Can developmental interventions reduce households' vulnerability? Empirical evidence from rural India

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Vulnerability is a multidimensional concept incorporating notions of risk and poverty. While it has been established that higher incidence of poverty in developing countries exacerbates vulnerability, the role of risk requires closer inspection. Developmental interventions in these countries target poverty reduction, which in turn, could reduce vulnerability. However, a key question is whether developmental interventions reduce the vulnerability and risks faced by households. To answer this, the present study empirically examines the impact of developmental interventions on the vulnerability of households in a rural Indian setting. The major advantage hence is that it not only looks into the impact on aggregate vulnerability but also its different components such as poverty, covariate, idiosyncratic and unexplained risks. Empirical analysis is based on a survey of 800 households in the drought-prone villages of western Odisha, India, where a key developmental intervention, Western Orissa Rural Livelihood Project was implemented during the last decade. Adopting 'vulnerability as expected utility' approach, this study reveals three major findings. First, both aggregate risk and poverty are the dominant sources of vulnerability, with the former accounting for a sizable share. Second, the households that benefited from livelihood interventions are found less vulnerable. Third, the other major determinants of vulnerability are education, access to social network, family size and crop-diversification. From a policy perspective, results support continuation of these programmes, but realigning these also target risk reduction.

Keywords: Covariate, developmental interventions, idiosyncratic risk, rural setting, vulnerability.

THE past three decades have witnessed a growing body of literature on measuring vulnerability at household and regional levels to a variety of risks and shocks, particularly in the developing nations[1,2]. Vulnerability, in general, is a multidimensional concept encompassing numerous factors, and hence different definitions of vulnerability exist across the research community[3]. Although the notion of vulnerability is complex to be bounded within the realms of economics discipline, it is adequately documented in the poverty literature where it is conceptualized as an outcome of responses of a household to risks and shocks, assuming a set of underlying conditions[4]. Based on this notion, vulnerable households are those that have moved or are likely to move into a state of poverty or destitution as a result of the process of risk and response[1]. Risks and shocks encountered by the households affect their well-being, particularly for the households with fewer resources to cope[5]. The outcome is an *ex post* state (poverty status/consumption poor) that is assumed to be the primary concern of policy makers, especially in the developing nations.

In addition to poverty, households living in the developing nations are recurrently hit by idiosyncratic and covariate shocks, resulting in higher income volatility[6,7]. In general, a shock is the realization of risk with either known or unknown probability distributions. While covariate shocks refer to the ones that affect most within a sample frame (like cyclones, floods, droughts affecting most households within a village or cluster of villages), idiosyncratic shock is specific to each entity within the sample frame (i.e. unsystematic and unique to each household like illness, injury, unemployment, etc.)[7]. Rural households, in particular, are highly susceptible to diverse risks and shocks as their main source of livelihood, e.g. agriculture is sensitive to climate variability and extremes[8]. Given the absence of perfect insurance against income fluctuations, these risks and shocks foster a state where the households either become poor or remain poor if already so[1,7]. The development economics literature, therefore, has emphasized to go beyond the static measure of poverty to dynamic *ex ante* risk assessment, i.e. to identify the potentially exposed entity to future risks and shocks[6,9]. This has larger policy relevance in the context of developing nations where it is yet to

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achieve objectives of sustainable development goals and continues to be characterized by soaring population, higher incidence of poverty, large economic inequality and rudimentary state of infrastructure that amplify the outcomes as a result of exposure to risks[10].

Developing nations tend to address these concerns through various developmental interventions targeting issues like poverty eradication, infant mortality reduction, rural development, provision of access to basic needs, etc. Although it is well documented in the literature that such interventions could reduce the vulnerability of households, impacts may vary across socio-economic groups; there is a limited empirical evidence existing particularly in rural India. Addressing this issue, the present study contributes to the literature by specifically examining the impact of developmental interventions on vulnerability at a micro-level based on data derived from large-scale primary household surveys. With regards to method, we have adopted vulnerability as expected utility approach. To the best of our knowledge, no previous studies have followed this method of vulnerability analysis taking India as a case study. The major improvement is that the study examines the impact on aggregate vulnerability while it explores the determinants as well, e.g. poverty, covariate, idiosyncratic and unexplained risks. In doing so, we study the effects of a specific developmental intervention undertaken in rural Western Odisha (prior to 2011 spelled as Orissa), India on the vulnerability of households. This region is highly vulnerable to climatic risks like droughts, deficient rainfall spells and flash floods[11–13]. The intervention in question is the Western Orissa Rural Livelihoods Project (WORLP) funded by the Department for International Development, United Kingdom and implemented over a period of ten years (2000–10) by the Odisha Watershed Development Mission (OWDM), an autonomous agency of the Government of Odisha. The overall goal was to reduce poverty in rain-fed areas and promote sustainable livelihoods for the poorest in the pre-selected districts[14]. From a policy perspective, the results derived from the analysis provide insights regarding effective policy designs to alleviate poverty for households which are either already vulnerable or likely to be vulnerable sometime in future.

Vulnerability and developmental interventions

Vulnerability refers to an *ex ante* risk (forward-looking) that the well-being of a household falls below some benchmark in future due to risks and shocks, given the socio-economic characteristics of household[15]. This identifies the likelihood of a household to become consumption poor in the next time-period, i.e. next year, in ten years or being poor in old age – that could be estimated but not observed[15]. In general, the vulnerability of a household depends on the characteristics of the risk and/or shocks to which it is exposed and its internal ability to mitigate potential impacts[16]. The primary onus of doing vulnerability analysis is to identify who is vulnerable and to which risks and shocks, while also identifying characteristics that make them susceptible[9]. Whereas the poverty status of a household is captured through expected mean consumption, idiosyncratic and covariate shocks and coping strategies of household to insure consumption against these shocks determine variance of consumption. Although voluminous data has been accumulating on vulnerability over the years across the world[1,3,9,15,17–19], it continues to be a subject of discussion and research in different geographical settings. It is much more relevant in the context of rural India, where households often witness climatic shocks such as cyclonic storms, floods and droughts which are likely to increase in the foreseeable future due to climate change[12,13,20,21].

Previous studies in the Indian context assess risks and shocks that affect welfare of the households and intensity of these shocks, identify potential groups of vulnerable households and determinants, and constraints and effectiveness of various coping strategies[2,7,10,13,18–20,22–24]. Concurrently, over the years, various developmental interventions have also been implemented in rural India to eradicate poverty and for enhancing living standards of rural households. The studies on linkage between developmental interventions and vulnerability of househols are scanty. In view of this, it is imperative to study to what extent developmental interventions reduce vulnerability of households, measured in terms of income and consumption expenditure. As mentioned above, there are different components of vulnerability, i.e. poverty, aggregate risk, idiosyncratic risk and unexplained risk[5]. Hence, it is imperative to analyse the impacts of developmental interventions on these components of vulnerability.

Previous studies outline that various development-based activities undertaken as part of the poverty eradication programme in a developing nation like India enhance the coping capacity of the households, so that they can withstand various risks and shocks, including climatic ones[25]. For instance, it is found that various agriculture based activities undertaken through Mahatma Gandhi National Rural Employment Guarantee Scheme (MGNREGS) (e.g. water conservation and harvesting, irrigation provisioning and improvement, renovation of traditional water bodies, land development, drought-proofing, flood control, etc.) reduce vulnerability of poor households to climatic risks in rural India[26,27]. With regards to western Odisha, OWDM has taken a special initiative to implement WORLP in four districts, i.e. Bolangir, Nuapada, Bargarh and Kalahandi. The total project outlay was INR 2.3 billion and designed to cover 1180 villages over 677 watersheds (an area of land drained by a river or a stream) spread across four districts of western Odisha based on a new approach known as 'watershed plus', i.e. assisting in various other livelihood supports, including watershed

components[28,29]. The major interventions in WORLP are related to land and water management, economic support and capacity building of the poorest. In doing so, it aims to reduce poverty in rainfed areas and promote sustainable livelihoods for the poorest households in western Odisha[28,29]. Overall, it is expected that such interventions could reduce vulnerability of the rural households. In fact, the end-line survey of the WORLP report highlights that the incidence of poverty has been come down in the programme implementation villages.

Empirical approach

There are three methods in the poverty literature to estimate household-level vulnerability: (i) vulnerability as expected poverty (VEP), (ii) vulnerability as low expected utility (VEU) and (iii) vulnerability as uninsured risk (VER)[15,17]. While both VEP and VEU estimate *ex ante* vulnerability of a household, the VER approach is *ex post*. Again, both the VEP and VEU follow a common assumption that a household will fall below a threshold level sometime in the future due to the risks and shocks. The VEU approach has the advantage to estimate the effects of developmental interventions not only on aggregate vulnerability but also its components, e.g. poverty, covariate, idiosyncratic and unexplained risks. The present study, therefore, adopts the VEU approach to estimate the vulnerability of households. To the best of our knowledge, no previous study has adopted this approach to estimate vulnerability, especially in the Indian context.

In the VEU approach[5], vulnerability is defined with reference to the difference between the 'utility derived' from some level of certainty equivalent consumption, Z_{CE} at and above which the household would not be considered vulnerable, and the 'expected utility' of consumption, $EU_h(C_h)$. Hence vulnerability is measured as[5,15]

$$V_h = U_h(Z_{CE}) - EU_h(C_h), \tag{1}$$

where C_h is the consumption of a household h and U_h is its utility, which is weakly concave and strictly increasing function. Equation (1) can be rewritten as[15]

$$V_h = [U_h(Z_{CE}) - U_h(Ec_h)] + [U_h(Ec_h) - EU_h(C_h)]. \tag{2}$$

In eq. (2), the first term in square brackets is the measure of poverty which is the difference of utility at Z_{CE} compared to the expected utility of household h at c. The second term measures the risk faced by household h. This can be further decomposed into covariate and idiosyncratic risks. Allowing $E(C_h|X_t)$ to represent the expected value of consumption, conditional on a vector of covariant variables X_t, eq. (2) can be rewritten as[15]

$$V_h = [U_h(Z_{CE}) - U_h(Ec_h)] \rightarrow \text{(Poverty)}$$

$$+ \{U_h(Ec_h) - EU_h[E(C_h/X_t)]\} \rightarrow \text{(covariate risk)}$$

$$+ \{EU_h[E(C_h/X_t)] - EU_h(C_h)\} \rightarrow \text{(Idiosyncratic risk)}. \tag{3}$$

Study area, data and variables

The state of Odisha, geographically situated in the eastern part of India, is prone to many disasters, including cyclonic storms, floods and droughts[29,30]. The western part of Odisha is vulnerable to droughts and frequent deficient rainfall spells which affect a majority of rural households[12,13]. Further, there is a possibility of increase in probability of severe and extreme droughts in the state[31]. Within the state, Bolangir is one of the highly drought-prone districts[29,32–34]. It is a constituent of the erstwhile KBK (Kalahandi–Bolangir–Koraput) region, one of the poorest and underdeveloped regions in the entire country. It is located in the West Central table land zone of Odisha and receives a normal annual average rainfall of 1443.5 mm (ref. 11). While the district experienced severe drought situation in 2002 and 2009, moderate drought events were reported in 1996, 1998 and 2000; the drought that occurred in 2002 cost the Odisha Government INR 1.7 billion[32]. In fact, the district has experienced drought for 17 years between 1962 and 2002, i.e. at least one drought in three years with the frequency increasing over time[33]. When this could have negative impact on agricultural households across the district, around 75% of total cultivated land is under rainfed condition, which could amplify the vulnerability of farm households.

A second reason for choosing Bolangir district was because WORLP interventions were introduced here first and subsequently expanded to the remaining three districts. Four blocks (administrative division within a district) were chosen from the Bolangir district to conduct household surveys: (i) Agalpur, (ii) Bongamunda, (iii) Gudvela, and (iv) Patnagarh (Figure 1). In these blocks, the WORLP interventions were carried out during the initial phase of implementation. Stratified random sampling was adopted to select both study villages and households, and the survey was conducted during late 2014. Based on within and outside of the watershed command area, the sample villages were chosen; it was assumed that villages within the command area are WORLP beneficiaries while those outside are non-beneficiaries. A total of 800 households were interviewed, of which 600 belong to the beneficiary group and the rest are non-beneficiary households (200 households). Information was elicited through a structured pre-tested interview schedule that included questions related to household characteristics, land, crop and livestock details, consumption details, health and food security, household assets, loan, credit and savings, impact of climatic aberrations and adaptation measures.

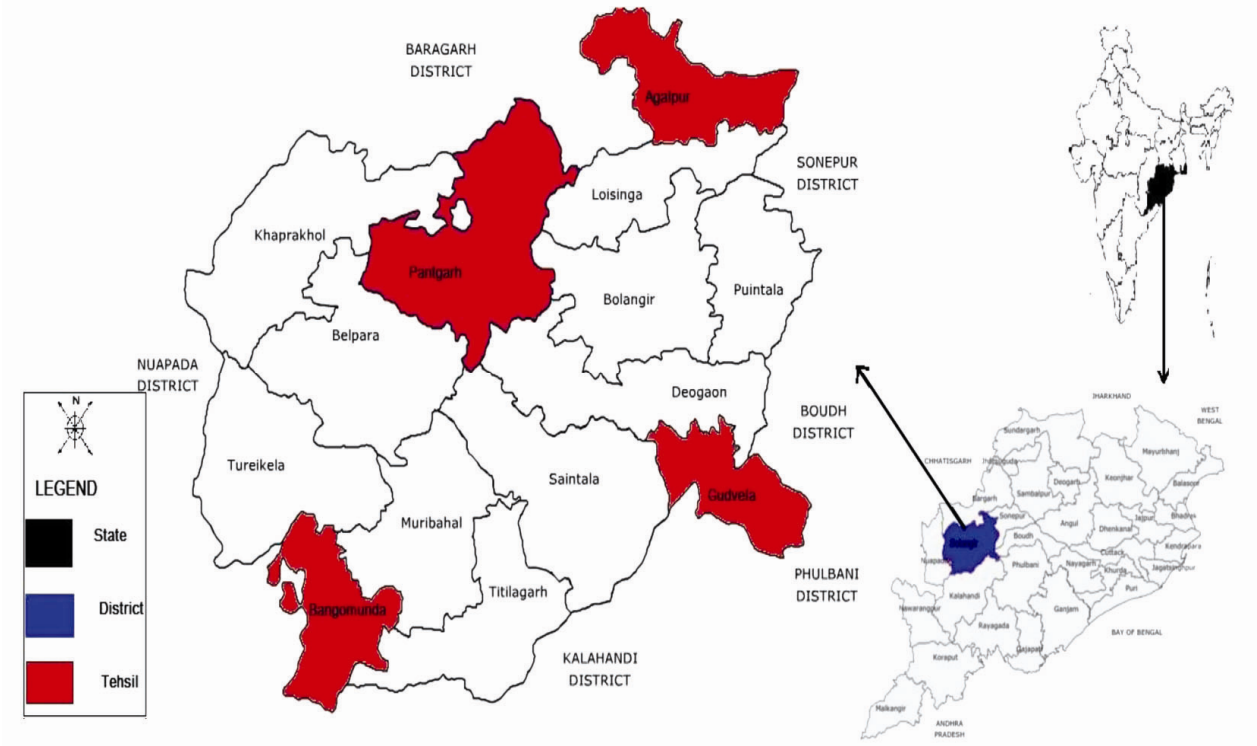


Figure 1. Map of surveyed blocks in Bolangir district, Odisha.

Table 1 presents the variables used in the analysis along with their definitions and descriptive statistics for the sample. Following the development economics literature, per capita consumption expenditure variable has been considered to capture the welfare of households which can measure their relative level of vulnerability. Per capita income and land ownership account for the household-level idiosyncratic risks. While income is likely to differ across households contingent upon the risks and shocks witnessed in the preceding time-periods, land ownership to a large extent represents the level of exposure faced by the households besides embodying the resilience to a smaller extent. It is in this sense that they are hypothesized to be a manifestation of the idiosyncratic shocks and risks. While on an average each household has an income of around INR 6230, the average land holding per household is 0.66 ha. As the main objective is to look into impact of developmental interventions on the vulnerability of households, this study has considered two variables to capture it such as WORLP beneficiary households (WORLP) and performance of WORLP programme (PERF). In discussion with key officials of OWDM, the project implementing agencies, and other secondary literature[28,35,36] we have demarcated the study villages into two categories, i.e. the ones with better performance of WORLP and those where the performance was not so good. It is anticipated that households in the former category have benefited more from WORLP than those in the latter category. Whereas three-fourths (75%) sample households were WORLP beneficiaries, the performance of the interventions was better for approximately half of them (37%).

In addition, other covariates which possibly influence the vulnerability of households are also included in the analysis, and depict the taste and preference of a household. These variables are age of the household head (AGE), years of education of the household head (EDU), family size (SIZE), crop-diversification (CRP_{NO}), number of big and small ruminants owned by the households (RUM_B and RUM_S), access to self-help groups (SHGs) and presence of migrant members in the family (MIG). Previous studies report that combinations of these variables associated with demography, agriculture and economic capacity are the major determinants of vulnerability, and are likely to exhibit either positive or negative relationship with the outcome vulnerability[7,24,37–40]. It is expected that an inverse relationship exists between the educational qualification of the household head and vulnerability level[7,24]. Family size could have either positive or negative relationship with vulnerability level – it mainly depends upon the composition of the size of the household. Crop diversification will definitely have a negative impact on the vulnerability of households which was reported in previously cited studies. Households with higher assets and amenities tend to be richer, and are able to smoothen consumption either through dis-saving and/or by depleting their existing assets[7]. However, these households will also have a higher level of exposure

Table 1. Summary and descriptive statistics of the variables used

Variables	Definition of the variables	Mean	SD	Minimum	Maximum
Dependent variables					
PCC	Consumption per capita (INR)	5287	4654	250	4239
Idiosyncratic shock variables					
PCY	Income per capita (INR)	6230	5684	250	46,178
LAND	Ownership of land (Ha)	0.66	0.82	0	7.29
Independent variables					
Developmental interventions					
WORLP	Programme treatment (dummy equals 1 if the household resides in the treatment village, 0 otherwise)	0.75	0.43	0	1
PERF	Interactive dummy of treatment and performance of WORLP (dummy equals 1 if beneficiary and performance is good; 0 otherwise)	0.37	0.48	0	1
Other covariates					
AGE	Age of the head of the household	51.46	12.15	25	104
SIZE	Number of members in the household	5.22	2.76	1	15
EDU	Number of years of education of the head of the household	3.26	3.41	0	15
CRP_{NO}	Number of crops cultivated during the previous agricultural season	0.92	1.02	0	4
RUM_B	Number of big ruminants owned by the household	1.09	1.38	0	8
RUM_S	Number of small ruminants owned by the household	2.18	4.55	0	40
SHG	Access to social networks (dummy equals 1 if the household has membership in self-help groups, else 0)	0.76	0.43	0	1
MIG	Presence of migrant members (dummy equals 1 if the household has migrant member in the household; else 0)	0.403	0.783	0	1
Decomposition of vulnerability by Ligon and Schechter method[5]					
VULN	Vulnerability	0.698	0.76	–0.61	3.13
POV	Poverty	0.231	0.55	–0.68	2.19
$RISK_{AG}$	Aggregate risk	0.375	0.12	0.11	0.58
$RISK_{ID}$	Idiosyncratic risk	–0.0004	0.02	–0.06	0.14
$RISK_{UN}$	Unexplained risk	0.093	0.16	–0.20	0.78

$N = 800$ for all variables, except those for PCC, PCY and LAND which were used to calculate vulnerability and its constituents estimated by vulnerability as low expected utility (VEU) method following Ligon and Schechter[5]. Here $N = 1600$ as PCC, PCY and LAND of the households before the start of WORLP (2000) after the end (2014) were used. The idiosyncratic risk variables considered for VEU formulation were PCY and LAND.

and hence the relationship could work either ways. Households having access to social networks and those with migrant members are likely to exhibit an inverse relationship with vulnerability.

Results and discussion

Empirical analysis involves estimation of the model outlined in eq. (3). This is done by quantifying vulnerability through the Ligon and Schechter[5] method and thereby estimating a median quintile regression for vulnerability and its components. The adoption of median quintile regression is necessary due to the presence of high variability in per capita consumption and income for the sample; Table 2 presents the results. Appendix 1 shows the plots for coefficients of the quintile regression depicting the significant variables obtained in Table 2. The analysis has decomposed vulnerability into four distinct components, i.e. poverty, aggregate risks, idiosyncratic risks and unexplained risk. Appendix 2 shows ordinary least square (OLS) regression for determinants of vulnerability and its components. Appendix 3 reports the correlation between the components of vulnerability. Vulnerability of households is measured in terms of per-capita consumption expenditure. The goodness-of-fit (R^2) varies between 0.103 and 0.287. The estimated coefficients of variables taken in the models are consistent with those reported in the literature. The vulnerability of the households in the full sample is estimated to be 0.698 (Tables 1 and 2), suggesting that the utility of the average household in our sample is approximately 70% less than it would be if all the resources are redistributed to eliminate all inequality and risk in consumption.

Table 2 also shows the decomposition of vulnerability into poverty, aggregate risk, idiosyncratic risk and unexplained risk. Both aggregate risk and poverty are the major sources of vulnerability, accounting for 87% of all of vulnerability. While the aggregate risk component

Table 2. Estimation results for median quintile regression for vulnerability and its components

Variables	VULN 0.698*** (= 0.019) (1)	POV 0.231*** (+0.014) (2)	$RISK_{AG}$ 0.375*** (+0.003) (3)	$RISK_{ID}$ –0.001* (+0.0003) (4)	$RISK_{UN}$ 0.093*** (0.004) (5)
Developmental interventions					
WORLP	–0.048	–0.002	0.003	–0.005**	–0.024
	(0.080)	(0.051)	(0.013)	(0.002)	(0.016)
PERF	–0.197***	–0.126***	–0.032***	0.007***	–0.001
	(0.058)	(0.037)	(0.010)	(0.002)	(0.013)
Other covariates					
AGE	–0.009***	–0.006***	–0.002***	0.0002***	–0.0004
	(0.002)	(0.001)	(0.0003)	(0.0001)	(0.001)
SIZE	0.171***	0.136***	0.030***	–0.004***	0.018***
	(0.010)	(0.006)	(0.001)	(0.0002)	(0.003)
EDU	–0.016**	–0.013***	–0.004***	–0.0001	–0.003
	(0.008)	(0.005)	(0.001)	(0.0002)	(0.002)
CRP_{NO}	–0.111***	–0.075***	–0.018***	0.004***	–0.006
	(0.022)	(0.011)	(0.004)	(0.001)	(0.006)
RUM_B	0.003	–0.004	0.0002	0.001	0.008*
	(0.014)	(0.008)	(0.002)	(0.001)	(0.004)
RUM_S	0.006*	0.0000	0.0001	0.0004***	0.003
	(0.003)	(0.002)	(0.001)	(0.0002)	(0.002)
SHG	–0.261***	–0.132***	–0.034***	–0.001	–0.090***
	(0.047)	(0.028)	(0.008)	(0.001)	(0.016)
MIG	–0.057**	–0.060**	–0.016***	0.005***	0.016
	(0.025)	(0.025)	(0.004)	(0.001)	(0.011)
Constant	0.653***	0.067	0.387***	0.002	0.066*
	(0.138)	(0.095)	(0.023)	(0.004)	(0.038)
Pseudo R^2	0.254	0.279	0.287	0.169	0.103
N	800	800	800	800	800

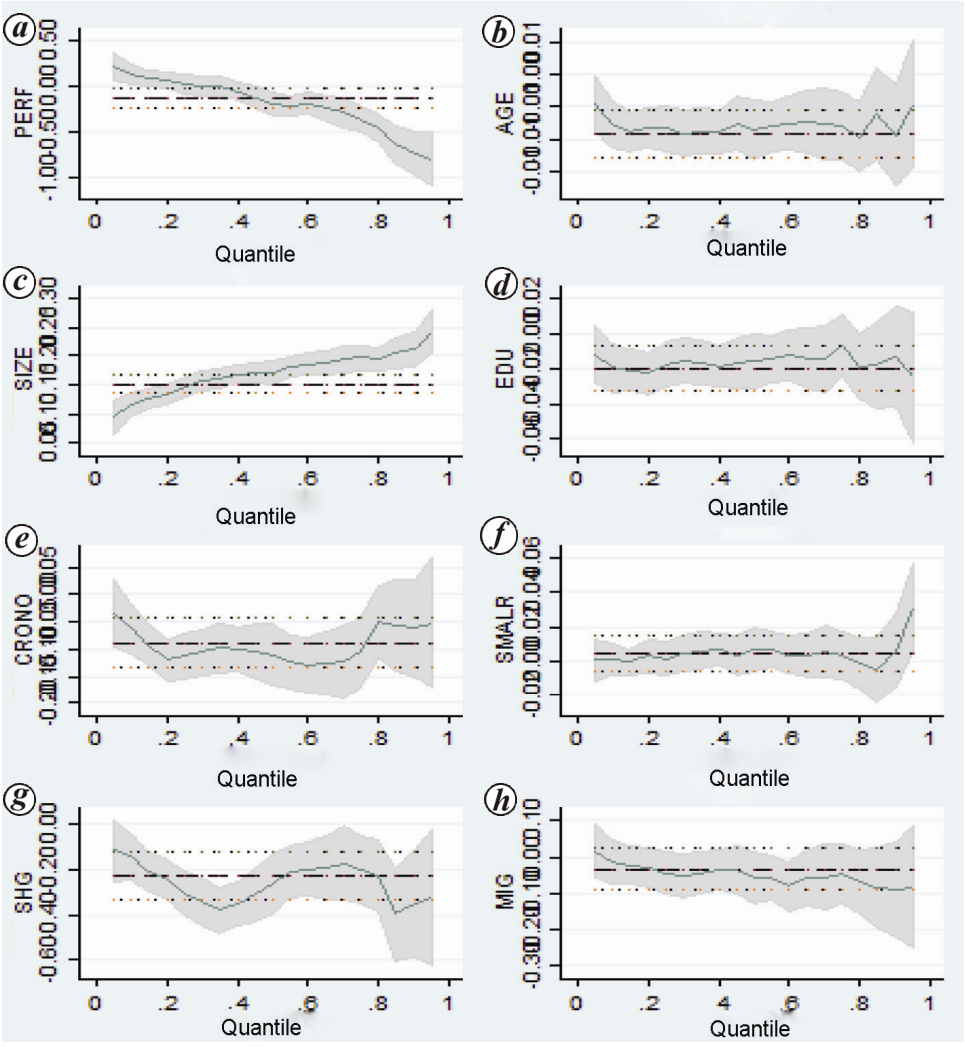
Robust standard errors in parentheses. ***$P < 0.01$, **$P < 0.05$, *$P < 0.1$. Regressions for the median quintile (50).

dominates explaining half of the vulnerability (i.e. 54%), poverty accounts for 33% of the total vulnerability. Aggregate risk seems to be much more important than poverty, idiosyncratic and unexplained risks. This reveals that aggregate risks such as drought and rainfall variability make household more vulnerable than the other components of vulnerability considered here. In sum, aggregate risk is the first largest component, followed by poverty, unexplained risk and idiosyncratic risk. Moreover, unexplained risk is larger compared to idiosyncratic risk.

The analysis also examined the determinants of vulnerability and its sub-components, where each component was regressed with variables related to developmental interventions and a fixed set of other covariates related to household characteristics (Table 2). Households that benefitted from WORLP seem to be less vulnerable and a significant negative coefficient value is reported for idiosyncratic risk. Moreover, households where WORLP programme performed better are likely to be less vulnerable compared to other households. For instance, the former households are around 20% less in terms of vulnerability compared to non-beneficiary households. Further, these households also face significantly less poverty and aggregate risk; whereas these households are 12.6% less vulnerable to poverty, and 3.2% less vulnerable to aggregate risk. Surprisingly, it is found that these households are marginally more vulnerable to idiosyncratic risk, i.e. 0.7%. The main objective of promoting WORLP was to eradicate poverty in the drought-prone regions of western Odisha, and indeed, findings of this study also support this argument.

Among the other covariates, age of the household head has negative relationship with the level of vulnerability and other components of vulnerability, except the idiosyncratic shocks. Households with larger family size are more vulnerable due to non-diversification of income sources. In other words, an additional member in the family increases the vulnerability level by 17%; its impact on poverty is higher than that of aggregate risk. This is similar to the results obtained by other studies as well[37–40]. Moreover, it reduces idiosyncratic risks. The years of education of the household head reduce the level of

Appendix 1. Plots for coefficients of the quintile regression depicting the significant variables obtained in Table 2. ***a***, Interactive dummy of WORLP beneficiary and performance and vulnerability showing a negative relationships. ***b***, Age of the head of the household. ***c***, Household size. ***d***, Number of years of education of the head of the household. ***e***, Number of crops cultivated. ***f***, Number of small ruminants. ***g***, Access to self-help groups. ***h***, Presence of out-migrant members in the household



vulnerability. With an additional year of education of the household head, vulnerability on an average declines by 2%. Households where the head is educated to higher levels are able to diversify their consumption over space and time thereby reducing their exposure to aggregate and idiosyncratic risks. Moreover, households with better crop diversification are less exposed to vulnerability and its components. It is known that farmers in rural India practice crop-diversification to minimize the risk of crop damage due to climatic aberrations. Agriculture being the more risky source of livelihood, households which diversify their agricultural crops are less vulnerable.

As expected, access to SHGs and migration variables also reduces the level of vulnerability. While access to SHGs reduces vulnerability level by 16%, around 6% less vulnerability is observed due to the presence of migrant members in the household. Appendix 2 presents the relationship of the components of vulnerability. The numbers below the diagonals are Pearson correlation coefficients, while those above are Spearman rank correlation coefficients. It is found that poverty and aggregate risk have the same rank-order over households, i.e. decreasing marginal utility implies that the poor will be most affected by aggregate shocks; similar to the results of Ligon and Schechter[5]. Idiosyncratic risk is negatively correlated with poverty and aggregate risk. This suggests that the households vulnerable to idiosyncratic risks are not vulnerable to poverty and aggregate risk. Moreover, unexplained risk has positive correlation with poverty, aggregate as well as idiosyncratic risks.

Appendix 2. Ordinary least square (OLS) estimates for determinants of vulnerability and its components

Variables (1)	VULN (2)	POV (3)	$RISK_{AG}$ (4)	$RISK_{ID}$ (5)	$RISK_{UN}$ (6)
Developmental interventions					
WORLP	–0.010	0.013	0.007	–0.006***	–0.025
	(0.067)	(0.048)	(0.010)	(0.002)	(0.016)
PERF	–0.129**	–0.095**	–0.023***	0.010***	–0.020
	(0.059)	(0.043)	(0.009)	(0.002)	(0.014)
Other covariates					
AGE	–0.009***	–0.007***	–0.002***	0.0001	–0.001*
	(0.002)	(0.001)	(0.0003)	(0.0001)	(0.001)
SIZE	0.151***	0.117***	0.025***	–0.004***	0.014***
	(0.009)	(0.007)	(0.002)	(0.0003)	(0.002)
EDU	–0.020***	–0.015***	–0.003***	–0.0000	–0.001
	(0.007)	(0.005)	(0.001)	(0.0002)	(0.002)
CRP_{NO}	–0.089***	–0.068***	–0.015***	0.003***	–0.010
	(0.024)	(0.017)	(0.004)	(0.001)	(0.006)
RUM_B	0.002	–0.002	0.001	0.001**	0.002
	(0.018)	(0.013)	(0.003)	(0.001)	(0.005)
RUM_S	0.004	0.0004	0.0001	0.0002	0.003**
	(0.006)	(0.004)	(0.001)	(0.0002)	(0.002)
SHG	–0.229***	–0.113***	–0.025***	–0.002	–0.089***
	(0.055)	(0.039)	(0.008)	(0.002)	(0.015)
MIG	–0.033	–0.050**	–0.010**	0.006***	0.021**
	(0.035)	(0.024)	(0.005)	(0.001)	(0.009)
Constant	0.754***	0.212**	0.378***	0.012***	0.151***
	(0.139)	(0.099)	(0.020)	(0.004)	(0.035)
N	800	800	800	800	800
R^2	0.366	0.387	0.408	0.275	0.145
F	38.50***	38.11***	44.19***	26.81***	11.82***

Robust standard errors in parentheses. ***$P < 0.01$, **$P < 0.05$, *$P < 0.1$. Average variance inflation factor (VIF) = 1.26.

Appendix 3. Correlation coefficient between elements of vulnerability

	POV	$RISK_{AG}$	$RISK_{ID}$	$RISK_{UN}$
POV	1	1***	–0.542***	0.545***
		(1.00, 1.00)	(–0.575, –0.506)	(0.509, 0.578)
$RISK_{AG}$	0.962***	1	–0.542***	0.545***
	(0.958, 0.965)		(–0.575, –0.506)	(0.509, 0.578)
$RISK_{ID}$	–0.463***	–0.488***	1	0.008
	(–0.5, –0.423)	(–0.525, –0.450)		(–0.041, –0.057)
$RISK_{UN}$	0.525***	0.517***	0.021	1
	(0.488, 0.559)	(0.481, 0.552)	(–0.028, –0.070)	

***$P < 0.01$, **$P < 0.05$, *$P < 0.1$. 95% confidence intervals in parentheses. Pearson correlation coefficients are depicted below the diagonal and Spearman rank correlations above the diagonal.

Concluding observations

Households in developing nations are not only exposed to poverty but also to risks and shocks consisting of both idiosyncratic and covariate components. In order to cope with such risks and shocks, households undertake both income and consumption-smoothing measures. Various interventions are also taken from time to time by the respective national and state governments for upliftment of the livelihoods of the poor households. The WORLP that was implemented by the Government of Odisha, was based on a different approach which encompassed the development of sustainable livelihoods for the rural poor while also addressing poverty reduction. The programme targeted development of micro-watersheds in drought-prone regions of the state while also accommodating

mechanisms to provide alternative sources of livelihood, especially for the non-agricultural households[29]. Given this background, the onus of the present study is to investigate the effects of these on the vulnerability level of households in a historically drought-prone region.

The analysis suggests that level of utility of the average households in the sample is approximately 70% less than it would be if all the resources are redistributed to eliminate inequality and risk in consumption. Aggregate risk (climatic aberrations and extremes) and poverty emerge as the major sources of vulnerability. Importantly, it is observed that beneficiary of the WORLP interventions in general and those particularly living in regions where the performances of the interventions were better are less vulnerable compared to the non-beneficiaries. The major household-level characteristics that reduce vulnerability are: age of the household head, education, number of crops cultivated, access to SHGs and presence of migrant members in the family. This study concludes that development interventions promoted by the government agencies to eradicate poverty have also acted as a deterrent to the appreciation in vulnerability. However, the results need to be interpreted with caution due to certain limitations of the study. Lack of longitudinal data is seen as a major limitation and so also is the non-availability of specific information regarding other covariate and idiosyncratic shocks at a micro-level. Future studies should aim to overcome these while also deriving results comparing multiple locations within a country, which will provide scope for more rigorous inferences on a temporal and spatial scale. Nonetheless, from a policy perspective, the present findings indicate that the government should promote various developmental interventions in rural India for poverty reduction. However, there is a need to concurrently re-design these interventions for minimizing the impact of aggregate and idiosyncratic risks.

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