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Linking Food Security with Household's Adaptive Capacity and Drought Risk: Implications for Sustainable Rural Development

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Abstract In spite of green revolution and rapid economic growth, India's vast population still suffers from hunger and poverty, especially in the rural areas. Moreover, drought adversely affects India's economy by declining agricultural production and purchasing power. It also escalates rural unemployment which ultimately affects household food security. Our study investigated the food security of drought prone rural households in a broader context by linking the dimensions of food security with dimensions of climate change vulnerability. We used the primary data of 157 drought prone rural households of Odisha state in India for analysis. This study employed polychoric principal component analysis to construct an aggregate food security index. An ordered probit model was used to estimate the determinants of food security. The FSI showed that three-fourth of the respondents were facing food security issues with varying degrees. The estimates of ordered probit model indicated that joint family, education, migration and health insurance are key variables that determine food security, whereas drought adversely affected food security of rural households. Overarching strategies are required to effectively address food

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security issues in the wake of increased drought risk. This study provides an insight for policy makers in India and in similar south Asian countries who must consider food security in the light of drought.

Keywords Availability · Access · Exposure · Sensitivity · Stability · Utility · Vulnerability

1 Introduction

Food and Agriculture Organization (FAO) of the United Nations defined food security as a situation "that exists when all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life" (FAO 2002). Though the world has changed remarkably over the past 25 years, food security still remains an unfulfilled dream for many. FAO mentioned that 795 million people in the world suffered from food security problems during 2014–2016, of which 281 million people are in South Asia (FAO 2015). Unfortunately, India has the largest share among those. Five decades after advent of the Green Revolution, India's food grain production has increased fivefold making India as one of the largest producers of rice and wheat in the world (Sarkar and vanLoon 2015). Furthermore, since 1990, India has achieved a consistent rapid economic growth (Narayanan 2015). Annual GDP growth rate in India averaged 6.08% from 1951 until 2016. Nevertheless, its hunger and malnutrition levels are still extremely high as evinced by the fact that India still remains a land of one-fourth (194.6 million) of world's total undernourished people (Rai et al. 2015). Such situation raises serious implications under fast changing climatic conditions.

Climate change has increased the frequency and intensity of extreme events, such as droughts, floods, cyclones etc. World Bank reports India as the second most severely drought affected country in Asia after China (World Bank 2006). During the period from 1900 to 2015, several droughts affected nearly 1061 million people and killed 4.25 million people in India (CRED 2016). Droughts directly affect agriculture (Edame et al. 2011), while they indirectly affect economic growth, income distribution, household welfare and agricultural demand (Schmidhuber and Tubiello 2007). Overall impact of drought may be reduction in agricultural production, purchasing power and employment opportunities resulting into serious threat of hunger, food insecurity, poverty and malnutrition in any region of the world (Kumar and Sharma 2013; Sam et al. 2016).

Household food security is investigated often in a relatively narrower framework (Azeem et al. 2016). The central theme of many researches lies in the nutrition security, food consumption and expenditure pattern (Li and Yu 2010; Carletto et al. 2013; Alexandri et al. 2015), which are the end results of many other factors. The food consumption and nutrition security studies are crucial, but a broader perspective is needed in researches that link food security with other basic factors which are directly or indirectly affecting the food consumption. Of particular importance is the need to broaden the concept of food security to include not just the issues of food consumption but also the key relationship of production, access to land and assets, health status and malnutrition and a range of other structural factors. In addition to that, drought can affect all those factors that are linked to the food security. In this context, studying food security in the realm of climatic adversity may help to understand the basic indicators that really contribute to the household food security

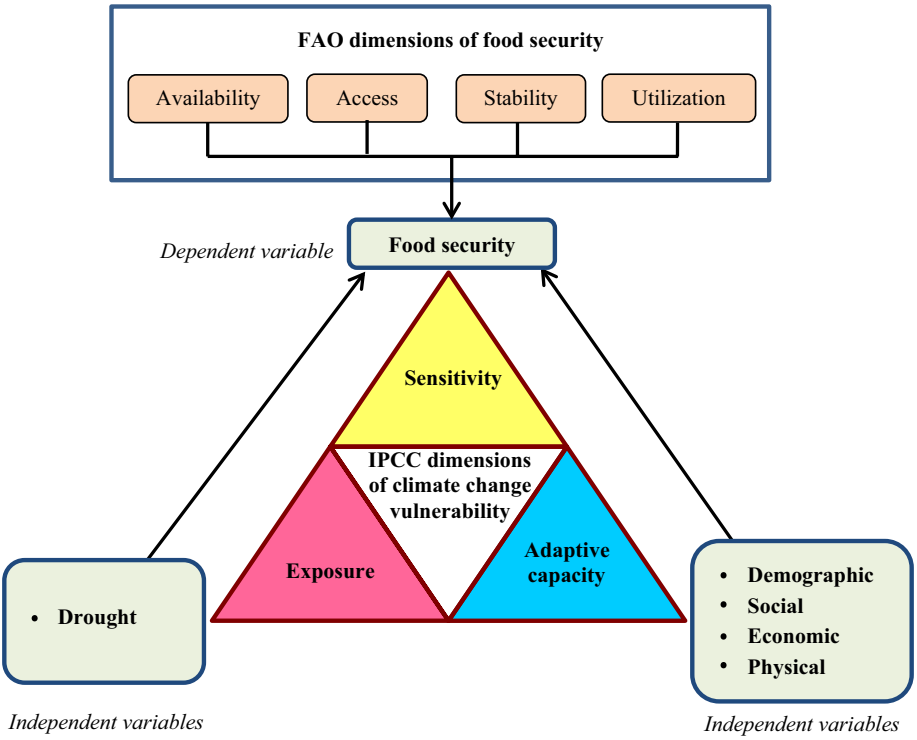

Fig. 1 Theoretical framework of household food security in the context of IPCC dimensions of vulnerability

in drought affected areas. Given this background, the overall objective of this study is to evaluate food security situation of rural households which are highly prone to recurrent drought risk. For this, an index is constructed by incorporating various dimensions of food security. Specific research questions addressed by this study are as follows: (1) what is the food security status of households in drought prone rural areas of India, and (2) how do IPCC dimensions of climate change affect the household food security status in drought prone rural areas of India?

2 Definitions, Conceptual Framework and Indicators

The conceptual framework of this study is depicted in Fig. 1. Our study links the FAO concept of food security with the Intergovernmental Panel on Climate Change (IPCC) dimensions of climate change vulnerability. According to FAO (1996), food security is a function of four major dimensions: availability, access, stability and utilization. Food availability refers to the availability of sufficient quantities of food of appropriate quality, supplied through domestic production or imports. Food access is ensured when all individuals have sufficient resources to obtain appropriate food for a nutritious diet. Food access is a function of the physical environment, social environment and policy environment which determine how effectively households are able to utilize their resources to meet their food security

objectives. Food stability relates to ensuring enough food availability for those households that are at high risk of temporarily or permanently losing access to the resources needed to consume adequate food due to income shocks, lack of enough 'reserves' for adequate consumption, or both (Shah and Dulal 2015). Food utilization consists of ample diet, clean water, sanitation and health care to reach a state of nutritional well-being and this expresses the importance of non-food inputs in food security (Timmer 2000).

The IPCC (2007) defines vulnerability as the degree to which a system is susceptible to and unable to cope with the adverse effects of climate change and extremes such as droughts, floods, cyclones etc. Vulnerability is a function of system's adaptive capacity, sensitivity and exposure to climatic change or natural disasters. According to IPCC (2007), adaptive capacity of a system is its ability to respond successfully to climatic variations and extremes. Sensitivity is the predisposition of a system to be negatively affected by climate variability or natural disaster (Birkmann et al. 2013). Exposure refers to the presence of people, livelihoods, resources, infrastructures and settlements, in places that could be adversely affected by climatic disasters (Ajibade and McBean 2014). When these functions are described at household level, food security comes under the sensitivity dimension. The household's demographic, social, economic and physical characteristics do have a significant role in household's adaptive capacity. Drought factors are included under the IPCC dimension of exposure.

3 Data and Methods

3.1 Study Area

Odisha state of India is a coastal state located on the eastern coast along the Bay of Bengal. Odisha was selected as study area for two main reasons: (1) Government of Odisha (2013) documented that the state faced droughts or moisture stress for 22 years during the 1950–2013, even though it falls under high rainfall zone. Odisha has high vulnerability to drought due to variability of seasonal rainfall, long breaks of dry spells during the crop growing season, dominant rain-fed agriculture, poor social and economic developments and lack of other livelihood sources for the rural people (Mahapatra 2007; Mishra and Nagarajan 2011). (2) Odisha is the least developed state in India based on monthly per capita consumption expenditures, poverty rate, education, health and household amenities, female literacy, urbanization rate, financial inclusion and physical connectivity (Savath et al. 2014). The 68th round of National Sample Survey Office (NSSO) stated that the monthly per capita consumer expenditure (MPCE) for rural and urban Odisha is below the respective national averages (Government of Odisha 2013). The Engel's ratio[1] (proportion of consumption expenditure on food items to total expenditure) of rural and urban Odisha is higher than that for whole India ratios (Government of Odisha 2015).

3.2 Sampling and Household Survey

A multi-stage sampling procedure was used for the study. Six stages of sampling frames were developed to select the final sampling unit viz. households. The state, district, block and *grama panchayat* are the four different administrative layers in India. Odisha was selected specifically because of the occurrence of frequent droughts, poverty and

[1] Engel's ratio for rural and urban India is 48.32 and 37.26 respectively; whereas Engel's ratios for rural and urban Odisha are 51.98 and 39.26 respectively.

a high dependence on agriculture. The Balangir district of the state was purposively selected from among 30 districts. Balangir is a drought prone district and has faced 16 droughts during 1970–2013. It is one of the poorest districts of Odisha with 61% of its population living below poverty line, while about 30% of its population is undernourished (Government of Odisha 2013). This district is less-developed in terms of basic infrastructure such as roads, electricity, irrigation, and communication networks and has very poor basic amenities for health, sanitation, and drinking water. The two blocks selected randomly from the Balangir district were the Patnagarh and Puintala. The Tamian and Mahimunda *grama panchayats* were selected randomly from the Patnagarh and Puintala blocks, respectively. The Aintalunga and Bagbahali villages were selected randomly from Tamian *grama panchayat,* whereas Bilaikani and Sirabahal villages were selected randomly from Mahimunda *grama panchayat*.

The final sampling units, i.e. the households were selected randomly at the sixth stage of sampling. The sample size required for this study was calculated at 95% confidence interval and 7% precision level. Out of 689 households in the study villages, 157 households were surveyed for this research. We constructed a survey questionnaire to collect the primary data as well as data on drought and food security aspects of the households. Based on pretesting of the questionnaire and focus group meetings with local stakeholders, we modified the questions to better fit the context of rural households of drought prone regions of India. The data were collected from the households by four trained interviewers from March to June 2015.

The date used in this article is cross sectional data, due to which this study would be a static one. Though, this is the limitations with the data, it's a common issue in the region which lacks good panel dataset. In spite of these, the study brings new insights about the food security of drought affected rural households with poor socioeconomic conditions. The sample size is representative of the study area.

3.3 Analytical Framework

3.3.1 Food Security Index: Principal Component Analysis

There are two different approaches for measuring food security in literature: (1) derived or indirect approach and (2) direct or fundamental approach. The extensively used indirect methods for estimating food security status of households are (i) FAO method for estimating calories available per capita at the national level; (ii) household income and expenditure surveys; (iii) individual's dietary intake; and (iv) anthropometry (Bashir and Schilizzi 2013). There are research articles which had discussed both direct and indirect approaches in detail, presenting advantages and disadvantages of both (Pérez-Escamilla and Segall-Corrêa 2008; Carletto et al. 2013). But none of them provide any proof of its superiority over other. In our study, we adopted the fundamental approach of measuring food security.

The methodology we adopted for developing indicators to measure food security is mostly used in household level assessment of food security. In order to find more precise picture of household food security, we need information on factors that ultimately result in household level food security outcomes. This may include various non-food factors that contribute in determining those outcomes: such as expenditure, farm assets, access to a public program, crop diversification, health care inputs, feeding practices, access to

basic services etc. Based on that, we developed Food Security Index (FSI) for our study. FSI was developed by using a systematic approach of constructing composite indices proposed by several studies on health, education, poverty etc. (Filmer and Pritchett 2001; Antony and Rao 2007; Mutabazi et al. 2015). The FSI was constructed as a weighted index that combines all the indicators of food security (Table 1) viz; food availability, food access, food stability and food utilization into a single composite indicator.

In order to derive an objective weighting outline for merging the indicators, principal component analysis (PCA) was carried out. Some indicators used for calculating FSI were discrete and these variables violate the Gaussian distributional assumption of PCA and thus create bias in the analysis (Dong et al. 2015). To avoid this bias, we used polychoric PCA based on the polychoric correlation coefficient. The results of polychoric PCA were used to construct FSI. The FSI was calculated as given by Eqs. 1 and 2.

$$PF_{jk} = \sum_{l} a_k^l \left(X_j^l \right) \tag{1}$$

where PF_{jk}: kth principal factor for jth household; a_k^l: factor loading of kth factor for lth indicator; X_j^l indicators of jth households.

$$FSI_j = \sum_{k} V_k \left(PF_{jk} \right) \tag{2}$$

where FSI_j: composite score of FSI for jth household; V_k: variance accounted by kth principal factor.

The FSI may consist of negative and positive values. For the ease of comparison as well as for doing regression analysis, this index is standardized to a scale of 0–1 as in the Eq. 3.

$$FSI(A)_j = \frac{H_j - H_{min}}{H_{max} - H_{min}} \tag{3}$$

where $FSI(A)_j$: adjusted FSI for jth household; H_j: unadjusted FSI for jth household; H_{min}: minimum value of FSI in the sample; H_{max}: maximum value of FSI in the sample.

3.3.2 Food security and Vulnerability Dimensions: Ordered Probit Regression

The theoretical framework presented in Fig. 1 depicts the linkages between food security (sensitivity dimension) and other vulnerability dimensions (adaptive capacity and exposure) of climate change. The measurement of food security commands an econometric model beyond the application of binary choice models. Given that the food security measures are categorical and ordinal, we employed the ordered probit model[2] for the analysis.

[2] In our study we used ordered probit model and had interpreted the signs of the coefficients to discuss about the direction of movement. We were more interested in showing the casual relationship rather than using it for prediction. Regression models with categorical dependent variable (logit, probit and multinomial logit/probit) computes marginal effects. Marginal effects show the difference between predicted probabilities of one category against the reference category. But in our case estimating marginal effects would undo the very advantage of using ordered regression. The reason for using ordered regression is that we can use the ordered nature of the dependent variable to get the effect on each other. To capture magnitude, we can use odds ratio. Odds ratio gives as the relative odds of the occurrence of a category. But there is no odds ratio estimation available for ordered probit. So we had also calculated ordered logit and odds ratio. The signs of the co-efficient don't vary in both the models.

Table 1 Indicators used for FSI construction

Food security dimension	Indicator	Explanation	Source
Food availability	Monthly household food expenditure (Indian Rupees)	Poor people allocate high proportions of their income for food with less left for essential non-food items necessary for better living	Paul et al. (2014), Pangaribowo et al. (2013)
	Sufficient food across the year (1 = yes, 0 = no)	Households may not suffer from food insufficiency for whole year rather this can take place during the year courtesy drought, disease or economic crisis	Coates et al. (2006)
	Dependence on farm for food (1 = yes, 0 = no)	Many rural households in developing countries primarily rely on farms for their own food production for its consumption	FAO (2013)
Food access	Agricultural land (acres)	Land ownership is crucial in achieving food security through increased agricultural production	Frelat et al. (2016)
	Access to PDS[a] (1 = yes, 0 = no)	Food and nutritional aid programs are immediate options to ensure food access by distributing subsidized food and non-food items	FAO (2006)
	Livestock (number)	Livestock being source of food and income in developing countries contributes significantly to ensure food security among rural inhabitants.	Frelat et al. (2016), Wilson et al. (1995)
Food stability	Yield loss (1 = yes, 0 = no)	Yield loss due to drought affecting the overall agricultural production	Savary et al. (2012)
	Instable food supplies (1 = yes, 0 = no)	Fluctuations in food prices, idiosyncratic and covariant shocks affect food supply and hence affect food security	Devereux (2007)
	Crop diversification index[b]	Crop diversification serves as a boon for attaining food security by increasing household income through production of different edible and field crops and provides variety of food for consumption and sales	Wani et al. (2012)

Table 1 (continued)

Food security dimension	Indicator	Explanation	Source
Food utilization	Distance to public health center (km)	Access to health center and facilitates therein cures diseases. Proper medication with easy access can ensure proper food intake	Carletto et al. (2013)
	Malnutrition (1 = yes, 0 = no)	Malnutrition is the condition when diet fails to provide adequate nutrients for growth and maintenance	Pangaribowo et al. (2013)

[a]Public distribution system, an Indian government initiative to ensure food security of rural households through network of fair price shops

[b]The inverse of the number of edible crops cultivated + 1 reported by households

There is no theoretical justification for the choice between ordered logit and probit. Though the underlying distribution (logistic or normal) is nearly distinguishable, the inferences are seldom different. We had also calculated ordered logit and odds ratio (Table 6 of Appendix). The ordered probit is constructed on a latent (unobservable) random variable which is stated in the Eq. 4.

$$F_j^* = \beta' z_j + \varepsilon_j \tag{4}$$

where F_j^*: the latent and continuous measure of FSI; z_j: a vector of explanatory variables describing adaptive capacity and exposure dimension; β: a vector of parameter to be estimated; ε_j: the error term assumed to be normally distributed.

The calculated FSI is coded as four discrete categories and determined by the model is given below:-

$$F_j = \begin{cases} 1 & \text{if } 0 \le F_j^* \le 0.25 \text{ (\textit{low food security})} \\ 2 & \text{if } 0.251 < F_j^* \le 0.50 \text{ (\textit{medium food security})} \\ 3 & \text{if } 0.501 < F_j^* \le 0.75 \text{ (\textit{high food security})} \\ 4 & \text{if } 0.751 < F_j^* \le 1.00 \text{ (\textit{higher food security})} \end{cases}$$

The probabilities associated with the coded depended variable are as follows (Eq. 5):

$$\Pr\left(F_j = i\right) = \Pr\left(k_{i-1}\right) < \beta_1 x_{1j} + \beta_2 x_{2j} + \cdots + \beta_k x_{kj} + u_j \le k_i \tag{5}$$

where j is individual and i is a response alternative. The model is estimated as a linear function of independent variables with a set of cut points as dependent variable. The probability of the outcome (F_j) corresponds with the probability of estimated linear function and random error within the range of cut points estimated for the outcome and u_j is assumed to be normally distributed. The coefficients β_1, β_2, …, β_k are estimated with the cutpoints k_1, k_2, …, k_{I-1}. For further details of the model please refer Greene (2000).

The explanatory variables used in the model are sub-components representing adaptive capacity and exposure dimensions of climate change. Under the adaptive capacity dimension, there are four major components namely; demographic, social, economic and physical profiles. Each major component comprises of few sub-components. Therefore, these four major components constitute a total of thirteen sub-components. Drought is the major component of exposure dimension. A total of five sub-components constitute the exposure dimension. The explanatory variables (sub-components) are defined in Table 2 along with the expected signs of the estimated coefficients.

4 Results and Discussion

Results of this study are presented in two parts. The first part presents results related to FSI. The second part presents results obtained by ordered probit regression analysis. This sub-section also discusses possible reasons for the significance of variables in detail along with the results.

Table 2 Definition of variables used in ordered probit regression model

Major components	Sub-components (variable)	Explanation	Expected sign
Demographic	Family type[a]	1 = joint family; 0 = nuclear family	(+)
	Household head	1 = female-headed household; 0 = otherwise (If male head is away from home for more than 6 months per year, the female is considered as head of the household)	(−)
	Age of household head	Age of household head in years	(−)
	Education of mother	1 = literate mother or female responsible for cooking; 0 = otherwise	(+)
	Social caste	1 = household members belong to backward caste, 0 = otherwise	(−)
Social	Borrow money	1 = household borrows money from kinship in crisis; 0 = otherwise	(+)
	NGO[b] access	1 = access of household to NGOs; 0 = otherwise	(+)
	School access	1 = access of household to school; 0 = otherwise	(+)
Economic	MGNREGA[c]	1 = household joined MGNREGA; 0 = otherwise	(+)
	Migration	1 = household with migrant member; 0 = otherwise	(+)
Physical	Durable assets	Total number of durable assets per household	(+)
	Housing structure	1 = permanent housing structure; 0 = otherwise	(+)
	Health insurance	1 = household has health insurance; 0 = otherwise	(+)
Drought	Impact of climate variations on agriculture	1 = household reports negative impact on agriculture in the locality due to variation in temperature and/or rainfall during the period 2009–2014; 0 = otherwise	(−)
	Stress	1 = household reports stress among family members due to drought during the period 2009–2014; 0 = otherwise	(−)
	Unemployment	1 = household reports unemployment due to drought during the period 2009–2014; 0 = otherwise	(−)
	Disease	1 = household reports any disease among family members due to drought during the period 2009–2014; 0 = otherwise	(−)
	Deterioration of income earning environment	1 = household reports deterioration of income earning environment in the locality due to drought during the period 2009–2014; 0 = otherwise	(−)

[a]A joint family consists of more than one married couples who live in a single unit along their children; while a nuclear family consists of one married couple with their children as a single unit

[b]Non-Governmental Organization

[c]Mahatma Gandhi National Rural Employment Guarantee Act: An employment scheme by government of India

Table 3 Eigen values and variance of factors used for FSI construction

Factors	Eigen value	Variability (%)	Cumulative variance (%)
F1	3.442	31.29	31.29
F2	2.076	18.87	50.17
F3	1.355	12.32	62.48
F4	1.090	9.91	72.39

Table 4 Polychoric PCA factors used for FSI construction

Food security dimension	Indicators	Factors			
		F1	F2	F3	F4
Food availability	Monthly household food expenditure (Indian Rupees)	0.192	0.176	**0.602**	0.446
	Sufficient food across the year	0.218	0.035	**−0.811**	0.235
	Dependence on farm for food	**0.783**	0.122	−0.200	0.089
Food access	Agricultural land (acres)	**0.785**	−0.202	0.259	0.016
	Access to PDS	−0.389	**0.690**	0.066	0.288
	Livestock (number)	0.237	0.006	−0.128	**0.860**
Food stability	Yield loss	**0.976**	0.125	−0.013	0.151
	Instable food supplies	−0.147	**0.501**	0.068	0.283
	Crop diversification index	**−0.842**	0.179	0.180	−0.101
Food utilization	Distance to public health center (kms)	−0.035	**−0.755**	0.263	0.397
	Malnutrition	0.288	**0.711**	0.320	0.152

Bold figures highlight the highest factor loading

Barlett's test of sphericity: Chi square: 84.82 ($P < 0.0001$), *df*: 65

4.1 Construction of FSI

The primary result of our research is the construction of composite index viz. FSI, which portrays the food security situation of households. We employed polychoric PCA for FSI construction by using 11 indicators, all of which measure different aspects of food security. The extensively used criterion for selecting the number of principal factors proposed by Kaiser (1960) was employed (Osorio et al. 2013) for this purpose. This criterion suggests retaining factors with eigen values greater than 1 (Table 3). Based on this, we identified four factors explaining 72.39% of the total variance.

Table 4 shows the results of polychoric PCA. In PCA, the correlation between a factor and variable is known as factor loadings. These loadings provide information regarding the contribution of indicators to the variance accounted by each factor (Li et al. 2016). The highest factor loading for each variable is highlighted in bold letters in Table 4. They were used for the construction of FSI after varimax rotation with Kaiser Normalization procedure using Eq. 2.

The first factor (F1) explains 31.29% of the variance and is correlated with four variables viz. dependency on family farm for food, agricultural land, yield loss and crop diversification. The second factor (F2), which explains 18.87% of the variance, is correlated with access to PDS, instability of food supplies, distance to public health centre and issue

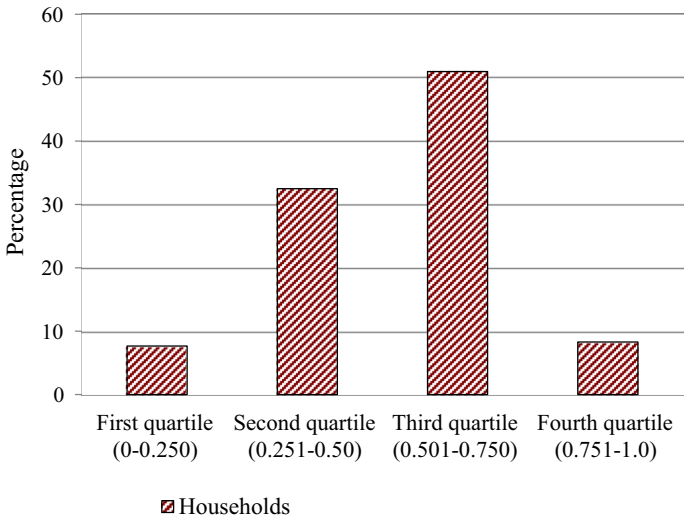

Fig. 2 Distribution of respondents according to FSI scores

of malnutrition. Third factor (F3) is correlated with monthly household food expenditure and sufficient food across the year while accounting for 12.32% of the variance. The fourth factor (F4) explains 9.91% variance and is correlated with the variable livestock. Nevertheless, the PCA analysis gives more insight into the hidden correlation among various food security indicators as the key aim of PCA framework in this study is to create weights for the construction of FSI as mentioned in the methodological section.

The adjusted FSI ranges from 0 to 1; where 0 indicates food insecurity and 1 food security. This range has been utilized to categorize respondents into four quartiles. Based on this classification, Fig. 2 depicts the percentage of households falling under each quartile. It is evident that more than 90% of households fall in the first three quartiles and are facing food security issues although its intensity varies among them. FSI distribution based on family type, caste, household head and agricultural land area is also calculated and included in the appendix (Figs. 3, 4, 5, 6 of Appendix).

4.2 Factors Affecting Food Security

The estimated coefficients of the ordered probit model for food security of households in drought prone areas of India are presented in Table 5. Many of the estimated coefficients are statistically significant and have expected signs. The results offer insights about the linkages of adaptive capacity and exposure dimensions to the food security of households.

4.2.1 Demographic Attributes and Food Security

The demographic factors of a household are important determinants of household's food security status. Food security of a household may likely vary according to the type of family. The joint family system had positive and significant relationship with the household food security. About 52% of the respondent households belonged to joint families (Table 5). Joint family is considered as an option for adapting to practical concerns like

food issues, health problems, economic insufficiency, childcare and natural hazards (Kamo 2000). The joint family encourages dependency on other family members for living as well as in household decision making. Moreover, this system has more earning members than in nuclear family households, and often contributes substantially to the total household earnings (Griffiths et al. 2002). As the income of household increases, the money spent on food items also increases. However, the economy of scale in terms of expenditure on different food and non-food items helps, especially among low income households. Joint family system may also prevent the sub-division of family land.

The estimated association of variable for mother's education was found to be statistically significant and positive, implying that the probability of being food secure for a family increases if the mother is literate. It is justifiable as FAO has termed education as one of the most powerful tools for hunger reduction (FAO 2005). While rural women play a vital role in the translation of agricultural products into both food and nutritional security of their households, it is also a fact that they are generally responsible for food selection, preparation and feeding of their children in most developing countries. The positive linkage of mothers' education to various aspects of households including the wellbeing of children, allocation of resources to health and nutrition are depicted in previous studies as well (Kaiser et al. 2015; Angelos et al. 2016). Most of the females in the villages are illiterate because when they were school aged, several restrictions prevailed in the society that prevented them from going to school.

4.2.2 Social Attributes and Food Security

Social institutions, social networking and societal integration play a significant role in improving household food security (Mertens et al. 2015). In the present study, this role is evident from the results in Table 5. The coefficient of the variable on borrowing money has a significant positive effect on food security of the household. Studies of Shariff and Khor (2008) and Gupta et al. (2015) show that borrowing money from family members, relatives and neighbours is considered as a strategy to help households from experiencing food insufficiency. It also reflects better social capital available with the households in case of exigencies. Norhasmah et al. (2010) also affirmed that households during food insecurity, tended to borrow money from friends and relatives. In these villages, borrowing money from the kinship network is quite normal. They prefer borrowing money within the kinship rather than approaching money lenders who more often charge exorbitant interest rate, sometime goes even up to 120% per annum (Kumar et al. 2015).

The coefficient of NGO access was found to be positive and significant. NGOs are playing a vital role in supporting the efforts of poor people in tackling the causes and effects of food security issues (Porter 2003). In India, NGOs are involved in wide range of social welfare activities and development work, addressing issues of food security, health, education and justice. They are also involved in the upliftment of overall economic status of low income groups by starting income generating activities and microcredit facilities. Apart from that, they are also involved in various disaster management and preparedness activities in drought prone rural areas of India.

4.2.3 Economic Attributes and Food Security

Government of India notified MGNREGA in 2005 and implemented it in April 2008 (Government of India 2005). It is the largest employment providing programme ever started

in a country for ensuring source of livelihood to the rural populace. The mandate of the program is to provide 100 days of guaranteed wage employment in a year to every rural household, whose adult members volunteer to do unskilled manual work (Pellissery and Jalan 2011). Our assumption regarding the MGNREGA was that the households who have joined MGNREGA will have better food security as compared to those who couldn't participate but have similar economic background. But, contradictory to the assumption the results turned out to be negative and we could not establish a significant relation between MGNREGA and household food security (Table 5). The possible reasons for this may be that mostly local people with abject poverty only join the scheme, while relatively economically better households consider it an inferior work. Besides, the beneficiaries also find several anomalies hindering its effective implementation. Frequent delays (of months) in wage payments create concerns which lead to further worsening of the situation for subsistent rural masses. Other lacunae linked with this scheme are lack of awareness about this scheme, irregularities in job card distribution, and improper maintenance of muster rolls (Jha et al. 2009). All these together mask the effect of MGNREGA on food security of the rural households especially in drought prone regions.

The coefficient for migration has a significant positive effect on food security of the household (Table 5). Globally, labour migration is considered as an important approach to improve livelihood security for farming households (Adger et al. 2002; Gartaula et al. 2012). As food security is a component of livelihood security, migration is aptly considered as a strategy to increase household food security, particularly in the region marred with frequent occurrence of drought. Furthermore, migration-cum-remittance strategies counter balance the insecurities associated with subsistence food production (Schrieder and Knerr 2010), as well as an ex-ante risk management strategy (Osawe 2013). Remittances increase overall welfare of the households, which in turn reduces the severity of their problems linked with food access and consumption. The main push factors of migration are drought and low wages in the villages (Jülich 2011). The young males of the study villages migrate to other districts or states in search of jobs, and as many are less-educated, they work in construction sites, factories, restaurants, brick kilns, etc.

4.2.4 Physical Attributes and Food Security

Physical capital is made up of basic infrastructure and producer goods that are needed to support livelihoods (Reid and Vogel 2006). Ellis (2000) argued that people's ability to cope with or adapt to poverty depends on their access to different assets. We observed how households with higher number of durable assets are able to cope with food shortages. The coefficient associated with this variable was found to be statistically significant and positive (Table 5). Durable assets include moveable assets that can be converted into cash or exchanged for goods and services, such as furniture, electronics and vehicles. The common durable assets found in the study region were bicycles and mobile phones. Generally, these assets are purchased during well-off periods and sold for grain in response to negative income shocks (Devereux 2001), and thus, they act as the instruments for ensuring food security during drought periods. The housing structures are proxy indicators of the households' economic status in Indian rural context. We hypothesized that households with permanent housing structure would be more food secure, which was supported by our findings as the coefficient for this variable showed a positive and significant impact on food security of rural households (Table 5). Based on building materials used for construction of structure, houses are classified as permanent or *pacca* (building materials used for construction

are brick and mortar while roofs are concreted) and temporary or *katcha* (materials used for construction are mud and roofs are thatched with paddy straw or tiles).

The coefficient of health insurance was found to be positive and significant. Poor rural population is mostly affected by environmental vagaries and has limited water supply, inadequate sewage disposal and general sanitation, contaminated surface water, overcrowded and poor housing, limited food availability and unhygienic food preparation that may increase the exposure to infectious disease (FAO 1997). These infectious diseases may contribute to deteriorating health and nutritional status in several ways, which includes decreased food intake, inefficient nutrient absorption, loss of body weight and increased nutritional requirements. Consequently, diseases and illness create out-of-pocket expenditures for households (Uplekar et al. 2001), as well as challenging income generation which eventually risk future economic welfare and food security (Gertler and Gruber 2002; Flores et al. 2008). During disease periods, these families devote part of food expenditure for the treatment of diseases forcing them again to compromise their food security. Having health insurance is a great relief for poor families during illness. Being poor, they have fewer resources to pay the premium for private health insurance. In the study area, few households have health insurance provided by the government. *Rastriya Swathya Bima Yojana* (RSBY) is a national health insurance scheme launched by Indian government to facilitate health coverage for Below Poverty Line (BPL) families. This scheme provides protection to BPL households from financial liabilities arising from illnesses that involve hospitalization. Beneficiaries need to pay only Rs. 30 as a registration fee while the central and state governments pay the premium to the insurer and cover hospitalization charges up to Rs. 30,000 annually (Singh et al. 2013).

4.2.5 Drought Attributes and Food Security

All the variables related to drought showed a negative relationship with food security of sampled households (Table 5). The coefficient for the variable 'whether variation in temperature/rainfall impacted agriculture' showed negative and statistically significance relation with the household food security. This result was expected, as agriculture in rural areas is highly dependent on weather conditions and a slight variation in rainfall/temperature may affect its performance in these areas (Mottaleb et al. 2015). Other possible impacts of temperature/rainfall variation on agriculture include damage to crop quality, insect infestation, plant diseases, increased irrigation costs and cost of new or supplemental water resource development.

A negative and significant coefficient of the variable on 'having stress due to drought' suggests that more the stress due to drought less will be the food security of the household. Previous studies portray this link between food security and mental stress (Carter et al. 2011; Friel et al. 2014). In principle, drought can affect mental health directly by exposing people to the psychological stress associated with higher frequency, intensity and negative impacts of drought risk (Berry et al. 2010). Mental stress, depression and anxiety make significant contributions to the burden of food security issues by infusing uncertainty and unpredictability into the lives of individuals and households. The coefficient of unemployment is negative and statistically significant. As drought affects crops, livestock and livelihoods in the area, the employment opportunities decrease consequently contributing to increased food insecurity. Unemployment is one of the most important risk factors for household food security which mainly affects household food consumption through negative income shock and income volatility (Huang et al. 2016).

Table 5 Ordered probit regression estimates of the determinants of FSI

Major components	Variable (sub-components)	Mean	SD	Coef.	SE	z
Demographic	Family type	0.522	0.501	0.408	0.218	1.88*
	Household head	0.191	0.394	−0.254	0.284	−0.89
	Age of household head	46.994	11.534	−0.001	0.009	−0.14
	Education of mother	0.497	0.502	0.461	0.211	2.19**
	Social caste	0.866	0.341	−0.087	0.289	−0.3
Social	Borrow money	0.669	0.472	0.390	0.211	1.85*
	NGO access	0.325	0.470	0.393	0.219	1.79*
	School	0.599	0.492	0.049	0.209	0.23
Economic	MGNREGA	0.809	0.394	−0.312	0.252	−1.24
	Migration	0.490	0.502	0.603	0.338	1.79*
Physical	Durable assets	2.025	1.012	0.300	0.115	2.61***
	Housing structure	0.363	0.482	0.417	0.233	1.79*
	Health insurance	0.096	0.295	0.667	0.366	1.82*
Drought	Impact of climate variations on agriculture	0.675	0.470	−0.552	0.217	−2.54**
	Stress	0.580	0.495	−0.891	0.261	−3.42***
	Unemployment	0.516	0.501	−0.557	0.295	−1.89*
	Disease	0.777	0.418	−0.156	0.240	−0.65
	Deterioration of income earning environment	0.548	0.499	−0.188	0.210	−0.89
cut1				−1.687	0.718	
cut2				−0.168	0.706	
cut3				2.136	0.730	

Model diagnostics: observations: 157; LR $chi^2 = 66.27$; $Prob > chi^2 = 0.0000$; $R^2 = 0.195$

***, **, *0.01, 0.05 and 0.1 significance levels, respectively

5 Conclusions

When drought hits poor in rural areas, there is drastic reduction in crop production, purchasing power of the households, increase in unemployment and health issues, which ultimately affects the food security of that region. The present study analysed food security in a broader way by incorporating the elements that lead to consumption pattern, food expenditure and nutritional security. This study constructed a composite FSI considering various dimensions of food security suggested by FAO that are intended to create household food security. We carried out our research in Odisha state of India, which is the least developed states among India and faces recurrent droughts, even though being in high rainfall and coastal region. The living conditions of the people in Odisha are pitiful, making them to remain in the vicious circle of poverty and hunger. The results proved that majority of the respondents are affected by food security issues.

We also analysed the factors that affect FSI by linking the FAO dimensions of food security with the IPCC dimensions of climate change vulnerability. Moreover, the analysis of the determinants of food security also reveals some interesting outcomes and policy guidelines. Adaptive capacity of a household has a significant role in attaining the food security. This study recommends some specific interventions to strengthen the adaptive

capacity of the households. Strengthening the demographic profile of household emerged as one of the most influential interventions, which eventually increases their food security status through improved decision making abilities due to raising level of formal education of mothers and household heads. Livelihood diversification is another intervention that will help in attaining a better economic security for the households thereby ensuring food security. Due to high dependency of agriculture on rainwater, it brings more risks and uncertainty. Therefore, employment opportunities outside of agriculture should be created, so that even in the case of agriculture failure, households would have an alternate income source. The provision of health insurance programs are useful adaptation options to combat food insecurity issues as it would provide a cushion against the health problems which robs off entire saving of the poor rural households, who finally compromises with food security.

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Appendix

See Figs. 3, 4, 5, 6 and Table 6.

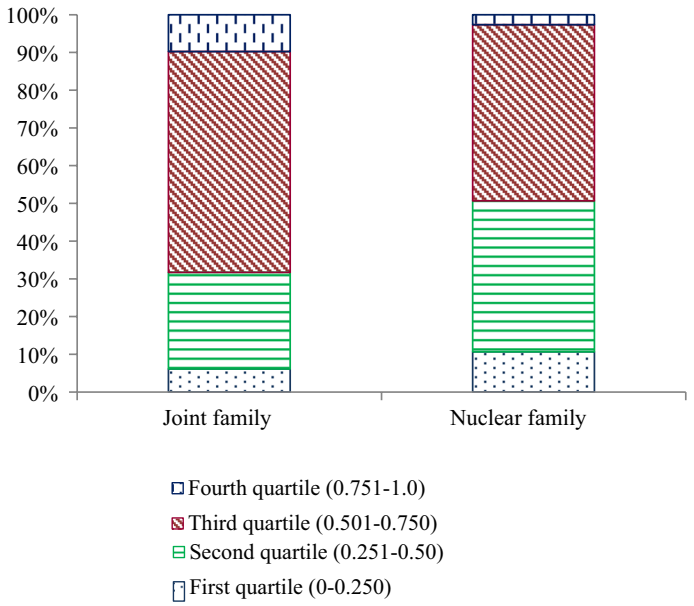

Fig. 3 Distribution of FSI in joint families and nuclear families

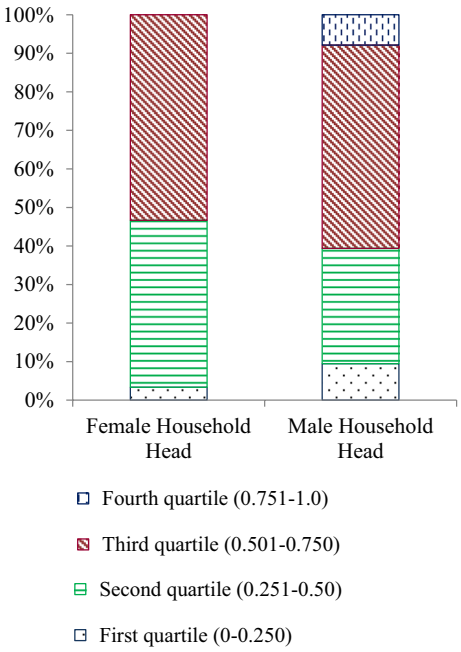

Fig. 4 Distribution of FSI in male headed and female headed households

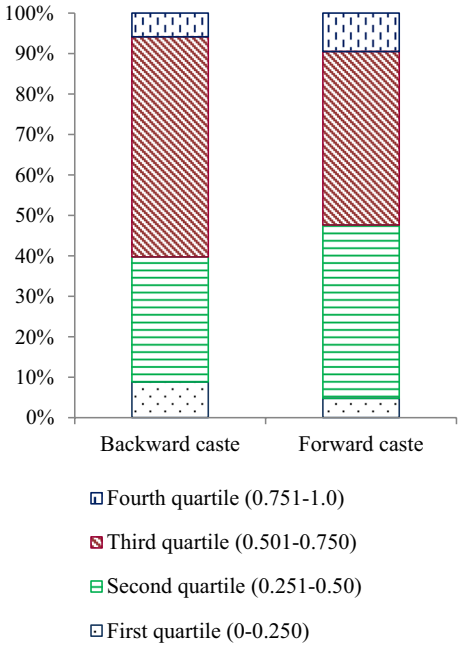

Fig. 5 Distribution of FSI in backward caste families and forward caste families

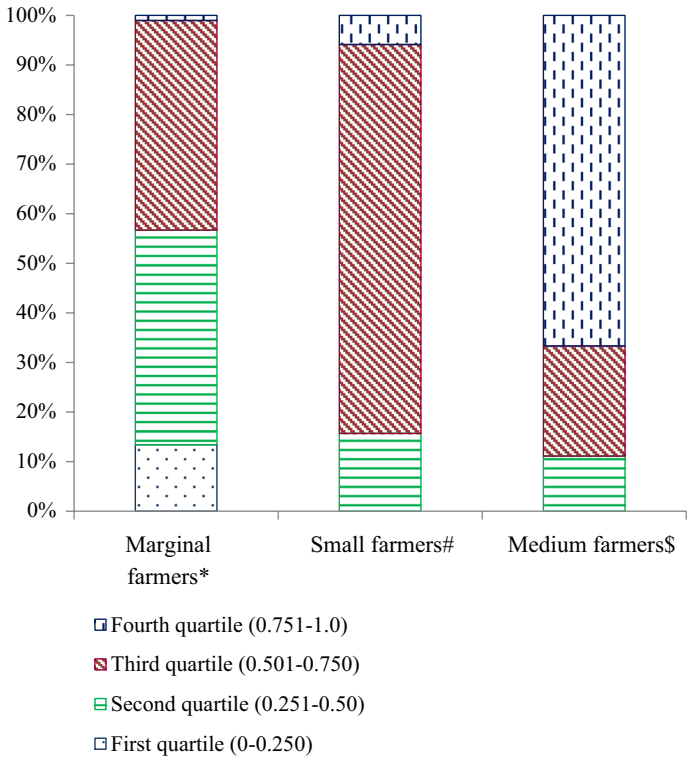

Fig. 6 Distribution of FSI according to land area of households. *Land area between 0 and 1 ha, #Land area between 1 and 2 ha, $L and area between 2 and 4 ha

Table 6 Ordered logit regression estimates and odd ratios of the determinants of FSI

Major components	Variable (sub-components)	Coef.	Odds ratio	SE	z
Demographic	Family type	0.681	1.975	0.385	1.77*
	Household head	−0.533	0.587	0.499	−1.07
	Age of household head	−0.005	0.995	0.017	−0.33
	Education of mother	0.710	2.034	0.375	1.89*
	Social caste	−0.192	0.826	0.510	−0.38
Social	Borrow money	0.651	1.918	0.376	1.73*
	NGO access	0.694	2.002	0.391	1.78*
	School	0.147	1.158	0.371	0.4
Economic	MGNREGA	−0.677	0.508	0.471	−1.44
	Migration	1.161	3.194	0.595	1.95*
Physical	Durable assets	0.521	1.685	0.201	2.59***
	Housing structure	0.685	1.983	0.414	1.65*
	Health insurance	1.260	3.525	0.667	1.89*
Drought	Impact of climate variations on agriculture	−1.031	0.357	0.388	−2.65***
	Stress	−1.428	0.240	0.465	−3.07***
	Unemployment	−1.106	0.331	0.525	−2.1**
	Disease	−0.286	0.751	0.424	−0.67
	Deterioration of income earning environment	−0.189	0.828	0.374	−0.51
/cut1		−3.226		1.272	
/cut2		−0.563		1.237	
/cut3		3.487		1.275	

***, **, *0.01, 0.05 and 0.1 significance levels, respectively

Model diagnostics: observations: 157; LR $chi^2 = 64.91$; $Prob > chi^2 = 0.0000$; $R^2 = 0.190$

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