

# Sensitivity Analysis for the Assessment of Adaptive Capacity to Climate Change: A case of study from Brazil

Ileana Grave, Luis A. Bojórquez-Tapia, Alejandra Estrada-Barón,  
Donald R. Nelson, Hallie Eakin

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Evaluate the sensitivity of household rankings to the uncertainty of both criteria weights and criteria magnitudes used in adaptive capacity indices

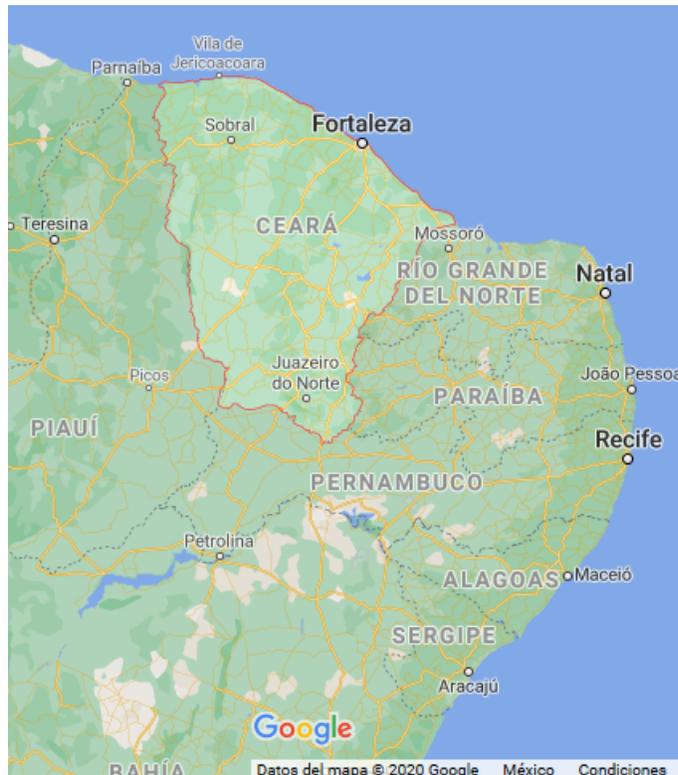
Our approach draws from Triantaphyllou (Triantaphyllou and Sánchez, 1997) to identify the most critical indicators.

The analysis entailed two tests:

- 1) Indicator removal
- 2) Threshold value

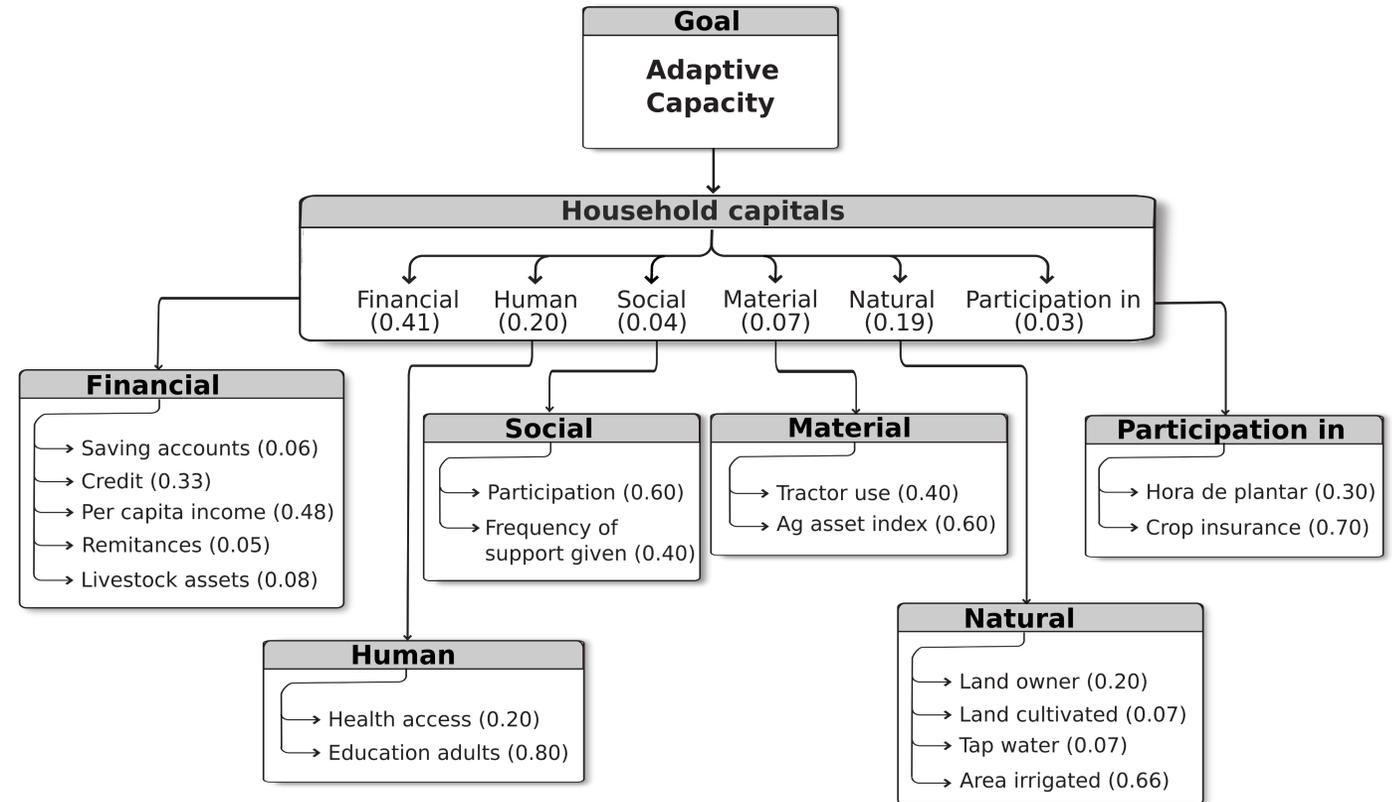


# Explore the role of anti-poverty conditional cash transfer programs in building Adaptive capacity in the state of Ceará, Brazil



Which indicators were the most influential in the household rankings and whether such an influence varied between the surveys of 1998 (n=484) and 2012 (n=477)?

- Five indicators were not measured in 1998:
  - Saving accounts
  - Health access
  - Participation
  - Frequency of support given
  - Crop insurance
- One indicator was not measured in 2012:
  - Hora de plantar



The global importance weights are rescaled linearly setting to zero the weights for the missed indicators



## Adaptive Capacity Index: weighted linear combination

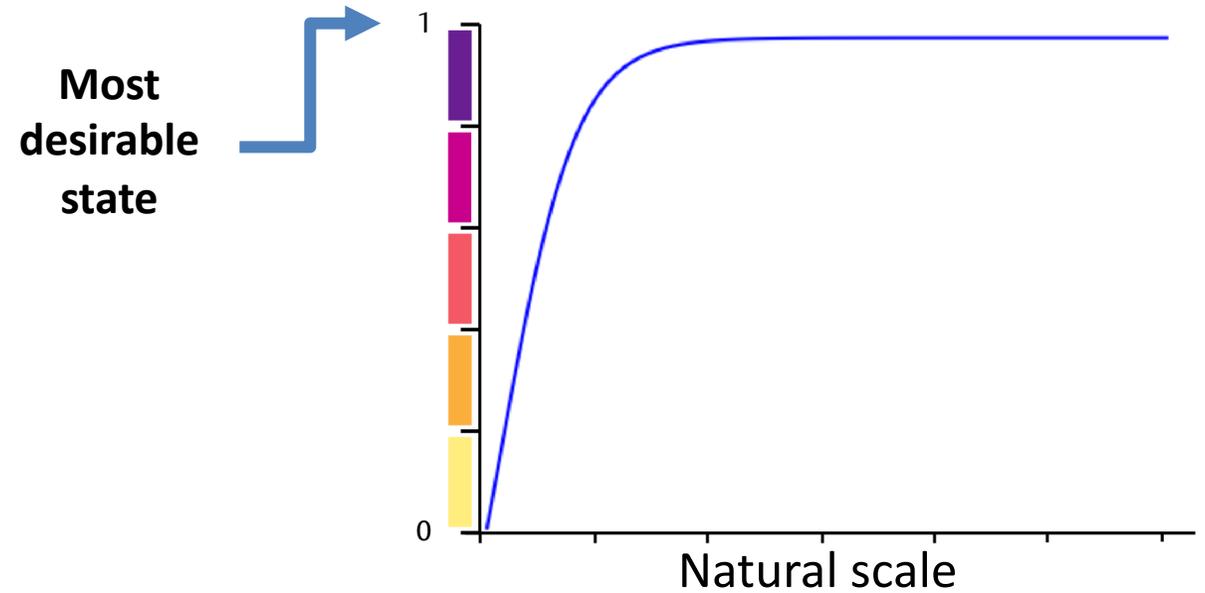
For each household,  $h$ , the vulnerability index,  $i$ , is obtained as

$$V_i^h = \sum_j^J w_{ij} x_{ij}^h$$

where

$w$  is the weight of an indicator  $j$

$x$  is the standardized score





## Indicator removal test (steps)

1. Set to zero the weight for indicator  $r$  ( $w_{ir} = 0$ )
2. Rescale the remaining indicator weights linearly ( $w'_{ij} = w_{ij} \div \sum_{j \neq r}^J w_{ij}$ )
3. Generate the respective household vulnerability index ( $V_{ij \neq r}^h = \sum_{j \neq r}^J w'_{ij} x_{ij}^h$ ).
4. Calculate the change (in percentage) of the median vulnerability by the removal of the  $r$ -th indicator

$$V_{ir}^{\Delta Q_2} = \left| \frac{V_{ij \neq r}^{Q_2} - V_i^{Q_2}}{V_i^{Q_2}} \right| \times 100$$

where  $V_{ij \neq r}^{Q_2}$  is the median vulnerability by the removal of the  $r$ -th indicator and  $V_i^{Q_2}$  is the median vulnerability of all the indicators



## Threshold value test

It is based on the concept of the probability of “rank reversal” between the vulnerability scores of a household  $V_i^h$ , and some reference value  $V_i^\rho$ , resulting from changing the standardized scores  $x$ .

If  $V_i^\rho \geq V_i^h$  swaps to  $V_i^\rho < V_i^h$ , or if  $V_i^\rho \leq V_i^h$  swaps to  $V_i^\rho > V_i^h$

Calculations:

- 1) Rank reversal change value
- 2) Feasible changes
- 3) Probability of rank reversals
- 4) Critical indicator value

\* Based on the work by Triantaphyllou (Triantaphyllou, 1997)



## Threshold value test\*: $\tau_{ij}^h$

The change required to generate a rank reversal is calculated as

$$\tau_{ij}^h = \frac{V_i^h - V_i^\rho}{w_{ij}}$$

Note: the feasible change for each indicator is conditioned to the range  $x_{ij}^h - 1 \leq \tau_{ij}^h \leq x_{ij}^h$  to avoid changes  $\bar{x}_{ij}^h = x_{ij}^h - \tau_{ij}^h$  of a standardized score  $x_{ij}^h$  to be outside the standardized value [0,1].

\* Based on the work by Triantaphyllou (Triantaphyllou and Sánchez, 1997)



## Threshold value test: Critical indicator value $C_{ij}$

It is obtained by the product of the probability  $p_{ij}$  of rank reversals and the sensitivity coefficient

$$s_{ij} = \frac{1}{\Delta_{ij}}$$

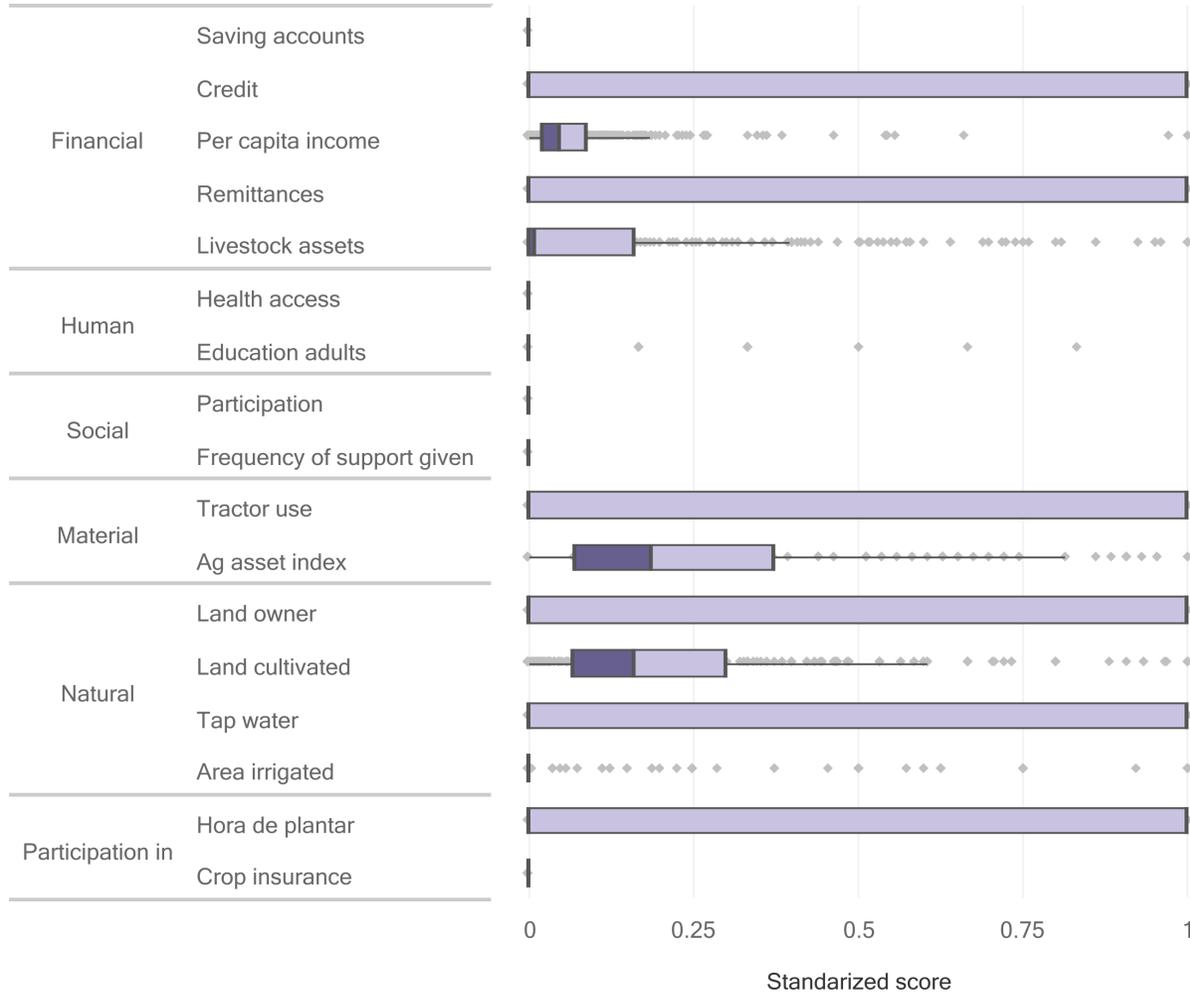
where  $\Delta_{ij} = |\tau_{ij}^h|^{Q_m}$  is taken for a particular quantile  $Q_m$ . Thus, the higher the frequency and magnitude of rank reversals, the higher the criticality of a criterion.

\*When  $V_i^h = V_i^p$  the sensitivity coefficient goes to infinity, in this case,  $\Delta_{ij}$  is approximated with 0.001.

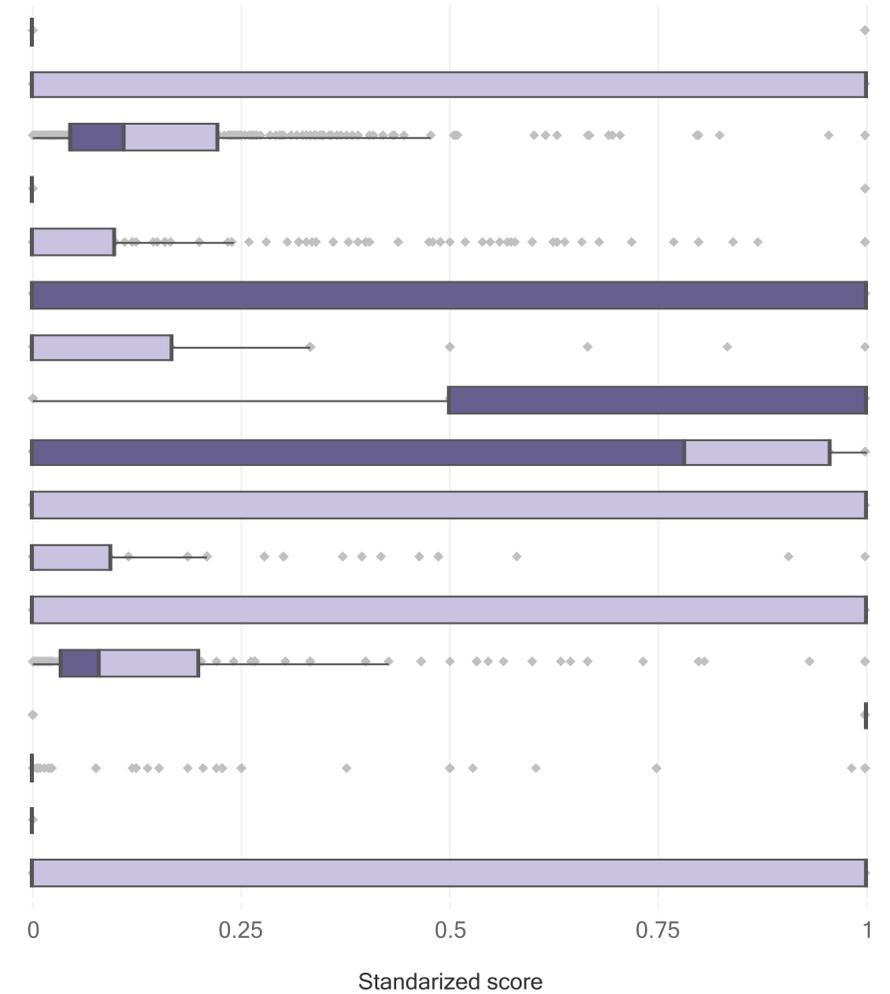


# Box plots of the standardized scores of Adaptive capacity indicators

## Adaptive capacity indicators: survey 1998

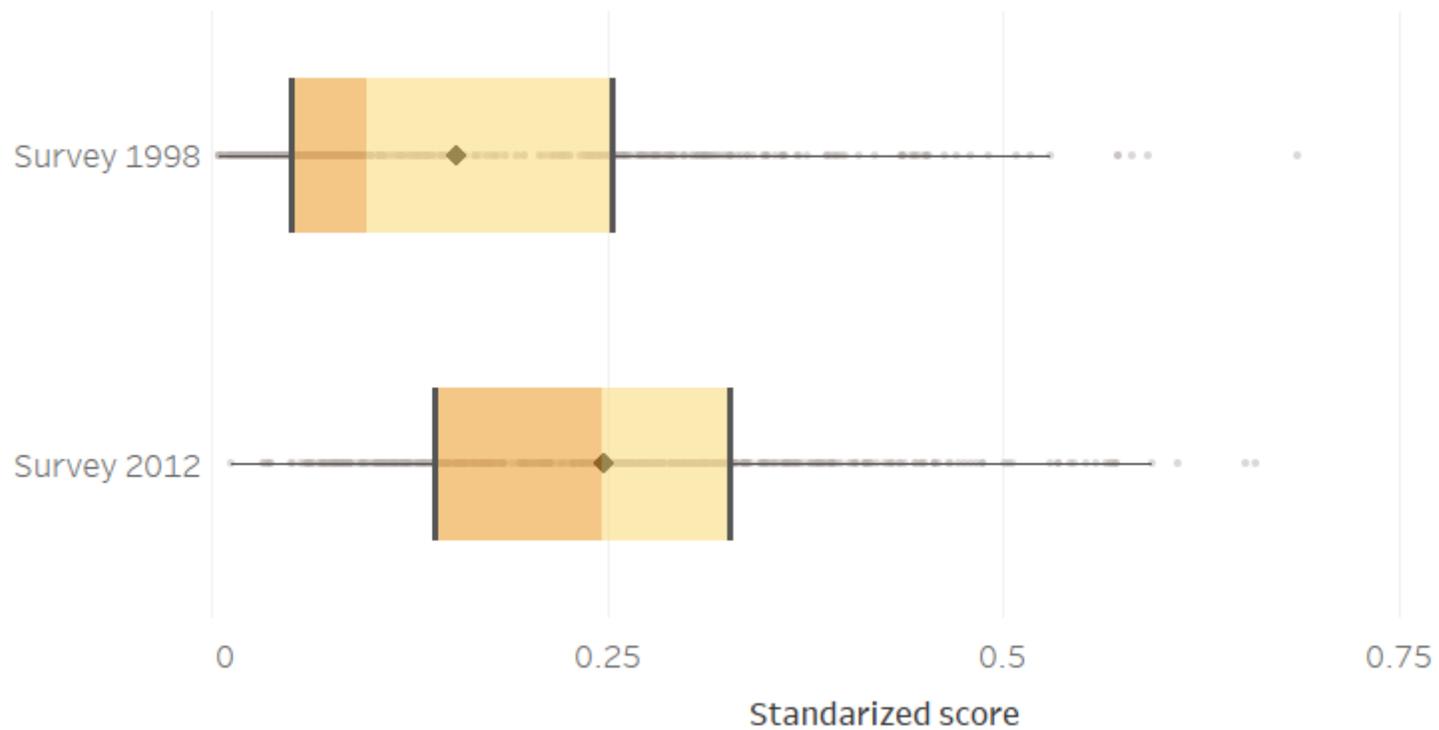


## Adaptive capacity indicators: survey 2012



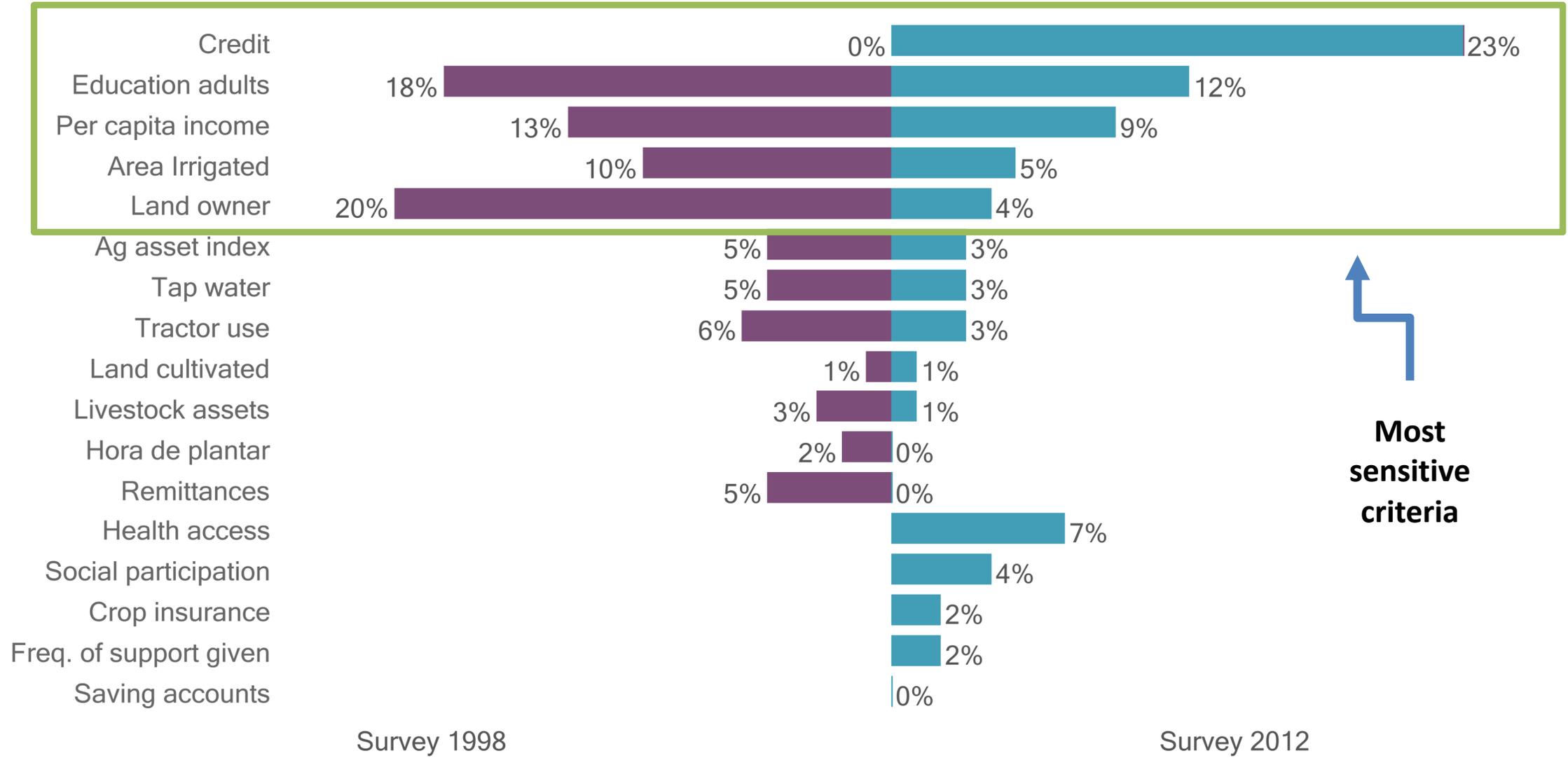


## Box plots of the standardized scores of Adaptive capacity index





## Results of the indicator removal test





## Results of the threshold value test

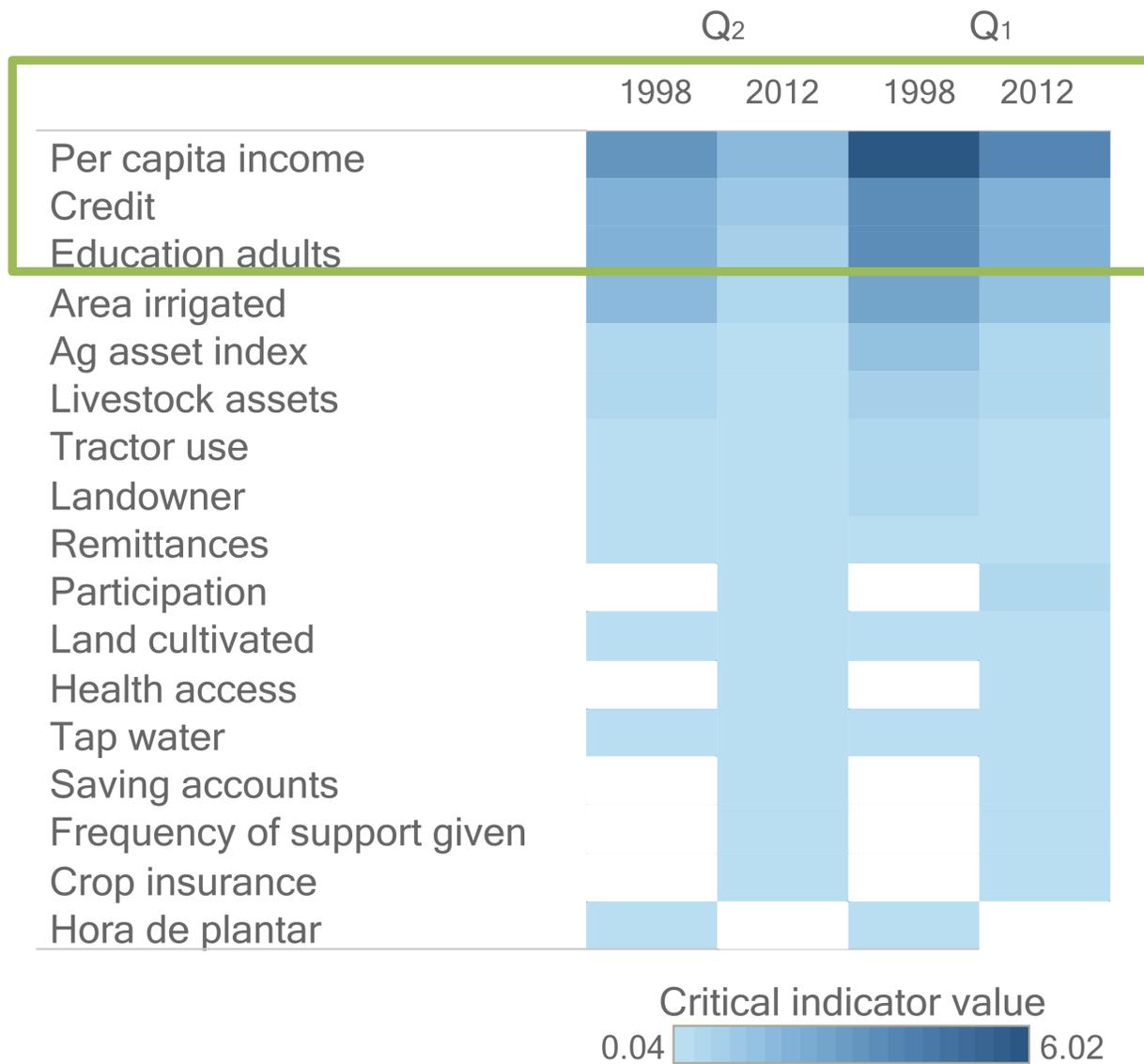
Sensitivity coefficient,  $s_{ij}$  and the probability of rank reversals,  $p_{ij}$  for adaptive capacity indicators

Capital / Indicator	1998			2012		
	$s_{ij}^{Q_2}$	$s_{ij}^{Q_1}$	$p_{ij}$	$s_{ij}^{Q_2}$	$s_{ij}^{Q_1}$	$p_{ij}$
<b>Financial</b>						
Saving accounts	—	—	—	2.17	3.37	0.07
Credit	3.3	5.65	0.61	1.84	3.03	0.66
Per capita income	5.89	11.08	0.54	2.60	6.24	0.61
Remittances	1.73	3.28	0.10	1.90	3.32	0.06
Livestock assets	1.76	3.62	0.22	2.85	5.24	0.08
<b>Human</b>						
Health access	—	—	—	2.04	3.13	0.11
Education adults	3.98	6.52	0.51	1.87	4.25	0.44

High sensitivity coefficient  
and  
low probability of rank reversal



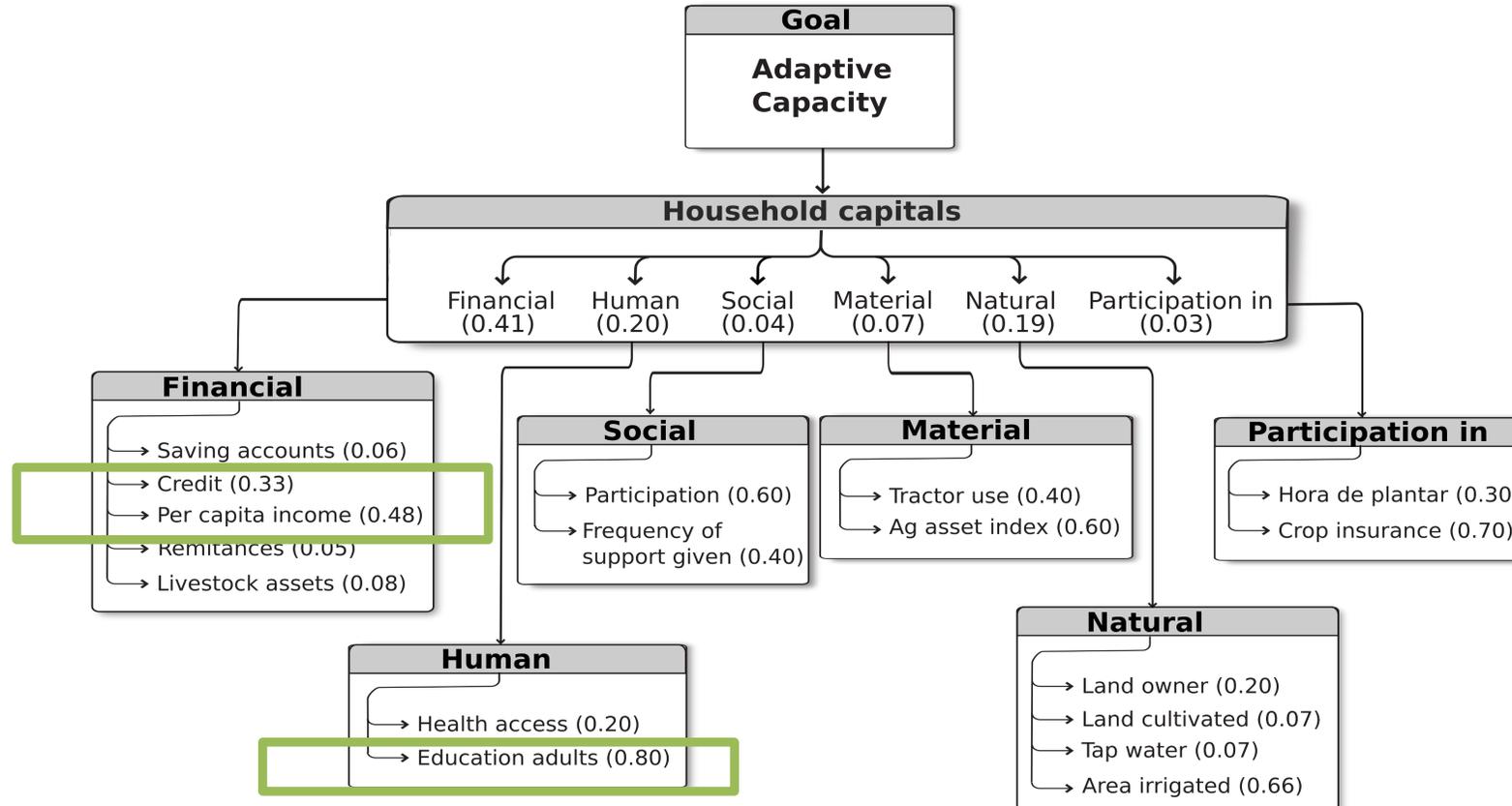
## Results of the threshold value test



←  
**Most sensitive criteria**



# Most important criteria





## Most important vs most sensitive criteria

Ranking	Importance	Indicator removal test		Critical indicator value
		1998	2012	
1	Per capita income	Land owner	Credit	Per capita income
2	Education adults	Education adults	Education adults	Education adults
3	Credit	Per capita income	Per capita income	Credit

- For the indicator removal test, the most critical indicator in the 1998 survey is one with medium importance (land owner).
- Five indicators were not measured in 1998 and one in 2012, a comparison between surveys showed a decrease in the critical indicator value between 1998 and 2012 for the most sensitive adaptive capacity indicators, but the sensitivity rank was preserved.



- In order to identify the most influential vulnerability indicators for household rankings, it is important to consider the uncertainty involved in the magnitudes and weights of the standardized scores of vulnerability indices.
- Vulnerability indicators which were ranked as the most important were not necessarily the most influential and changes generated by certain indicators cannot be ignored.
- Even when the uncertainty in the judgments and magnitude evaluation is considered, only indices defined as linear combinations can be analyzed. However, this also gives a wide field of applications in problems related with land suitability, environmental impact assessment and socio-ecological vulnerability indicators.

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