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Vulnerability of rural households to food and nutritional insecurity in arid regions of India: some evidence from Rajasthan

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Abstract Using data on household consumption we have examined the incidence of vulnerability of rural households to poverty and nutritional insecurity in the state of Rajasthan, a large part of which is arid. Our findings show that ex ante poverty is less (7.7%) than ex post poverty (12.4%). Surprisingly, there appears to be a disconnect between poverty and undernourishment; the incidence of nutritional insecurity is much higher than the incidence of poverty. However, there are significant regional differences; households in the southern region, and non-agricultural and socially disadvantaged households, are more vulnerable to poverty and nutritional insecurity.

Keywords Undernourishment, poverty, vulnerability to expected poverty (VEP), vulnerability to expected undernourishment (VEU)

JEL classification Q01, Q18, I32

1 Introduction

Production risk is a characteristic of Indian agriculture, and the incidence of poverty and nutritional insecurity is closely related to risk. Poverty and nutritional insecurity, therefore, represent a stochastic phenomenon: currently non-poor households may fall into poverty because of expected adverse shocks, and poor or nutritionally insecure households may continue to be so (Chaudhuri et al. 2002). Thus, policies for mitigating poverty and nutritional insecurity should consider the current head count poverty status of households and their vulnerability to expected shocks (Celidoni 2013; Hoddinott & Quisumbing 2003; Ligon 2005; Ligon & Schechter 2003; Gaiha & Imai 2004; Dercon 2005). If the poverty alleviation policies are designed for the current year using the income threshold of the previous year(s), the 'poor' who receive income support might have already escaped poverty. And the 'non-poor' just above the threshold who do not receive such support might have fallen into poverty due to unanticipated shocks such as a fall in the farm harvest price or crop loss due to drought.

A household's current poverty or nutritional status is not necessarily a good indicator of vulnerability; we need to go beyond cataloguing head counts of the poor and nutritionally insecure population and assess their vulnerability in the future to design appropriate, forward-looking anti-poverty interventions. Consumption during a particular period depends on many factors, including expected future income and its uncertainty. Climate change creates an additional strain on the livelihoods and coping strategies of the poor; it is expected to affect poverty and nutritional intake directly and indirectly. This paper examines the vulnerability of rural households to poverty and undernutrition in the Indian state of Rajasthan, where frequent droughts affect crop and livestock production adversely (Kanwal et al. 2019; Kanwal 2018; Dutta et al. 2015; Dutta et al. 2013; Jain et al. 2010; Singh et al. 2006; Rathore 2005; Chatterjee 2005).

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2 Data and descriptive statistics

We make use of data from the household consumption survey conducted by the NSSO in 2011-12, which contains a sample of 2,579 rural households from Rajasthan. The descriptive statistics of the variables that we subsequently use in assessing households' vulnerability to poverty and undernutrition is given in table 1.

The household heads are 45 years old on average and about 50% are illiterate. Most households are male-headed. The average household size is five. Over 92% of the households are Hindus, and about 35% are from the Scheduled Castes (SCs) and Scheduled Tribes (STs). About 50% of the households are engaged in agriculture as cultivators and agricultural labourers, and about 33% in non-agricultural activities including salaried employment. The rest of the households are engaged in other economic activities. The average landholding size is 1.9 hectares (ha), and about 73% of the landholdings are 2 ha in size or smaller.

3 Empirical strategy

Following Chaudhuri (2003) we use the three-stage feasible generalized least square (FGLS) technique to assess households' vulnerability to expected poverty (VEP) and vulnerability to expected undernourishment (VEU). Several studies use this methodology (Thorat 2017; Imai 2011; Jamal 2009; Gaiha & Imai 2008; Omobowale 2008; Jha & Dang 2008). Let us define the vulnerability level of a household *h* at time *t* as the probability that the household will find itself consumption-poor or nutritionally insecure at time *t+1*. Then the vulnerability (V_{ht}) can be specified as,

$$V_{ht} = Pr\ (C_{h,t+1} \leq Z) \ldots (1)$$

Where, $C_{h,t+1}$ is the household's per capita consumption level at time t+1 and Z is the threshold consumption level.

We consider the MPCE of Rs. 1,035.97 for 2011-12 as the poverty threshold (GoI 2009). For undernutrition, we take the recommended intake of 2,730 kcal/capita/

Table 1. Variables used in three-stage feasible generalized least square

Variable	Unit of measurement	Mean	Standard deviation
Dependent variables			
Monthly per capita consumption expenditure (MPCE)	Rupees	1,528	767
Calorie consumption	Kilocalorie per consumer unit per day*	2,761	851
Protein consumption	Gram per consumer unit per day	86.2	27.4
Independent variables			
Age	Age of household head	45.01	13.66
Gender	1 if male, 0 otherwise	0.89	0.30
Household size	Number of family members	5.06	2.39
Religion	1 if Hindu, 0 otherwise	0.92	0.28
Education	1 if household head illiterate, 0 literate	0.49	0.49
Land possessed	Hectare	1.9	3.02
Agricultural households	1 if households engaged as agricultural labour and self-employed in agriculture, 0 otherwise	0.49	0.48
Non-agricultural households	1 if households self-employed in non-agriculture and other labour, 0 otherwise	0.25	0.44
Scheduled Tribe (ST)	1 if ST, 0 otherwise	0.16	0.37
Scheduled Caste (SC)	1 if SC, 0 otherwise	0.19	0.40
Regular salary	1 if regular salary earner, 0 otherwise	0.10	0.37
Ration card	1 if ration card holder, 0 otherwise	0.26	0.42

*To estimate calorie and protein intake, we converted all household members into consumer units following the norms in GoI (2014).

day and 60 g of protein/capita/day as thresholds (Rao & Sivakumar 2010). The literature suggests that a household's consumption in any period will depend on factors such as wealth, current and expected income and the ability to smoothen consumption to income shocks (Browning & Lusardi 1995; Deaton 1992) which, in turn, are influenced by observable and unobservable household characteristics and the macroeconomic and socio-political environment. It is thus possible that a household's vulnerability to poverty and undernourishment is a non-linear function of its future consumption levels (expected consumption) and volatility in consumption stream (i.e., variance, from an inter-temporal perspective). The cross-section data do not allow us to control for the household characteristics, and we assume that the stochastic process generating consumption of a household *h* to follow the log-normal distribution. Thus, we use the following equation:

$$\ln C_h = X_h\beta + \varepsilon_h \quad \ldots(2)$$

Where, C_h is per capita consumption (MPCE, intake of calories and protein), X_h represents a vector of household characteristics, β is a vector of associated parameters and ε_h is a mean-zero disturbance term that captures idiosyncratic shocks and unobservable characteristics. The assumption of error term representing the impact of idiosyncratic shocks on household consumption implies that inter-temporal variance in consumption depends on certain household characteristics. Thus, the variance of ε_h is given by:

$$\sigma_{h^2 e,h} = X_h\theta \quad \ldots(3)$$

The variance of the disturbance term is assumed not to be identically independently distributed, as the assumption of equal variance across households is quite restrictive. The possibility that a household with lower mean consumption may face greater consumption volatility than a household with a higher level of consumption cannot be ruled out. Hence, Eq.(3) is heteroscedastic and it needs to be estimated using FGLS instead of ordinary least squares (OLS). β and θ are estimated using a three-step FGLS procedure suggested by Amemiya (1977). The procedure leads to asymptotically efficient FGLS estimates (Eq. 4). The log-normally distributed consumption is an estimate of the probability that a household with characteristics X_h is either poor/undernourished or not known as vulnerability to expected poverty/undernourishment. Letting Φ (.) denote the cumulative density of the standard normal, the estimated probability ($\hat{V}_h$) can be obtained by:

$$\hat{V}_h = \Pr[lnC_h < \ln Z / X_h] = \Phi\left[\frac{ln\,Z - X_h\hat{\beta}_{FGLS}}{\sqrt{X_h\,\hat{\theta}_{FGLS}}}\right] \quad \ldots(4)$$

Where, Z represents either poverty line or minimum calorie/protein requirement, $X_h\hat{\beta}_{FGLS}$ is the expected mean of real household consumption and $X_h\hat{\theta}_{FGLS}$ is the estimated variance in the consumption. Further, the households whose probability exceeds 0.5 are considered as vulnerable to poverty and undernourishment (Chaudhuri 2003; Chaudhuri et al. 2002). Based on the current consumption thresholds (Z), expected consumption and vulnerability, the households or populations can be classified into chronic poor/undernourished, frequently poor/ undernourished, infrequently poor/undernourished, vulnerable to chronic poverty/undernourishment, vulnerable to frequent poverty/undernourishment and low vulnerability poor/undernourished (table 2). These six groups in turn make up four broad categories: transient poor/undernourished (B+C), poor/undernourished (A+B+C), high vulnerability (A+B+D+E) and totally vulnerable (A+B+C+D+E).

To see if a household is vulnerable by virtue of its geographical location, we estimate vulnerability at the zonal level. The NSSO has classified Rajasthan into five zones: northern, southern, eastern, north-eastern and south-eastern (figure 1). The north-eastern zone houses 33.6% of the total population, followed by northern (20.5%), western (20.1%), southern (13.6%) and south-eastern (12.2%).

4 Results and discussion

4.1 Status of food and nutritional security

The average MPCE in Rajasthan is Rs. 1,528, over 50% more than the poverty threshold (table 3), but regional differences are significant; the MPCE is greatest in the northern region (Rs. 1,744) and least in the southern region (Rs. 1,208). Likewise, in the northern region, the average calorie intake (2,761 kcal/ capita/day) is higher than the recommended level (2,730 kcal/consumer unit/day); it is the lowest in the southern region and almost equal to the threshold level

Table 2. Classification scheme for vulnerability

		Observed food security status based on current consumption			
		Current poor/undernourished	Current non-poor/secured		
Vulnerability	High vulnerability >0.5	Chronic poor/undernourished (A)	Vulnerable to chronic poverty/undernourishment (D)	Expected consumption < Z	Expected MPCE/nutritional intake
		Frequently poor/ undernourished (B)	Vulnerable to frequent poverty/ undernourishment (E)	Expected consumption > Z	
	Low vulnerability <0.5	Infrequently poor/ undernourished (C)	Low vulnerability poor/ undernourished (F)		
		Current consumption < Z	Current consumption > Z		

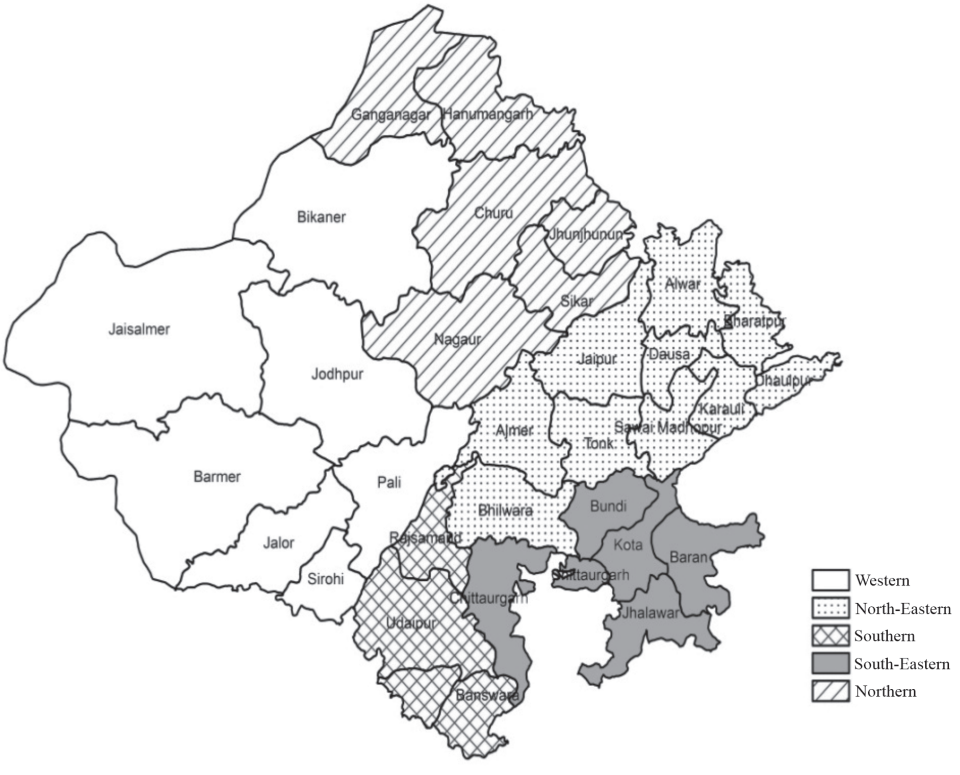

Figure 1. Zones of Rajasthan

Table 3. Food insecurity and undernourishment parameters

	Region	Mean	Standard deviation
Per capita consumption (Rs.)			
	West	1,496	819
	North-east	1,573	738
	South	1,208	601
	South-east	1,454	679
	North	1,744	826
	Overall average	1,528	767
Calories (kcal/capita[#]/per day)			
	West	2,743	900
	North-east	2,836	943
	South	2,493	797
	South-east	2,731	719
	North	2,847	696
	Overall average	2,761	851
Protein (g/capita[#]/day)			
	West	83.1	28.0
	North-east	89.1	31.2
	South	78.1	24.0
	South-east	86.2	22.0
	North	89.6	23.2
	Overall average	86.2	27.4

[#]Per capita is equivalent to one consumer unit

in the eastern region. To our surprise, the protein intake exceeds the recommended level in all the regions, but the high standard deviations of calorie and protein intake suggest a significant variation in the food security and nutritional status of households.

4.2 Determinants of food and nutritional insecurity

The results of three-stage FGLS are presented in table 4. We estimate separate regressions for per capita consumption expenditure, calories and protein in log-linear form. The household head's age has a positive and significant effect on calorie and protein consumption, but its squared term carries a negative and significant sign. This implies that households headed by elderly persons enjoy better food and nutrition security, as education improves households' food and nutritional status. On the other hand, the household head's gender has a negative and significant effect on calorie and protein consumption, which indicates that female-headed households enjoy better food and nutrition security. We find a negative association of household size with calorie and protein intake. Calorie and protein intake appear to be significantly better in households directly or indirectly engaged in agriculture than in non-agricultural households. This means those who produce food tend to be nutritionally better off. This is also confirmed by a positive and significant coefficient on landholding size.

Indian society is fragmented along ethnicity, religion and caste. Our results indicate that the intake of protein is significantly less among Hindus as compare to Muslims, Christians and households belonging to other religious minorities. Scheduled Caste and Scheduled Tribe households are at the bottom of the social hierarchy, and their calorie and protein intake is low. Along expected lines, calorie and protein intake is higher in households that have at least one member who earns a regular salary. In the case of MPCE too we find most of the variables carrying expected signs; MPCE is positively related to landholding size, education and income sources other than agriculture.

4.3 Household profile based on vulnerability to poverty and undernourishment

Using the results from the FGLS model, we assess the vulnerability status of rural households in Rajasthan. On the assumption that consumption is normally distributed, we estimate the probability that a household's per capita consumption will fall below the threshold in the future; if the probability exceeds 0.5, a household is considered food-insecure or nutritionally insecure.

4.3.1 Distribution of food-insecure and nutritionally insecure households

Are all nutritionally insecure households food-insecure? What is the distribution of food and nutritional insecurity across household characteristics? What is the extent of undernourishment among food-insecure households? How many poor/undernourished households and non-poor/nutritionally secure households will be highly vulnerable in the future? Table 5 shows a comparative distribution of VEP and

Table 4. Results of three-stage feasible generalized least square (FGLS) regressions

	LnMPCE	LnCalories	LnProtein
Constant	7.4771	8.1271	4.6387*
	(0.0799)	(0.0517)	(0.0537)
Age	0.0206*	0.0074*	0.0074*
	(0.0031)	(0.0020)	(0.0021)
$(Age)^2$	-0.0002*	-3.12E-05	-3.22E-05
	(3.24E-05)	(2.11E-05)	(2.21E-05)
Gender	0.0360	-0.0686*	-0.0639*
	(0.0289)	(00165)	(0.0167)
Household size	-0.1676*	-0.1111*	-0.1135*
	(0.0103)	(0.0063)	(0.0067)
$(Household\ size)^2$	0.0075*	0.0051*	0.0053*
	(0.0007)	(0.0004)	(0.0005)
Agricultural households	-0.0559*	0.0227	0.0454*
	(0.09194)	(0.0116)	(0.0123)
Non-agricultural households	-0.1788*	-0.0523*	-0.0429*
	(0.0200)	(0.0123)	(0.0128)
Land possessed	0.0402*	0.0282*	0.0279*
	(0.0058)	(0.0038)	(0.0040)
$(Land\ possessed)^2$	-0.0012*	-0.0012*	-0.0011*
	(0.0004)	(0.0002)	(0.0002)
ST	-0.1376*	-0.0829*	-0.0653*
	(0.0214)	(0.0133)	(0.0136)
SC	-0.1005*	-0.0426*	-0.0349*
	(0.0181)	(0.0115)	(0.0118)
Regular salary	0.1585*	0.0417*	0.0383*
	(0.0225)	(0.0130)	(0.0137)
Education	-0.1112*	-0.0375*	-0.0418*
	(0.0150)	(0.0097)	(1.0101)
Religion	-0.0367	-0.0253	-0.0265***
	(0.0240)	(0.0144)	(0.0151)
Ration card	-0.1700*	-0.0225**	-0.0131
	(0.0175)	(0.0111)	(0.0114)
Number of observations	2,579		

Note: ***, ** and * indicate significance at 10%, 5% and 1% respectively; figures in parentheses indicate standard errors

Table 5. Distribution of food and nutritional insecurity at the regional level

NSS zones	Poverty (%)	VEP (%)	Undernourishment (%)	VEU (%)
Western	23.7	12.8	57.2	52.1
North-eastern	18.4	8.1	52.4	59.6
Southern	48.2	32.9	68.7	71.9
South-eastern	23.0	10.7	54.6	58.8
Northern	9.7	6.5	48.5	52
Rajasthan	22.3	12.4	54.3	46

VEU and also the head count poverty and undernourishment status. The results indicate that the incidence of head count poverty (that also implies food insecurity) is 22.3%, and of undernourishment is 54.3%. The VEU is substantially higher (46%) than the VEP (12.4%).

The analysis at the regional level shows the highest incidence of poverty (48.2%) and undernourishment (68.7%) in the southern region, which has a sizeable tribal population and low education status. We, therefore, conclude that a food-secure household need not be nutritionally secure. The poverty and VEP are the least in the northern region; nearly half the population is undernourished. The other regions, too, exhibit a similar pattern. These results indicate that currently non-poor households may fall into poverty in the near future and currently food-secure households may become undernourished.

4.3.2 Extent of food and nutritional insecurity

Table 6 provides details on the chronic poor and the infrequently poor as a percentage of the total poor at the regional level and compares the extent of poverty and undernourishment. The southern region has the highest rate of poverty and the largest numbers of chronically poor and undernourished households. Interestingly, the proportion of the population that is infrequently undernourished is only 9.6% of the total food-insecure population. This implies that undernourishment is a deep-rooted problem in the region. The proportion of poor households is smaller than that of undernourished households, which indicates that the population do not know how to balance their diet.

4.4 Vulnerability and household characteristics

4.4.1 Vulnerability by household type

The activity in which a household is principally employed for income has an important bearing on its vulnerability status. Table 7 shows vulnerability in terms of poverty versus undernourishment. The

Table 6. Extent of food insecurity and undernourishment at the regional level

NSS regions	Chronic poor	Infrequently poor (%)	Chronic undernourished	Infrequently undernourished (%)
Western	7.8% (1,47,327)	15.9	37.8% (7,14,479)	19.4
North-eastern	4.2% (1,34,662)	14.1	39.7% (12,59,455)	12.7
Southern	23.6% (3,03,138)	24.6	58.6% (7,53,336)	9.6
South-eastern	6.9% (78,942)	16.1	42.6% (4,89,390)	12.6
Northern	3.1% (6,02,339)	6.6	32.1% (6,13,496)	16.4

Note: Figures in parentheses are estimated numbers for population.

Table 7. Distribution of vulnerability estimates across household type by region

NSS regions	VEP		VEU	
	Agricultural (%)	Non-agricultural (%)	Agricultural (%)	Non-agricultural (%)
Western	10.1	15.8	60.7	54.0
North-eastern	2.4	13.4	56.2	48.2
Southern	17.2	43.2	75.5	57.2
South-eastern	6.3	15.5	57.5	51.9
Northern	3.9	9.1	54.3	43.0
Rajasthan	6.5	18.0	47.0	68.8

findings indicate that agricultural households experience lower vulnerability to poverty than non-agricultural households, but their vulnerability to undernourishment is 47%, almost seven times more than their vulnerability to food insecurity. This ratio is four times in the case of non-agricultural households.

We find similar evidence at the regional level. The incidence of the VEP is greater among non-agricultural households (18%) in general, but highest in the southern region (43.2%) and lower in the western (15.8%) and south-eastern (15.5%) regions. The VEU shows a similar pattern across regions, but the difference is not large. Surprisingly, the VEU is higher among agricultural households, and the gap between the VEU and the VEP is larger than that for non-agricultural households. These findings indicate that rural households have limited income opportunities to escape poverty and nutritional insecurity. Livestock can reduce poverty and income inequality by providing rural households a constant flow of income and helping in smoothening consumption during crop failures (Chand & Sirohi 2015; Birthal et al. 2014; Birthal & Taneja 2012). But the productivity of livestock is poor in southern and south-eastern Rajasthan, as is the availability of livestock products (Chand & Sirohi 2012; Chand et al. 2011). That is why the livestock sector is not remunerative and it has performed poorly, and that may be why rural households are vulnerable.

4.4.2 Vulnerability by social group

Table 8 provides the status of the VEP and the VEU by caste. The long history of social atrocities against SCs and STs and exclusion of such households in rural India lead us to expect that they are more vulnerable, and the results bear us out. Vulnerability is higher among ST households. As expected, vulnerability to undernourishment is more prominent than vulnerability to poverty among all social classes and, like vulnerability to poverty, ST households are also more vulnerable to undernourishment. The evidence at the regional level shows a similar pattern of VEP and VEU across social classes. The ST households in the western region, however, are more vulnerable than in the other regions.

4.5 Poverty and nutritional insecurity

From a two-way classification of the rural households along VEU and VEP, we find that about 20% of the households in the state are poor as well as undernourished (table 9). The proportion of only poor

Table 8. Distribution of vulnerability across social groups in different regions of Rajasthan

NSS regions	VEP			VEU		
	ST (%)	SC (%)	Others (%)	ST (%)	SC (%)	Others (%)
Western	67.9	12.6	4.4	97.7	47.6	79.8
North-eastern	24.5	18.3	2.3	79.8	76.3	51.1
Southern	4.7	35.0	21.9	85.0	75.0	40.3
South-eastern	20.2	12.5	2.6	85.6	54.1	42.8
Northern	10.0	19.5	2.3	89.7	70.9	44.7
Rajasthan	47.8	28.3	12.2	85.8	65.3	47.1

Table 9. Households by poverty and food insecurity status

Undernourished	Poor	
	Yes	No
Yes	18,44,529	33,29,500
	(19.5)	(35.5)
No	2,51,038	39,75,464
	(2.7)	(42.3)

*Note: Numerical figures are estimated numbers and figures in parentheses are a percentage of the total estimated households.

households is merely 2.7%, but the proportion of non-poor and undernourished is as high as 35.5%.

5 Conclusions

The paper has examined the vulnerability of rural households to food and nutritional insecurity in the Indian state of Rajasthan. The estimates of food insecurity, as measured through the lens of vulnerability to poverty, is 12.4% while vulnerability to undernourishment is almost four times the vulnerability to poverty. At the regional level also, the incidence of undernourishment and vulnerability is found to be higher than the incidence of poverty. The incidence of poverty and undernourishment is higher in the southern region on account of the dominance of tribals in the population and their low level of education. The highest numbers of chronically poor households are also concentrated in this region, but the proportion of infrequently poor is more than the chronically poor. Sadly, among the non-poor and nutritionally secure households also, a considerable proportion is highly vulnerable, especially in the southern region. Further, the agricultural households are found less vulnerable to food insecurity but more vulnerable to nutritional insecurity. The socially disadvantaged households are more vulnerable to food as well as nutritional insecurity. Overall, we find no significant relationship between poverty and undernutrition. There emerge a few important implications from this analysis.

One, a disconnect between poverty and nutritional insecurity implies the need for a probe into the causes of this high incidence of undernourishment and for strategies designed to mitigate the problem. Two, the strategies should focus on socially disadvantaged agricultural households that are more vulnerable to nutritional insecurity. Three, the strategies should be regionally differentiated; these should focus on regions that have a larger proportion of the poor and undernourished population.

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