Disaster Risk Reduction

RISK is the (measurable) probability that a hazard turns into a disaster.

RISK can not be eliminated, but it can be managed.

International goals adress the priorization of management of RISK instead of management of disasters.
Research areas

Epidemiology
Precipitation Modeling
Climate dynamics (multi-scale)
Extreme events
Risk modeling (measurement scales, multidimensionality, economy)
Hydrological models
Urban mobility
Areas (Maths):

Statistics
Complex networks
Econometrics
Ordinary differential equations
Partial differential equations
Project 1: Modelling rainfall with applications to flood risk and food insecurity:

- Need of a global index for flooding
- Latest climate models work at 0.5° resolution
- Impossibility to use hydrological information
- We still want to include soil information

Autoregressive structure as weighting scheme:

$$P_i = \sum_{j=0}^{364} w_{ij} p_{i-j}$$

Effective quantity of retained rainfall

Question: how to calibrate the weights?
TAMSAT can be applied at individual locations or country-wide, but needs accurate information on soil and crop types.

TAMSAT does not make use of predictive meteorological/crop models and CEMADEN does not use soil moisture persistence.

TAMSAT has only been trialled in Africa.

CEMADEN have an app where local people can submit this type of information. Or something like this could be developed.

We could share our expertise in these different areas to move both products forward.

CEMADEN can help apply it in Brazil, in conjunction with their existing products.
Project 2: Leptospirosis phylodynamics in an outbreak after flood

(Luciana, Luiz, Leo, Alice, Jair)

**Question:** Can we associate some hydrological properties with the time-axis in a phylodynamic tree for leptospirosis?
Leptospirosis cases

Londe et al. (2016). Flood-related leptospirosis outbreaks in Brazil: perspectives for a joint monitoring by health services and disaster monitoring centers. Natural Hazards (Dordrecht. Online), v. 84, p. 1419-1435.
**HAND INDEX**

**Height Above Nearest Drainage**


Let $T_n$ denote the time for $n$ lineages to coalesce, i.e., merge into one ancestral lineage, in a population of size $N_e$. Then:

$$Pr(T_n = t) = \lambda_n e^{-\lambda_n t}$$

$$\lambda_n = \binom{n}{2} \frac{1}{N_e} = \binom{n}{2} \frac{1}{N_e \tau}$$

where $N_e$ is the effective population size and $\tau$ is the generation time. Let $T_{\text{mrca}}$ denote the age of the most recent common ancestor:

$$\mathbb{E}[T_{\text{mrca}}] = \mathbb{E}[T_n] + \mathbb{E}[T_{n-1}] + \ldots + \mathbb{E}[T_2]$$

$$= \frac{1}{\lambda_n} + \frac{1}{\lambda_{n-1}} + \ldots + \frac{1}{\lambda_2}$$

$$= 2N_e \left(1 - \frac{1}{n}\right)$$

**Time scales:**
Flooding (Amazon region): 3 months
Bacteria evolution: ??? or any similar proximity matrix
Project 3: Flooding damage estimation using urban mobility data, Geographical Complex Networks and Nash Equilibrium approach - (Leonardo, Andres, Luciana, Selma, Viviana, Guillermo);

Questions:

1. How to assess the different economic risks in floods?
2. Is there any geographical Complex Networks index able to estimate flood’s impacts on urban mobility?
3. Could be possible to analyse the urbanization - disasters relationship under a Nash Equilibrium approach?
First approach:

Santos et al. (2015): based on an ODD from the Rio de Janeiro and using a Google Maps based script, was estimated the amount of people directly and indirectly affected in their mobility in a potential flood episode.

There is a economic impact related to floods that must to be studied in order to understand where the most vulnerable region are. A (geographical) Complex Network approach could be applied to this task.
Second approach:

Challenges of climate change (and natural disasters) and globalization occur simultaneously: "games in the sense of Nash's theory"
Others projects

An early warning indicator for arboviroses in urban environment

- Arboviroses (dengue, yellow fever, zika, etc) are major health threats in Brazil and other developing tropical countries. Early warning systems give policy makers and health authorities time to prepare.
- The final goal of the project would be to provide a complementary tool to early warning systems already in use (https://info.dengue.mat.br/).
- INFO-DENGUE already uses real-time meteorological data provided by Cemaden
- Disease notifications are assigned to the residence areas; however, many of the infections may have happened in other nodes (city sections) of the graph formed by the city districts (mobility complex networks)
- Can the inverse problem be addressed, namely finding the amount of real infections occurring on a given place?
Dengue - Taxa de Incidência por Bairro - MRJ Janeiro 2007

Superintendência de Vigilância em Saúde
Gerência de Vigilância Epidemiológica

Taxa de Incidência por 100.000 habitantes
Mapa Atualizado em 22-02-2008

Tx. Inc. Fev.

- 0 - 0.01
- 0.01 - 27
- 27 - 150
- 150 - 250
- 250 - 470
- 470 - 2000
- 2000 - 5000
- 5000 - 20000

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The risk of disasters can be understood as indices based on spatial-temporal models, with the difficult objective to preview their scales of magnitude and intensities. For floods, for instance, it is possible to adjust prediction systems using observational data, such as rainfall, soil moisture, vegetation and geology. We can also compare the cost/benefit of preventive measures with the economic and social costs for remediation of impacts. One of our challenges is to link models on a global scale and those on local scales. Infectious diseases often happen in sequence of an impact (floods, earthquakes, spills, ...). Innovative research must be done in a way that links mathematics and the different themes related to the study of disasters, to develop improved risk models.