Drought, Hunger and Malnutrition: Spatial and socioeconomic variations in the desert state of India

by Vinita Kanwal, Smita Sirohi, Prem Chand, and Arti Thakur

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Drought, Hunger and Malnutrition: Spatial and socioeconomic variations in the desert state of India

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Abstract

In least developed and developing countries alleviation of hunger and malnutrition has been a paramount policy concern. In this respect, head-count hunger or malnunutrition are of limited use from policy perspective. Today's food secure person may on experiencing the shock like drought become food insecure tomorrow. Therefore an ex-ante assessment of hunger and malnourishment i.e. who are expected to be food insecure holds greater relevance. Rajasthan being most drought prone state was chosen for the study. We used household consumption expenditure data of National Sample Survey Office for two years; normal year and drought year. We used three stages feasible generalised least square techniques to estimate Vulnerability to Hunger and malnutrition (VEH and VEM); a measure of future probabilities of households being food insecure. Ex-ante vulnerability to hunger in normal year was found to be 7.7 % and ex-post was 12.4% which increased to 13.9% and 20.9% respectively in drought year. Regional variations in hunger were very high, southern Rajasthan being most disadvantaged; that inflated in event of drought. Incidences of malnourishment were found to be much higher than hunger that further rose in drought year. Interestingly proportion of infrequent hungry people is more as compare to chronic hungry that means a majority has where vital to come out of hunger. But situation is seriously dim and reversed in term of malnutrition. In this regard providing skills, creating awareness about a wholesome diet and balance nutrition will play an important role. Promoting bio-fortified varieties and fortification of food in diets is also crucial

Keywords: Hunger, Malnutrition, Vulnerability to expected Hunger (VEH), Vulnerability to expected malnutrition (VEM)

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Introduction

Alleviating hunger and malnutrition are important development goals. Despite the notable similarity, these two are interestingly emerging as technically different concepts. Unlike 'Millennium Development Goals, 2015, where eradicating hunger and malnutrition targeted in a common goal, the world recognized the need for policy interventions to target them separately in ‘Sustainable Development Goals, 2030.

Hunger is a persistent inability to meet bare minimal food requirements and is commonly recognized as a resultant of the inability to 'access' food owing to lack of purchasing power. Malnutrition is discerned as '*chronic food insecurity*, apparently, a situation in which people consistently consume diets inadequate in calories and biologically essential nutrients (NRC, 2006). Although malnutrition includes overnutrition and undernutrition, the policy focus for global starvation is largely undernutrition. Hunger and malnutrition in any form are designated ‘food insecurity' that lead to impoverishment that in extreme cases could expedite starvation and ultimate demise.

Although correlates of food and nutritional insecurity are deeply entrenched in structural, institutional, and financial bottlenecks viz. are endogenous to a region, yet exogenous shocks, especially natural calamities have a very strong impact. Among natural calamities, drought alone bears the burden of highest global economic losses than any other climatic hazard (Wilhite 2000).At the micro-level, drought often leads to assets diminution, soil degradation, environmental hampering, insolvency, joblessness, forced migrations, etc. (Hellmuth et al., 2007; Bhavnani et al., 2008; Scheffran et al., 2012). From a macro perspective, drought reduces the GDP growth and threatens the development gains of a country (Jury, 2002; Sadoff 2008; Brown et al., 2011; Hellmuth et al., 2007). In the past five decades, drought is surfacing as a serious

problem in developing countries of Asia and Africa. Further expected increase in its frequency and severity are threats to the global food system (Dai 2013; Parry et al., 2010). Hence, to develop effective policies and mitigate the effect of climate change, it is important to understand the impact of droughts on hunger and nutritional insecurities. From a policy perspective, to help alleviate the negative consequences of drought, several issues are relevant that follows.

It is important to know not only the ex-post effect but also ex-ante susceptibilities to food insecurities. As food security status is a stochastic phenomenon, today's food secure person might become tomorrow's hungry and malnourished subjected to exposure and realization of income losses, idiosyncratic shocks, or covariate shocks in the future. Few researchers have tried to address this gap of current and future uncertainties by introducing the concept of vulnerabilities (Morduch 1994). While hunger and malnutrition are based on the current and traditional assessment status of income/nutritional intake, vulnerability stretches this notion by including potential risk. Precisely, if the policies are designed in the current year using a threshold of the previous year(s), the 'hungry' who receive policy support might have already escaped hunger currently whereas the 'food-secure' just above the threshold who do not receive it might become insecure due to various unforeseen shocks (e.g., mortality in family, fall in crop prices or crop loss due to natural hazard). Hence, the current hunger/nutritional status of a household need not necessarily be a good indicator of future uncertainty. In this regard the approach of vulnerability to hunger (VEH) and vulnerability to malnutrition (VEM) becomes important to investigate not only the ex-post effect but also ex-ante susceptibilities to food insecurities (Celidoni 2013; Hoddinott & Quisumbing 2003; Ligon 2005; Ligon & Schechter 2003; Gaiha & Imai 2004; Dercon 2005).Vulnerability assessment in event of drought can support decision-making processes (Sonmez et al. 2005; Pereira et al. 2014) through the

identification of the most prone section and thereby taking appropriate mitigation options in advance (Wilhelmi and Wilhite 2002), the design of contingency plans (Sonmez et al. 2005).

The extent of exposure to widespread drought hazard is envisioned as primarily responsible for regional vulnerabilities. However, infrastructural facilities such as a well-laid irrigation arrangement, good access to groundwater reserves, and an intense road network could help minimize the disaster havoc (Detges 2016). In far-flung and structurally deserted regions, the situation is different. In these settings, droughts are likely to compromise the livelihoods of vulnerable communities and thus exacerbate both anti-state grievances and local resource conflicts.

Also, diverse regional vulnerabilities have encompassed the evolution of region-specific adaptive capacities. The potential difference in the capacity to adapt to the losses out of drought damage is the main cause of its spatial differences. Jones et al., (2007) indicated that mitigation and adaptive capacity do not share the same scale, that is, adaptive capacity is largely the function of regional exposure, whereas mitigation capacity is individual or group-specific. Socio-economic factor constitutes the characteristics of a person or group in terms of their capacity to anticipate, resist, cope with, and recover from the impact of hazards (UN/ISDR 2009; Adepetu and Berthe 2007, Cheng and Tao 2010, Zarafshani et al., 2012, Safavi et al., 2014, and Naumann et al., 2013). These are primarily responsible for mitigating societal vulnerability to drought and cause the most severe drought impacts (Downing and Bakker 2000 in Wilhelmi and Wilhite 2002; Shiau and Hsiao 2012; Kim et al., 2013).

Limited income, assets, and inadequate access to government facilities might force existing hungry and malnourished to mobilize what assets they have to enhance their welfare. And hence,

this section is widely perceived to be relatively more sensitive to natural disasters: they have limited resources and a poor asset base limiting their capacity to adapt (Eakin et al., 2014; Olsson et al., 2014; Siegel and Alwang, 1999). The size of landholding has an important role in this regard. Large landowners are more adaptive to shocks than their counterparts (Paul 1998; Keshavarzet al., 2010). Empirically, the nature of households' engagement for livelihoods and social groups has emerged as an important socio-economic factor resulting in a sensitivity of consumption changes to shocks (Kurosaki 2011; Omobowale 2008).

In this context, drought vulnerability assessments are the first step in the identification of the section of the population that is most susceptible to the gruesome impact of droughts. It is also important to look into spatial and socio-economic variations. In this regard, this paper brings out empirical evidence from the highly drought-prone desert state of Rajasthan.

Spatial characterization of the state

India’s largest state by area, Rajasthan comprises 342000 square kilometers inhabiting 6.85 crore people and 56.8 million livestock. It is sparsely populated with an average landholding of 3.07ha due to the desert environment and posed vulnerabilities. Average annual rainfall ranges from 313mm in the west to 675mm in the east leading to aridity and floods in the state. An average household in the state has an operational holding of 2.73 hectares.

Decadal population growth is 21.3%, i.e. greater than the national average of 17.1%. The state is also among the lower performers in female education. The gender gaps are also significantly high. The state has a history of socio-economic discrimination towards disadvantaged sections (table 3). Rajasthan is now at a crossroads and faces serious challenges for sustaining rapid and inclusive growth as indicated by the low value of human development index. Gross domestic

product per-capita stood at INR 81 thousands, much lower than all India average of INR 109 thousands.

Table 1. General profile of the state

s no	Particular		Value	Unit	Datasource
1.	Area		3.42	Lakh sq km	Population Census
2.	Population		6.85	Crore	Population Census
3.	Total livestock		56.8	Million	livestock census
4.	Population density		200	/Km2	Population Census
5.	Average landholding		3.07	Ha	Agricultural Census
6.	The average size of operational holding		2.73	Ha	
7.	Average rainfall	Western Rajasthan	313	Mm	Indian meteorological department
8.		Eastern Rajasthan	675	Mm	
9.	Sex ratio		928	Per 1000	Population Census
10.	Literacy		66.1	%	Population Census
11.	HDI		0.629		Directorate of Economics and Statistics
12.	Per capita income	current price	118159	INR	Economic review of Rajasthan
13.		constant price (2011-12)	81355	INR	Economic review of Rajasthan
14.	Gross state domestic product (gsdp)	current price	929124	Crores	Economic review of Rajasthan

Rajasthan is water scarce state and as per Central Groundwater Development Board, total area in 140 out of 236 blocks is over exploited and is critical in 50 blocks. Yet it comprises of several zones having varied climatic features, from scanty rainfall to flood incidences. We present our results at the zonal level as delineated by National Sample Survey Office (NSSO). NSSO has divided the state into five zones having innate distinctiveness as a result of which zones behave differently to external shock. The western zone is comprised of 43.1% area of the state (fig. 1).The zone is characterized by the least precipitations and frequent droughts; consequently, mere 60% of the zonal area is under cultivated. The cultivation is limited to large farmers. This indicates a non-congenial situation for farming. The zone comprises nearly 20% of farm families of Rajasthan.

North and *north-eastern zon*e each encompasses nearly 19% of state area. The districts in the northern zone have rich water resources vastly irrigated by the network of Indira Gandhi Canal, Bhakra and Ganga canal. While the north-eastern zone falls under flood-prone plains drained by river Banas and Yamuna. This provides a congenital condition for cultivation and thus the land under cultivation stands 90% and 96% respectively in these zones.

The southern zone comprises merely 9% of the state area. Not even half (43.4%) of the zone is under cultivation. Nearly one-fourth of the land is not available for cultivation (either under non-agricultural uses or barren & unculturable land) and the remaining one-fourth is forest land. The remaining land of the zone comprises permanent pastures, misc trees, groves, and culturable wastelands. *The South-eastern zone* is equal to the *southern zone* in size but 91% area of the zone is under cultivation stating a vigorous state of agriculture therein. Additionally, the river Chambal and its tributaries in the region of *Southern* and *south-eastern* zone make them vulnerable to frequent floods.

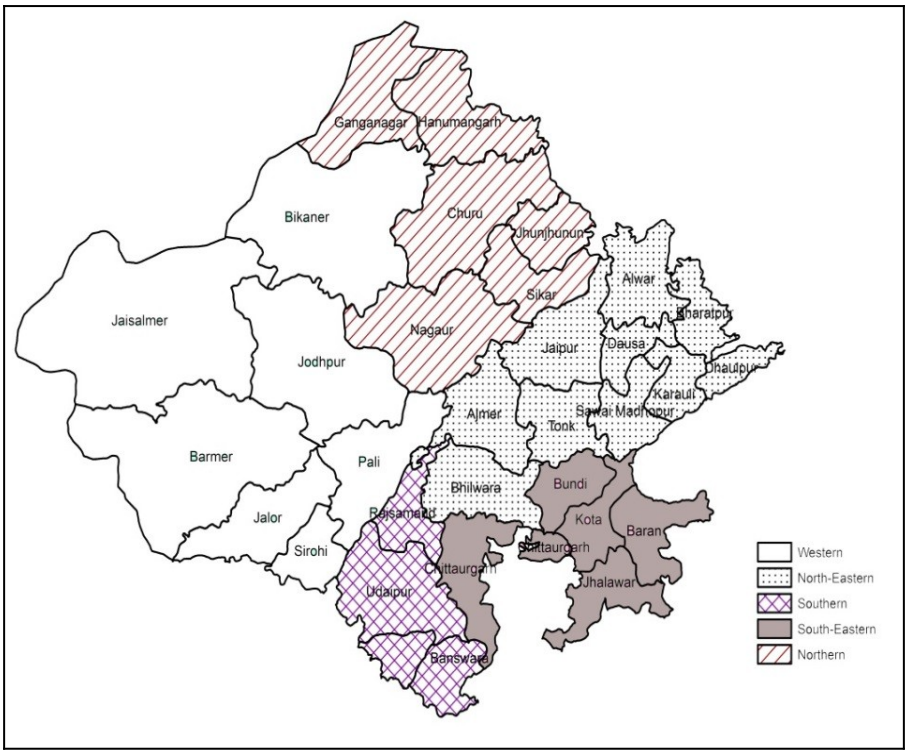

Fig 1. Zoning of Rajasthan by NSSO

Methodology

Database

The cue on designated drought years was taken from the estimates of losses, affected geographical area, and population (GoR, 2019). We took 2009 as drought year as estimated losses were highest affecting more than 33000 villages and 42 million people and 2011-12 as the normal year for the comparison. Other researchers also establish and used 2009-10 as a major drought year (Shah and Mishra 2020; Tandon and Landes 2014). We used National Sample Survey Office (NSSO) consumption expenditure unit record data for drought and normal years. Besides providing monthly per capita expenditure (MPCE), these surveys also cover total quantities of food items consumed (that includes cereals, pulses, vegetables, fruits, meat, milk, etc.) over the last 30 days. The data on MPCE and consumption expenditure on food items (excluding beverages and other non-food items) for rural households was used for drought (2009-10) and normal year (2011-12) with 2579 and 2585 households respectively.

The approach of the present study

We captured hunger as 'inability to meet bare minimal food requirements as a result of the lack of purchasing power. A household earning less than a threshold is most likely to be hungry. In absence of parameters capturing income of the household correctly, we used MPCE as a proxy, to capture incidences of hunger.

For calculating malnutrition our steps proceed very much in the same way as Kanwal et al., (2019). Although malnutrition includes overnutrition and undernutrition, due to policy concerns, the focus of this paper is undernutrition. Data on food consumption reflected in NSS is the only source measuring food intake near precisely. For understanding the impact of drought on nutritional insecurities, we converted quantities of food intake into household nutritional (calorie and protein) intake using methodology of Gopalan et al. (1991). Following Carpena (2019), we could not capture the nutrition accounting from meals consumed outside the home, meals provided by households to non-household members, nutritional loss in cooking, and food wastageon account of non-significant contribution to overall nutritional intake and underlying complexities in measurements.

Hunger and malnutrition in any form are designated 'food insecurity'. The hungry and malnourished are always in fear of future uncertainties. These uncertainties could be in the form of income losses, idiosyncratic shocks (health issues including mortality or morbidity), or covariate shocks (natural disasters). Also, the impact of these risks may vary across the households; given various sets of characteristics. Vulnerability is an important tool in this regard. The concept of 'vulnerability' was introduced to examine the relationship between existing food security status with future qualms (Morduch 1994). It is a forward-looking state of the expected

outcome and has widely been used to estimate uncertainties (Celidoni 2013; Hoddinott & Quisumbing 2003; Ligon 2005; Ligon & Schechter 2003; Gaiha and Imai 2004; Dercon 2005).According to Hoddinott and Quisumbing (2003), vulnerability is uninsured exposure to different risks or it can be defined as the risk of food secure individuals or households falls below the thresholds line or those already food insecure remaining so in the future.

The conceptual framework of hunger, malnutrition in response to the vulnerability of a particular household can be understood in presence of some external shocks. Households are vulnerable if a shock is likely to push them below a predicted welfare threshold, e.g. hunger threshold, minimum recommended calorie or protein consumption, etc. (Heitzmann *et al.,* 2002). The level of resource endowments along with socio-economic characteristics strongly influences households' level of food security and future vulnerabilities. The food-insecure are typically the most exposed to different risks and they also have the fewest instruments or resource endowments to deal with these risks. Hence, food insecurity and vulnerability are two sides of the same coin (Chaudhuri et al., 2002; Tu Dang 2009).

Estimation method

This study adopted the vulnerability to expected poverty (VEP) framework to analyze the vulnerability of households to hunger and malnutrition in presence of drought (Chaudhuri (2003). We use the three-stage feasible generalized least square (FGLS) technique to assess households' vulnerability to expected hunger (VEH). We extended the methodology for estimating vulnerability to expected malnutrition (VEM) in line with Kanwal (2019). We start our estimation with a reduced form of consumption function written as eq 1.

$$\ln C_i = Y_i\beta + \varepsilon_i \ldots (1)$$

Where, C_i is per capita consumption (MPCE, calories, and protein), Y_i represents a vector of observable household characteristics, β is a vector of associated parameters and ε_i is a mean-zero disturbance term that captures idiosyncratic shocks and unobservable characteristics. The three-step feasible generalized least square (FGLS) technique is used to obtain the expected log consumption $\hat{E}[\ln C_h / Y_h = \pi r^2]$ and variance $\hat{V}[\ln C_h / Y_h]$. Assuming that LnC_h is normally distributed the estimated probability ($\hat{V}_h$) that a household will be prone to hunger or malnutrition in near future is given by eq2 (Amemiya 1977).

$$\hat{V}_h = \Pr[lnC_i < \ln Z / Y_i] = \mu \left[\frac{lnZ - Y_i \hat{O}_{FGLS}}{\sqrt{Y_i \hat{\theta}_{FGLS}}} \right] \quad \ldots (2)$$

Where μ (.) denotes the cumulative density of the standard normal and Z represents either minimum purchasing power or minimum nutritional requirement. We consider the monthly per capita expenditure (MPCE) of INR 865 for the drought year (2009-10) and INR 1,036 for the normal year (2011-12) as the minimum purchasing power or hunger threshold (GoI 2009). For malnutrition, we take recommended calorie intake of 2,730 kcal/capita/day and protein intake of 60gm/capita/day as thresholds (Rao & Sivakumar 2010) for both periods. $Y_i \hat{\dot{O}}_{FGLS}$ is the expected mean of real household consumption and $Y_i \hat{\theta}_{FGLS}$ is the estimated variance in the consumption.

Further, the households whose probability exceeds 0.5 are considered prone to hunger/ malnutrition (Chaudhuri 2003; Chaudhuri et al., 2002).

Based on the current consumption thresholds (Z), expected consumption, and vulnerability, the households can be classified into chronic hungry/malnourished, infrequently hungry/malnourished, vulnerable to chronic hunger/malnutrition, and low vulnerability poor/undernourished (table 2). These four groups, in turn, make up two broad categories: hungry/ malnourished (A+B+C) and prone to hunger/malnourishment (A+B+D+E)

Table 2. A classification scheme for vulnerability

<table>
<tr><td rowspan="3"></td><td rowspan="3"></td><td colspan="2">food security status</td><td rowspan="3"></td><td rowspan="3"></td></tr>
<tr><td>existing food insecure (current consumption < threshold)</td><td>existing food secure (current consumption > threshold)</td></tr>
<tr><td></td><td></td></tr>
<tr><td rowspan="3">Vulnerability status</td><td rowspan="2">Highly prone (vulnerability >0.5)</td><td>Chronic hungry/malnourished (A)</td><td>Prone to chronic hunger/malnutrition (D)</td><td>Expected consumption < Z</td><td rowspan="3">Expected MPCE/calorie consumption</td></tr>
<tr><td>Frequently hungry/malnourished (B)</td><td>Vulnerable to frequent hunger/malnutrition (E)</td><td rowspan="2">Expected consumption >Z</td></tr>
<tr><td>Less prone (vulnerability <0.5)</td><td>Infrequently hungry/ malnourished (C)</td><td>Current and future food secure (F)</td></tr>
</table>

Socioeconomic characterization of the sample

A statistical summary of variables from both NSS rounds is presented in table 3. On average, household-heads are of 45 years of age, and close to half of them are illiterate. A majority of the households are male-headed. The average household size is five. More than 93% of the households are Hindus, and near to 40 % belong to scheduled castes (SC) and tribes (ST). About

half of the households are engaged in agriculture as cultivators and agricultural laborers, and about one-fourth are self-employed in the non-agriculture and other labors. Rests of the households are engaged in other economic activities including regular salary earnings. The average land size is less than 2.0 hectares. Only 8% households are earning a regular salary, and 26% has ration card.

Table 3. Socio-economic characteristics of sample households

Variable	Mean	SD
Age of head of household	44.101	13.770
Male (1/0)	0.897	0.304
Literacy (1/0)	0.521	0.500
Household size	5.320	2.480
Schedule tribe (1/0)	0.171	0.377
Schedule caste (1/0)	0.220	0.415
Hindu (1/0)	0.929	0.257
Agricultural households (1/0)	0.514	0.500
Non-agricultural households (1/0)	0.243	0.429
Land possessed	1.812	2.931
Regular salary (1/0)	0.086	0.280
Ration card (1/0)	0.261	0.439

A significant decline in MPCE (137 to 486 INR), calorie (116-272 Kcal), and protein (2.1-12.4 gm) consumption has been observed across the zones of Rajasthan in drought year. Interestingly, the decline in protein intake in drought year is insignificant across zones. To our surprise, calorie and protein intake in drought year was significantly high over normal year in south zone. In drought year, calories consumption and protein consumption were 268 Kcal/capita/day and 5 gm/capita/day more respectively over normal year. Southern Rajasthan is dominated by tribal with major forest regions and sparse cultivation. Increased animal slaughter for meat and dependency on local groves during droughts could be the reason for increased nutritional consumption (Khera 2005; Kanwal 2020). Dependency on local food variants and regional tree species are additional adaptive strategies against malnutrition in the region (Kanwal et al., 2021).

Western zone also displayed an increase in calorie consumption in drought year though insignificantly. Hence, about different adaptive capacities of zones, there appears the different impact of drought on hunger and malnutrition status of households across them.

Table 4. Change in MPCE, calorie and protein intake in drought year across zones

Region	MPCE	Calorie (Kcal/ cu/day)	Protein (g/ cu/day)
West	1135.3	2750.1	81.2
	(+361.1)	(-2.6)	(+2.1)
North-east	1085.9	2663.6	83.5
	(+486.6)	(+172.2)	(+5.7)
South	1070.6	2761.5	83.7
	(+137.2)	(-268.2)	(-5.5)
South-east	1021.5	2459.0	73.7
	(+432.0)	(+272.4)	(+12.4)
North	1172.4	2721.5	83.1
	(+571.7)	(+116.4)	(+6.1)

*Figure in parenthesis indicates rise or fall in particular consumption in the normal year. Rise and fall in MPCE, calorie and protein is indicated by + and – signs in that order

Results and discussion

This section discusses about status of hunger and malnutrition followed by their estimates and extent.

Status and estimates of hunger and malnutrition

In the drought year an average household's monthly expenditure is Rs419 less than the normal year. Interestingly this expenditure in both the period is significantly above the hunger threshold (table 3). On contrary, nutritional intake is below (2674 Kcal/cu/day) the threshold level in the drought year and just online (2760Kcal/cu/day) in normal year indicating persistent nutritional deficiencies in the state. The state is protein sufficient in normal and the drought year indicating better consumption of milk, meat, pulses, and other protein-rich dietary intakes. Given that henceforth, less emphasis is given on protein vulnerability estimates in the state.

Table 5. The parameters of food security in Rajasthan

Variable	Mean	Min	Max
Monthly per capita consumption expenditure	1101.2	278.7	9748.4
(MPCE)	(+419.3)	(+61.3)	(+48.6)
Calorie consumption (Kcal/ consumer unit/day)	2674.6	721.9	7591.6
	(+86.0)	(+246.1)	(+2641.1)
Protein consumption (g/ consumer unit/day)	81.6	19.7	241.2
	(+4.6)	(+11.1)	(+55.0)

Figure in parenthesis indicates rise or fall in respective consumption in a normal year. Rise and fall are indicated by + and – signs respectively.

The results of the three-stage FGLS are reported in table 4. We estimate regressions for per capita consumption expenditure and calories in log-linear form; separately for drought and normal year.

Age of the household head has a positive significant effect on consumption of MPCE as well as calorie, but its squared term carries a negative and significant sign. This implies that households headed by elderly persons are secured from hunger. But as age increase beyond mean age; chances of household hunger increases. Literacy secures households from hunger. Socially disadvantaged sections of the population (schedule cast and tribe) appear to be more prone to hunger as compare to others. Further, we find a negative association of household size with purchasing power as reflected by MPCE. Households directly or indirectly engaged in agriculture are moreprone to hunger as compare to regular salary earners. Security from hunger increases as the size of land possessed increases.

Table 6. Estimates of vulnerability to hunger

Variables	**Coefficient**		**t-Statistic**	
Dependent variable	**Ln MPCE**			
Constant	6.9676*	(7.4771*)	99.7806	(93.5323)
Age of head	0.0202*	(0.0206*)	7.0308	(6.5204)
Age^2	-0.0002*	(-0.0002*)	-5.6586	(-5.4461)
Male	0.0054	(0.0360)	0.2032	(1.2440)
Literacy	0.1331*	(0.1112*)	9.2267	(7.3944)
Household size	-0.1111*	(-0.1676*)	-16.4081	(-16.2502)

Household size^2	0.0035*	(0.0075*)	8.1225	(9.7171)
ST	-0.1426*	(-0.1376*)	-7.9467	(-6.4259)
SC	-0.1129*	(-0.1005*)	-6.5421	(-5.5444)
Hindu	-0.0021	(-0.0367)	-0.0772	(-1.5250)
Agricultural households	-0.0397**	(-0.0559*)	-2.2243	(-2.8815)
Non-agricultural households	-0.1323*	(-0.1788*)	-7.4539	(-8.9010)
Land possessed	0.0406*	(0.0402*)	10.6733	(6.8158)
Land possessed^2	-0.0008*	(-0.0012*)	-5.0609	(-2.7491)
Regular salary	0.2074*	(0.1585*)	8.3708	(7.0335)
Ration card	-	(-9.7058*)	-	(-9.7058)
Number of observations	2568	(2578)		

Age, literacy, and household size similarly impact malnutrition as hunger. But schedule tribe appears to be nutritionally secure during drought as compared to other sections. Interestingly, male-headedness of the household has a negative and significant effect on nutrition consumption, which indicates that female-headed households tend to consume nutritionally rich diets.

Households directly or indirectly engaged in agriculture happen to be significantly more affluent in nutritional (calorie and protein) intake compared to those engaged in non-agricultural activities. 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, additionally, the intensity of food insecurities rose in the drought year.

Table 7.Estimates of vulnerability to malnutrition

Variable	**Coefficient**	**t-Statistic**	**Coefficient**	**t-Statistic**
	LnCalorie		**LnProtein**	
Constant	7.9784*	158.4111	4.4298*	81.9944
	(8.1271*)	(157.0088)	(4.6387*)	(86.3343)
Age of head	0.0061*	2.9446	0.0065*	2.9592
	(0.0074*)	(3.5757)	(0.0075*)	(3.4664)
Agesquare	-1.71E-05	-0.8240	-2.15E-05	-0.9705
	(-3.12E-05)	(-1.4792)	(-3.22E-05)	(-1.4568)
Male	-0.0623*	-3.8073	-0.0623*	-3.5381
	(-0.0686*)	(-4.1443)	(-0.0639*)	(-3.8242)
Literacy	0.0335*	3.4345	0.0315*	2.9751

	(-0.0375*)	(-3.8671)	(-0.0418)	(-4.1035)
Household size	-0.0775*	-15.2633	-0.0708*	-13.4773
	(-0.1111*)	(-17.3783)	(-0.1136*)	(-16.8375)
Household size square	0.0028*	8.3865	0.0025*	7.4597
	(0.0051*)	(10.6217)	(0.0054*)	(10.5272)
ST	0.0009	0.0680	0.0151	1.0970
	(-0.0829*)	(-6.2311)	(-0.0653*)	(-4.7953)
SC	-0.0414*	-3.8026	-0.0358*	-3.0270
	(-0.0426*)	(-3.6956)	(-0.0349*)	(-2.9421)
Hindu	0.0096	0.5442	0.0146	0.7902
	(-0.0253***)	(-1.7430)	(-0.0266***)	(-1.7558)
Agricultural households	0.0382*	3.3564	0.0588*	4.7105
	(0.0227***)	(1.9398)	(0.0455*)	(3.6851)
Non-agricultural households	-0.0404*	-3.3886	-0.0352*	-2.7525
	(-0.0523*)	(-4.2390)	(-0.0430*)	(-3.3357)
Land possessed	0.0198*	7.9512	0.0191*	7.0816
	(0.0282*)	(7.3982)	(0.0279*)	(6.9205)
Land possessed square	-0.0004*	-4.2890	-0.0004*	-3.9215
	(-0.0012*)	(-4.0960)	(-0.0012)	(-3.9811)
Regular salary	0.0329**	2.5009	0.0208	1.4613
	(0.0417*)	(3.1984)	(0.0383*)	(2.7900)
Ration card	-	-	-	-
	(-0.0225**)	-2.0135	(-0.0131**)	-1.1500

Figure 2 illustrates the comparative distribution of hunger, malnutrition, VEH, and VEM across NSS zones for drought and normal year. Headcount hunger is 33.5% for the state of Rajasthan in a drought year, around 11.2% higher than the normal year. The number of households prone to hunger also rose by three-fourth in the drought year. Corresponding households that were prone to malnutrition rose by 22.7%.Headcount malnutrition is significantly high relative to hunger; sometimes as higher as 68.7% (southern zone). Households prone to malnutrition are even higher. They inflate during droughts, though marginally; the southern zone being an exception.

On expected lines, drought escalated incidences of hunger and malnutrition in all zones of Rajasthan except the south. South Rajasthan largely comprises tribal (Joshi and Raghav 2020). A high level of hunger and malnutrition is widespread among these tribes owing to the conspicuous

consumption of nutritionally poor food. The non-availability of nutritionally rich food items such as pulses, oil, milk, vegetables, and fruits in the region has been an additional challenge in the road to food security (Mohan et al., 2016). These tribes live in extreme scarcity and rely largely on outward migration for sustenance (Saxena et al. 2020). Drought has the least impact on the food security status of these areas as an insignificant rise in the number of hungry and malnourished is witnessed. Larger areas under forest, low dependency on agriculture, and higher tribal inhabitation could validate the observed pattern. Frequent flood occurrences in the zone could be other possible reasons.

In northern and north-eastern zones hunger and malnutrition increased significantly in the drought year. This indicates a lack of households' preparedness for this unanticipated shock. Irrigation facilities and crop cover are good in these regions implying greater dependencies of rural households on cropping enterprise. A good irrigation network also implies growing water-intensive crops and non-preparedness towards water scarcity. Thus, drought is more likely to hit the regions that are least prepared. These zones are considered relatively affluent in terms of resource endowment and basic infrastructures. This surge indicates a lack of preparedness of these zones towards any shock.

Unlike these comparative precipitation-sufficient zones, the west Rajasthan appeared exceptionally resilient to drought. It appears that frequent droughts and poor resource endowments have constrained the local community to evolve through centuries of learning, ingenious ways to cope with it (Narain and Kar 2005). Some of these include land fallowing (exclusively left for grazing), mixed farming, agro-forestry, traditional water harvesting in ponds, covered tanks, etc. Other than these, households make provision for grain and fodder storage, trade and sacrifice animals, and use food for work strategies to mellow the effects of

drought and sustaining resources for a longer time (Kanwal 2020; Kanwal 2021). In drought year there appears less proportionate rise in numbers of hungry and malnourished in West Rajasthan.

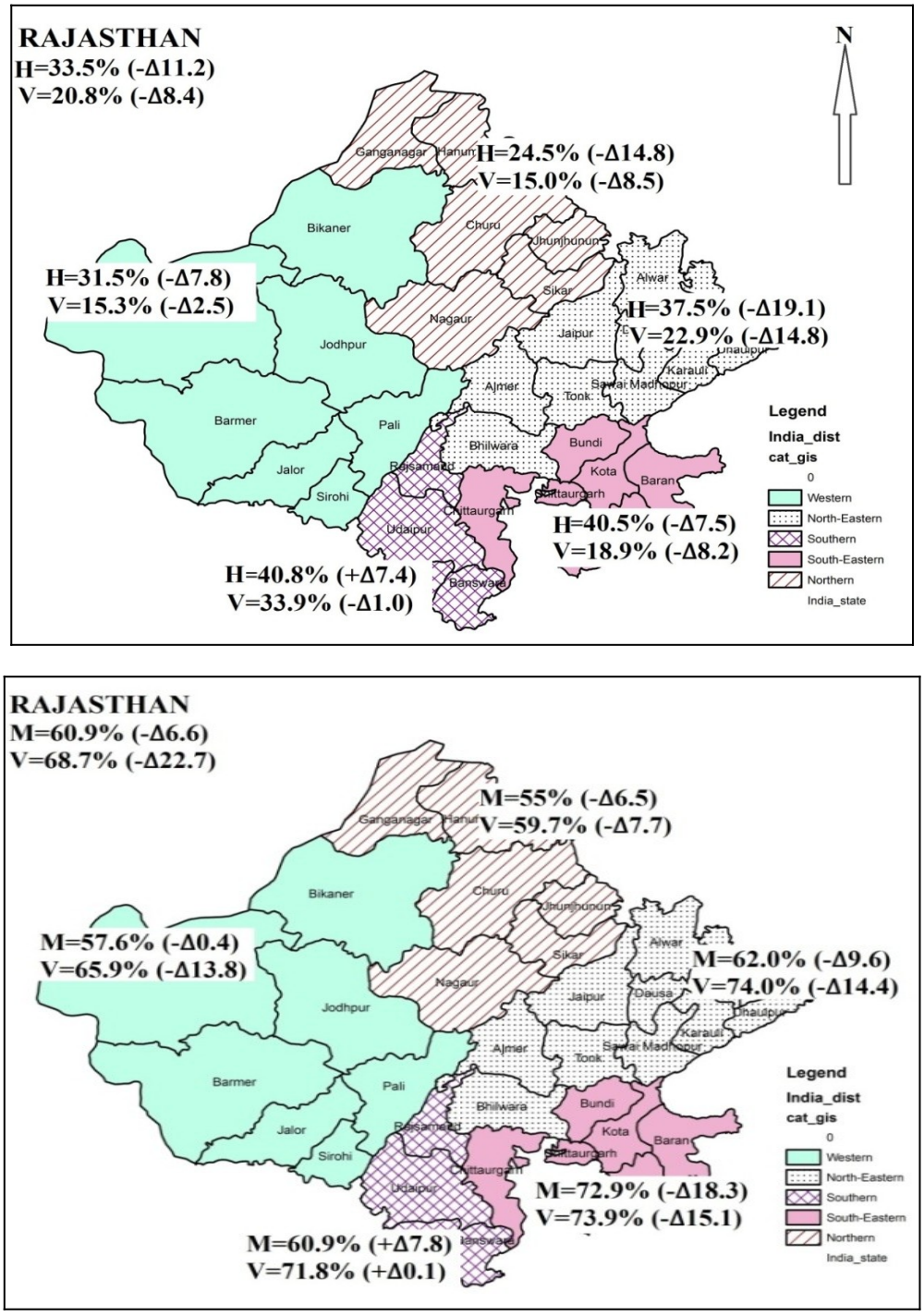

Fig 2. Estimates of hunger, malnutrition and respective vulnerabilities across regions

The extent of household hunger and malnutrition

Hunger and malnutrition are deep-rooted among ‘chronic hungry/malnourished households’. It is difficult for them to escape hunger and malnutrition without enhanced income, fortified diet, and accumulated assets. On the other hand, frequent hungry/malnourished households need a slight policy push to escape hunger generally in form of skill development and training. Table 6 furnish a breakdown of total food insecure (hungry and malnourished) households into chronic hungry/malnourished and infrequent hungry/malnourished at the zonal level.

Interestingly, infrequent hungry are proportionately more than chronic hungry across all the zones. This implies that a majority of hungry households need a slight policy push to secure in near future. This policy support could be in the form of human capital formation (training and skill impartment for enhanced earning) or financial capital formation (direct cash transfer or universal basic income) (Antwi-Agyei et al. 2012; Bhattacharya and Das 2007).

On the other hand, unlike hunger, malnutrition is a chronic problem in the region. Results indicate that malnutrition is deep-rooted and its eradication needs crucial efforts. A condition of food security but comparative nutritional insecurity points towards the fuller but inferior diet. This also points towards the need for awareness about balanced diets and the promotion and inclusion of bio-fortified crop varieties. It is necessary on the part of the government and public authority to make available affordable nutritious food with essential micro-nutrients to vulnerable groups.

Across zones, the highest numbers of chronic hungry and malnourished households reside in Southern Rajasthan (estimated number being 282535) and are largely tribal (Joshi and Raghav 2020). Along with increased total hunger, chronic hunger more than doubles in the north zone and nearly triples in the north-east zone in the drought year.

To our surprise, a mere 7% of chronic households in north Rajasthan account for nearly 130 thousands estimated individuals that are persistently poor and do not have enough to eat. Also, the corresponding individuals ending up with nutritionally non-fulfilling food stood 820 thousands. The estimates of chronic hungry and malnourished are as high as 450 thousands and 1.5 million respectively in the north-eastern zone. These figures are draconian and demand immediate policy attention in terms of food security.

Table 8. The extent of household hunger and malnutrition

	Hunger				Malnutrition			
	Drought year		Observed changes		Drought year		Observed changes	
Region	Chronic	Infrequent	Chronic	Infrequent	Chronic	Infrequent	Chronic	Infrequent
West	10.8	20.7	-3	-4.8	45.7	11.9	-7.9	7.5
	(188599)		(-41272)		(793190)		(-78711)	
Northeast	15.9	21.6	-11.7	-7.5	52.8	9.4	-13.1	3.3
	(455853)		(-321191)		(1507984)		(-248529)	
South	23.3	17.4	0.3	7.2	52.2	8.7	6.4	0.9
	(282535)		(20603)		(631554)		(121782)	
South-east	14.8	25.7	-7.9	-9.6	60.4	12.5	-17.8	0.1
	(163402)		(-84460)		(667189)		(-177799)	
North	7	17.6	-3.9	-11	44.4	10.6	-12.3	5.8
	(128331)		(-68095)		(818406)		(-204910)	

*Figures in parenthesis represent estimated population under respective heads

Hunger, malnutrition, and vulnerability; Socio-economic variation

Other than estimating VEH at the aggregate level, it has also been worked out for different household types, land size categories, and social groups across NSS regions. Results are presented here under.

Vulnerability according to household type

The activity in which a household is principally employed for income has an important bearing on the vulnerability status of the households. The findings indicate that hunger proneness is lower among agricultural households (supplementary material fig 1). But corresponding

malnutrition is more than three times. For households engaged in non-agricultural activities, malnutrition is deeply entrenched and widely spread; covering 80 % of the section (supplementary material fig 2).

These findings indicate that there are limited income opportunities for rural households to enable them to escape hunger and nutritional insecurity. Livestock is one of the potential sectors in reducing hunger and income inequalities by providing a constant flow of income and helps in consumption smoothening during the periods of crop failures (Chand and Sirohi 2015; Birthal et al. 2014; Birthal and Taneja 2012). However, the poor performance of this sector may be one of the probable reasons for high vulnerability in the south and southeastern regions of Rajasthan. Livestock in these regions is relatively less remunerative mainly on the account of low livestock productivity and poor availability of livestock products (Chand and Sirohi 2012; Chand et al. 2011). And hence, indigenous food habits may offer an opportunity for nutritional enhancements (Kanwal, 2021).

We find similar evidence at the regional level. The vulnerabilities to hunger among non-agricultural households are highest in the south (34.6%) followed by north-east (25.8%) and north (21.5%) regions respectively. Also provided external shocks, over two-thirds of these households are likely to become malnourished in near future.

Vulnerability according to land size

Possessing land is considered prestigious in Indian society primarily due to its high dependence on agriculture and allied activities. Findings indicate that the households owning large lands are comparatively less hungry, malnourished, or prone to food insecurity in comparison to landless

or small landowners (supplementary material fig 3 and fig. 4). Vulnerabilities reduce significantly with increasing land size.

Drought inflates the vulnerabilities among landholders; though in different proportions. Results at the regional level also exhibit a similar pattern; small landowners in the southern region being comparatively more vulnerable.

Vulnerability according to social group status

Incidences of current hunger, malnutrition along future vulnerability are expected to be more among disadvantaged sections (particularly SC and ST households) in rural India. This is due to the history of social exclusion and atrocities. Results show ST and SC households are more poor, malnourished, and prone (supplementary material fig 5 and fig 6). Furthermore, ST households display a higher incidence of vulnerability compared to SC households.

Surprisingly, malnutrition and associated vulnerabilities marginally decline among ST in the drought year. This is associated with eating habits and nutrient-rich diets of tribal. Tribal are known to feed on animal products and flesh whose consumption increases in the dry season (Kanwal 2021). The evidence at the regional level shows a similar pattern across social classes. The ST households in the north and south-east regions are comparatively more prone.

Identifying problematic categories

From a two-way classification of the rural households along with associated vulnerabilities, we identified two problematic categories. One is of households that are hungry and malnourished altogether. Other comprises of those who are not hungry but malnourished. Together these categories comprise 60% of households.

The number of households in the first category significantly increases in the drought year. While in the second category there is a minor decline. Results point towards the need of targeting hunger and malnutrition holistically in event of drought instead of separate intervention.

Table 9 Transition matrix for hunger and malnutrition

	drought year		change (Δ) in normal year	
Category	Hungry	hunger-secure	hungry	hunger-secure
Malnourished	2653800	2678974	-809271	650526
	(30.3)	(30.6)	(-10.8)	(4.9)
malnutrition secure	350424	3067539	-99386	907925
	(3.2)	(35.9)	(-0.5)	(6.4)

Conclusions

The paper has looked into the impact of drought on the status of current food insecurity and the prone to food insecurity in western India. Where hunger and malnutrition are static concepts; vulnerability is dynamic. Drought as a covariate shock is expected to inflate the incidences of these. Also, on experiencing drought, the current non-hungry and nutritionally secure yet highly vulnerable households are expected to fall into hunger and nutritional insecurity trap in the future. Thus it is necessary that besides knowing the headcount of current hunger and food insecurity, one must know the extent of it across households.

The estimates of households that are prone to hunger are 20.8% while corresponding malnutrition estimates are more than three times. At the regional level also, the incidence of malnourishment and vulnerability is found to be higher than hunger incidences. Sharp regional variations in the extent of hunger are observed. The southern region being the most disadvantaged. Desert-prone regions are less susceptible to external shock, particularly drought

as compare to irrigated regions indicating that on impeding drought, irrigation alone is insufficient to act as a cushion against hunger and malnutrition.

Also, the higher headcount of hunger (22.3%) than VEH estimates (12.4%) along with more infrequent hungry suggests that a sizable percentage of rural households have the wherewithal to come out of hunger. Therefore, the asset base of the households is of less concern, and skill development and capacity building can be important policy interventions.

Incidences of malnutrition are about three times that of hunger that rises in the drought year. This indicates that government interventions including public distribution and national food security mission will be least effective unless emphasis is given on nutritional management along with public distribution system. In this regard awareness about a wholesome diet and balance nutrition will also play an important role. Fortification of food in farmers' diets is also crucial.

Widespread hunger among non-agricultural rural households implies that the non-farm sector offers limited opportunities to rural households until farm and non-farm linkages are strengthened. Hence, the development of both the sectors will be crucial. The non-farm sector doesn't have the absorptive capacity for the livelihood security of rural households. Therefore, the policy focus on the rural non-farm sector through development of agro-processing and agro-based industries is vital in this context.

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Supplementary material

Fig 1. Estimates of VEH across household types

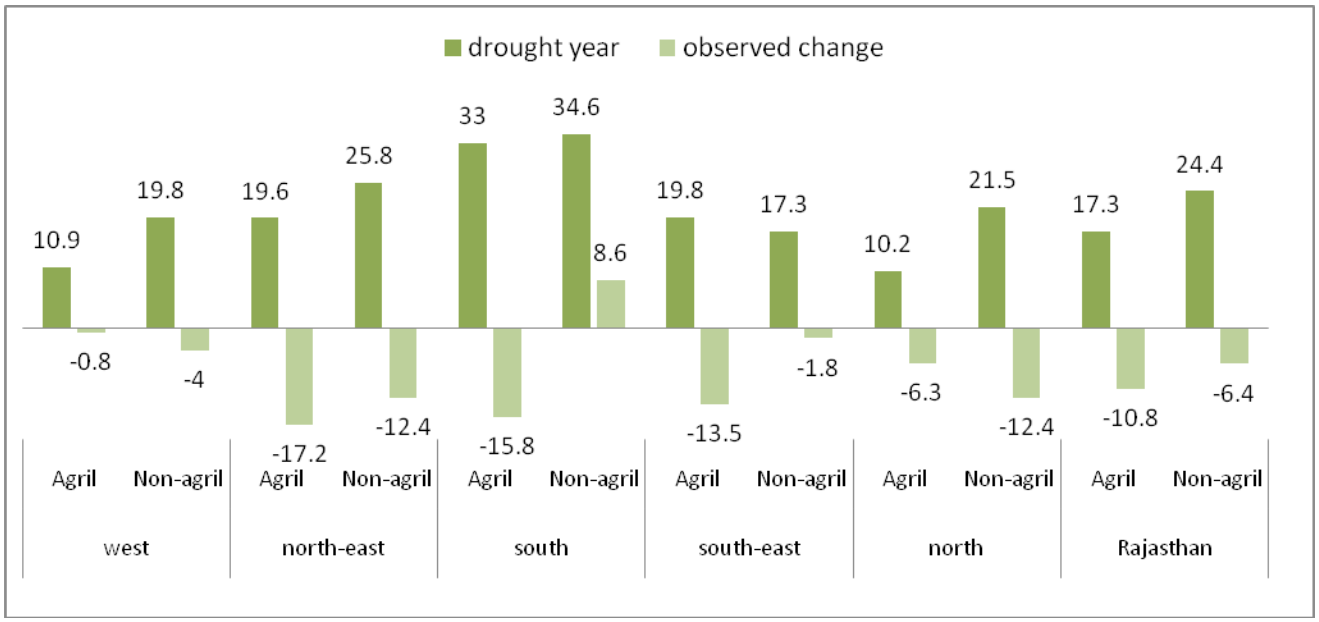

Fig 2.Estimates of VEH across household types

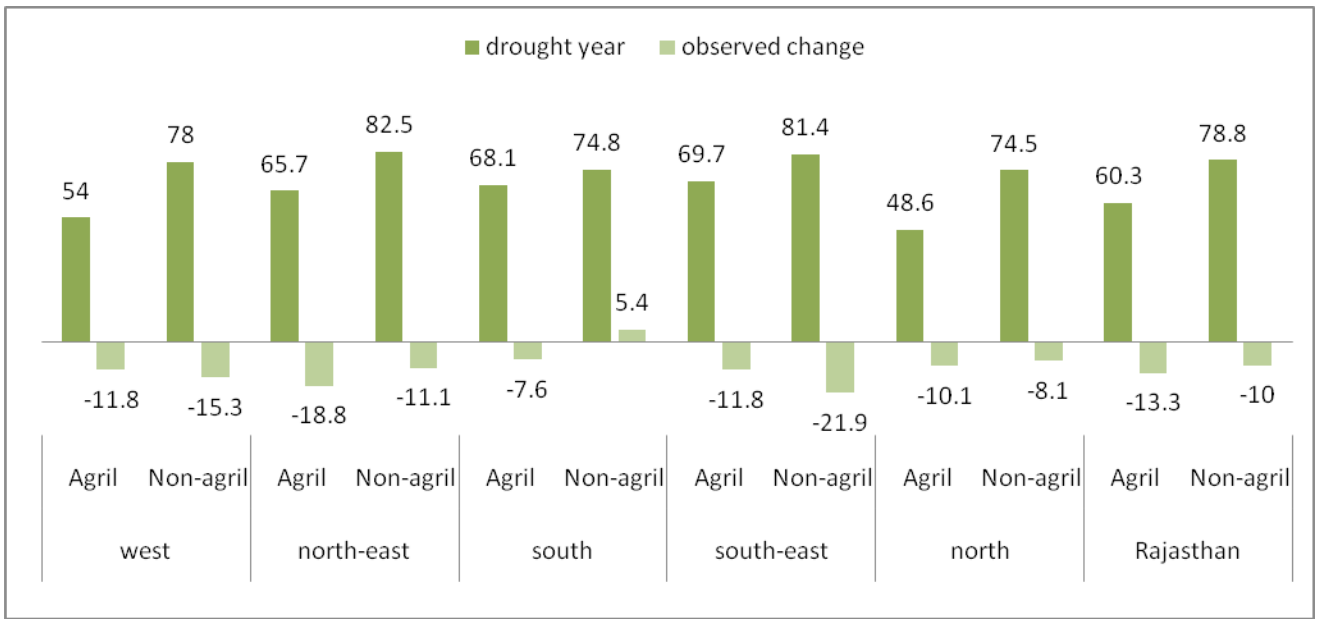

Fig 3. Estimates of VEH across land size

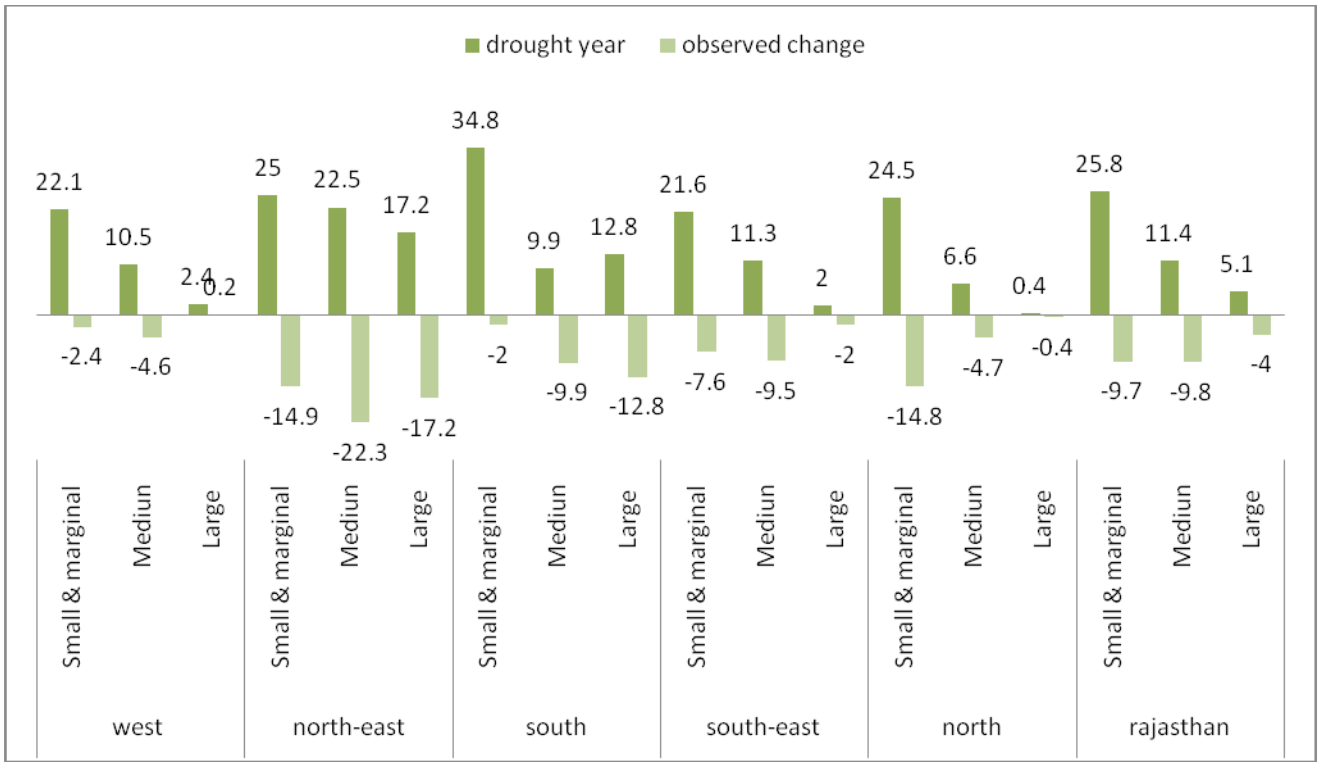

Fig 4. Estimates of VEM across land size

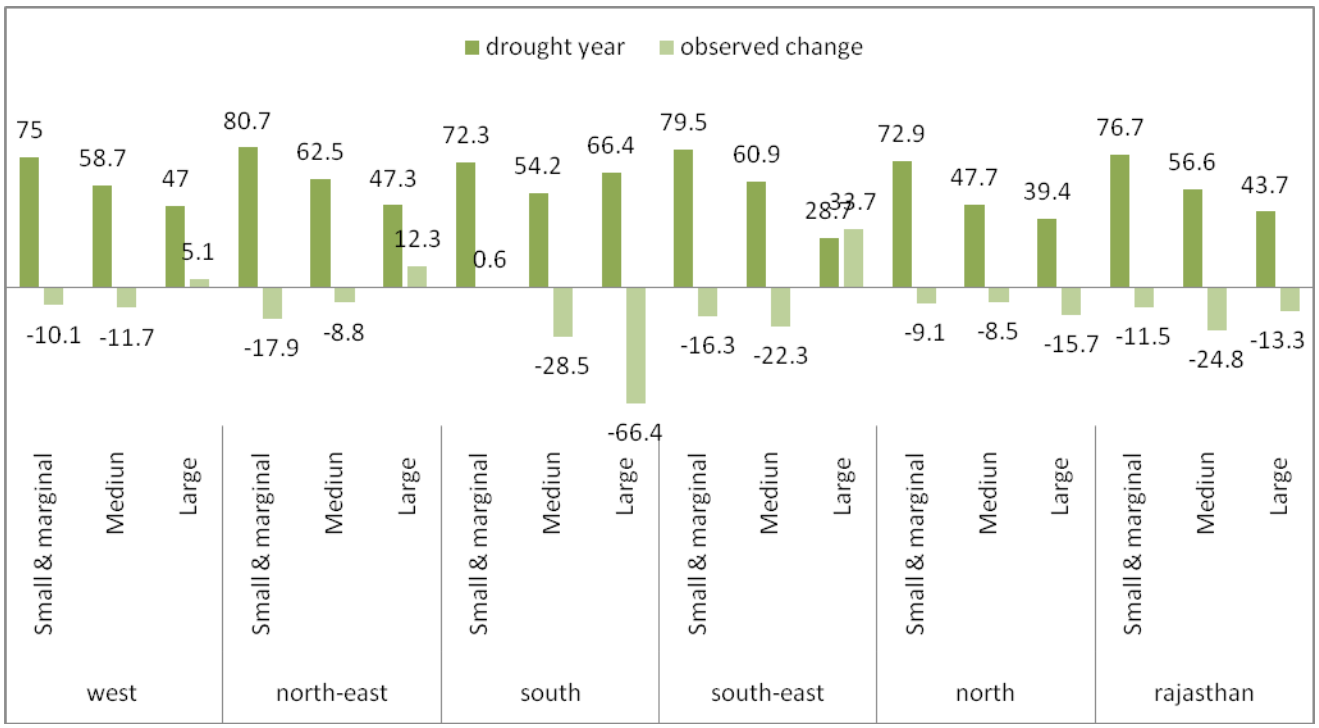

Fig 5. Estimates of VEH across social groups

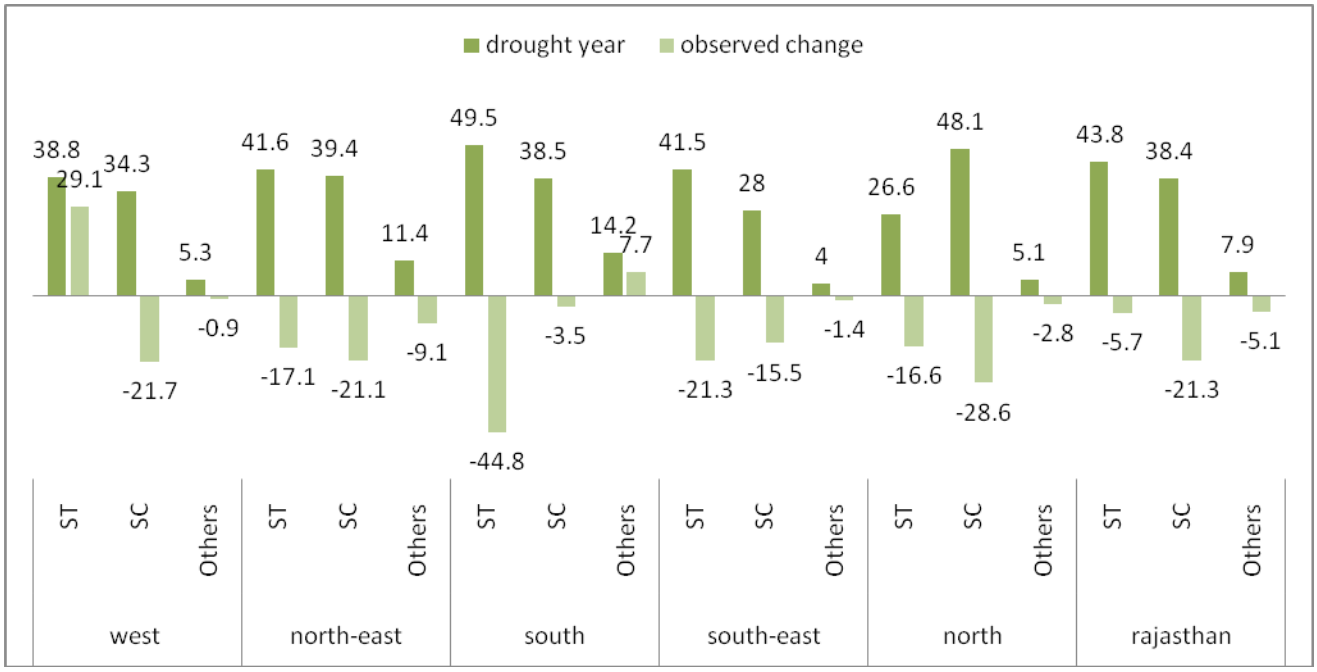
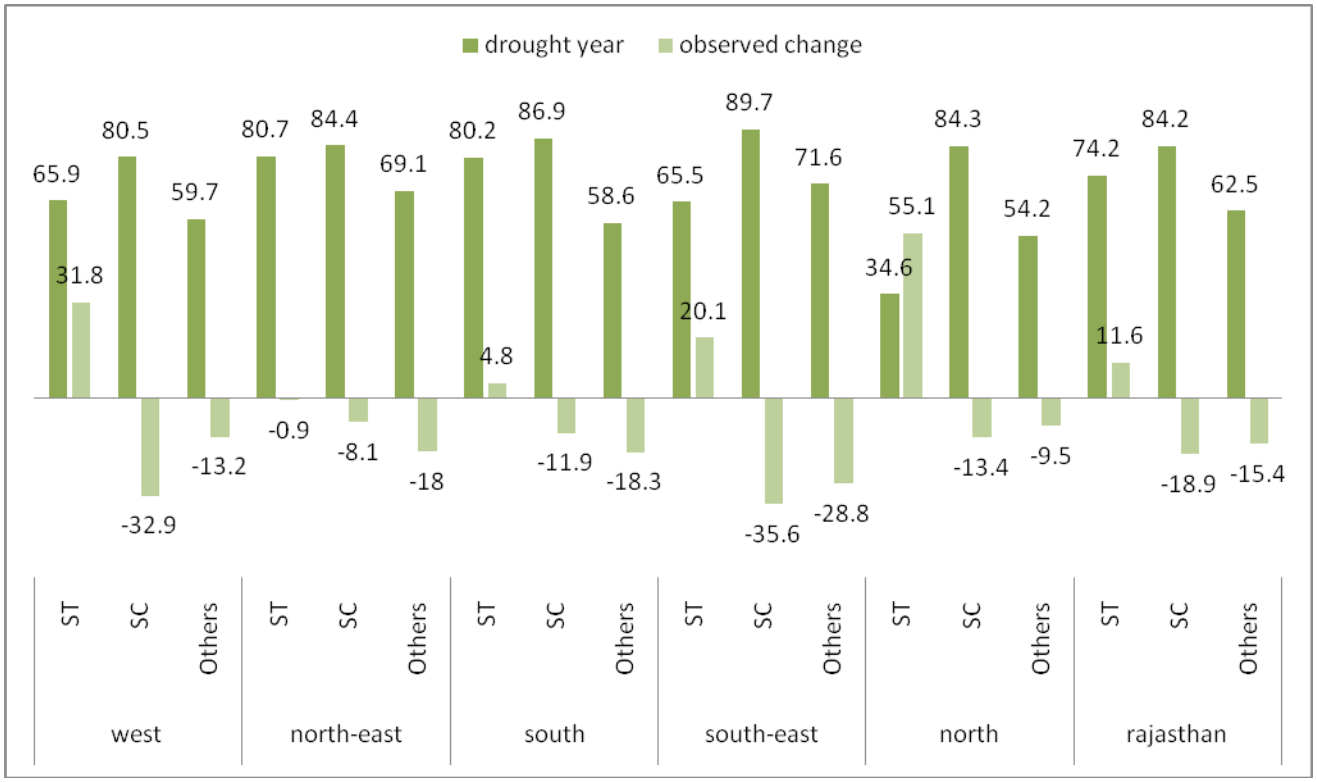
Fig 6. Estimates of VEM across social groups