Water in the Anthropocene: Challenges for Science & Governance

Bonn, Germany , 21-24 May, 2013
Session: Working with uncertainties: Models & Data I

# Towards Participatory-based Water Resilience Index for Coupling Vulnerability, Impacts and Adaptation Strategies at Areas Under Land Use Change

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# Contribution

A contribution towards participatory-based water resilience index ($PWRI_{IVA}$) is discussed for crosscutting issues of impact, vulnerability and adaptation (IVA) in the context of Global Water System Project (GWSP)

# Interdisciplinary scope

- Common strengths & limits for $PWRI_{IVA}$ used by teams faced with resilience to climate change & disaster management of:
  - Floods ($PWRI_{IVA}$-$F$), Landslides ($PWRI_{IVA}$-$L$), Droughts ($PWRI_{IVA}$-$D$)
- Novel hypotheses & needs for a new generation of $PWRI_{IVA}$, viable for Anthropocene's conditions:
  - as relevant for dialogue among stakeholders, and
  - as robust to scaling (x,t) processes.

# Challenge

- $PWRI_{IVA}$ robustness: variables (with uncertainties) from multisource database.
- Water resilience redefined: how does $PWRI_{IVA}$ incorporate collaborative frameworks or friendly-user domains of GWSP?
- Usage: spatial transects or temporal scenarios

# Example

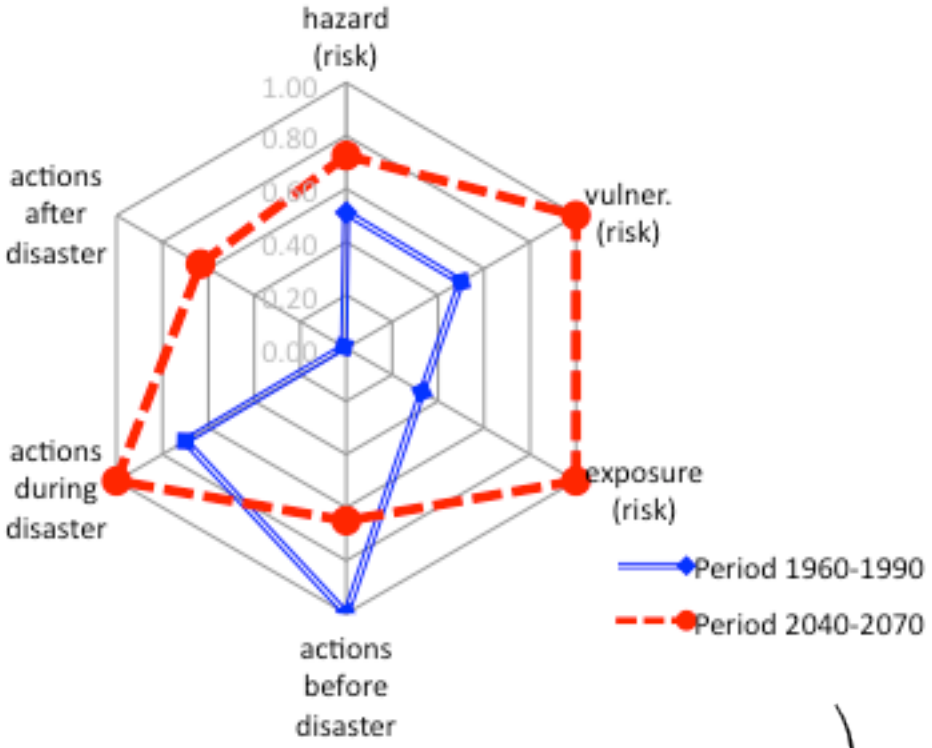
- We outline some of these yardsticks and brainstorm lessons learnt on $PWRI_{IVA}$ from an ongoing IVA project Assessment of Impacts and Vulnerability to Climate Change in Brazil and Strategies for Adaptation Options, FAPESP 2008/58161-1.
- Interdisciplinary teams among components, ranging complex scales and with the crosscutting question:
- "…although levels of uncertainty of data coexist among groups, which postures towards $PWRI_{IVA}$ can be feasibly translated from risk-schemes into resilience-scores-and-actions…?

# Method

- $PWRI_{IVA}$: risk assessment * risk management.
- $PWRI_{IVA}$ acknowledges:
  - multisource variables for several types of hazards
  - flexible layouts: each group can redefine their own $PWRI_{IVA}$ at participatory/comparable platforms
  - Non-dimensional weights factoring hazard, exposure, vulnerability, and management steps before, during and after the occurrence of hazards

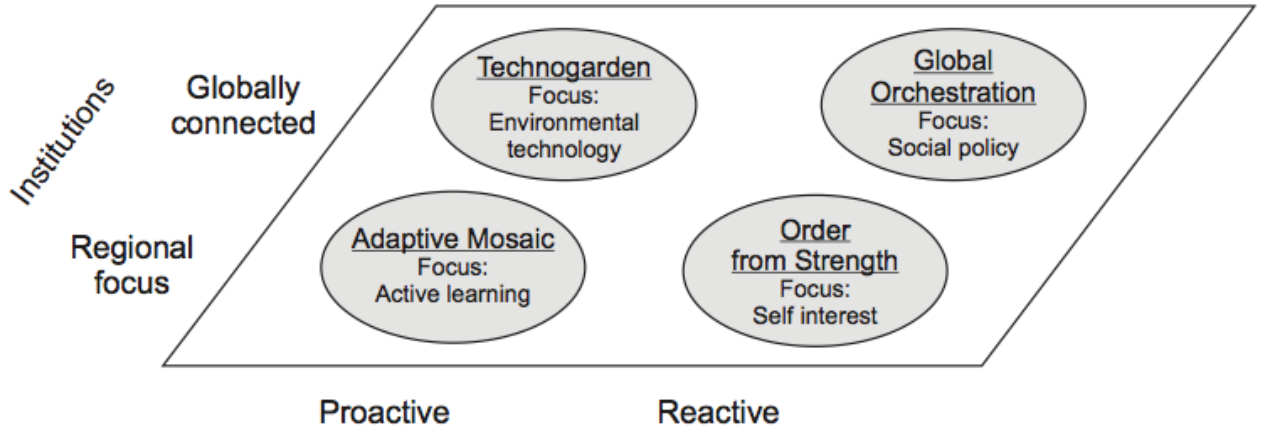
# $PWRI_{IVA}$

*PWRI* is a composite index expressing the lack of resilience related to water extremes at an area under land-use change




$$\Big(\underbrace{\underbrace{\text{hazard}}_{\substack{\text{climate}\\\text{change}\\\text{variables}}},\underbrace{\text{vulnerability}}_{\text{land use maps}},\underbrace{\text{exposure}}_{\substack{\text{socio-economic}\\\text{surveys}}}}_{\substack{\text{risk assessment}\\\text{(impact scores)}}},\underbrace{\underbrace{\underbrace{\text{"before"}}_{\substack{\text{long-term}\\\text{early-warning}\\\text{ability}}},\underbrace{\text{"during"}}_{\substack{\text{emergency}\\\&\text{rescue}\\\text{capacity}}}}_{\text{non-structural measures}},\underbrace{\text{"after"}}_{\substack{\text{mitigation \&}\\\text{reconstruction}\\\text{system}}}}_{\substack{\text{structural}\\\text{measures}}}}_{\substack{\text{risk management through}\\\text{"participative", "collaborative", "voluntary"}\\\text{(adaptation strategies of disaster management)}}}\Big)$$

# *PWRI-$F_{IVA}$ & Land Use Change*




risk assessment (impact scores)

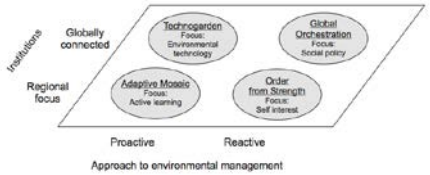
risk management through "participative", "collaborative", "voluntary" (adaptation strategies of disaster management)

| hazard | vulnerability | exposure | "before" | "during" | "after" |
|---|---|---|---|---|---|
| climate change variables | land use maps | socio-economic surveys | long-term early-warning ability | emergency &rescue capacity | mitigation & reconstruction system |
| | | | non-structural measures | | structural measures |

# Land use change scenarios & policies

*PWRI*$_{IVA}$

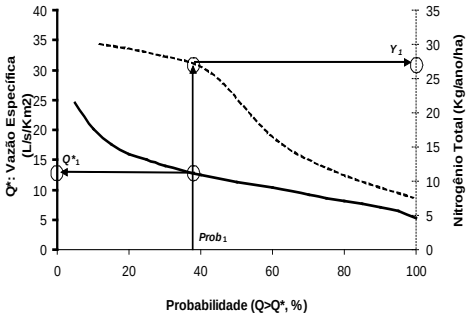
South American impacts on floods from global scenarios 2010-2100




*Arrows indicate the development over time of issues named in the left-most column.*
*Full lines indicate the best case, dashed lines the worst case envisaged for each scenario. The row below the arrows for each issue contains a qualitative indication of changes in the relevant drivers.*
*The symbols indicate: "++": strongly increasing pressure by this driver; "+": increasing pressure; "0": no change when compared to today; "–": decreasing pressure; "– –": strongly decreasing pressure; "→": a change in the pressure of the driver during the scenario. Source: Mendiondo (2005).*

| | Reactive | proactive | Reactive | proactive |
|---|---|---|---|---|
| | Scenario development for period 2010-2100 (horizontal axis) | | | |
| Component | "Global Orches–tration" (GO) | "Technogarden" (TG) | "Order from Strength" (OS) | "Adapting Mosaic" (AM) |
| Flood prone areas impacted (total area degraded) |  |  |  |  |
| *Direct Drivers:* | | | | |
| Hard Flood Control | ++ | + → 0 | 0 | 0 → – |
| Risk Exposition | + | 0 | ++ | + → 0 |
| Climate Change | ++ | + | + | + |
| Land-use Change | + | 0 | ++ | + → 0 |
| FPC threats (frequency of flood disasters) |  |  |  |  |
| *Major Drivers:* | | | | |
| Poverty | – | 0 | –– | + → 0 |
| Climate Change | ++ | 0 | ++ | + |
| Flood exposition | – | + | + | 0 |
| Security to cope with flood disasters |  |  |  |  |
| *Elements:* | | | | |
| Preparedness | – | + | –– | + + |
| Capacity building | 0 | + | –– | + |
| Early Warning Act | 0 | + + | 0 | + |

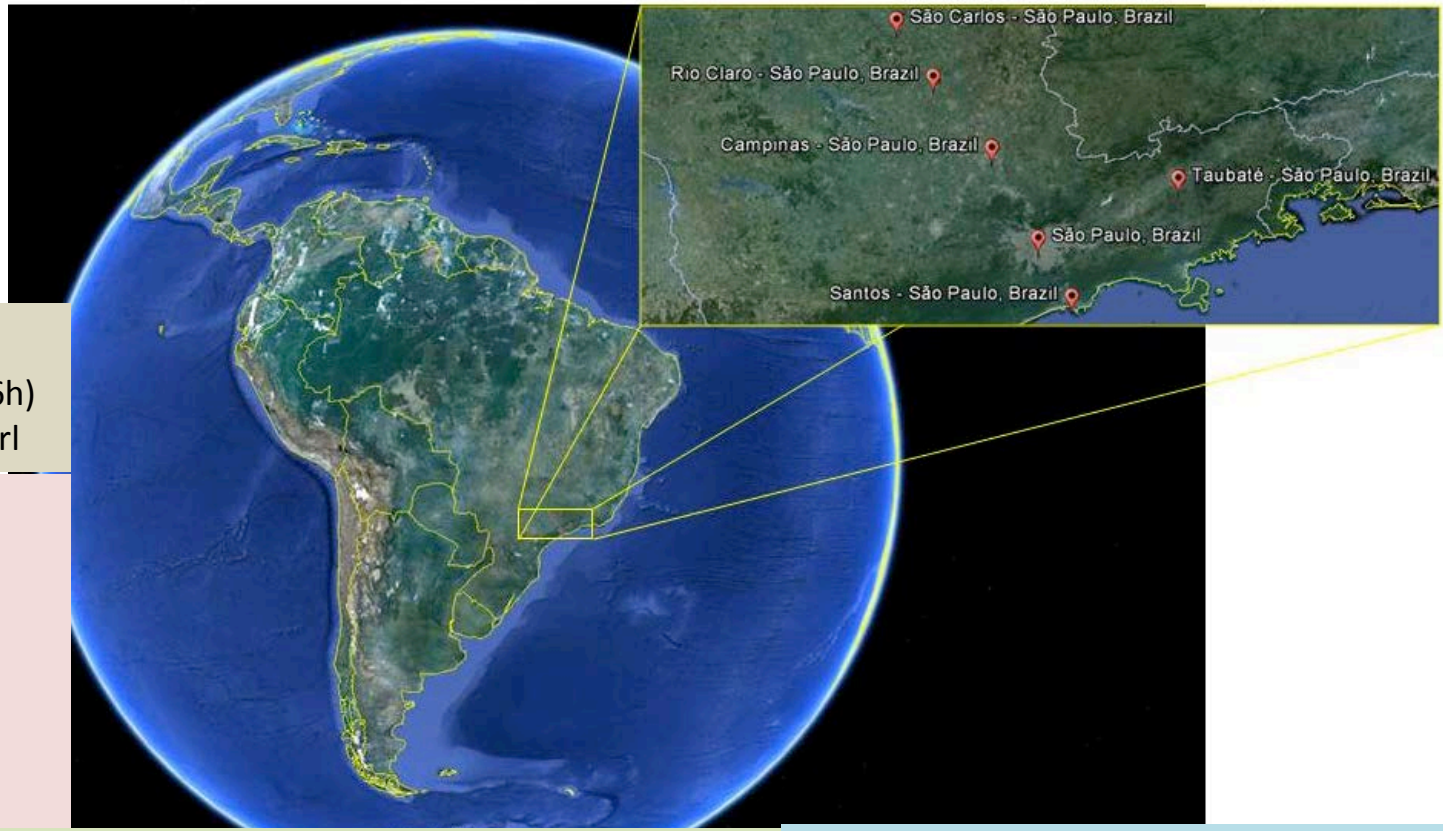
**Table 1-** Relations of INPE-Eta variables with Participatory Water Resilience Index – *PWRI* and factors of vulnerability, impact and adaptation IVA




| INPE-Eta Model variable[1] [units] | Definition of INPE-Eta-Model variable | $PWRI_{IVA}$ <br> $PWRI_{IVA}$-*F* : flood hazard[3] |
|---|---|---|
| *prcv* [kg/m²/day] | convective precipitation | $prcv \rightarrow i\max \rightarrow Q\max \rightarrow \left( (h\max \; v\max) / (h \cdot v)^* \right)\Big\|_{\text{small/ urban watershed}}$ |
| *agpl* [kg/m²/day] | instantaneous precipitation water | $agpl \rightarrow i\max_{agpl} \rightarrow Q\max \rightarrow \left( (h\max \; v\max)_{agpl} / (h \cdot v)_{agpl}^* \right)\Big\|_{\text{small/ urban watershed}}$ |
| *prge* [kg/m²] | large scale precipitation | $prge \rightarrow i(t)_{prge} \rightarrow Q(t) \rightarrow Q\max_{prge} \rightarrow \left( (h\max \; v\max) / (h \cdot v)^* \right)\Big\|_{\text{medium – large – basins}}$ |
| *rnof* [kg/m²/s] | runoff | $runoff \rightarrow Q_{durationcurve,\%} \rightarrow Q_{highwaters} \rightarrow \left( Q_{highwaters} / Q_{bankfull}^* \right)\Big\|_{\text{medium – large – basins}}$ |
| *rnsg* [kg/m²/day] | acm bsfl-gdwr runoff | $rnsf \rightarrow Q_{durationcurve,\%} \rightarrow Q_{highwaters} \rightarrow \left( Q_{highwaters} / Q_{bankfull}^* \right)\Big\|_{\text{medium – large – basins}}$ |

**Legend**: Asterisk "*" depicts hazard benchmark score for water hazard resilience; [1] Scenario A1B (runs #1, #2, #3), period 2010-2100, at grid cells of 40x40km, $\Delta t$= 6h; [3] Ref.: Mendiondo, E M (2010) Reducing vulnerability to water-related disasters in urban areas of the humid tropics, In: J Parkinson, C Tucci & J Goldenfum (eds.) UNESCO Urban Series, Vol. 6, "Chapter 6, p.109-127.

# Application




**Ensembles**:
Eta_HadCM3 (A1B;40kmx6h)
Runs: Low-, midi-, high-, ctrl

**Time periods** :

1960-1990;

2010-2040;

2040-2070;

2070-2100

| **variable** [unit.] | | **Definition** |
|---|---|---|
| prcv | [kg/m2/day] | convective precipitation |
| agpl | [kg/m2/day] | instantaneous precipitation water |
| prge | [kg/m2] | large scale precipitation |
| rnof | [kg/m2/s] | runoff |
| rnsg | [kg/m2/s] | acm bsfl-gdwr runoff |

## Sites:

São Carlos: 22.0178° S, 47.8908° W
Rio Claro: 22.4108° S, 47.5608° W
Campinas: 22.9069° S, 47.0613° W
Sao Paulo: 23.5000° S, 46.6167° W
Santos: 23.9667° S, 46.3333° W
Taubaté: 23.0333° S, 45.5500° W

# *Water Resilience Opportunity-WRO*

- *Water Resilience Opportunity:* adaptation capacity of comparing $PWRI_{IVA}$ values over time between reactive and proactive scenarios.
- WRO lets monetary values be included, demonstrative pilot experiments like signboards or web-mapping collaborative scores can be further developed from this $PWRI_{IVA}$.

| | Scenario development for period 2010-2100 (horizontal axis) | | | |
|---|---|---|---|---|
| Component | Global Orchestration (GO) | Order from Strength (OS) | Adapting Mosaic (AM) | Technogarden (TG) |
| Flood prone areas impacted (total area degraded) | | | | |
| *Direct Drivers:* | | | | |
| Hard Flood Control | ++ | 0 | 0 → - | + → 0 |
| Risk Exposition | + | ++ | + → 0 | 0 |
| Climate Change | ++ | + | + | + |
| Land-use Change | + | ++ | + → 0 | 0 |
| FPC threats (frequency of flood disasters) | | | | |
| *Major Drivers:* | | | | |
| Poverty | - | - - | + → 0 | 0 |
| Climate Change | ++ | ++ | + | 0 |
| Flood exposition | - | + | 0 | + |
| Security to cope with flood disasters | | | | |
| *Elements:* | | | | |
| Preparedness | - | - - | + + | + |
| Capacity building | 0 | - - | + | + |
| Early Warning Act | 0 | 0 | + | + + |

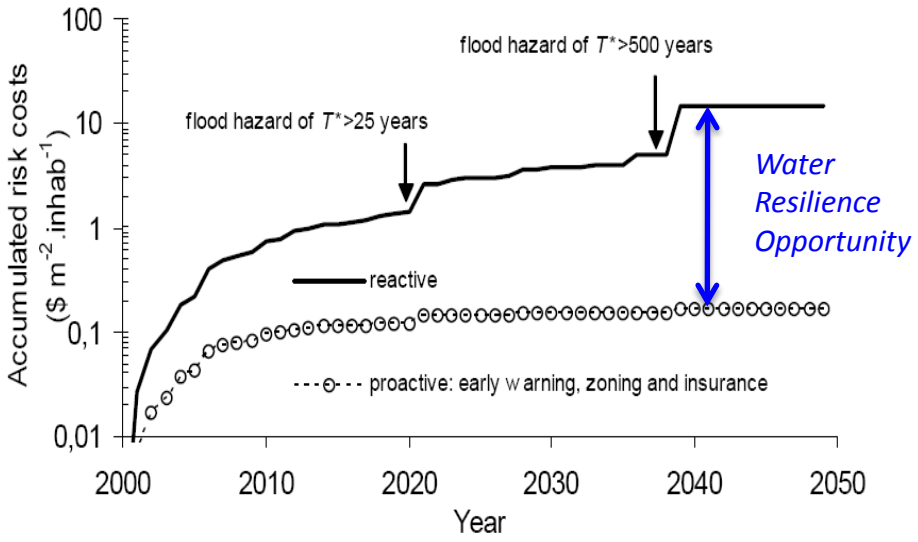
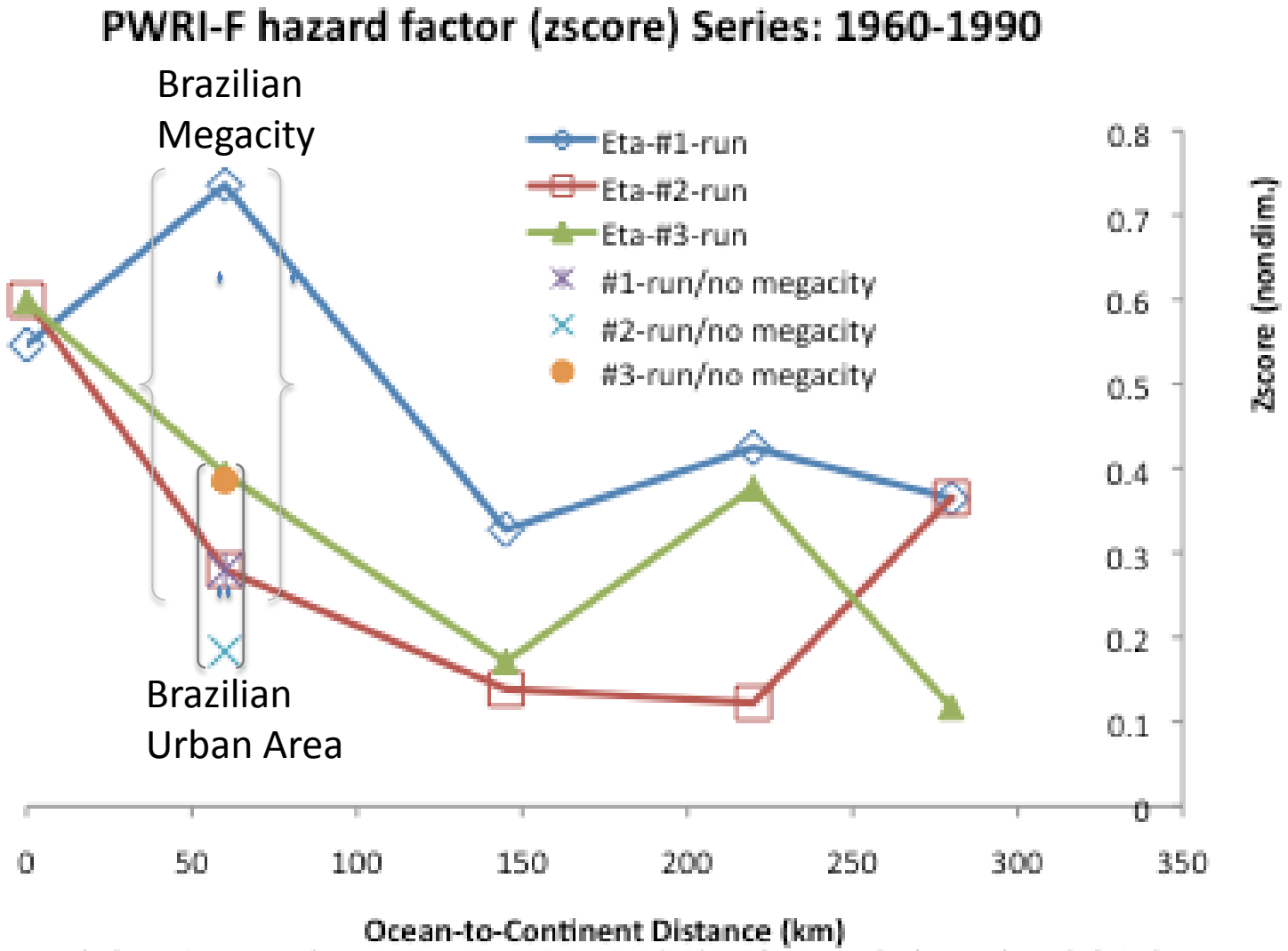



Figure 3- Simulation of accumulated nominal costs from two policy scenarios of risk management to cope with flood hazards and with growing urbanization at a subtropical basin. Proactive policies have early warning systems, land zoning of flood prone areas and insurance for risk-transfer. Adapted from Mendiondo *et al* (2005).

# *PWRI-F* : preliminary results of spatial variability transect of water hazard across areas under change, according to Q1% ÷ Q5%

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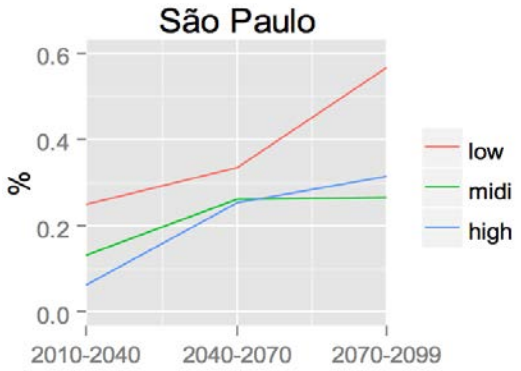
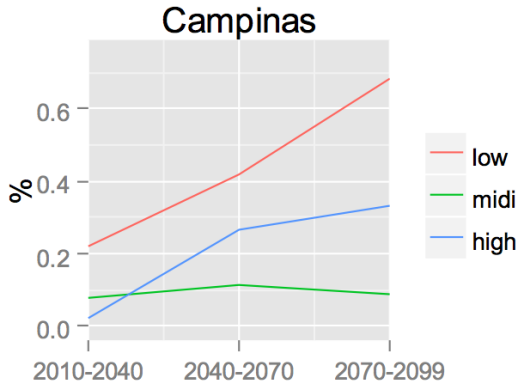
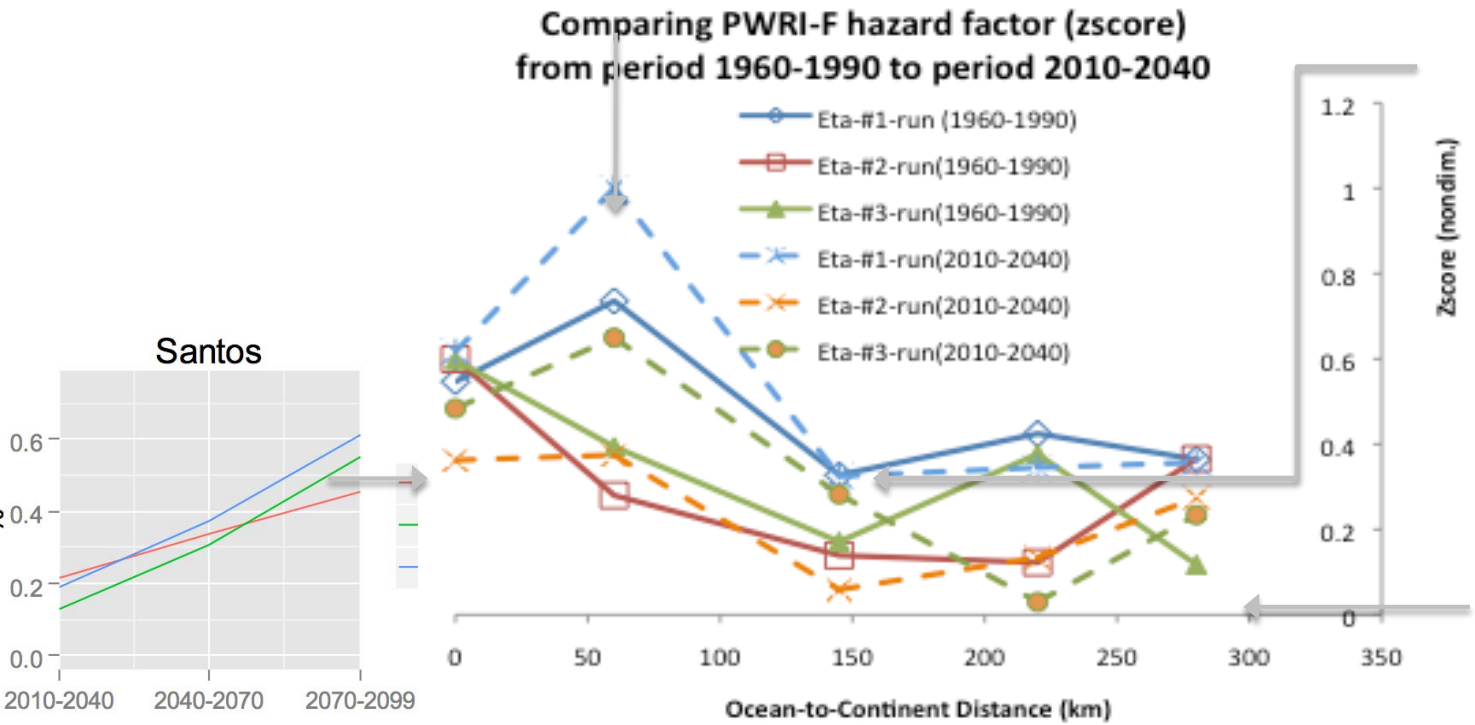
# *PWRI-F*: uncertainties from GCM's hazard factors
# Change rate between 2010-2040 & 1960-1990 periods
# fraction of Q1% / Q5% (permanency curves)

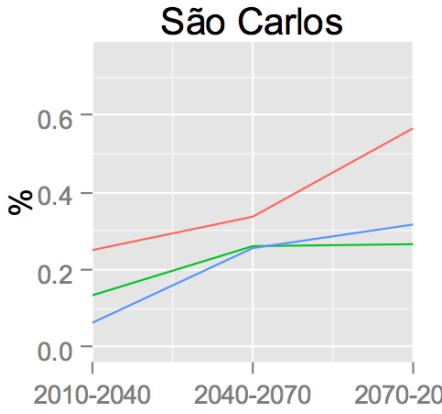



Courtesy work:
Gustavo Romero (USP)

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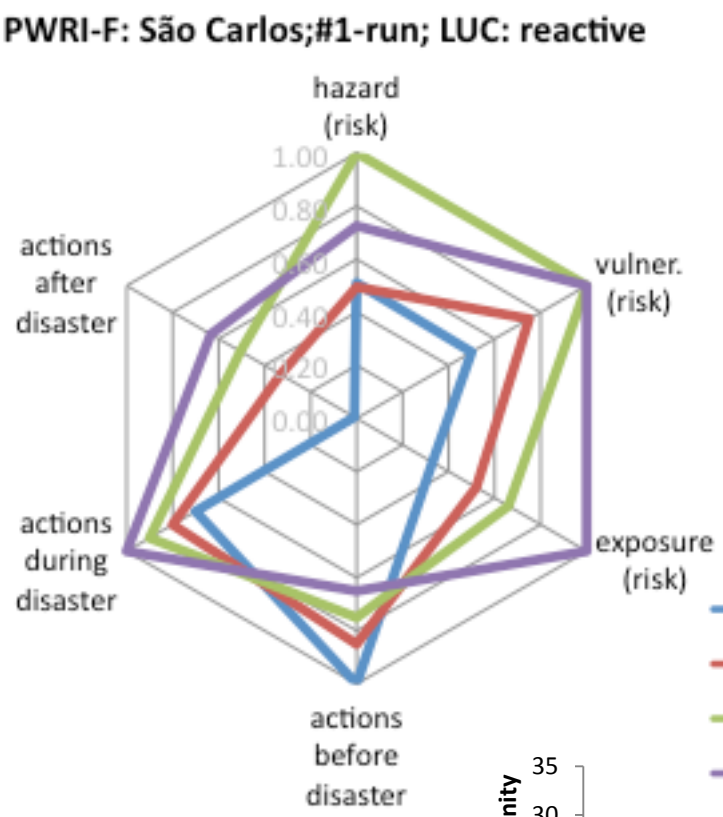
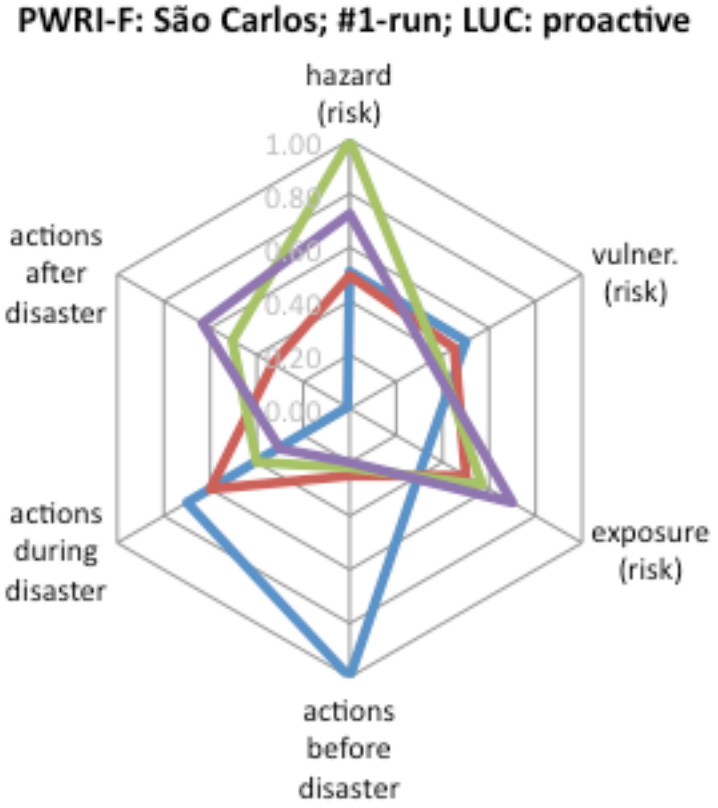
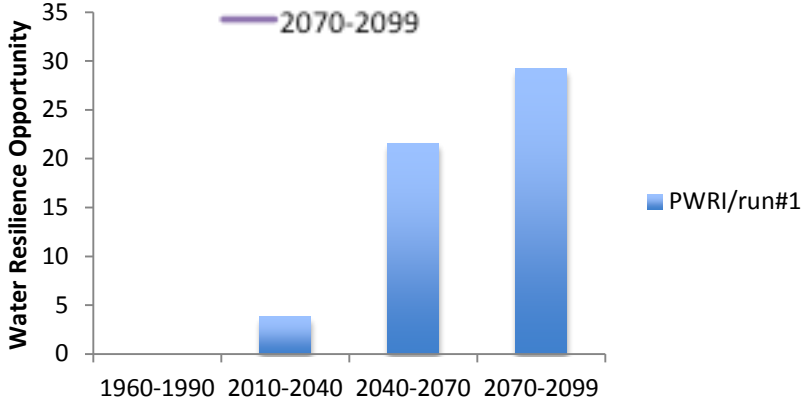
# *PWRI-F : 1960 – 2100*; reactive & proactive scenarios

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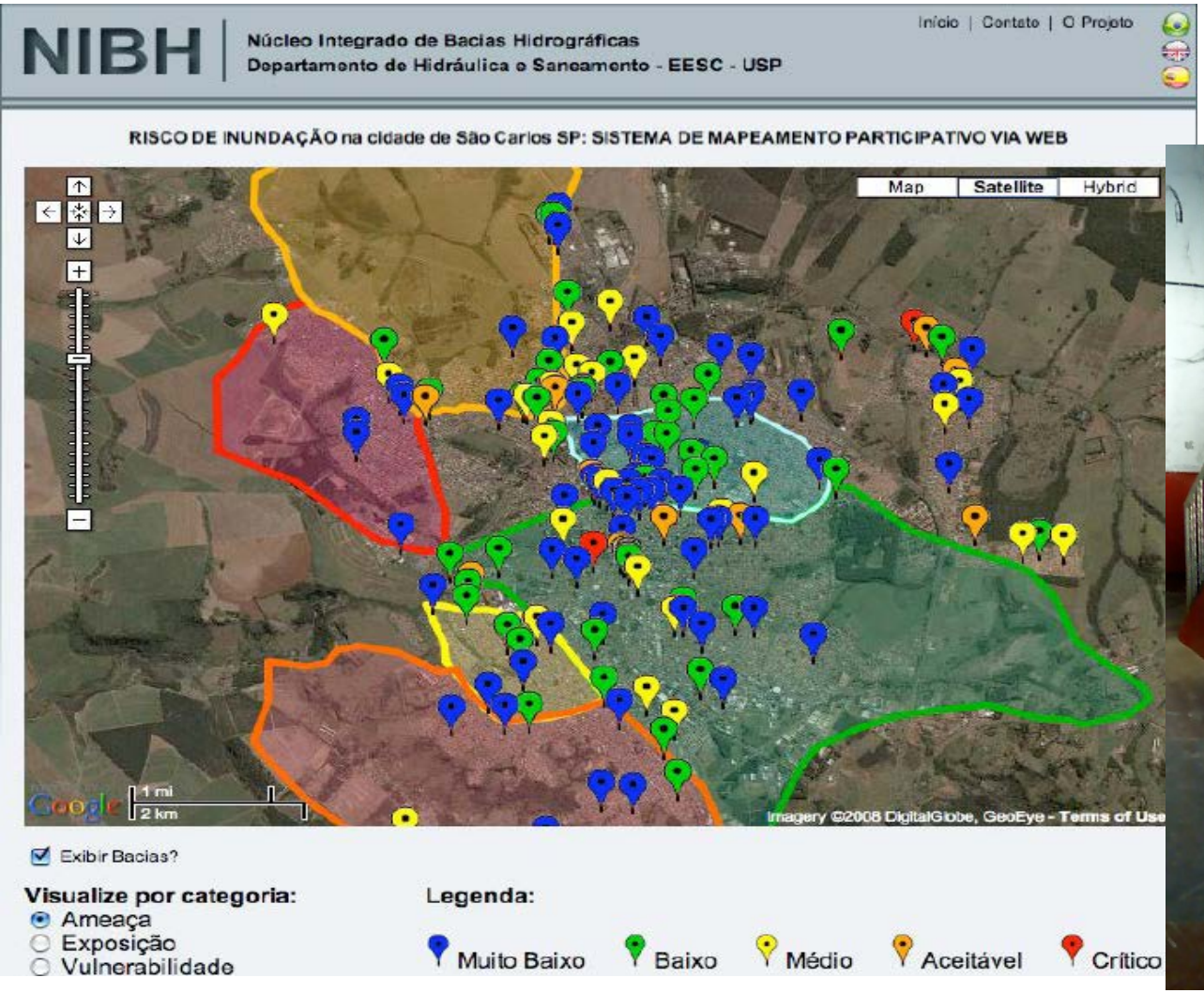
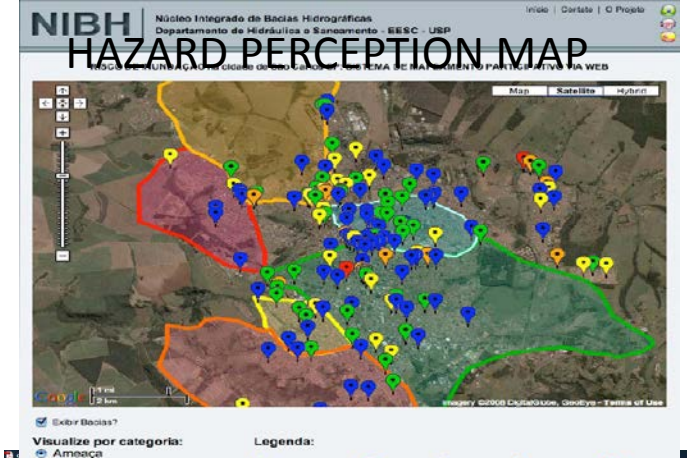
# Community perception of reactive urban drainage control (no planning, “Order from Strength” Scenario)



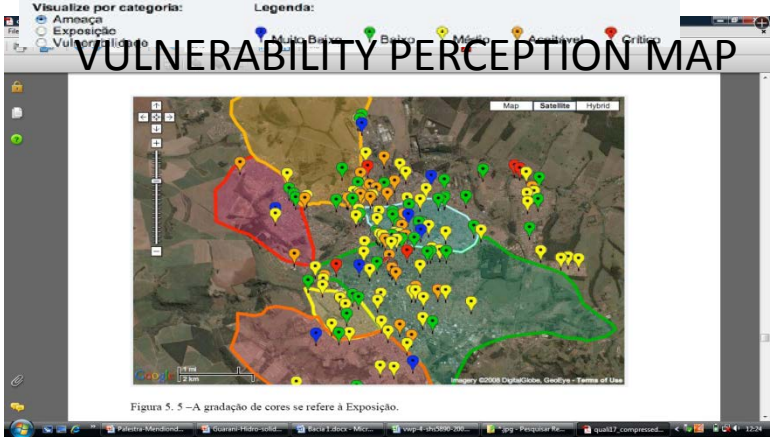


from Giuntoli & Mendiondo (2008)

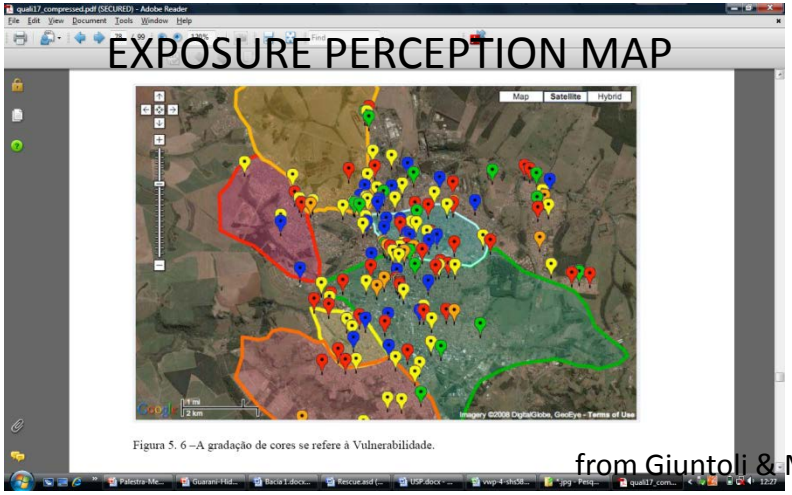
HAZARD PERCEPTION MAP




VULNERABILITY PERCEPTION MAP




EXPOSURE PERCEPTION MAP




*PWRI-F* updated from local perception of flood risks through cognitive maps of hazard, vulnerability and exposure to floods

from Giuntoli & Mendo[illegible]008)

# *PWRI* – Water Resilience Opportunity
# Next steps forward…

*Because this structure let monetary values be included, demonstrative pilot experiments like signboards or web-mapping collaborative scores can be further developed from this $PWRI_{IVA}$

*ADAPTOMETER TECHNOLOGY IS COMING SOON…*
*INSURANCE & SECURITIZATION BEING UPDATED…*

- An example of application of a $PWRI_{IVA}$-*F* at a real case study of Sao Carlos City, Brazil, until the year 2050, is under progress.

- New technologies for *PWRI* to overcome uncertainties:
  *VGI (VOLUNTEER GEOGRAPHIC INFORMATION)*
  *WSN (WIRELESS SENSOR NETWORK)*

- Pathways for future development of $PWRI_{IVA}$-*L* and $PWRI_{IVA}$-*D* at Brazilian biomes are summarized for growing urbanization and agriculture drivers,
- A POST-DOC VACANCY ON *PWRI* IS STILL OPEN…!
  …(please, send your CV to: emm@sc.usp.br)