

A conceptual probability-based climate-driven model for population vulnerability

Indicadores* de Vulnerabilidade* a Extremos Climáticos
para o Nordeste do Brasil: Um Modelo Conceitual.

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Quais desastres naturais clima-dependentes podem ocorrer?



How to assess the impacts of these disasters in NEB?

Vulnerability

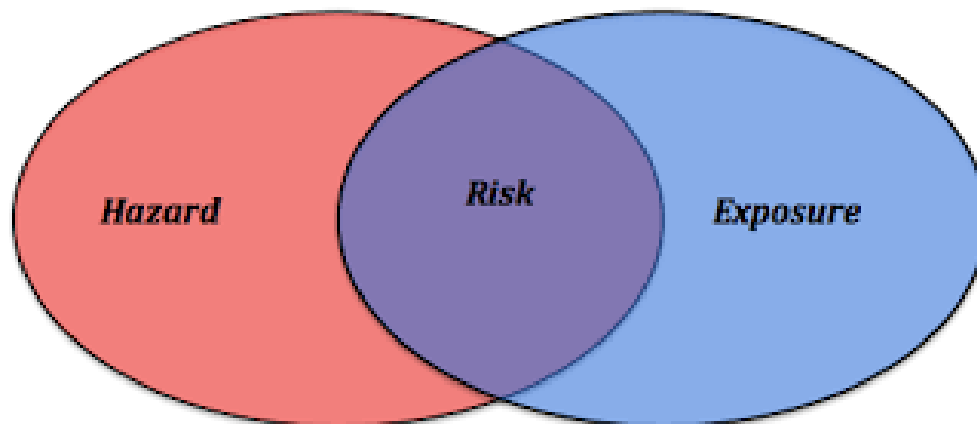
The vulnerability is a function characterized by the magnitude and climate variation, which the system is exposed to hazard, sensitivity and adaptative capacity (IPCC, 2007). In the AR5 (IPCC, 2014) it is defined as the propensity or predisposition to the adversely affected!

The vulnerability encompasses a variety of concepts and elements, including hazard and exposure do damage, susceptibly and the lack of ability to dealing with the adaptation!

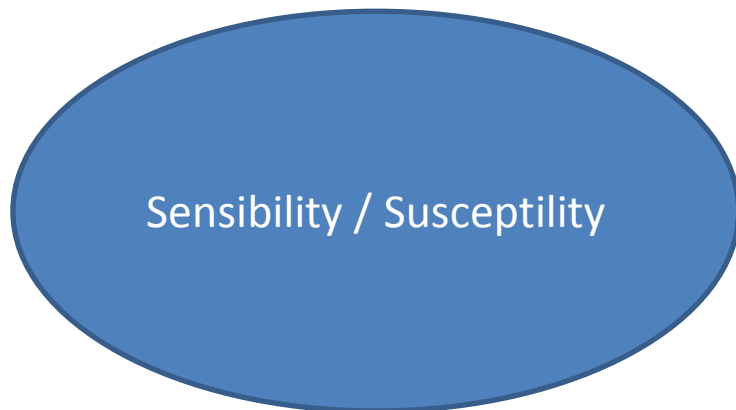
VIGNOLLI (2006) define a vulnerabilidade sociodemográfica como uma “síndrome na qual se conjugam os eventos sociodemográficos potencialmente adversos, a incapacidade para responder à materialização do risco e a inabilidade para adaptar-se ativamente ao novo quadro gerado pela mencionada materialização”.

How to assess the impacts of these disasters?

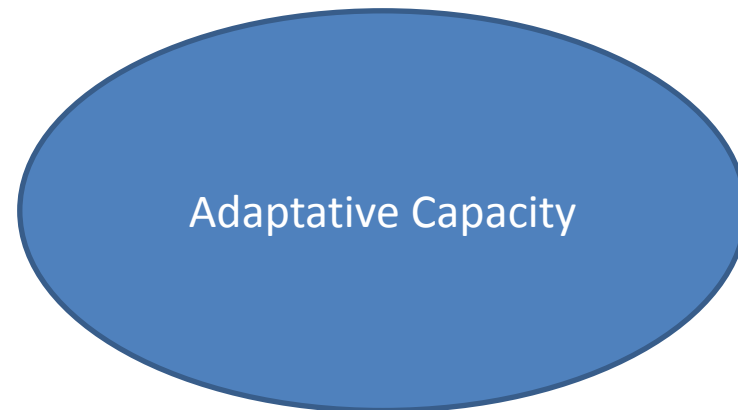
VULNERABILITY:
CLIMATE & POPULATION



ATTRIBUTES



RESILIENCE



How to assess the impacts of these disasters in NEB?

*Terms to describe characteristics of systems that are pertinent to adaptation (from Smit et al., 1999)
IPCC (2007, 2014)*

Sensitivity	Degree to which a system is affected by or responsive to climate stimuli (note that sensitivity includes responsiveness to both problematic stimuli and beneficial stimuli)
Susceptibility	Degree to which a system is open, liable, or sensitive to climate stimuli (similar to sensitivity, with some connotations toward damage)
Vulnerability	Degree to which a system is susceptible to injury, damage, or harm (one part—the problematic or detrimental part—of sensitivity)
Impact Potential	Degree to which a system is sensitive or susceptible to climate stimuli (essentially synonymous with sensitivity)
Stability	Degree to which a system is not easily moved or modified
Robustness	Strength; degree to which a system is not given to influence
Resilience	Degree to which a system rebounds, recoups, or recovers from a stimulus
Resistance	Degree to which a system opposes or prevents an effect of a stimulus
Flexibility	Degree to which a system is pliable or compliant (similar to adaptability, but more absolute than relative)
Coping Ability	Degree to which a system can successfully grapple with a stimulus (similar to adaptability, but includes more than adaptive means of "grappling")
Responsiveness	Degree to which a system reacts to stimuli (broader than coping ability and adaptability because responses need not be "successful")
Adaptive Capacity	The potential or capability of a system to adapt to (to alter to better suit) climatic stimuli or their effects or impacts
Adaptability	The ability, competency, or capacity of a system to adapt to (to alter to better suit) climatic stimuli (essentially synonymous with adaptive capacity)

*These definitions of systems characteristics are based on widely (but not unanimously) held conventions. They focus on distinguishing generic properties and do not include factors that might influence the state of a property or the forms it might take. The terms "climate stimulus" and "system" are used as established earlier.

How to assess the impacts of these disasters in NEB?

$$V = f(R \cap S \cap (W \cap \overline{CA} \cap \overline{A}))$$

The multiplication rule: Considere um conjunto finito de eventos

$$A_1 \cap A_2 \cap \dots \cap A_n$$

tais que os eventos condicionais

$$A_i | A_1 \cap A_2 \cap \dots \cap A_{i-1}$$

sejam bem definidos e tenham probabilidades positivas.

Então tem-se que:

$$P\left(\bigcap_{i=1}^n A_i\right) = P(A_1) \cdot P(A_2 | A_1) \cdot P(A_3 | A_1 \cap A_2) \dots P(A_n | A_1 \cap A_2 \cap \dots \cap A_{n-1})$$

$$V = P(R \cap S \cap \overline{CA}) = P(H \cap E \cap S \cap \overline{CA}) = P(H) \cdot P(E | H) \cdot P(S | H \cap E) \cdot P(\overline{CA} | H \cap E \cap S)$$

The Study Area: NEB

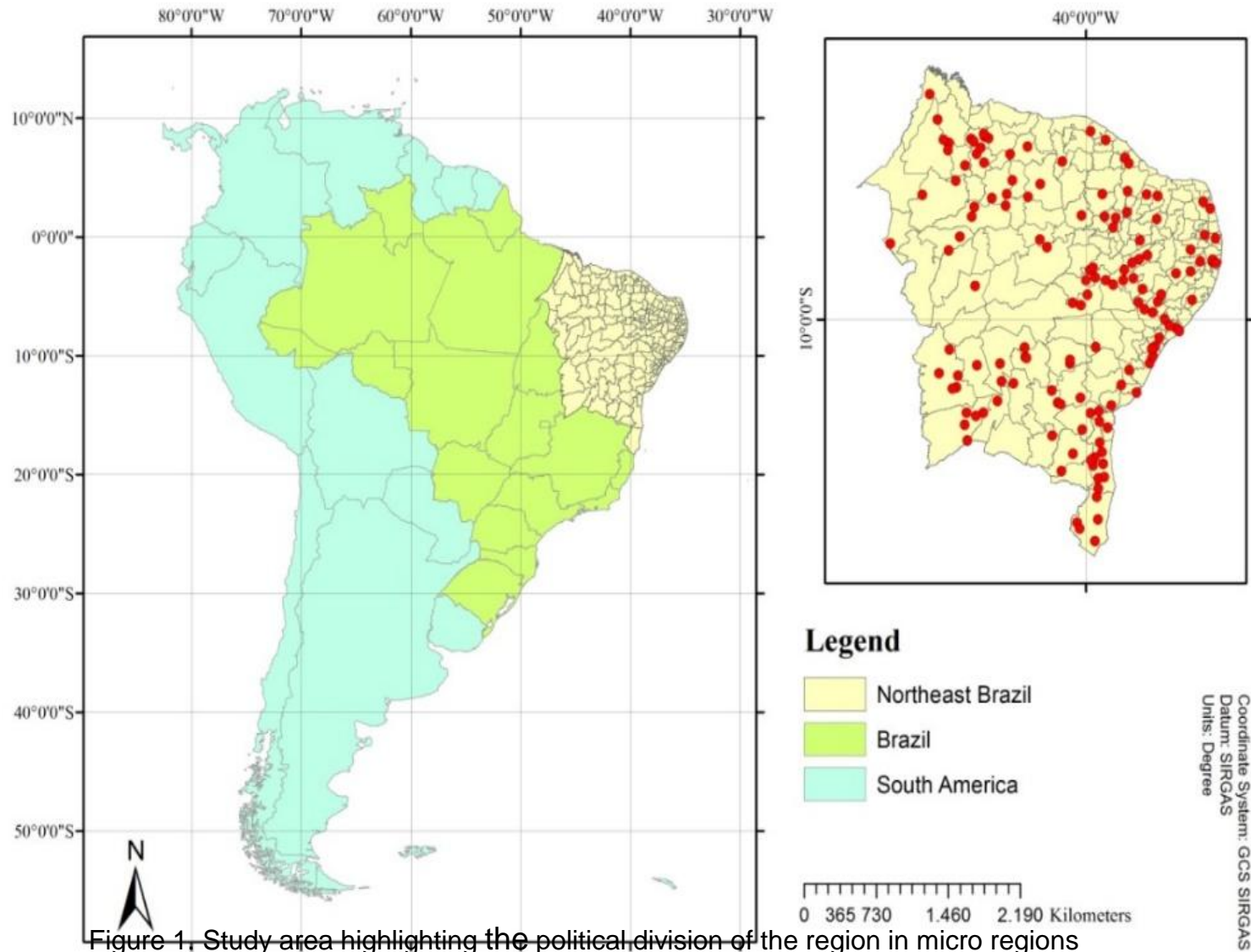
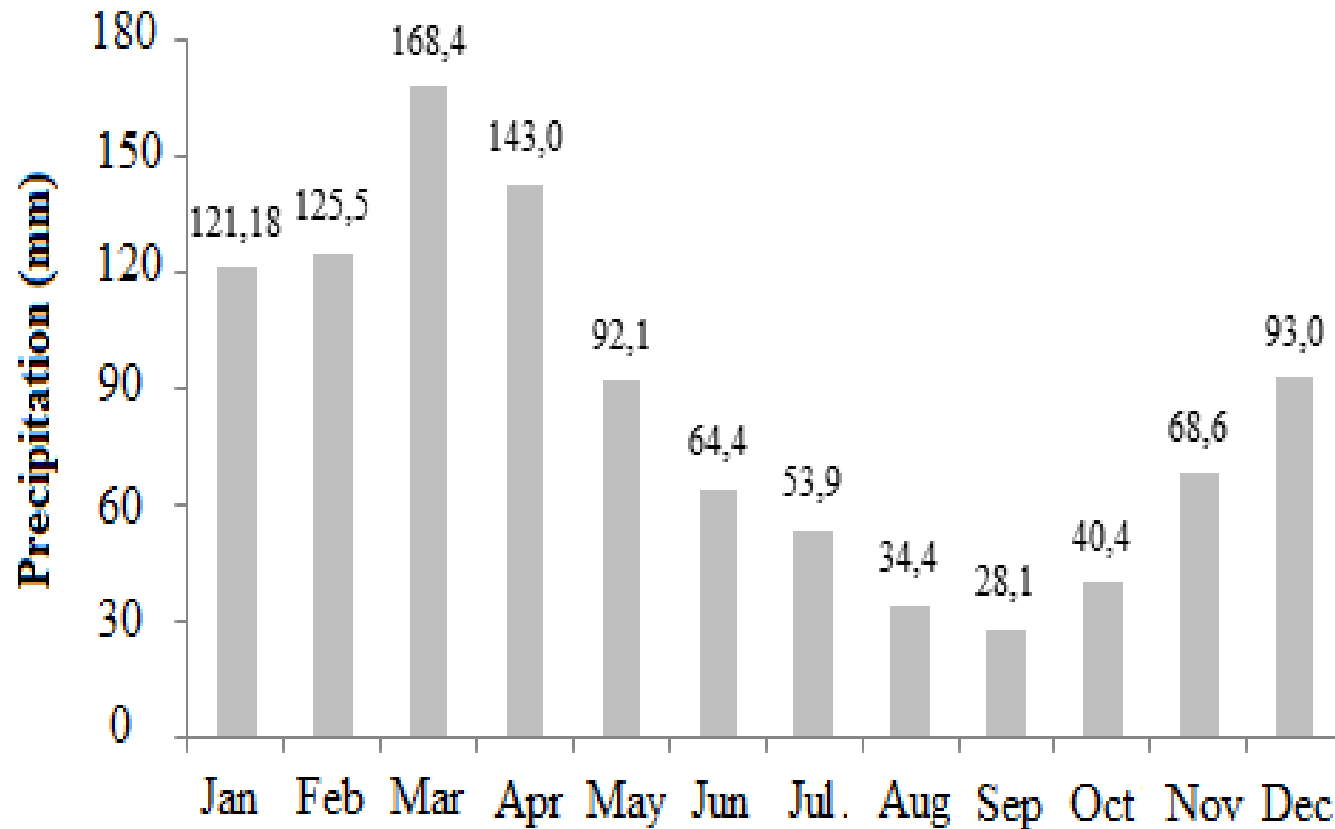


Figure 1. Study area highlighting the political division of the region in micro regions along with the gauges stations of the National Agency of Waters (ANA).

The NEB Precipitation-based Climate



Climate characterization of the rainfall in the Northeast of Brazil (NEB), 1980-2011.

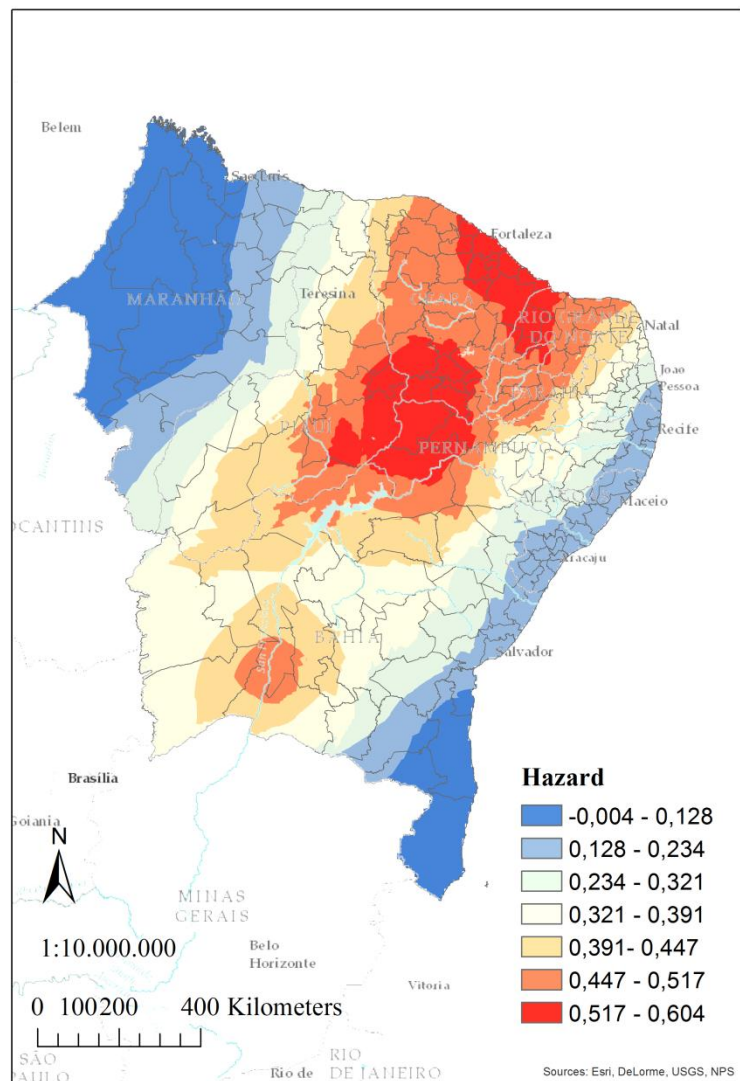
Agricultural **RISK** Indicator to Climate Extremes. A conceptual model for the Northeastern Brazil

$$\text{Risk} = \text{Hazard} * \text{Exposure}$$

Perigo climático	Variáveis	
	SPI	
	Desastres	
Exposição: uso de algum tipo de recurso hídrico (rio, riachos lagos ou açude) protegido ou não por matas (atividade econômica e subsistência) %	Lavoura temporária	
	Lavoura permanente	
	Pecuária e criação de outros animais	
	Pesca	

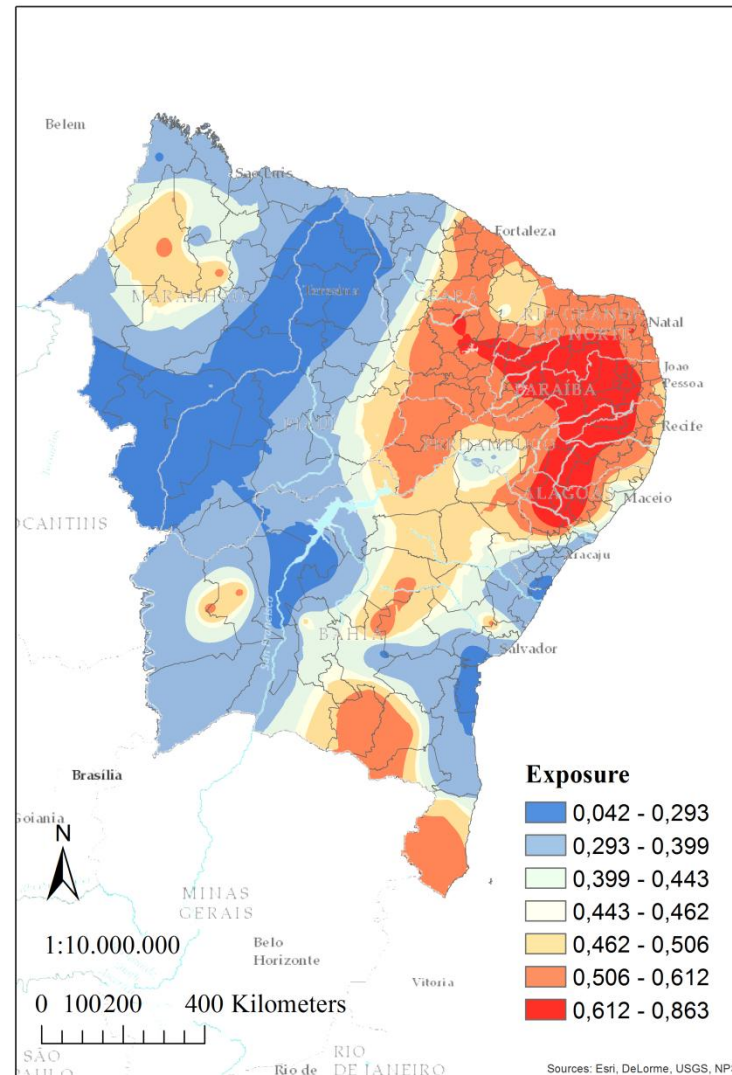
Composed Indicator characterized by drought (CID) based on the data from the BR Civil Defense, defining hazard. The exposure is based on water resources. The composition of the CID is based on the spatial SPI (**PRP, PCP, PCD, etc.**).

Agricultural **HAZARD** Indicator to Climate Extremes. A conceptual model for the Northeastern Brazil



Geographical distribution of the **Hazard** (Climate-based) factor characterized by extreme events over the NEB.

Agricultural **EXPOSURE** Indicator to Climate Extremes. A conceptual model for the Northeastern Brazil



Geographical distribution of the **Exposure** factor given **Hazard** characterized by extreme events over the NEB.

Agricultural **SUSCEPTIBILITY** Indicator to Climate Extremes. A conceptual model for the Northeastern Brazil

Sensibilidade Agrícola		
	Área dos estabelecimentos agropecuários com agricultura familiar (Hectares)	Área
	Valor total da produção dos estabelecimentos agropecuários com agricultura familiar (Mil Reais) Grau de investimento Renda total dos estabelecimentos agropecuários com agricultura familiar (Mil Reais)	Receita corrente
	Densidade demográfica da unidade territorial (Habitante por quilômetro quadrado) Dir. estabelecimento >=65anos	População
	Lavoura temporária Horticultura e floricultura Lavoura permanente	Grupo de atividade econômica
	Pecuária e criação de outros animais Lavouras - permanentes	Utilização de terras
	Lavouras - temporárias Pastagens - naturais Sistemas agroflorestais - área cultivada com espécies florestais também usada para lavouras e pastoreio por animais	

Composed Indicator to characterize **Agricultural Susceptibility**.

The composition is based on the IBGE dataset.

Agricultural Adaptative Capacity Indicator to Climate Extremes. A conceptual model for the Northeastern Brazil

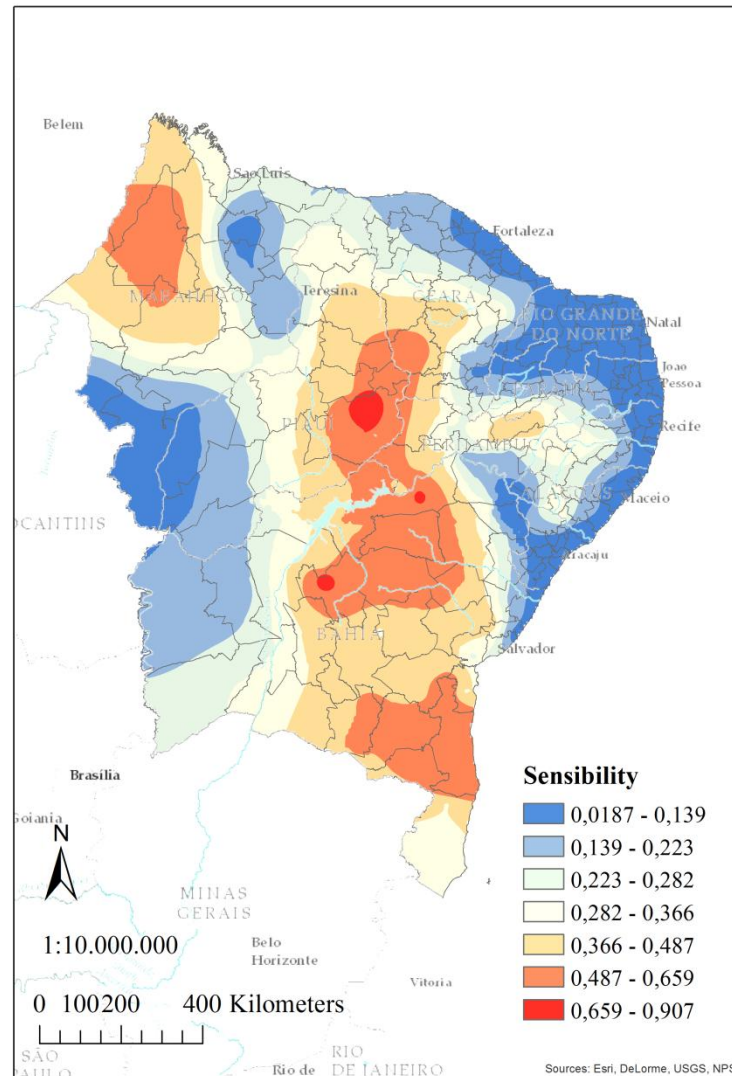
Adaptative Capacity

Capacidade de adaptação		
	<p>Área dos estabelecimentos agropecuários com uso de irrigação (Hectares)</p> <p>Variável = Número de máquinas e implementos agrícolas existentes nos estabelecimentos agropecuários (Unidades)</p> <p>Uso de adubação</p> <p>Alfabetização de adultos</p> <p>Ensino fundamental completo (1º grau)</p> <p>Ensino médio ou 2º grau completo (outro)</p> <p>Nenhum, mas sabe ler e escrever</p> <p>Não sabe ler e escrever</p> <p>Tipo de alternativa para controle de pragas e/ou doenças em vegetais</p>	<p>Tecnologia envolvida na produção</p> <p>Nível educacional</p>
	<p>Plantio em nível</p> <p>Rotação de culturas</p> <p>Uso de lavouras para reforma e/ou renovação e/ou recuperação de pastagens</p> <p>Queimadas</p> <p>Proteção e/ou conservação de encostas</p> <p>Taxa de estabelecimentos que utilizam alguma fonte de energia renovável</p> <p>Número de estabelecimentos que obtiveram financiamento (Unidades)</p> <p>Produto Interno Bruto a preços correntes médio (2010-2013)(Mil Reais)</p> <p>Número de estabelecimentos agropecuários em que o produtor declarou ter atividade fora do estabelecimento no ano (Unidades)</p>	<p>Práticas agrícolas</p> <p>práticas ambientais</p> <p>Aporte financeiro</p>

Composed Indicator characterizing Agricultural **Adaptative Capacity**.

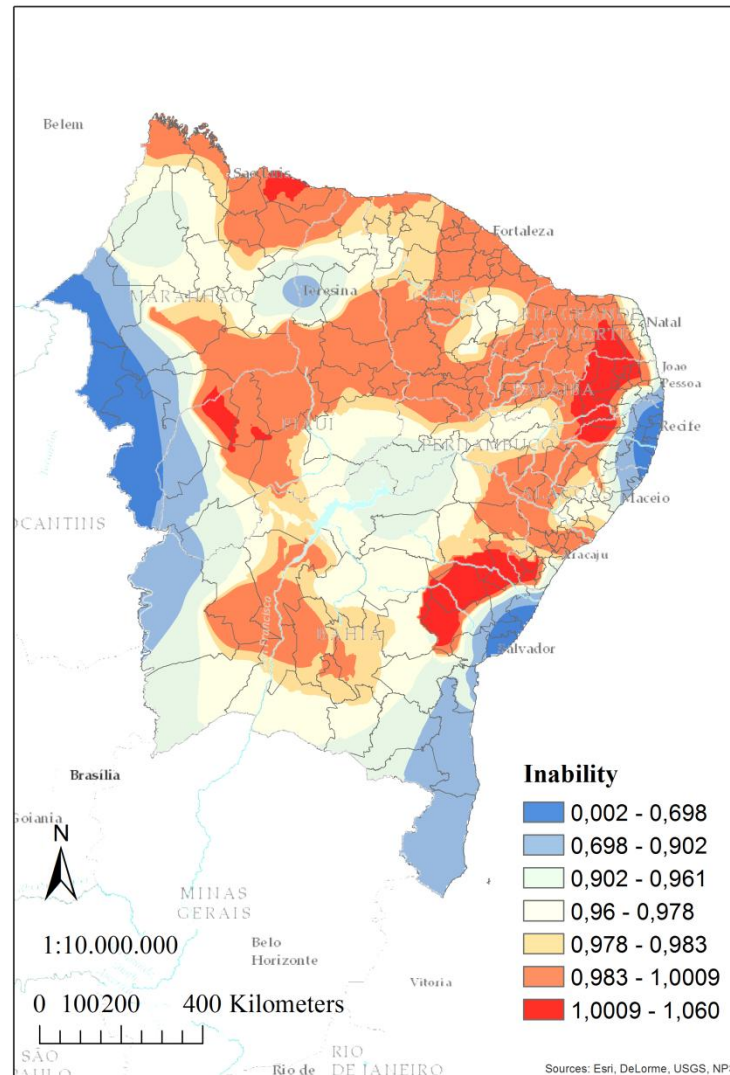
The composition is based on the IBGE dataset.

Agricultural **SUSCEPTIBILITY** Indicator to Climate Extremes. A conceptual model for the Northeastern Brazil



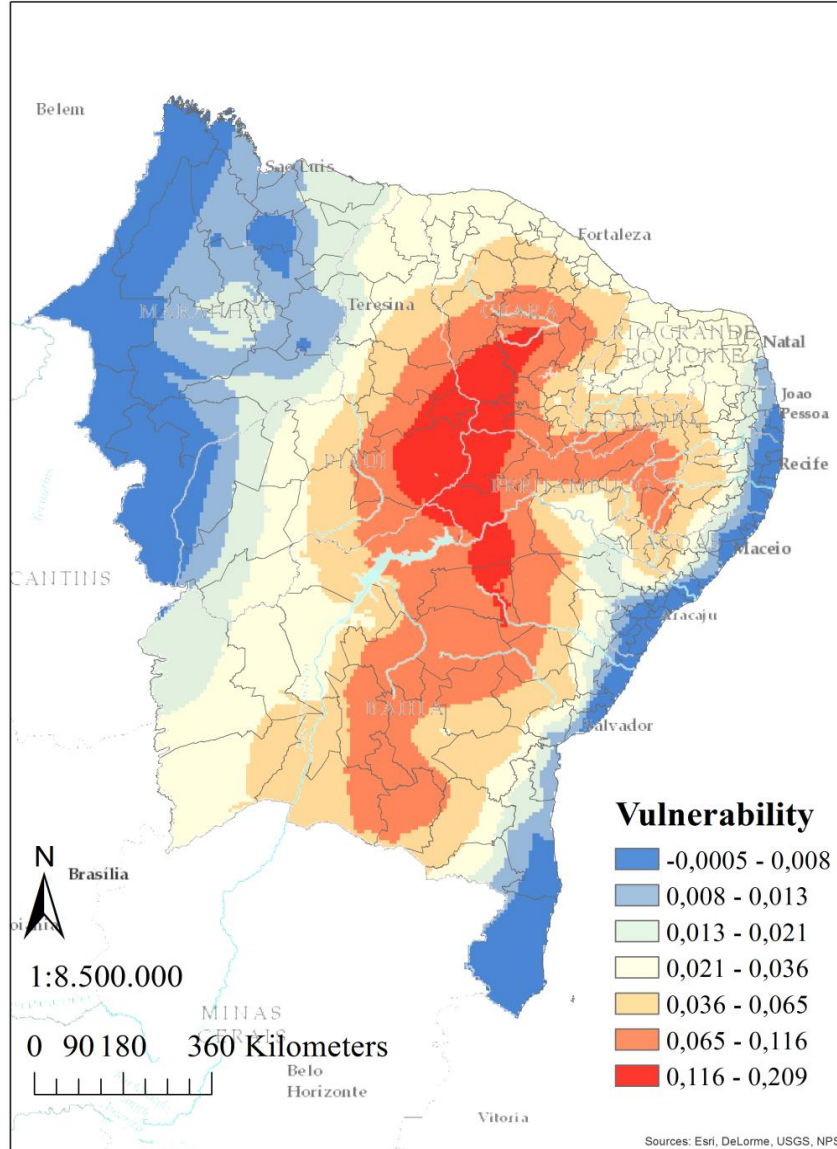
Geographical distribution of the **Susceptibility** factor given (**Hazard** and **Exposure**) characterized by extreme events over the NEB

Agricultural **INABILITY** Indicator to Climate Extremes. A conceptual model for the Northeastern Brazil



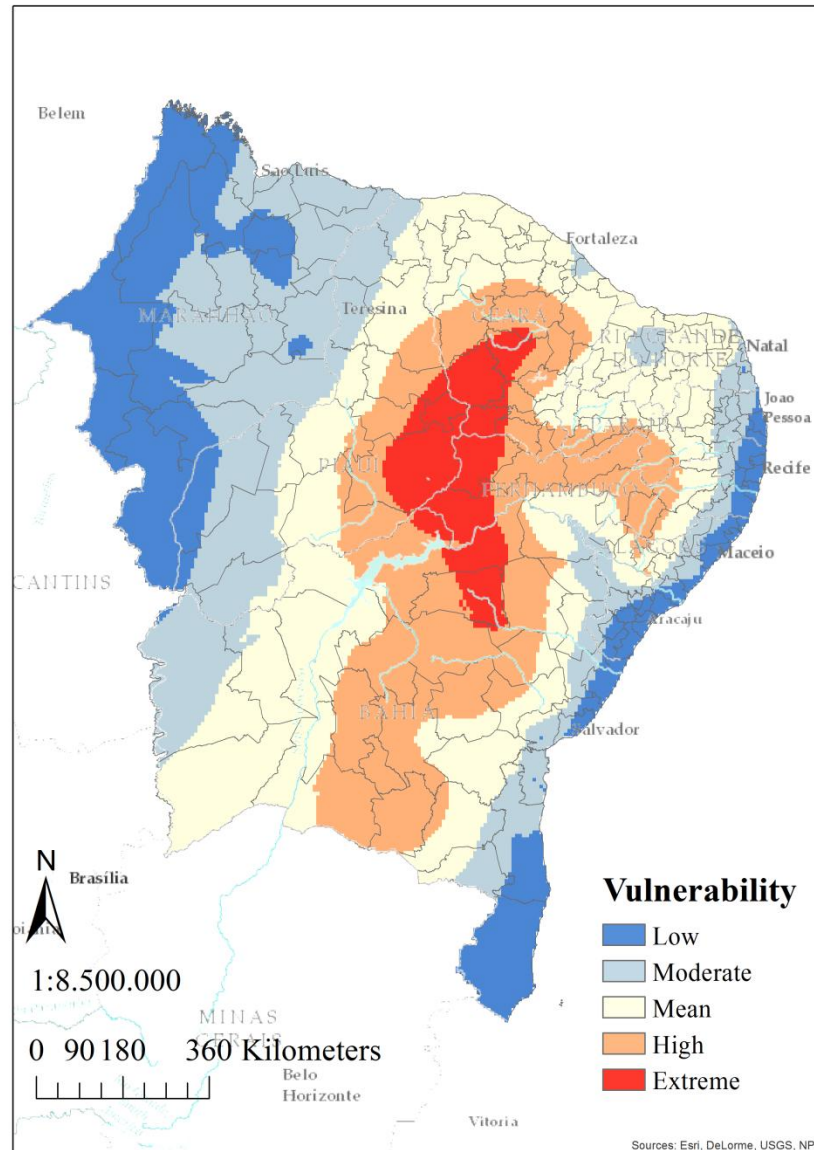
Geographical distribution of the **Inability** factor given (**Hazard, Exposure** and **Susceptibility**) characterized by extreme events over the NEB

Agricultural **Vulnerability** Indicator to Climate Extremes. A conceptual model for the Northeastern Brazil



Geographical distribution of the **Vulnerability** factor given (**Hazard, Exposure and Susceptibility and Inability**) characterized by extreme events over the NEB

Agricultural Vulnerability Indicator to Climate Extremes. A conceptual model for the Northeastern Brazil



Geographical distribution of the **Categorical Vulnerability** factor given (**Hazard, Exposure and Susceptibility and Inability**) characterized by extreme events over the NEB

An agr climatological vulnerability-probability-based model for the Brazilian rural population

Quarta-feira dia 7/junho, eixo 2- Métodos e/ou modelagem para avaliação dos riscos e de impactos de desastres.

Sociodemographic typology of municipalities for the Brazilian semiarid: an approach *via* grade of membership (gom)

Tuarta-feira dia 6/junho, Sessão Especial- Ciência, Riscos e Desastres.

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