Complex Socio-Ecological Dynamics driven by Extreme Events in the Amazon”

“Food Insecurity and Climate Change Brazilian Amazon” project

Patricia Pinho
Interdisciplinary Center for Climate Change Research
University of São Paulo
May 13th 2015
Anthropogenic Earth System Alterations over the last Century

Ozone depletion

CO2 Increase

Northern Hemisphere Temperature increases

Number of Climatic Disasters Increase
Extreme Events

- Southeast Asian tsunami (2004)
- Hurricane Katrina (2005)
- Pakistan earthquake, together with the **bird flu** (2005);
- Continuing droughts in Africa

### Amazon Extreme Droughts
- 1997
- 2005
- 2010

### Amazon Extreme Floods
- 2006
- 2009
- 2015

Illustrate the potential vulnerability of human society to disturbances and variability (Jansen & Ostrom 2009)
Some Extreme unusual events during 2007-2010-South America

- Drought Solimões river (2010)
- Floodings in the Amazon (2009)
- Rainfall Alagoas (2010)
- Rainfall São Paulo (2010)
- Storm Agatha Central America (2010)
- Floods Colombia (2008)
- Cold Wave Bolivia (2010)
- Rainfalls/Landslides Andes Central Peru (2009)
- Rainfalls/Landslides Ilha Grande (2010)
- Intense rainfalls S.Brazil/Uruguay (2009)
- Rainfall Vale do Itajai (2008)
- Drought S. Venezuela (2009)
- Intense rainfalls S.Brazil/Uruguay (2009)
- Cold Wave Bolivia (2010)
- Rainfall Alagoas (2010)
- Rainfall São Paulo (2010)
- Storm Agatha Central America (2010)
- Floods Colombia (2008)
- Cold Wave Bolivia (2010)
- Rainfalls/Landslides Andes Central Peru (2009)
- Rainfalls/Landslides Ilha Grande (2010)
- Intense rainfalls S.Brazil/Uruguay (2009)
- Rainfall Vale do Itajai (2008)
The Amazon Basin and Extremes Events

• Constant Temperature

• Seasons are Hydrological: flooded and non-flooded seasons -> predictable

• Region does experience inter-annual variability in the amplitude, height and timing (onset and end) of the rainy seasons.

• These are influenced by the El Ninõ Southern Oscillation (ENSO) and the tropical Atlantic, which can cause droughts or heavy floods.

• Projections shows that variability hydrological extremes is increasing (IPCC 2007).
Amazon in the context of a changing climate

We explore:

1. Whether there is a real increase in variability

2. Whether the community perceives that recent extreme events are outside the experience which shapes their responses to ‘normal’ levels of variability -> severe impacts on:
   - Food Security
   - Health
   - Infrastructure

3. What science-based policy could contribute to greater local resilience.
Regions of Case Study

Central Brazilian Amazon

Legend

- >100,000
- 50,000 to 100,000
- 30,000 to 50,000
- 10,000 to 30,000
- <10,000

Silves Municipality

Eduardo Giglioti's map
Pristine forest and drivers of socio-ecological change

Developmentalists Programme: Agricultural expansion, Markets, Institutional Arrangements which influence the spatial and temporal patterns of deforestation.
• Severe droughts in Amazonia, like that of 1997 and 2010 are El Niño-related.

• 2005 drought related to the rainfall anomalies over SW Amazonia driven by sea surface temperature anomalies in the Tropical North Atlantic.

• Severe Floods (2009 and 2012) associated with La Ninã

• Both Extremes returning in 100 years time!

Tomasella, CEMADEN
The flow of the river and flood pulse

- Dictate ecological patterns
- Human settlements
- Land tenure
- Production (economy)
- Social organization
Hydrological Seasons and Food System
Hidden Social Dimension

- 30 million people living in the region
- 29% of the population is indigenous but also rich diversity of other ethnic groups, including Afro-Brazilian communities, traditional inhabitants, and migrants from other regions of the country.
- Income-based poverty, in the Amazon affects up to 42% of the population – whereas for the entire country it is 28.8% (IBGE 2010)
- Livelihoods of the poor residing in these areas are highly dependent upon, and sensitive to, changes in the provision of the prevailing ecosystem services.
Severe Droughts
Impact on Local Communities

- High fish mortality
- Isolation
- High mortality of crops
- Difficulty to cultivate subsistence crops (for instance manioc – staple food)
- Lack of clean drinking water
- Interrupted Transportation
- Interrupted Health
- Education

Solimões River, 2005 Drought
2005 drought
Isolated communities in Silves, central Amazon
Interrupted Transportation – isolation
Interrupted access to market -> exacerbating food insecurity
Interrupted access to market -> exacerbating food insecurity

Closed communication to get access to water and goods, and
Extreme Floods: Impact on Local Communities (urban and rural)

Low Yield return in fisheries -> Fish spread out during high water level & difficult to catch in normal years – extreme floods it is even worse.

Difficult to maintain livestock and husbandry

High mortality of crops

Lack of clean drinking water

Health: incidence of malaria outbreaks diarrhea increases specially in infants and elderly

Infrastructure (houses and business) destroyed

Source: Folha de Sao Paulo (Maio, 2012)
## Local Perceptions and responses about Extremes

<table>
<thead>
<tr>
<th>Ecological features affected (as described by local Amazonia people)</th>
<th>Early Warning Signals (variability)</th>
<th>Cultural Adaptive Responses</th>
<th>Limitations to local adaptive responses in extreme events (uncertainty)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Hydrological Regime</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rising water</td>
<td>Observe rain and hydrological regime Knowledge about rain patterns at regional scale</td>
<td>Mobility Hydrological daily measures Predicting the length of the seasons</td>
<td>Uncertainty about ecological system in extremes Lack of robust predictability</td>
</tr>
<tr>
<td>Full water</td>
<td>Receding water</td>
<td>Dry (rivers and lakes)</td>
<td></td>
</tr>
<tr>
<td><strong>Fisheries</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fish species behavior</td>
<td>Observing salient fish species behavior: breeding, feeding, sheltering and migration</td>
<td>Integrated understanding of the amphibious habitat Droughts allow maximized yield</td>
<td>Habitat changes dramatically no time for rapid turning over the ecological system Food shortage causing reduced social system resilience Increased social conflict over natural capital</td>
</tr>
<tr>
<td><strong>Forest (timber and non timber)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Forest services, food species, forestry</td>
<td>Phenological observations: opening of leaves; return of migratory birds</td>
<td>Flood increases forest productivity Flood allows the logging season In dry season can harvest of non-timber products (e.g. rubber)</td>
<td>Loss of forestry production Loss of non-timber productivity Uncertainty of impact on forest productivity Perceived alteration of fauna species behavior associated with forest</td>
</tr>
<tr>
<td><strong>Agriculture and livestock</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Manioc cultivation (Other subsistence cultivation) Livestock (cattle, chicken, pigs)</td>
<td>Observations river water level Observation of rain Phenological observations</td>
<td>Multi-resource uses strategies Livestock serve as an exchange currency if food low</td>
<td>Extreme drought reduces productivity and livestock Short floods reduce productivity; Extreme floods reduce productivity, make cultivation impossible, kill livestock Food insecurity</td>
</tr>
</tbody>
</table>
Bigger Peaks

*Decreased minimal flows*

*Increasing Amplitudes*
Uncertainty altering Coping Range

Inter annual Variability

vulnerability
Public Policy Responses in Extreme in the Amazon

The civil defense are in charge:

- to give technical support and financing reconstruction activities.
- preventive actions
- to evaluate and reduce risks
- readiness for actions as mitigation
- problem solving
- In adverse events to alleviate and reduce human suffering

The reality for Civil Defense Action

- Lack of Personal and Capacity at the Municipal Level
- Delay in actions during extreme events
Governance:
implications for policy & management responses

• Better governance to secure social wellbeing, food and livelihood and natural resources conservation under the uncertainty of extremes.

• The Civil Defense should invest more time and resources in proactive instead of reactive actions in the region.

• The State could collaborate with investing in better roads and transportation, education and establishment of clean drinking water (wells) – all basic needs that should be provided in order to increase the resilience and reduce the vulnerability of the local inhabitants.

• The actions at the federal and state level needs to be a nested enterprise that would reduce severely the number of people impacted and disrupted by extreme events like this in the Amazon basin.
Final Remarks

• Local communities in the Amazon are really well adapted to the interannual variability – and respond very well and in an optimum manner to this;

• For them, seasons are hydrological and over time have developed skills and shared knowledge systems to cope with and manage their natural resources;

• As the extreme events are becoming more frequent it is uncertainty that is increasing the vulnerability of these communities rather variability.

• The Amazonia communities are vulnerable but resilient, however these extreme events are out of their learned coping range – haven’t experienced it over their lifetime.

• Extremes in the Amazon only exacerbates the remoteness of these communities: from market, basic infrastructure, education, health and governance.
Conclusion

1. Hydrological analyses suggest that variability is indeed increasing, in line with expectations from future climate change.

2. Current measures of hydrological regimes do not predict years with social hardship very well.

3. Interviewees in two regions are able to express their strategies for dealing with ‘normal’ variability very well, but also identify ways in which abnormal years exceed their ability to cope.

4. Current civil defense arrangements struggle to deliver emergency assistance in a sufficiently timely and locally appropriate fashion.

5. Combining these insights in the context of social–ecological change, we suggest how better integration of science, policy and local knowledge could improve resilience to future trends, and identify some contributions science could make into such an arrangement.
Further steps

• **Module 3: Household food insecurity**

• **Aim:** Understanding household vulnerability to (and recovery from) food insecurity – Dr. *Luke Parry*, Lancaster University.

How vulnerability to food insecurity is influenced by both food prices and other dimensions of adaptive capacity at household, neighbourhood and city-scales.

We predict that a significant increase in industrialized food prices would have severe impacts on households with low internal adaptive capacity (e.g. limited income, assets), weak social networks (i.e. limited support from neighbours) and/or limited potential for municipal intervention (i.e. poorly functioning social and health services).
Other projects

- "Climate Change Mitigation and Avoided Deforestation and commodity agriculture: assessing private sector innovation for sustainable coffee and cattle in Brazil"  Oxford University, University of Michigan, University of Sao Paulo, Rainforest Alliance , IMAFLORA, CGIAR Program on Climate Change , and CCAFS Agriculture and Food Security ; PI: Dr Arun Agrawal (UM)

- "Governance of land-use change: a collaboration to understand the impacts of institutional arrangements on Amazonian Forest resource use." FAPESP: 2013/50105-3; Cooperation between FAPESP & University of Michigan; PI: Dr . Arun Agrawal (University of Michigan, USA) , and Dr Patricia Pinho.
Thank you!
Obrigada!
“...if we can identify the true source of our own desire for an unspoiled natural paradise...we might see not only the richness of life forms but also the experience that exists within Amazonia. Then, we can resist the tendency to dehumanize or erase whole populations and we will be able to respond in a less uniform and effective manner to this world of different people, plants and animals.”

“Entangled Edens: Visions of the Amazon”: Candace Slater, 2002