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Assessing Local Vulnerability to Climate Change in Agriculture for Tocantins, Brazil

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Assessing Local Vulnerability

to Climate Change in Agriculture for Tocantins, Brazil

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We propose a reliable indicator of vulnerability to climate change in agriculture that allows measuring within the system the main components of vulnerability at a local level: climate exposure (EX), stressors sensitivity (SS), and adaptive capacity (AC).

Objective

To develop a reliable indicator of local vulnerability that captures its dynamics and the criterion of tractability and comparability across time and location. This indicator will allow identifying main vulnerability drivers and planning policies to increase system resiliency as well as designing climate change adaptation policies at the local level.

Methodology

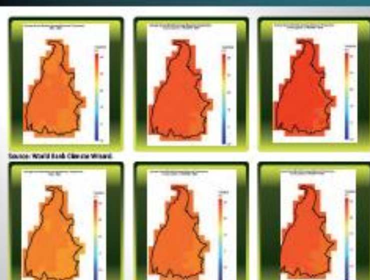
This indicator combines the methodology of Luers et al. (2003) and the estimates a fixed effects model at the county-level to measure how climate stressors (growing degree days, GDD_{ijt} and accumulated precipitation, $Prec_{ijt}$) influence agricultural systems (yields) using information on geographical, geomorphological, socioeconomic and temporal characteristics of local systems.

$$Y_{ijt}=\alpha_1 Prec_{ijt}+\alpha_2 GDD_{ijt}+\gamma' T_t+\eta' T_t+\theta' X_{it}+\beta_k Prec_{ijt}' X_{it}+G_k GDD_{ijt}' X_{it}+d t' s+\varepsilon_{ijt}$$

We define a set of outcome variables that represent a system to define a fourfold indicator of local vulnerability.

$$Exposure\,(E)=Pr_z\,dS \qquad (1)$$

It is a frequency measure of climate adverse events for the crop development at municipality level.



Source: World Bank Climate Wizard.

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Stressor sensitivity (SS)

$$SS=f\left(\frac{\text{Sensitivity}}{\text{Distance to Threshold}}\right)=f\left(\frac{\hat{Yield}_{S_j}}{Yield_{Yield_{threshold}}}\right) \qquad (2)$$

The SS captures the system response to changes in stressors, where $\hat{Yield}_{S_j}$ is the estimated response of yields to stressor S_j, Yield is the observed yield in a given system (county) and $Yield_{threshold}$ represents the point of reference for a given system below which the agricultural sector becomes "damaged".

Vulnerability measure is defined as the expected value of the ratio of the system's sensitivity to a given threshold.

$$V=Expected\ Value(SS)=\int\left(\frac{\hat{Yield}_{S_j}}{Yield_{Yield_{threshold}}}\right)Pr_z\,dS \qquad (3)$$

It is projected that Climate Change will affect Tocantins by decreasing the average daily precipitation during wet season and increasing the minimum and maximum temperatures, affecting the growing degree days for the region. This research is focused in the period of study 1981-2001.
The sources used for the study were: NOAA for climate data, Ministério da Agricultura, Pecuária e Abastecimento for yield information and the Instituto Brasileiro de Geografia e Estatística for sociodemographic data at municipality level. Climate change data were obtained from the Climatic Research Unit (CRU) at the University of East Anglia (UEA).

Estimation and Results

Econometric estimation

Independent variables	Yield
Accum. Precipitation	0.0841277 (0.0374109)
Accum. Precipitation^2	2.000000 (-0.0150077)
Growing degree days	1.863238 (0.7687155)
Growing degree days^2	-0.2744428 0.0457782

Sensitivity to Stressor Indicator*

Municipalities	Exposure Index*
1. Aliança do Tocantins	0.217
2. Alvorada	0.174
3. Araguaçu	0.217
4. Cariri do Tocantins	0.174
5. Cristalândia (1ª Etapa)	0.217
6. Crixás do Tocantins	0.261
7. Dueré	0.217
8. Figueirópolis	0.174
9. Formoso do Araguaia	0.217
10. Lagoa da Confusão (1ª Etapa)	0.261
11. Pium (1ª Etapa)	0.304
12. Sandolândia	0.174
13. Santa Rita do Tocantins	0.217
14. Talismã	0.174
Tocantins Average	0.318

/* Exposure index

Case of Study

We applied this methodology for measuring local vulnerability of the municipalities where the Development Program for the Southwest region of the state of Tocantins (PRODOESTE) (BR-L1152) is operating in Brazil. This project is an Inter-American Development Bank's agricultural project for expand irrigation area in the region and improve the productive conditions of the region.

Sensitivity to Stressor Indicator*

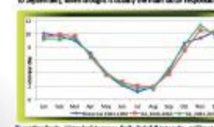
Municipalities	Precipitation	GDD**
1. Aliança do Tocantins	0.05	0.51
2. Alvorada	0.08	0.45
3. Araguaçu	0.03	3.56
4. Cariri do Tocantins	0.05	2.06
5. Cristalândia (1ª Etapa)	0.10	0.00
6. Crixás do Tocantins	0.10	3.65
7. Dueré	0.07	0.50
8. Figueirópolis	0.06	0.57
9. Formoso do Araguaia	0.00	0.11
10. Lagoa da Confusão (1ª Etapa)	0.06	0.52
11. Pium (1ª Etapa)	0.06	0.70
12. Sandolândia	0.03	0.47
13. Santa Rita do Tocantins	0.06	1.34
14. Talismã	0.10	3.21
Tocantins Average	1.00	1.00

/* Indicates a normalization with the Tocantins Average.
/** GDD means Growing Degree Days.

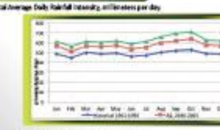
Municipalities	Vulnerability
1. Aliança do Tocantins	1.243
2. Alvorada	2.032
3. Araguaçu	1.217
4. Cariri do Tocantins	1.810
5. Cristalândia (1ª Etapa)	1.084
6. Crixás do Tocantins	0.742
7. Dueré	3.002
8. Figueirópolis	0.683
9. Formoso do Araguaia	4.025
10. Lagoa da Confusão (1ª Etapa)	2.684
11. Pium (1ª Etapa)	1.451
12. Sandolândia	1.056
13. Santa Rita do Tocantins	0.805
14. Talismã	0.731
Tocantins Average	1.000

/* Indicates a normalization with the Tocantins Average.

PRODOESTE is being implemented in Tocantins basin, one of the Brazil's agricultural frontier regions, specialized in the production of soybean, corn, rice, beans and watermelon. Most of the region is dryland, so, growing season is largely determined by occurrence of the rainy and dry seasons of the region (May to September), when drought is usually the main factor responsible for crop losses.



Tocantins Basin, Historical Average Daily Rainfall Intensity, millimeters per day.



Tocantins, Growing degree days per year.

Conclusions

- Local vulnerability to climate change in agriculture in Tocantins will diverge according to their location.

This research was carried out with the financial support of the Inter-American Development Bank.