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Call for Action to Address Hidden Hunger: Enabling Biofortification to Address Micronutrient Deficiencies

HarvestPlus and The Bihar Rural Livelihoods Promotion Society

Rewa Misra, HarvestPlus and BirenMendali, IFPRI

Hidden hunger is one of the most intractable public health challenges affecting about two billion people globally. The most significant gaps are in micronutrients such as iron, zinc, vitamin A and calcium. India has made initial improvements in terms of stepping up zinc uptake and has a long-standing program in iron supplementation and more recently fortification. However, a third of its children (below the age of 5) are stunted and nearly 65% are anaemic[1]. Over half of India's female population in reproductive ages (15-49) are anaemic. This is reflective of the lack of affordability of even a minimally nutrient adequate diet (nearly 40% cannot afford) and healthy diets (78% cannot afford)[2].

Biofortification is the process of enhancing micronutrients in staple food crops through conventional[3] breeding methods to make a positive measurable impact to the population that eats such staples daily. It is a cost-effective, market driven, sustainable food systems strategy and complementary in nature to existing health interventions such as supplementation and fortification. HarvestPlus initiated its biofortification research and development activities in India in 2011. After a decade of establishing robust evidence on nutritional efficacy and effectiveness HarvestPlus India started to scale up biofortification in 2018. Iron pearl millet, zinc wheat, zinc rice, iron legumes, vitamin A sweet potato and yams today comprise a portfolio of over 87 varieties in India alone (over 400 globally). Varietal development is carefully tailored to local agroecological conditions, market opportunities, dietary and cultural preferences and crops are competitive in terms of yield and climate tolerance.

The Bihar Rural Livelihoods Program or Jeevika has emerged as a leading social and economic development platform reaching over 12 million rural households. In 2021 HarvestPlus and the Bihar Rural Livelihoods Promotion Society (BRPLS) partnered to leverage their mutual strengths in biofortification and livelihoods development to pilot the introduction of seed and crop production for zinc wheat and iron -zinc lentils with Jeevika supported Farmer Producer Companies.

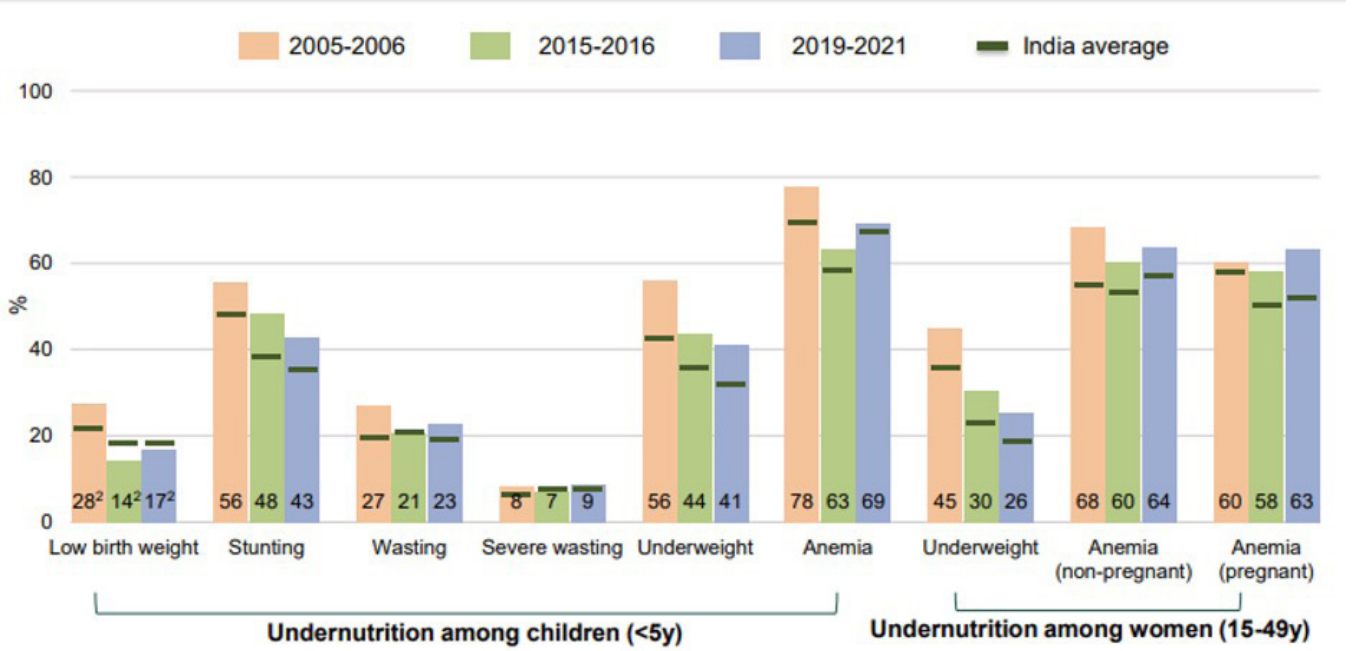
This case study takes stock of the food systems approach, implementation experience and lessons learnt for scalability emerging from this initial pilot. Lessons learnt are relevant not only for expansion within Bihar but also broadly for livelihoods development programs to demonstrate how farmer adoption and marketing of biofortified seed, grain and food can deliver both nutrition and economic gains.

Bihar – State Level and District Trends in Malnutrition

Bihar suffers one of the highest burdens of malnutrition related disease in India. Stunting affects nearly a quarter of its children while anaemia, which is on an increasing trend (see figure 1 below) affects

1. For Asia wide data see annex A. Author's own analysis based on FAO et. al. (2020) The State of Food Security and Nutrition in the World 2020.
2. National Family Health Survey Round 5.
3. There are increasingly also alternative approaches for biofortification such as agronomic and bioengineering based methods.

Figure 1. Trends in undernutrition outcomes 2005-2006, 2015-2016, 2019-2021



Source: NFHS-3 (2005-2006) national report and data [IFPRI estimates], NFHS-4 (2015-2016) national report, and NFHS-5 (2019-2021) national and state factsheets. Anemia among non-pregnant and pregnant women for 2005-2006 are IFPRI estimates using woman dataset. [1]WHO. Nutrition Landscape Information System (NLiS). Help Topic: Malnutrition in children. Stunting, wasting, overweight and underweight. (https://apps.who.int/nutrition/landscape/help.aspx?menu=0&helpid=391&lang=EN).
[2]In NFHS-3, NFHS-4, and NFHS-5, 83.8%, 38.7%, and 22.8% of data were missing, respectively.

Data presented in IFPRI, 2022, Poshan State Nutrition Profile, New Delhi

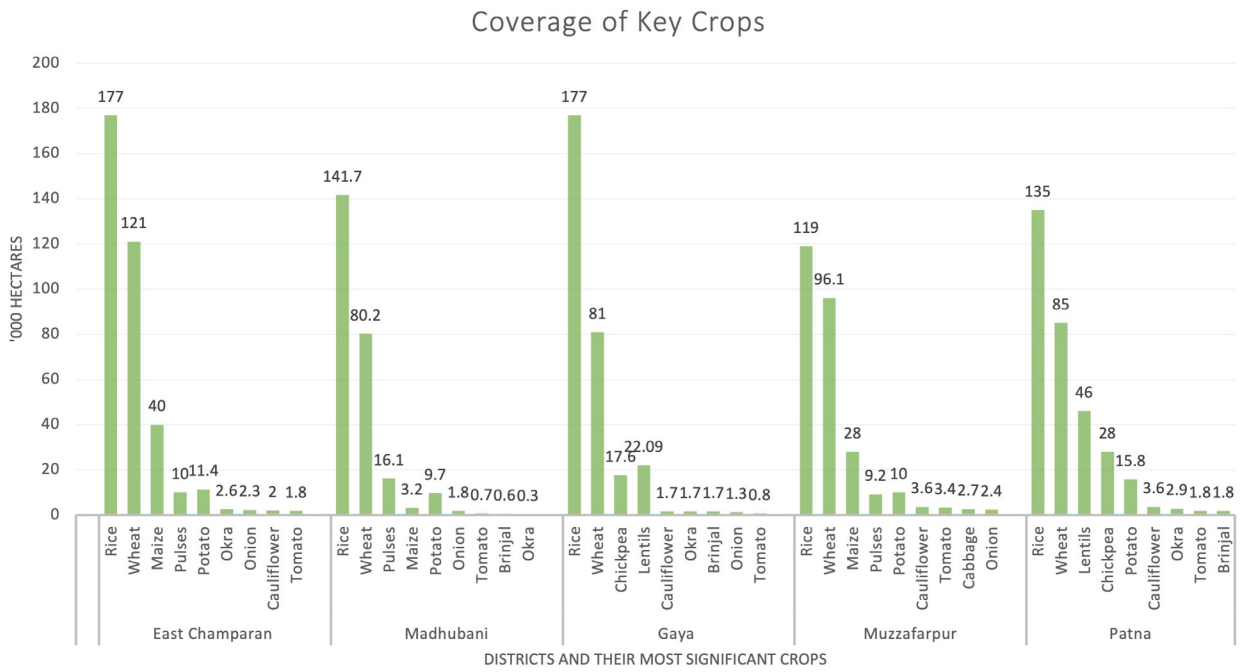
nearly 70%. Around 65% of Bihar's women are anaemic. Bihar is one of the few states which was initially unable to effectively roll out iron and folic acid supplementation with coverage levels of less than 10% in 2018. Coverage has gone up since then to approximately 35%[4] with the Anaemia Mukt Bharat (AMB) strategy however anemia rates have remained relatively high across most districts.

Addressing deficiencies through a sustainable approach requires a better understanding of local food systems and envisioning how these can be upgraded to enhance micronutrient uptake. Given the lack of affordability of diverse diets, a significant proportion of the most vulnerable households (rural) largely consume what they grow or what is available locally. The graph below presents key crops produced locally and highlight gaps for districts with the highest concentration of micronutrient deficient people. For districts with the largest concentrations of children and women with micronutrient deficiencies (See heatmap in Annex 1) namely East Champaran, Gaya, Muzaffarpur, Madhubani and Patna, local daily diets are unlikely to deliver adequate minerals for healthy physical, cognitive development and immune function. High potential nutrition smart crops like pulses and chickpeas do not have significant coverage yet.

Productivity for a range of cereal crops is lower in Bihar compared to all India. This alongside the low coverage of legumes, horticulture and biofortified crops has direct effects on nutrient availability.

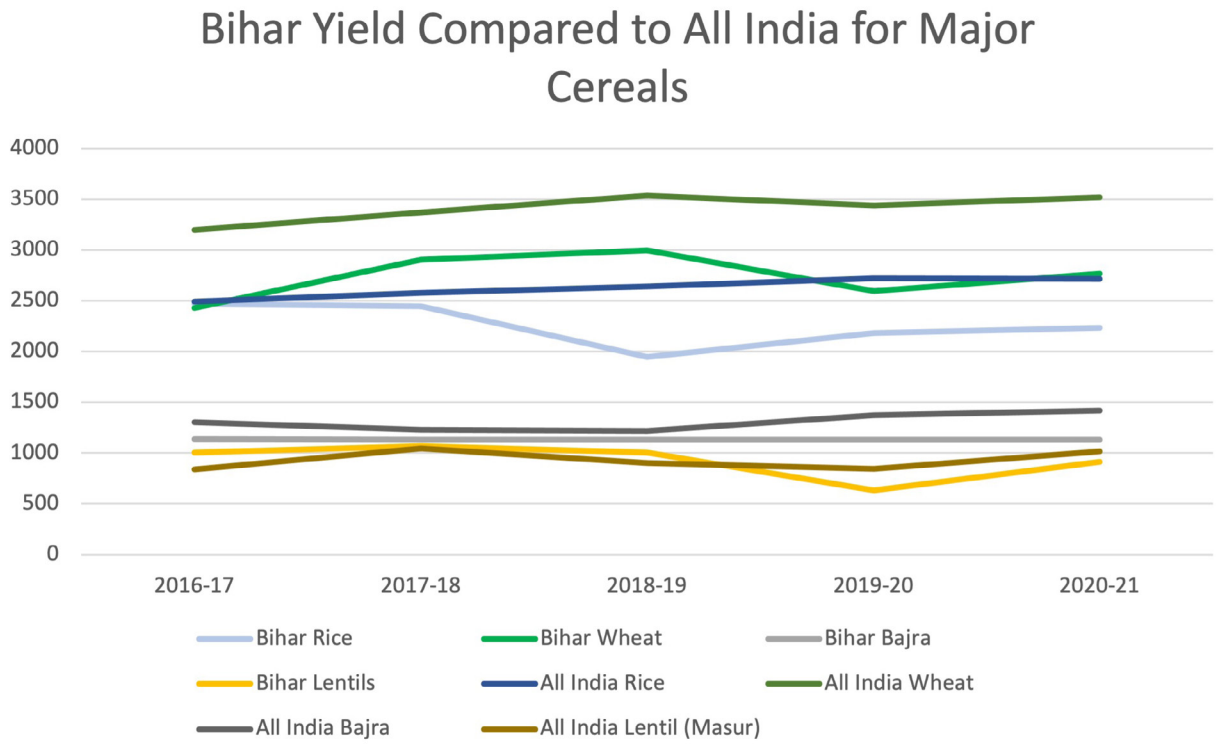
4. William Joe, Rinju, Narendra Patel, Ruby Alambusha, Bharati Kulkarni, Kapil Yadav, Vani Sethi, Coverage of iron and folic acid supplementation in India: progress under the Anemia Mukt Bharat strategy 2017–20, Health Policy and Planning, Volume 37, Issue 5, May 2022, Pages 597–606, https://doi.org/10.1093/heapol/czac015

Figure 2: Significant Crops and their Coverage in Five High Micronutrient Deficiency Districts (Excluding fruits and oilseeds)

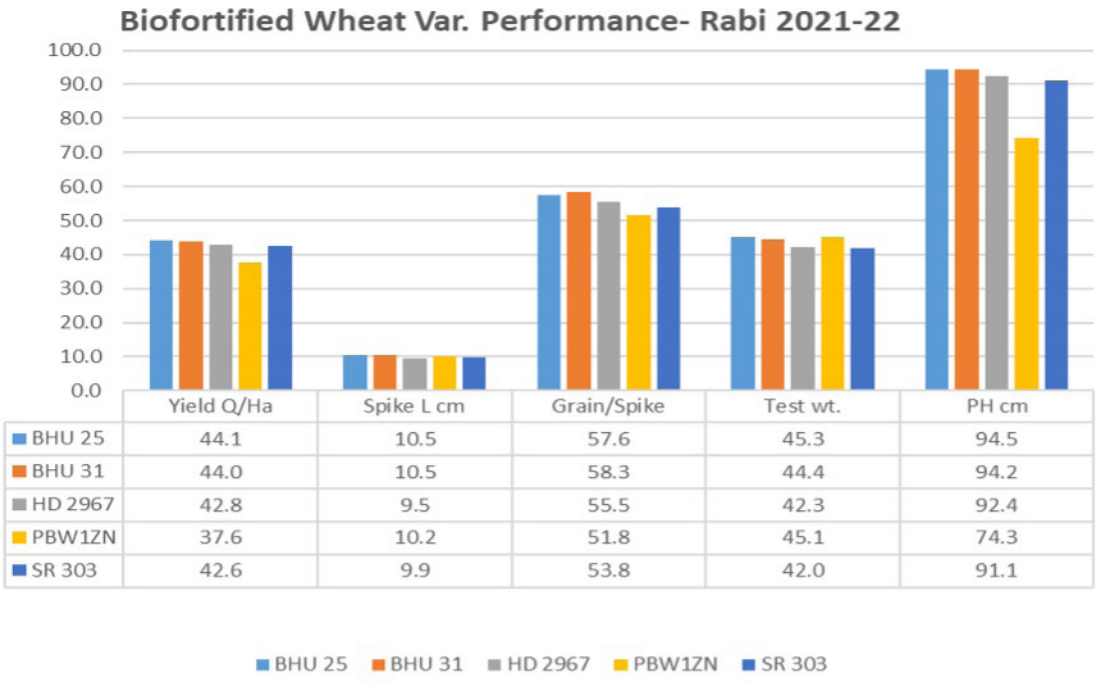


Source: Krishi Vigyan Kendra (KVK) District Plans accessed 02-27-2023 from (agricoop.nic.in) and KVK webpages accessed 5th Mar 2023.

Figure 3. Bihar Lags in Yield



Source: Area Yield Production (Normal Estimates) 2020-2021, Directorate of Economics and Statistics, Department of Agriculture and Farmers Welfare Website Accessed 5th Mar 2023.



	Yield Q/Ha	Spike L cm	Grain/Spike	Test wt.	PH cm
BHU 25	44.1	10.5	57.6	45.3	94.5
BHU 31	44.0	10.5	58.3	44.4	94.2
HD 2967	42.8	9.5	55.5	42.3	92.4
PBW1ZN	37.6	10.2	51.8	45.1	74.3
SR 303	42.6	9.9	53.8	42.0	91.1

There is strong potential to enhance the daily micronutrient availability from key local crops. As we can see from figure 2 staples still form the backbone of production across select districts and high potential crops like lentils, cowpea, and millets while nutritious[5] are yet to scale. Low incomes also drive higher consumption of cereals. The introduction of high zinc wheat (zinc availability is increased by up to 40% through biofortification) iron lentil and iron pearl millet can of itself significantly impact the nutrition composition of food plates as staples form the largest amount of product consumed. Coverage of horticulture crops is also low with a strong focus on fruits (which while high in vitamins and low in minerals) and specific vegetables value chains which do not necessarily include for example green leafy vegetables which are high in iron. Vegetables like potatoes, okra and cauliflower present some micronutrients but are not a significant source. Here as well introducing a more deliberate selection of horticulture crops such as multi-nutrient yams, vitamin A sweet potatoes, spinach etc. can support greater micronutrient availability.

Introducing nutrient rich crops is also an approach to improve farm returns. Productivity lags for conventional staples in Bihar are well documented (see Figure 3). Biofortified crops mentioned above are competitive in terms of yield with leading varieties. Varietal development also considers both micronutrient content and bioavailability as also demand side factors such as taste and texture that are important for the long term marketability and adoption of these crops. Yield remains key for farmers to benefit both in terms of health and economic status. Comparative yields of key biofortified varieties used in the Bihar initiative are given above:

During Rabi 2021-22 the field data received from various testing locations of KVKs and private partners which was compiled and analyzed by HarvestPlus team. The outcome of the data shows that biofortified variety BHU-25 was leader with 3% gain over local check HD-2967 while another biofortified variety BHU-31 followed BHU-25 with 2.6% gain over local check. The best commercial checks i.e., Sriram-303 was at fourth place with a negative gain of -0.7% compared to HD-2967.

Initial Steps Towards Scaling Biofortification within the Jeevika Platform

The overall vision of the HarvestPlus and BRPLS partnership is to increase food, nutrition and livelihoods security through the production, consumption, and marketing of suitable conventionally bred biofortified crop varieties in India specifically Bihar.

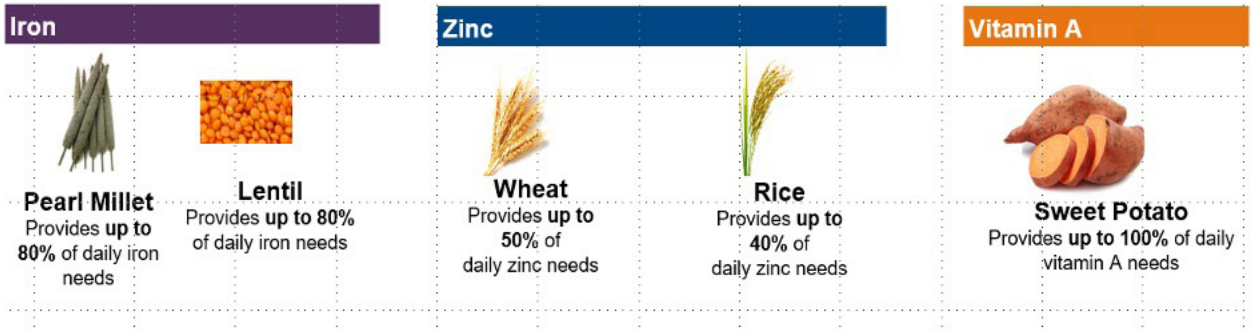
The specific objectives are to:
1.1. Increase the availability of conventionally bred high yielding, drought tolerant and high nutrient dense, biofortified varieties by enabling production and adoption of biofortified seeds.
1.2. Collaborate to strengthen the seed systems for biofortified crops.
1.3. Co-develop sustainable value chains for biofortified crops to increase their availability, and consumption, and by people, especially women in Bihar for their improved livelihoods.
1.4. Collaborate to design and analyze a pilot on nutrition-smart and climate- smart agriculture technologies and to improve nutrition and economic outcomes for low income households, with a focus on women.

Three biofortified crops i.e., iron pearl millet, vitamin A sweet potato and zinc wheat were selected for the pilot. Other biofortified crops available in India include zinc rice and, yams. Pipeline crops include iron finger millets.

HarvestPlus targeted a mix of districts with high micronutrient deficiencies and those with a competitive profile for biofortified crops.

The project has a three pronged strategy. This strategy – technical support for seed production and agronomy, facilitating economies of scale through working with clusters and farmer producer companies (FPC) and upfront focus on market linkages – has proven effective in terms of delivering initial results in the pilot. This also forms the basic framework within which future scale can be generated for biofortified grain.

Initially HarvestPlus provided technical assistance to Jeevika staff and community workers and also trained village organizations (VOs) and FPCs. The pilot included training farmer producer collectives in both seed production and agronomic practices for improved yields. Varieties were introduced in a phased manner. VOs and FPCs were selected and 20,000 are being targeted for TA (over three



High level initial snapshot of results:

Seed produced: Year 2021-22: 25 hacter (3 Metric Ton) Year 2022-23: 25 hacter (Expected 75 metric ton)	**Number of farmer collective trainings:** 14 (Coverage- 360 male & 1844 Female)
Amount of biofortified grain produced: Year -2021-22: 400 hac(1600 Metric Ton) Year 2022-23: 560 hacter (expected 2250 mt)	**Amount of grain marketed and amount consumed:** Marketed : 600 mt (approx.), Consumed : 1000 Mt. (tentative)
Piloting of zinc wheat flour marketing through Green delight and DIDI Ki Rasoi: 10 Metric ton	**Infrastructure:** Resources Sanctioned to a women's FPC (Saharsa Women Jeevika Farmer Producer Company) to establish wheat flour processing unit (1.5 Metric ton /per hours capacity

years) for seed multiplication and biofortified crop production in high potential clusters across five districts. Seed inventories were developed at the FPC level and linkages carefully facilitated for seed certification and distribution. Crop demonstrations and awareness generation initiatives helped bring multiple VOs and farmers on board for adoption. Secondly HarvestPlus supported both VO and cluster capacity for aggregation and storage. Thirdly linkages were developed by the Jeevika and HarvestPlus teams with market opportunities both within the BRPLS institutional platform and related retailers and also through other commercial distribution channels. Finally digital data management allows direct tracking of farmers engaged in the biofortification pilot and also lays the foundation for traceability going forward.

Women's engagement has been a critical cross cutting theme across all aspects of the project strategy. Biofortified food products are readily accessible for all members of the households as staples are relatively affordable and a key fallback during times of income shocks. As a part of the partnership with BRLPS a deliberate effort was made to engage women in seed production and extension related activities. Marketing of zinc wheat flour to women led enterprises such as *Didi ki Rasoi* has important direct potential impacts on women's nutritional status and livelihoods as also in terms of expanding the nutritional benefits of biofortification to high potential institutional markets such as hospitals and schools. Women's FPCs were also deliberately targeted to the extent possible in different types of technical assistance for value chain development.

Next Steps – Scaling the pilot

True to the goals of the Jeevika platform – biofortification has offered a multi-dimensional approach to address livelihood insecurity. The most visible linkage is that micronutrient security is key to not just economic productivity in the present but also for future generations. Also, the comprehensive seed to fork value chain approach taken in the HarvestPlus pilot has demonstrated that economic gains can be facilitated through seed multiplication, grain aggregation and marketing and value addition. The basic strategy and activities in the project have already provided a roadmap for future scaling. Biofortified grain not only has potential to scale through private sector channels but also through public procurement under the Integrated Child Development Scheme (ICDS), Mid-Day Meal Scheme, Public Distribution System (PDS). This can also further leverage marketing channels like *Didi ki Rasoi*. These are significant market opportunities where initial engagement has already highlighted demand for nutritionally enhanced grain. Going forward strong policy and program support to set procurement targets, advance investment in scaling seed production and agronomic training and expanded support to aggregators will be central to future scale. Continued work on crop production and value addition through women and women group participants in the program is an important additional opportunity. A vision for scaling biofortification in Jeevika would be to target at least 30% of the total farmer outreach in the program and ensure that at least 50,000 women's groups are actively engaged on value added activities.

Annex A

Issue – Affordability of Nutrient Adequate or Healthy Diet

ADB COUNTRY*	Population 2017 (Millions)	% That cannot afford energy sufficient diet	% That cannot afford nutrient adequate diet	% That cannot afford healthy diet
Armenia	2.9	0.8	11.2	51.7
Azerbaijan	9.9	0.1	0.1	0.1
Bangladesh	159.7	14.5	18.9	74.6
Bhutan	0.7	0.2	12.5	45.8
China	1386.4	0.1	0.8	16.3
India	1338.7	0.9	39.1	77.9
Indonesia	264.6	1.1	34	68.8
Kazakhistan	18	0.1	0.1	2.2
Kyrgyz Republic	6.2	0.2	18.6	60.3
Lao People's Democratic Republic	7	0.5	51.2	83.3
Maldives	0.5	0.1	1	6.5
Myanmar	53.4	0.2	17.7	60.9
Nepal	27.6	1.9	36.1	**76.2**
Pakistan	207.9	0.1	10.3	68.7
Philippines	105.2	2.6	30.6	63
Sri Lanka	21.4	0.1	6.8	53.5
Tajikistan	8.9	0.8	14.4	37.2
Thailand	69.2	0.1	1.8	19.5
Vietnam	94.6	0.6	9.5	26.6

Annex B

District	Number of Stunted Children (000)	Number of Anemic Children (000)	Number of Anemic Non Pregnant Women (000)	Number of Anemic Pregnant Women (000)
Araria	224	306	546	82
Arhwal	45	58	138	12
Aurangabad	142	212	464	47
Banka	136	203	391	41
Begusarai	160	283	545	64
Bhagalpur	168	297	647	56
Bhojpur	140	210	612	41
Buxar	88	136	342	27
Dharbangha	255	348	703	75
East Champaran	382	426	822	105
gaya	283	412	844	85
Gopalganj	116	171	436	46
Jamui	107	183	405	36
Jehanabad	62	84	230	21
Kaimur	100	145	333	31
Khatihar	213	286	611	69
Khagaria	992	160	275	38
Kishanganj	105	164	323	47
Lakhisarai	62	100	213	20
Madhepur	144	190	376	47
Madhubani	270	398	805	89
Munger	63	119	292	23
Muzzaferpur	280	381	827	96
Nalanda	169	287	613	55
Nawara	145	193	475	49
Patna	250	426	1236	110

Purnia	223	314	611	90
Rohtas	154	242	588	46
Saharsa	144	187	357	42
Samastipur	274	376	734	96
Sheohar	34	65	114	8
Shekhpura	50	67	130	13
Saran	204	323	750	74
Sitamarhi	278	322	594	68
Supaul	144	194	394	43
Sivan	152	238	551	64
Vaishali	180	326	632	81
West Champaran	255	325	559	60.68468468
Total	6,294	9,157	19,517	2,135