agricultural production and its sensitivity
6. Identification of health products, market competitors, primary and secondary processing units. establishment, identification of capable farmers community & development of sustainable business plans
7. Enhancing Behavioral Change Communication (BCC) towards nutrition, hygiene and health among target households
8. Livelihood promotion through formal and informal capacity building activities
9. Real-time monitoring of project KPIs and digital Monitoring & Evaluation through MEASURE platform
10. Assessing the project impacts on tribal households in terms of enhanced agricultural production, nutrition and livelihoods.

5. Proposed geographic locations and target population

The interventions will be carried out across selected mandals in Vikarabad. Twenty-five villages will be selected and in each selected village/cluster 26 households are considered which totals to 650 households considering 95% confidence interval, 5% absolute precision, 1.5% design effect, 10% non-response.

Sample Size: 650@4=2600 subjects

Note: *Details of sampling methodology (as proposed by the National Institute of Nutrition) is given in annexure-1*
Detail of nutritional profiling of traditional foods and improved food formulations are given in annexure-2

6. Activity linked budget and intended outputs

	Activities	Organization-wise budget (Rs in Lakhs)								Total (Rs in lakhs)	Expected Outputs/Outcomes
		ICRISAT	Worldveg	NIN	NRCM	NICE	GRAMEEN	NutrifyU8	Millet Bank		
Phase 1: Inception and Baseline Assessment											An evidence base developed for informed decisions
0-6 months											
0-3 months	Inception meeting for finalizing local partners' workplans; finalizing FPOs to collaborate	1				0.5	1		0.5	3	All stakeholders have a common understanding of the project activities and expected outputs and outcomes.
0-3 months	Inception Meeting with village communities	0.5	0.5	0.5	0.5	0.5	1	0.5	0.5	4.5	
0-3 months	Assessing the current agricultural production practices and identifying site for processing plant	0.5			0.5		0.5	0.5		2	Understanding of the current agronomy practices to suggest improvements.
0-6 months	Socio-economic baseline survey including consumer preferred products and identification of the product concepts	10		2		1	2	1	1	17	A benchmark for nutritional status and dietary diversity established to measure impact at end of project
0-6 months	Nutrition baseline survey			20		2	2	5		29	

0-3 months	Procurement of mobile nutrition survey equipment			13.5						13.5	
Phase 1 Total		**12**	**0.5**	**36**	**1**	**4**	**6.5**	**7**	**2**	**69**	
Phase 2: Implementation											Improved nutritional outcomes and enhanced livelihoods.
6-30 months											
Phase 2a: Crop Improvement											
0-24 months	Identification of promising nutri-rich (biofortified) sorghum, pearl millet and finger millet cultivars (6 each) for testing in target locations (4 villages in each Mandal), using standard (statistically appropriate) farmer-participatory varietal selection (FPVS) approach	5					1		1	7	Varieties suitable to the local agro-ecology and preferred by farmers identified for replication.
6-30 months	Assessing the cultivars for stability of grain yield and nutritional profile and selection of superior cultivars for promotion in target locations	2		2			1	0.5	0.5	6	Scientific evidence established for increased incomes and better nutrition.
6-30 months	Identification of promising forage sorghum and pearl millet cultivars and assessing the stability of forage yield, digestibility and selection of superior	2			2		1		0.5	5.5	Improved income from animal husbandry.

	varieties for promotion in target locations										
6-30 months	Demonstrating the production potential of selected cultivars (grain yield, nutritional quality, and forage yield) using improved cultivation practices to achieve higher yields	5			2		2		1	10	Farmers convinced to take up the new varieties.
12-36 months	Seed increase of selected varieties with support from local seed farmers and their dissemination	8					2		1	11	A sustainable seed system put in place within the community.
6-36 months	Knowledge sharing on crop management, quality seed production and seed storage	5					3		5	13	Capacity of local community built to ensure better income from agriculture.
24-36 months	Developing a sustainable community-based seed systems strategy to suit the target regions	3					2		2	7	Seed self-sufficiency and long-term sustainability of seed chain ensured.
Phase 2a Total		**30**	**0**	**2**	**4**	**0**	**12**	**0.5**	**11**	**59.5**	
Phase 2b: Vegetable Improvement											Diet diversification leading to enhanced nutrition ensured.
6-36 months	Preparation of seed kits		16							16	Availability of seeds ensured.
6-36 months	Preparation of training materials		5							5	Training content and messaging reinforced.
6-36 months	Training of trainers		5	1			1			7	Change agents created who can spread the work further in the communities.

6-36 months	Stakeholder meetings and Community-sensitization activities		3	1.5			1.5			6	Buy-in of community ensured for the proposed activities. Awareness built in the communities about the importance of vegetables as part of a diversified diet.
6-36 months	Farmer trainings		10				3			13	Farmers have the capacity to take up the new proposed activities.
6-36 months	Increasing area under vegetable cultivation and consumption, Follow-up trainings for farming households		10				3			13	Long-term sustainability of the project ensured.
Phase 2b Total		**0**	**49**	**2.5**	**0**	**0**	**8.5**	**0**	**0**	**60**	
Phase 2c: Content Development and Capacity Building											
6 -18 months	Creating content for knowledge enhancement	1	1	1	1	1	1	1	7	14	Social and behaviour change regarding food and nutrition
06-36 months	Capacity building and knowledge enhancement through micro-learning modules on agriculture and nutrition delivered through Digitally Enabled Extension Representatives (DEER)	2	1	1	1	1	1	1	10	18	Micro-learning-based modules building the skills and knowledge of the target population on good agriculture practices and important nutrition messaging.

3-18 months	Livelihood promotion through formal and informal capacity building activities	5		1		1	2			9	Increasing incomes for better family-level nutritional outcomes.
Phase 2c Total		**8**	**2**	**3**	**2**	**3**	**4**	**2**	**17**	**41**	
Phase 2d: Developing Value Chains											
0-6 months	Nutrition profiling of traditional diets to identify gaps.	2		8		1	1	2		14	
6-24 months	Distribution of improved poultry Goat & sheep				15		5			20	
6-12 months	Formulation development and optimization of the product concepts shortlisted, and acceptability studies undertaken	5		15				3		23	Formulations of food products to be used for nutritional intervention finalized and accepted by target beneficiaries
12-18 months	Development of business plans and operations model for the cereal processing units	3								3	Development of sustainable business model for the community
6-12 months	Procurement, installation and trial of cereal processing equipment (two locations)	70								70	Processing units established and operational (one in each district).
12-36 months	Procurement, installation and trial of meat processing equipment				40					40	Meat Processing units established and operational
12-24 months	Supply of nutrition rich foods to beneficiaries							45		45	

24-36 months	Production by the beneficiaries										
	Raw material procurement	12			5					17	Same as above
	Labour cost	15			15					30	Same as above
	Cost of hiring shed	4.8			4.8					9.6	
6-36 months	Running and maintenance cost of units	7			7					14	Same as above
12-18 months	Training on technical and business aspects to FPO members for managing primary cereal processing unit.	5		2	3		2			12	Tribal farmers start unit operations by themselves
18-20 months	Conducting mid-term study on nutritional improvement			30		2	2			34	
Phase 2d Total		**123.8**	**0**	**55**	**89.8**	**3**	**10**	**50**	**0**	**331.6**	
Phase 3: End line Assessment											Scientific evidence gathered of improved nutritional outcomes and enhanced livelihoods.
30-36 months											
30-36 months	End-line socio-economic survey including impacts	15	1	1	1	1	2.5			21.5	Detailed insights of the outcome and growth parameters and nutrition status of the vulnerable targets, enabling for quick actions in cases if necessary. Insights help monitoring the progress of growth among the target population

	End line nutritional survey			30		1	2	2		35	Detailed insights of nutrition status of the target population.
00-36 months	Digital Monitoring and Evaluation: through ICRISAT's MEASURE platform, enable real-time geo-based data for baseline, end line and continuous monitoring of different project activities including capacity building, distribution of inputs, profiling of beneficiary.	25	2	2	2	2	2			35	Real-time actionable insights/dashboards for tracking effective implementation of the project. Efficient management of beneficiaries
Phase 3 Total		**40**	**3**	**33**	**3**	**4**	**6.5**	**2**	**0**	**91.5**	
Grand Total		**213.8**	**54.5**	**131.5**	**99.8**	**14**	**47.5**	**61.5**	**30**	**652.6**	
	Overhead (@10% as per DST/DBT)	21.38	5.45	13.15	9.98	1.4	4.75	6.15	3	65.26	
	Grand Total (partners)	**235.18**	**59.95**	**144.65**	**109.78**	**15.4**	**52.25**	**67.65**	**33**	**717.86**	

Designation	**Year-1**	**Year-2**	**Year-3**	**Total**
Hyderabad Cluster Project Manager (Health Management Professional)	15	16.5	18.15	49.65
Project Executive	6	6.6	7.26	19.86
Total	**21**	**23**	**25**	**69.51**
Total Project Cost	**787.37**			

7. Project Budget (Over all)

Partner Organisation	Year-1	Year-2	Year-3	Total	Overheads 10% as per DST/DBT	Grand Total (Rs in lakhs)
ICRISAT	108	72.9	32.9	213.8	21.38	235.18
World Veg	19.5	21	14	54.5	5.45	59.95
NIN	59	38	34.5	131.5	13.15	144.65
NRCM	11	69.4	19.4	99.8	9.98	109.78
NICE	8	3	3	14	1.4	15.4
Grameen	20	15.5	12	47.5	4.75	52.25
NutrifyU8	10.5	48	3	61.5	6.15	67.65
Millet Bank	3.5	18.5	8	30	3	33
Hyderabad City Cluster Project Manager	15	16.5	18.15	49.65		49.65
Project Executive	6	6.6	7.26	19.86		19.86
					Total Project Cost	**787.37**

Sl No	Duration	Capex (Rs in lakhs)	Opex (Rs in lakhs)	Total Budget (Rs in lakhs)
1.	**36 months**	**110**	**677.37**	**787.37**

8. SDGs relevant to the project

This project will contribute to addressing the following SDGs

SDG 1 – No poverty
SDG 2 – Zero Hunger
SDG 3 – Good Health and Wellbeing
SDG 5 – Gender Equality
SDG 12 – Responsible Consumption and Production

9. National Ministries and Missions of relevance

This proposal links with the following:

a) 'Giri Poshana' programme of the Govt. of Telangana focusing on improving the nutritional status of women and children in tribal areas;
b) National POSHAN Abhiyaan aimed at improving nutritional outcomes and making India malnutrition free by 2022;
c) 'Anemia Mukt Bharat' programme of the Min. of Health and Family Welfare, GoI focusing on reducing the prevalence of anemia by one-third of NFHS-4 levels by 2022.

The ICDS programme of the Ministry of Women and Child Development will be an important entry point into the project. India is also a signatory to the SDGs and this proposal directly contributes to help India achieve the SDG targets (see section 6). Other Ministries of relevance include: Ministry of Tribal Welfare Development, GoI; Ministry of Agriculture and Farmer Welfare, GoI.

Appendix-1

Details of baseline, mid-term and post project study

Objectives

1. To educate them in terms of nutrition, sanitation through group meetings, seminars (through nutrition booklets) with the help of Anganwaadi centers, ASHA workers, DWACRA Groups and local leaders etc.
2. To assess the comprehensive nutritional composition (Intervention) and its organoleptic properties
3. To assess nutritional status by diet and anthropometric measurements and clinical evaluation of Hemoglobin (Hb) level
4. To analyze the bio markers of includes serum (Retinol, Vitamin E, Ferritin, TfR and CRP and Zinc)

$$n = \frac{1.96^2\, pq}{d^2}$$

Methodology

Samples will be selected based on the following criteria

Inclusion criteria:

·Pre-school children, adolescent girls, pregnant women and lactating mother will be enrolled

Exclusion criteria:

·Individuals having Hb less than 7 % will be excluded from the study and referred to higher centre

·Individuals suffering from haemoglobinopathies and significant GIT mal-absorption disorders are excluded from the study.

·Individuals not willing to give consent and part of the study

Sample size: 650 households in each district are included considering 95% confidence interval, 5% absolute precision, 1.5% design effect, 10% non-response. In each district, 25 villages will be selected and in each selected village/cluster 26 households are considered.

Total sample size: **650@4=2600** subjects.

Sample Size Calculation

The sample size is calculated on the basis of the major nutritional indicators of children and women reported in NFHS4. The Sample size has been calculated using the formula

where,

n= sample size,

p=anticipated prevalence and q=1-p, d= precision.

The following tables present the sample size required for different study subjects on the selected parameters with 5% absolute precision, design effect of 1. 5, non-response rate 10% and 95% confidence interval.

District:	Vikarabad	Sample Size
Children under 5 years who are stunted (height-for-age) (%)	26.2	490
Children under 5 years who are underweight (weight-for-age) (%)	25.8	485
Women whose Body Mass Index (BMI) is below normal (BMI < 18.5 kg/m2) (%)	19.3	617
Men whose Body Mass Index (BMI) is below normal (BMI < 18.5 kg/m2) (%)	18.1	587
Children age 6-59 months who are anaemic (<11.0 g/dl) (%)	48.2	633
All women age 15-49 years who are anaemic (%)	54.9	628

The maximum sample size in Vikarabad it was 660 HHs. The study will be carried out in 30 clusters/villages of the district, 20 households (HHs) in each cluster/village covering after mapping and listing of eligible HHs according to the inclusion and exclusion criteria and screening of the subjects. The village or the group of villages says a cluster should have at least of 70 HHs. The clusters are selected using probability proportional to size (PPS) method based on the number of HHs/Population belongs to SC/ST community. In each cluster/village, HHs will be selected using simple random sampling. Average family size was assumed to be four, hence the total subjects at baseline is required is 2640 subjects in Vikarabad district. These subjects will be followed up for at least two years and sample information will be collected at three time points namely, baseline, midline and endline.

Plan of Statistical Analysis

The collected data is stored in a password protected server at NIN. NIN team will check the secondary edits if any before finalization of the data set. Descriptive statistics, univariate and

multivariate analysis will be carried out for assessing the prevalence and associations of outcome variables, if any, with the independent variables using SPSS version 19.0. Significant level is fixed at 5% level. The primary data are analyzed using descriptive statistics and the results would be expressed as Mean ± SD, median (P25-P75) for quantitative variables and proportions for the qualitative variables. The plan of anthropometric and hemoglobin indicator analysis will be based on the WHO recommendations.

Appendix-2

Studying nutritional content of food samples

Proximate composition

The proximate constituents including moisture, fat, protein, ash and fiber of food samples will be evaluated. Moisture content of samples will be analyzed using hot air oven as described in Association of Official Analytical Chemists (AOAC 934.01). The protein content will be analyzed using Kjeldhal methods by applying Jones factor (1941) (AOAC 2001.11). Fat content will be estimated using soxhlet extraction method using ether (AOAC 963.15) while ash content will be analyzed by gravimetric method using muffle furnace (AOAC 942.05). Dietary fibers including soluble, insoluble and total dietary fibers will be evaluated using enzymatic methods as reported AOAC (991.43). The total carbohydrate will be calculated by difference method as reported by Greenfield & Southgate (2003).

Minerals

Mineral profiling of food samples will be done using Inductively Coupled Plasma (ICP)– Mass Spectrometry (MS) and Atomic Absorption Spectroscopy (AAS). Briefly, sample will be digested by acid hydrolysis using nitric acid followed by microwave digestion. After appropriate dilution, minerals and heavy and trace metal including Iron, Zinc, Copper, Manganese, Potassium, Magnesium, Sodium, Calcium, Aluminium, Phosphorous, Lead, Mercury, Antimony, Cadmium, Molybdenum, Selenium, Arsenic, Cobalt, Nickel, Chromium, Aluminum and Lithium will be evaluated using ICP-MS and AAS.

Fat soluble vitamins

Vitamin E

Vitamin E vitamers will be extracted by means of saponification in the presence of alcoholic potassium hydroxide using non-polar solvents. These vitamers will analyzed by normal phase HPLC (AOAC 992.03; AOAC 2012.10) using silica column and detected by diode array detector due to the presence of strong chromospheres in UV radiation.

Carotenoids

Caroteniods are soluble in less polar solvents. Samples therefore, homogenized and saponified in alcoholic potassium hydroxide to release the carotenoids and further, extracted with organic solvent such as petroleum ether. Separation of carotenoids will be performed using HPLC and quantified using external standards (Rodriguez-Amaya and Kimura, 2004). Detection and quantification will be achieved by means of UV-DAD.

Water Soluble vitamins

Vitamin B including thiamin, riboflavin, folic acid, pantothenic acids and biotin will be evaluated following the standard methods of AOAC.

Fatty acids profile

The fatty acids will also classify into saturated and unsaturated fatty acid. Individual fatty acids will be evaluated using Gas Chromatography-FID by method of AOAC official method

996.06(AOAC Official Method of Analysis, 1995). Fatty acid methyl esters (FAMEs) will be prepared from samples by direct trans-esterification using 2% sulphuric acid in methanol. FAMEs will be separated and quantified by Gas Chromatography coupled with FID. Supelco 37 FAME Mixture will be used as reference standard.

Phytochemicals and antioxidant properties

Individual polyphenols will be evaluated using HPLC as discussed by Kim et al. (2007). Different antioxidant activity assay including DPPH, free radical scavenging activity would be carried out using the method reported by Sharma and Gujral (2010), ABTS assay (Liyana- Pathirana & Shahidi, 2005), reducing power, metal chelating activity (Sharma & Gujral, 2014) and total flavonoids content (Zhishen et al., 1999).

Organoleptic evaluation of food

Processed foods will be evaluated for organoleptic properties using a nine-point hedonic scale with 1, dislike extremely; 5, neither like nor dislike and 9, like extremely was used.

Biochemical Analysis

Serum markers related too will be monitored using standard kit methods and ELISA reader.