Integrated assessment of vulnerability of rural households to climate stress across regional levels in Niger

by
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I. Objective

II. Research question

III. Methodology

3.1 Measuring vulnerability as expected poverty: econometric method

3.2 Vulnerability resilience index: method of indicators

IV. Results

4.1 Probability that daily per capita income falls below poverty threshold given climate and socioeconomic variables

- Specificity and sensitivity test
- ROC Curve

4.2 Results from method of indicators

- Principal Components Analysis
- Factor scores of the first principal component
- Vulnerability components
- Vulnerability resilience index

I. Objective

The main objective of the study is to analyze the vulnerability of rural households to climate stress across regional levels based on the integrated vulnerability approach using cross-section secondary data of national survey on households' vulnerability to food insecurity (2011)

II. Research question

What are the determinants of climate stress vulnerability and the related regional variations?

III. Methodology

3.1 Measuring vulnerability as expected poverty (Chaudhuri et al 2002)

Probability that daily per capita expenditure lies below the poverty threshold

$$p(y_i < \bar{y}/x_i)$$

$$Y_i = \begin{cases} 1 \text{ si } Y_i^* < \overline{Y} \\ 0 \text{ si } Y_i^* > \overline{Y} \end{cases}$$

Such binary model is fitted using logit regression by means of maximum likelihood

$$\text{Prob}(Y_i < \bar{Y}|X_i) = \frac{e^{X'\beta}}{1+e^{X'\beta}} = \text{Prob}(Y = 1|X_i)$$

$$\frac{\partial \Pr\left[y_i = \frac{1}{x_i}\right]}{\partial x_{ij}} = F'(X_i'\beta)\beta_j$$

3.2 Vulnerability resilience index by method of indicators : Temesgen Deressa, Rashid M. Hassan and Claudia Ringler (2008)

Vulnerability = adaptive capacity – (exposure + sensitivity)

The index formula for a region j is given by:

$$I_j = \sum_{i=1}^{k} w_i (x_{ij} - \overline{x_i}) / \sigma_{x_i}$$

Adaptive capacity index of region j for the i^{th} indicator

$$A_j = \sum_{i=1}^{k} w_i^A (x_{ij}^A - \overline{x_{ij}^A}) / \sigma_{x_i}^A$$

Exposure index of region j for the i^{th} indicator

$$E_j = \sum_{i=1}^{k} w_i^E (x_{ij}^E - \overline{x_{ij}^E}) / \sigma_{x_i}^E$$

Sensitivity index of region j for the i^{th} indicator

$$S_j = \sum_{i=1}^{k} w_i^S (x_{ij}^S - \overline{x_{ij}^S}) / \sigma_{x_i}^S$$

Vulnerability resilience index:

$$VRI_j = A_j - (E_j + S_j)$$

$$\boldsymbol{VRI_j} = \sum_{i=1}^{k} \left\{ \frac{w_i^A \left(x_{ij}^A - \overline{x_{ij}^A}\right)}{\sigma_{x_i}^A} - \left[\frac{w_i^E \left(x_{ij}^E - \overline{x_{ij}^E}\right)}{\sigma_{x_i}^E} + \frac{w_i^S \left(x_{ij}^S - \overline{x_{ij}^S}\right)}{\sigma_{x_i}^S} \right] \right\}$$

Where w_i is the weight for the i^{th} indicator in the Principal Components Analysis model, x_{ij} is the j^{th} region's value for the i^{th} indicator, $\overline{x_i}$ and σ_{x_i} are the mean and standard deviation respectively of the i^{th} Indicator for all regions

IV. Results

4.1 Probability that daily per capita income falls below poverty threshold given climate and socioeconomic variables

Dependent variable: y = Pr(daily per capita income < 290) = .77007874 (predict)	Coef	Marginal effects dy/dx	p>|z|
Gender	-.0044975	-.0007963	0.960
Household size	.035473098*	.0628078	0.000
Number of children under 5 years	.0348854	.0061767	0.419
Number of officials	-.01226696*	-.0217196	0.001
Mobile phones	-.06527005*	-.01199949	0.000
TVs	-.013012*	-.02171198	0.000
Ownership of fields	-.05957783*	-.0105487	0.000
Cereal bank	-.03236564*	-.0573058	0.000
Food against work	-.02238961***	-.0396425	0.054
Food distribution	-.04098677*	-.0725701	0.000
Blanket feeding	-.01288709	-.0228175	0.184
Donation of agricultural materials	-.03547108**	-.0628042	0.002
Disease	.0694865	.0123031	0.248
Increase of price of fuel/ transport	.03580827**	.0634012	0.025
Increase of price of labor	.02716102	.0480906	0.198
Increase of price of agricultural inputs	.04937146*	.0874159	0.000
Natural disasters (flood, drought, wind)	.01991569**	.0352622	0.012
Food insecurity range: severe	.07706504*	.01119516	0.000
Food insecurity range: moderate	.07877371*	.01145691	0.000
Food insecurity range: at risk	.0566197*	.09413	0.000

Specificity and sensitivity test

Vulnerability			
Test	**Present**	**Absent**	**Total**
Positive +	a = True Positive (TP)	c = False Positive (FP)	a + c
Negative -	b = False Negative (FN)	d = True Negative (TN)	b + d
Total	a + b	c + d	$\boldsymbol{Pro(y < \overline{y})} = \frac{a}{a+b+c+d}$

Sensitivity	$\frac{a}{a+b}$	**Test values**	**Specificity**	$\frac{d}{c+d}$
Positive likelihood Ratio	$\frac{Sensitivity}{1-Specificity}$		**Negative likelihood Ratio**	$\frac{1-Sensitivity}{Specificity}$
Positive Predictive Value	$\frac{a}{a+c}$		**Negative Predictive Value**	$\frac{d}{b+d}$

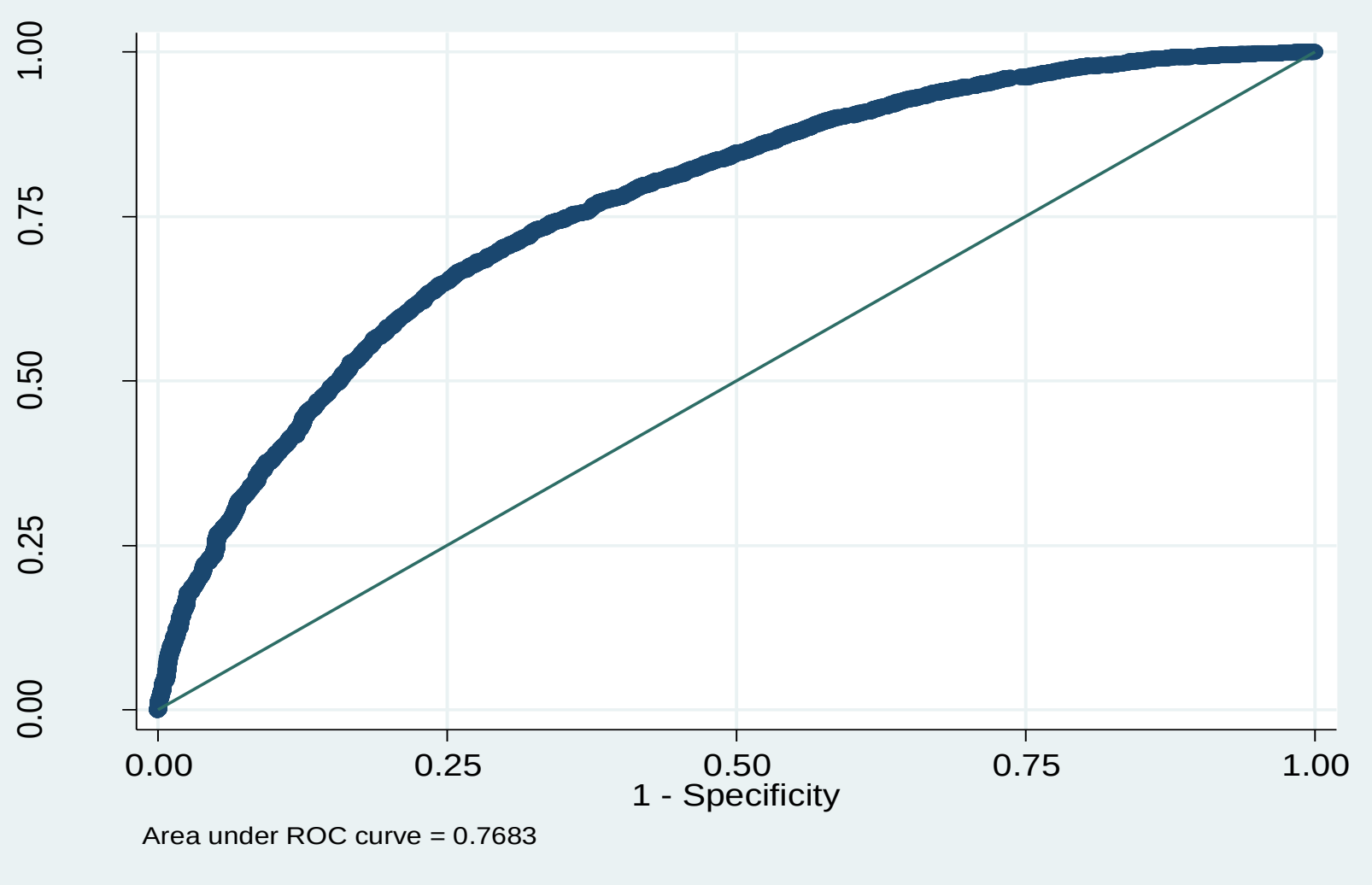
Logistic model for income

Classified	True D	True ~D	Total
+	6048	1686	7734
-	447	878	1325
Total	6495	2564	9059

Classified + if predicted Pr(D) >= .5
True D defined as income != 0

Sensitivity	Pr(+| D)	93.12%
Specificity	Pr(-|~D)	34.24%
Positive predictive value	Pr(D| +)	78.20%
Negative predictive value	Pr(~D| -)	66.26%
False + rate for true ~D	Pr(+|~D)	65.76%
False - rate for true D	Pr(-| D)	6.88%
False + rate for classified +	Pr(~D| +)	21.80%
False - rate for classified -	Pr(D| -)	33.74%
Correctly classified		76.45%

ROC Curve

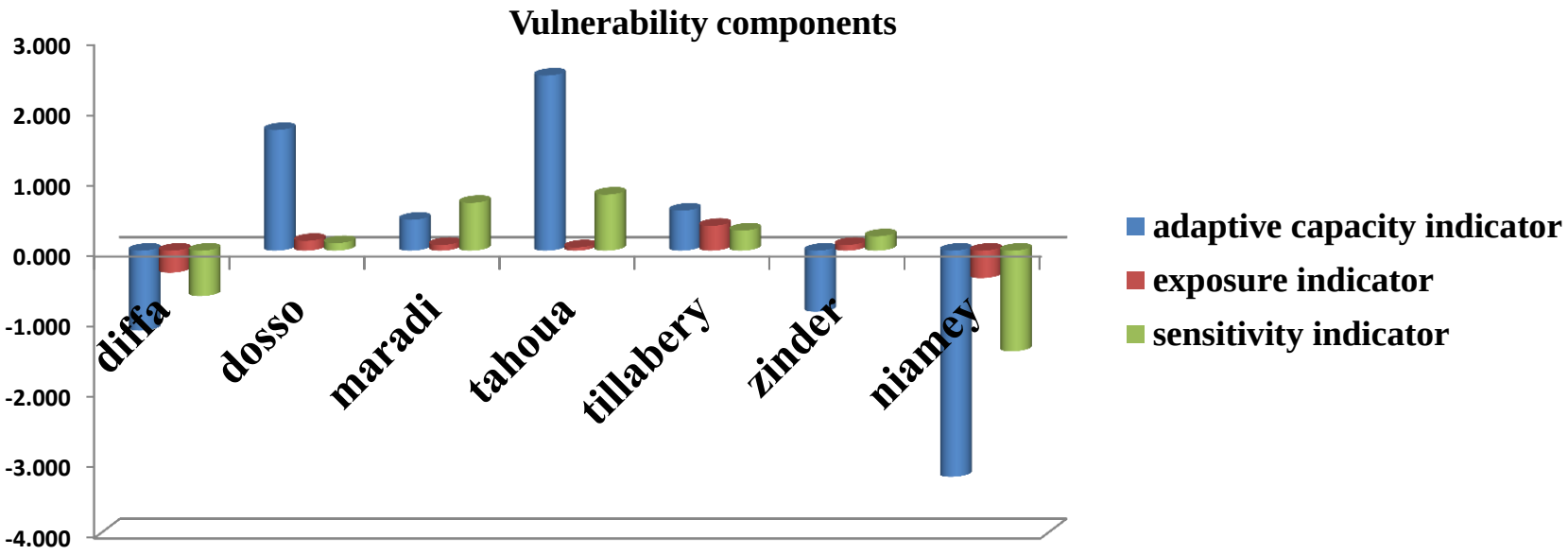

1.00
0.75
0.50
0.25
0.00
0.00
0.25
0.50
0.75
1.00
1 - Specificity
Area under ROC curve = 0.7683

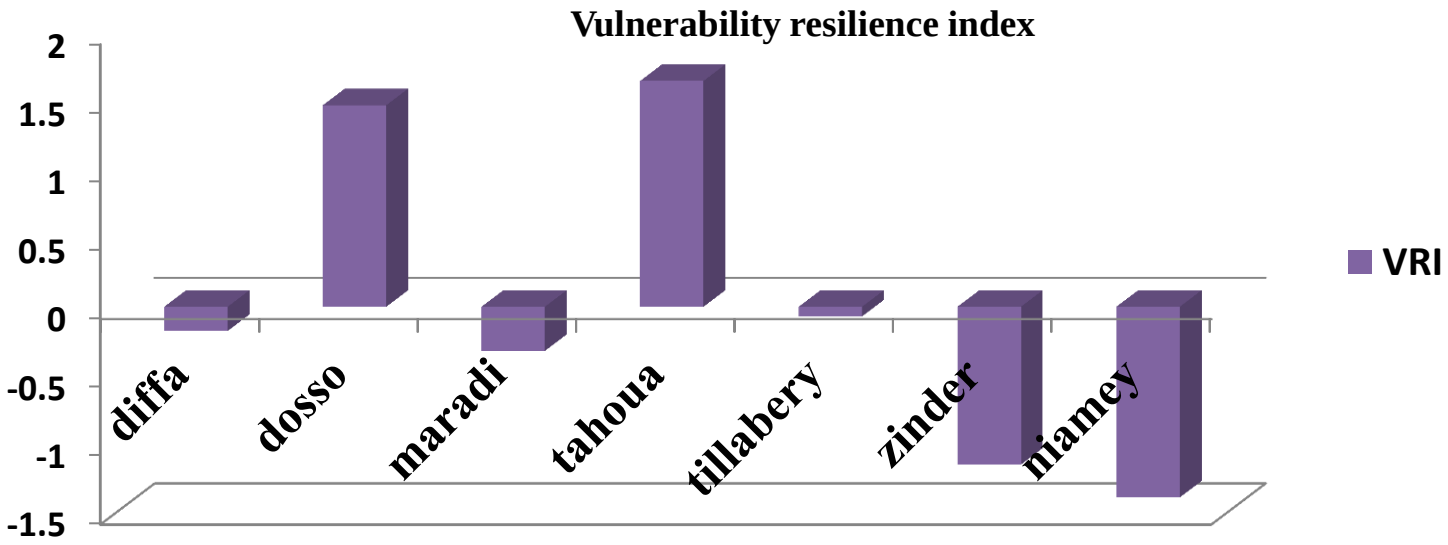
4.2 Results from method of indicators : factor scores of the first principal component

Indicators	factor scores
tropical livestock unit	-0.1064
Income	0.1283
mobile phone	-0.1825
plough for animals traction	0.1621
primary school	0.2985
secondary school	0.2522
health center	0.1423
improved drinking water source	-0.1948
vet box	0.1717
Market	0.3027
cereal bank	0.3218
supply of fertilizers and seeds	0.2041
community system for women support	-0.1358
infant nutritional rehabilitation center	-0.1194
community system for responding to climate shocks	0.2628
Drought	0.2676
Flood	-0.0445
presence of malnourished children	0.0786
increase of food prices	-0.0366
increase of agricultural inputs	-0.2176
attack of insects	-0.2346
low crop yield	0.2265
income decline	0.3144

For instance the vulnerability resilience index of the region of Diffa is calculated as follow:

$$\begin{pmatrix}(-0.1064*2.225)+(0.1283*1.336)+(-0.1825*0.060)+\\(0.1621*0.619)+(0.2985*-1.111)+(0.2522*-0.339)+\\(0.1423*-1.354)+(-0.1948*-0.931)+(0.1717*1.017)+\\(0.3027*-0.563)+(0.3218*-0.525)+(0.2041*-0.838)+\\(-0.1358*0.876)+(-0.1194*0.334)+(0.2628*-0.896)\end{pmatrix} - \begin{pmatrix}(0.2676*-1.363)+(-0.0445*-1.170)+\\(0.0786*-1.010)+(-0.0366*-0.780)+\\(-0.2176*-0.664)+(-0.2346*0.347)+\\(0.2265*-1.041)+(0.3144*-1.340)\end{pmatrix} = -0.177 \quad (10)$$


Vulnerability components
3.000
2.000
1.000
0.000
-1.000
-2.000
-3.000
-4.000
diffa
dosso
maradi
tahoua
tillabery
zinder
niamey
adaptive capacity indicator
exposure indicator
sensitivity indicator


Vulnerability resilience index
2
1.5
1
0.5
0
-0.5
-1
-1.5
diffa
dosso
maradi
tahoua
tillabery
zinder
niamey
VRI

Conclusion

- Up to 77% of rural households have their income below the poverty threshold (minimum requirement).
- Rural poverty status is significantly and positively correlated with household size, food insecurity status and increase of price of fuel and agricultural materials.
- Climate stress significantly exacerbates the risk that rural household fall into poverty.
- Number of officials, household assets and food-related distribution make households better off.
- Rural households living in the region of Niamey and Zinder are the most exposed to climate stress because of their low level of social networks and collective action while those in Tahoua and Tillabéry are the less vulnerable due to a high concentration of interventions and nongovernmental organization.