Iron-Biofortification *ex-ante* Cost- Effectiveness

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Cost-benefit and Cost-effectiveness

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	Definition	Units used for calculation
CBA	Cost Benefit Analysis assesses the profitability of investments over time by analysing discounted cash flows.	Project costs: in monetary value Project outcome: in monetary value
CEA	Cost Effectiveness Analysis compares different intervention strategies based on relative costs and outcomes, without quantifying the benefits.	Project costs: in monetary value Project outcome: in natural units

The easy way to remember the difference is a benefit is a desired financial reward while effectiveness is the potential success of the program.

In public health, Disability Adjusted Life Years (DALYs) is often used to measure the outcomes of interventions in terms of the disease burden of a particular condition (i.e. micronutrient deficiencies), expressed as the number of years lost due to ill-health, disability, or early death.

http://deza-pcmi-lernbuch-3.prod2.lernetz.ch/module-6-en/2-cost-benefit-and-cost-effectiveness-analyses

Biofortification

- The process by which the nutritional quality of food crops is improved through agronomic practices, conventional plant breeding, or modern biotechnology / (WHO)
- The process of increasing the density of vitamins and minerals in a crop, through plant breeding or agronomic practices, so that when consumed regularly will generate measurable improvement in vitamin an mineral nutritional status (Provit. A carotenoids, zinc, iron). Focus on major staples consumed by poor farming HHs in LMICs. Public good / (HarvestPlus).

Evidence of success: RCTs & Delivery

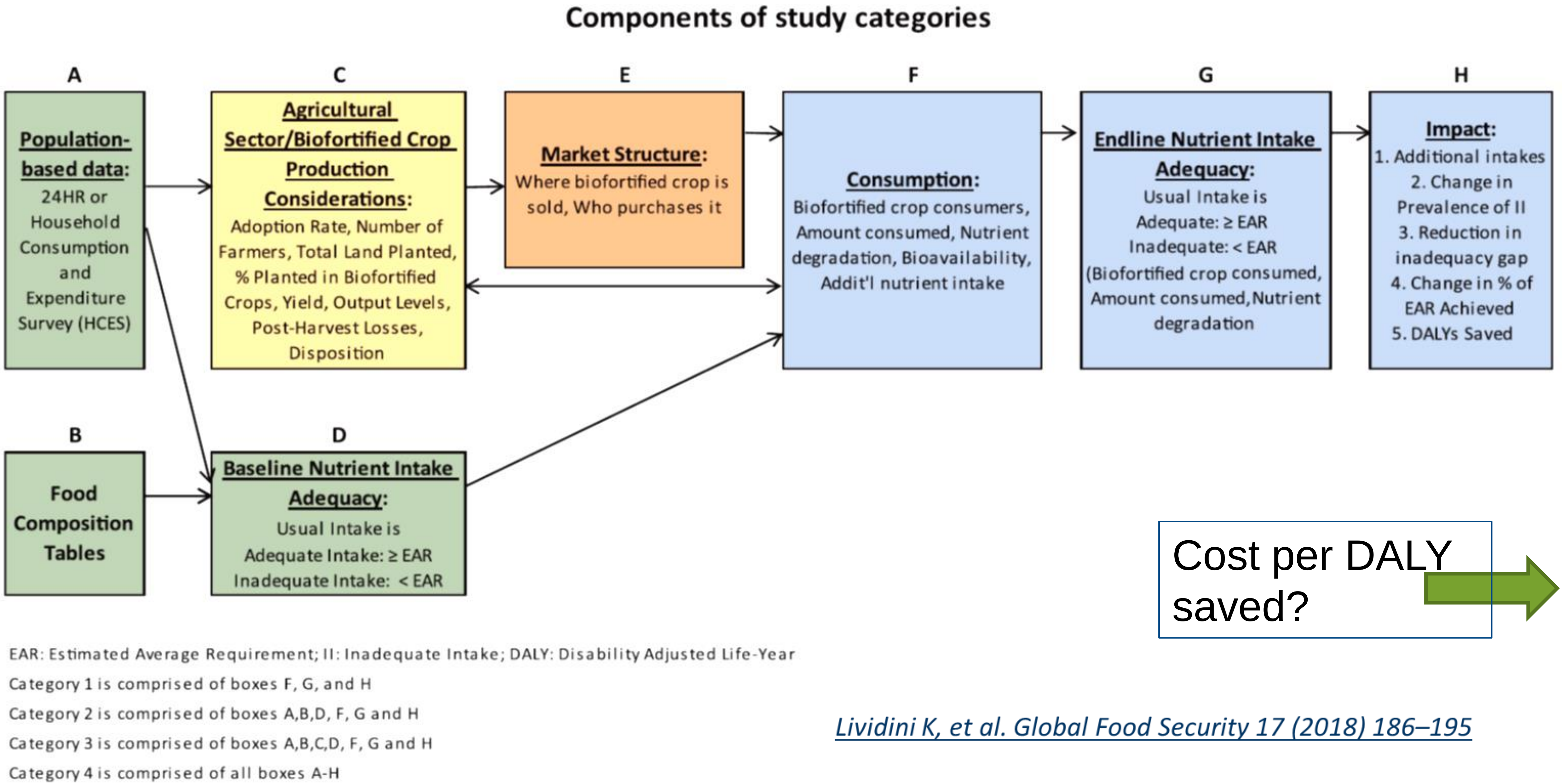
High iron beans: Murray-Kolb, et al. (2017), Haas JD, et al. (2016) Wenger MJ, et al. (2019); Pompano L et al. (under review)
High iron pearl millet: Finkelstein et al. (2015), Scott SP, et al. (2018); Kodkani B et al (2013); Cercamondi C et al (2013)
Iron enhanced rice: Haas JD, et al. (2005); Beard J et al. (2007)
Meta-analyses & Reviews:

- Cognitive performance: Finkelstein J et al. (2019)
- Iron status: Finkelstein J et al. (2017)

Farming households reached ('000)

Crop	Country	Nutrient	End of 2013	End of 2018
Beans	Rwanda	Iron	714	1,190
	DR Congo		301	500
	Uganda		72	486
Pearl Millet	India	Iron	70	1,700
Total			1,157	3,876

Evolution of Biofortification ex-ante Impact Simulation Models



Cost per DALY saved?

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RWANDA Hi Iron Beans

Overview of outcomes (2015-2018)

On average Iron Beans have an increased yield of about 20%

- HIB accounted for 20% of total bean production in 2018
- An additional $78 per hectare is earned from production of Climbing Iron Beans
- An additional $57 per hectare is earned from production of Bush Iron Beans
- The total additional revenue from production of Iron Beans through 2018 was about $20 million
- The total reduced burden of iron deficiency through 2018 was estimated at an additional savings of $4.9 million
- (Total estimated investment up to 2018: $11 million)

*Nationally representative

Methods

1. Calculate the number of households growing
   - Derive statistics from the Rwanda 2015 HIB survey for:
     - Continuation percentage
     - Diffusion percentage
     - New growers as a percentage of delivery
   - Utilize M&E delivery data as data inputs for years 2016-2018
2. Calculate average HIB and non-HIB bean yields through 2018
3. Calculate average HIB and non-HIB area per household growing; estimate total HIB and non-HIB production
4. Calculate the unit additional $ value of HIB production and the cumulative added value of HIB production since 2010
5. **Use the HIB percentage of total bean supply to calculate the reduction in iron deficiency disease burden (DALYs)**

Using the DALY to calculate disease burden

- To calculate the reduction in iron deficiency disease burden, we utilized the Disability-Adjusted Life Year (DALY)
- Simply put, a DALY is a year of life equivalent
  - Some diseases lead to death, but others do not necessarily (e.g. blindness, decreased physical activity, cognitive impairment, etc.)
  - Calculating only deaths then, can result in an underestimate of the negative effect of micronutrient deficiency
  - When we calculate a DALY we sum up total time lost to death (mortality) and/or non-fatal disease (morbidity) and report it in 1-year equivalents
- We use health statistics to identify disease outcomes related to a MN deficiency and the proportion of incidence associated with the deficiency; we use this to quantify DALYs in the status quo, i.e. with no biofortification
- We then calculate how much biofortification lowers disease incidence rates and then we recalculate total DALYs; the difference is the number of DALYs saved

Using DALYs to calculate disease burden: Rwanda

Functional outcomes (cause)	Target group	*T* Target group size	*M / I* Mortality / Incidence	Prevalence rate	*D* Disability weight	*d / L* Duration / rest Life	*r* Discount rate	DALYs lost	YLD	YLL	Deaths
Impaired physical activity (moderate IDA)	children 6-59 mo	2,050,171	0.016	0.07	0.011	4.5	0.03	1,527	1,5[illegible]7		
	children 5-14	3,315,367	0.016	0.13				[illegible]	[illegible]		
	women 15+	3,833,123	0.00025	0.01							
	men 15+	3,617,461	0.00015	0.01							
Impaired physical activity (severe IDA)	chil	[illegible]0,171	0.001	0.00	0.087	4.5	0.03				
	chi	[illegible]5,367	0.00000	0.00	0.087	9.0	0.03	0	0		
	wor	[illegible]3,123	0.00002	0.00	0.090	59.1	0.03	162	162		
	men 15+	3,617,461	0.00001	0.00	0.090	50.2	0.03	84	84		
Impaired mental dvpmt (moderate IDA)	children 28-59 mo	1,262,868	0.016		[illegible]	[illegible]	[illegible]	3,510	3,510		
Impaired mental dvpmt (severe IDA)	children 28-59 mo	1,262,868	0.001					486	486		
Maternal mortality (severe IDA)	live births	13,041,386	0.000024					7,823		7,823	316
Stillbirths (maternal mortality)	maternal deaths	316	0.3			60.0	0.03	2,636		2,636	95
Child death (maternal mortality)	maternal deaths	316	0.007			65.2	0.03	65		65	2.3
							Total burden	**11,278**	**11,278**	**0**	**0**

DALY formula inputs

Components of a DALY: mortality and morbidity

Adverse outcomes

Incidence rates: biofortification acts to lower these

Observed

(2010-2018)

$4.9 mil

Value of reduced iron deficiency

Simulated

(2010-2025)

Scenario 1: status quo

$16.2 mil

Value of reduced iron deficiency

Scenario 2: 40%

$22.3 mil

Value of reduced iron deficiency

How do these DALY benefits translate back to disease incidence rates (2010-2025)??

- If the population eats 40% of its beans as iron beans, then the annual burden of iron deficiency in DALYs would be reduced by 30.6%

- If the population eats 40% of its beans as iron beans, then the incidence of impaired physical activity due to iron-deficiency anemia among children under 5 and women of reproductive age would be reduced by 20% and 16%, respectively

Cost-effectiveness of biofortification: “cost per DALY saved”: 30-year horizon

Country	Micronutrient	Biofortification Cost per DALY saved
DRC	Iron	Beans: $4.95* ($18-$98**)
Rwanda		

*50% coverage average and cost per year at year 30;   **25-50% coverage; averages discounted over 30 yrs.

Conclusions

- Biofortification is highly cost effective (high iron beans).
- It is expected to benefit particularly poor farmers in rural areas. Generally biofortification will have a greater impact on reducing the prevalence of inadequate intakes among children and women in rural areas and the benefits will be directed more toward lower income groups.
- More research is clearly needed to better understand these differences, risks and impacts among these groups (rural, age, gender, etc.).

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Thank you for accelerating the eradication of nutritional anemia together!

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Extra slides

Formula for Calculating DALYs

$$DALYs_{lost} = \sum_j T_j M_j \left(\frac{1 - e^{-rL_j}}{r} \right) + \sum_i \sum_j T_j I_{ij} D_{ij} \left(\frac{1 - e^{-rd_{ij}}}{r} \right)$$

where:

T_j = total number of people in target group *j*
M_j = mortality rate associated with the deficiency in target group *j*
L_j = average remaining life expectancy for target group *j*
I_{ij} = incidence rate of disease *i* in target group *j*
D_{ij} = disability weight for disease *i* in target group *j*
d_{ij} = duration of disease *i* in target group *j*
r = discount rate for future years

(for permanent diseases *dij* equals the average remaining life expectancy *Lj*)

Evidence of Success: the Efficacy of Iron Crops

High iron beans: Murray-Kolb, et al. (2017), Haas JD, et al. (2016) Wenger MJ, et al. (2019); Pompano L et al. (under review)

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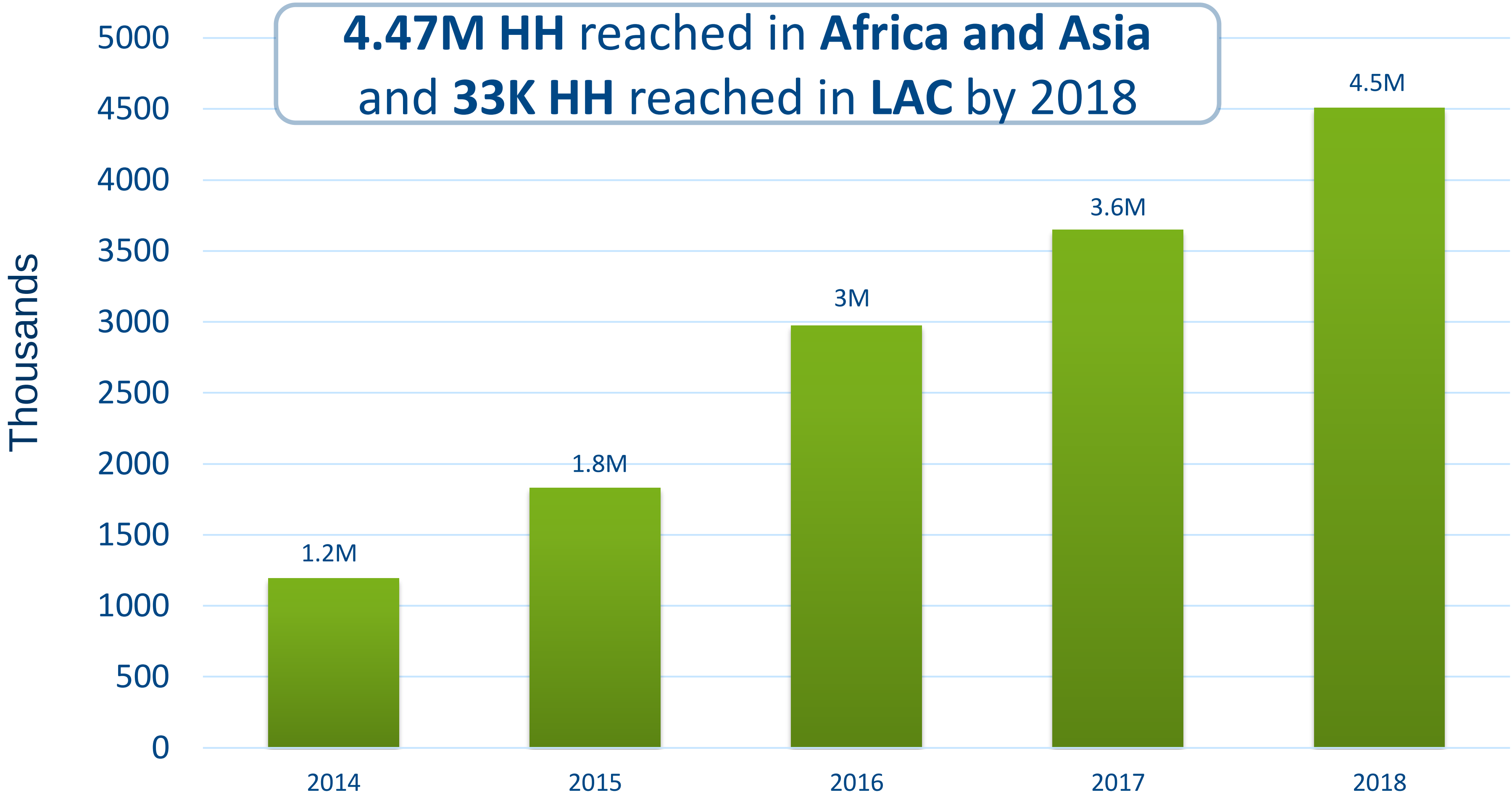
Evidence of success: Delivery



Biofortification Has Become a Core Nutrition Strategy

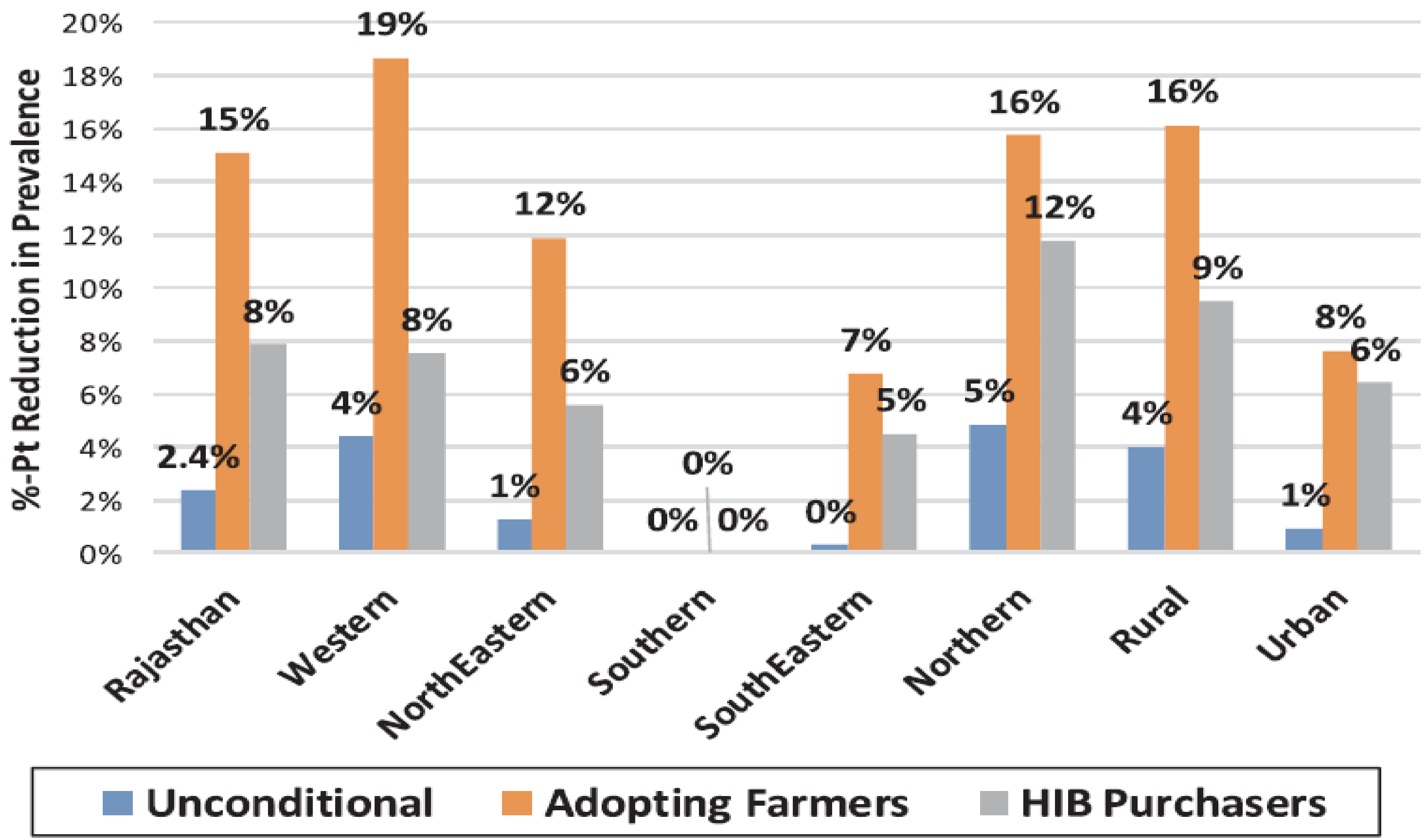
A nourishing, diverse diet is the ideal nutrition strategy *as long as people can afford and access the right mix of foods.*

Other strategies for increasing access to critical micronutrients:

Biofortification
of staple foods
(upfront investment)

Fortification
added to foods
(sustained investment)

Supplementation
Consumed as pills, powders, drops, etc.
(sustained investment)



Source: Fiedler and Lividini (2015)

Fig. 7. Reduction in the prevalence of inadequate intake with high iron pearl millet, by geographic region, Rajasthan, India 2043.