FIESP

INCT MC2
INCT para Mudanças Climáticas · Fase 2

WORKSHOP SANEAMENTO BÁSICO – 25/06/2019
INFRAESTRUTURA PARA SEGURANÇA HÍDRICA

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WADI Lab - Water-Adaptive Design & Innovation Lab
SHS - Departamento de Hidráulica e Saneamento
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USP - Univ Sao Paulo
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A contribution to:

Panta Rhei – Everything Flows
IAHS AISH
Change in Hydrology and Society

MOXXI Measurements & Observations in the 21st Century
Working Group - International Association of Hydrological Sciences

Water Footprint Working Group

This work is co-supported by the National Institute of Science and Technology for Climate Change Phase 2 under the Brazilian National Council for Scientific and Technological Development (CNPq) Grant 465501/2014-1, the São Paulo Research Support Foundation (FAPESP) Grant 2014/50848-9, and by the National Coordination for High Level Education and Training (CAPES) Grant 16/2014 PRO-ALERTAS Program

EESC • USP
PÓS-GRADUAÇÃO em ENGENHARIA HIDRÁULICA e SANEAMENTO PPG-SHS USP/SÃO CARLOS
nibH DEPARTAMENTO DE HIDRÁULICA & SANEAMENTO
The wadi lab water-adaptive design & innovation
CNPq Conselho Nacional de Desenvolvimento Científico e Tecnológico
FAPESP FUNDAÇÃO DE AMPARO À PESQUISA DO ESTADO DE SÃO PAULO

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www.cemaden.gov.br/inct-mudancas-climaticas

INCLINE

pnsh PLANO NACIONAL DE SEGURANÇA HÍDRICA

Infraestrutura Resiliente para Segurança Hídrica

CEPED-SP/USP
Centro de Estudos e Pesquisas sobre Desastres no Estado de São Paulo

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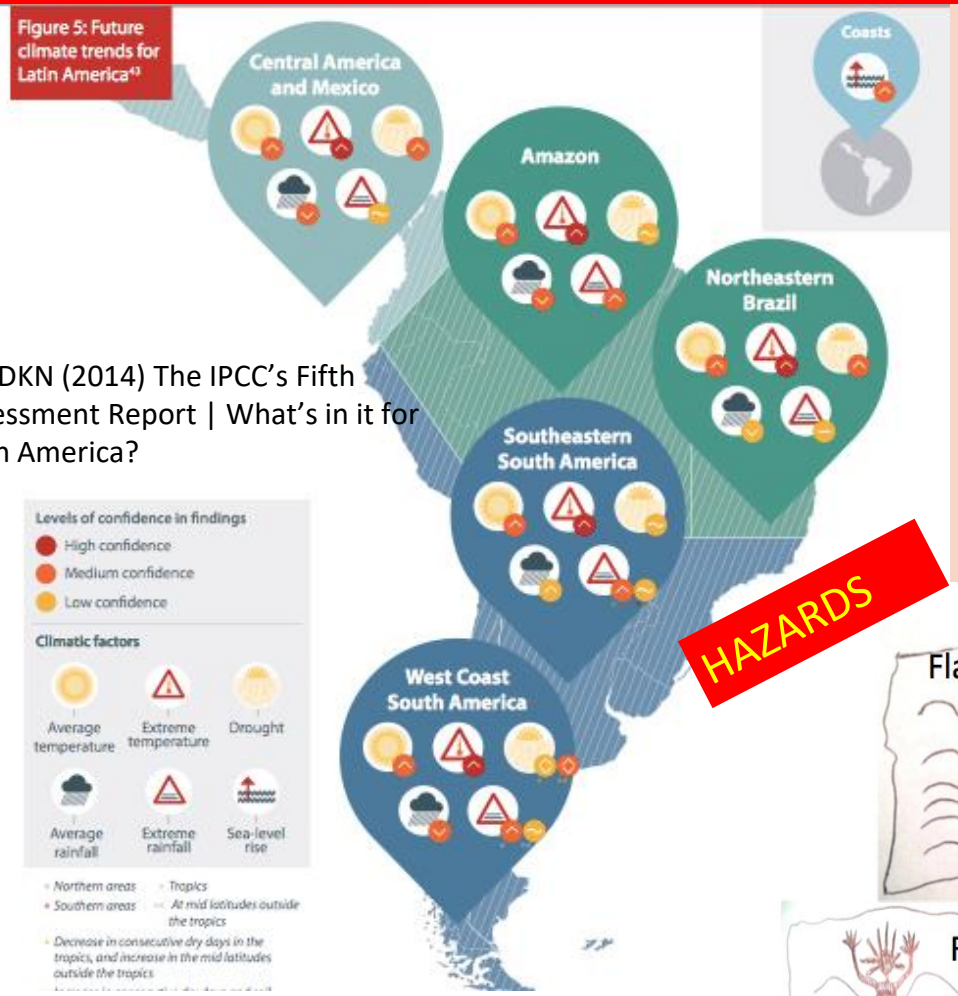
The wadi lab
water-adaptive design & innovation

CeMEAI
CEPID - Centro de Ciências Matemáticas Aplicadas à Indústria

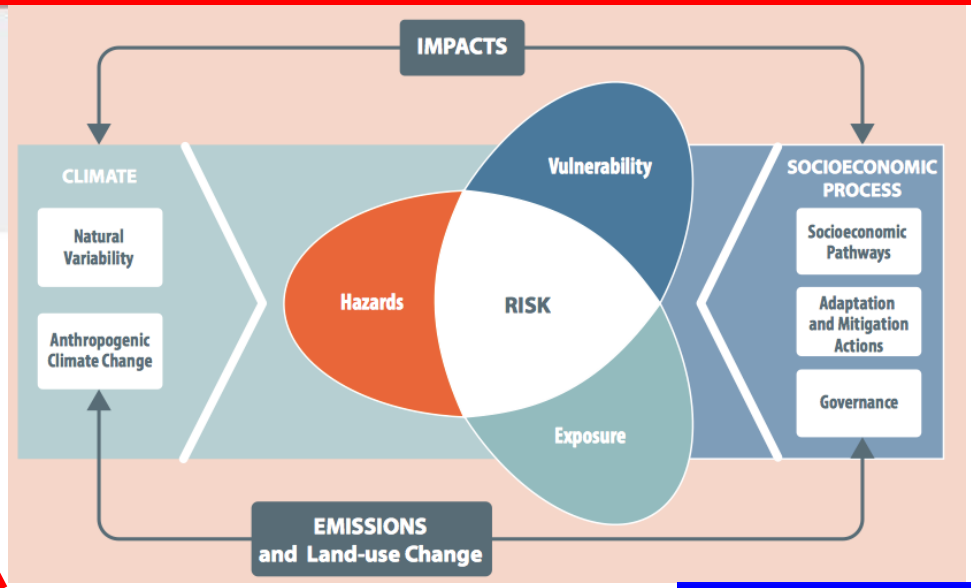
www.cemeai.icmc.usp.br

PNSH (ANA, 2019): "risco total da produção econômica no Brasil, num cenário de crise hídrica severa era de R$ 228,4 bilhões em 2017, correspondente a cerca de 13% do PIB dos mesmos setores naquele ano. Desse total, o risco pós-déficit é estimado em R$ 164,0 bilhões e o risco

- We present a contextualized insurance model to assist annually ca. US$ 200 billion of aging water services in South America, integrating Ecosystem-based Adaptation (EbA) with the water footprint demands, i.e. the Water-Energy-Food+Biodiversity (WEF+B) nexus.

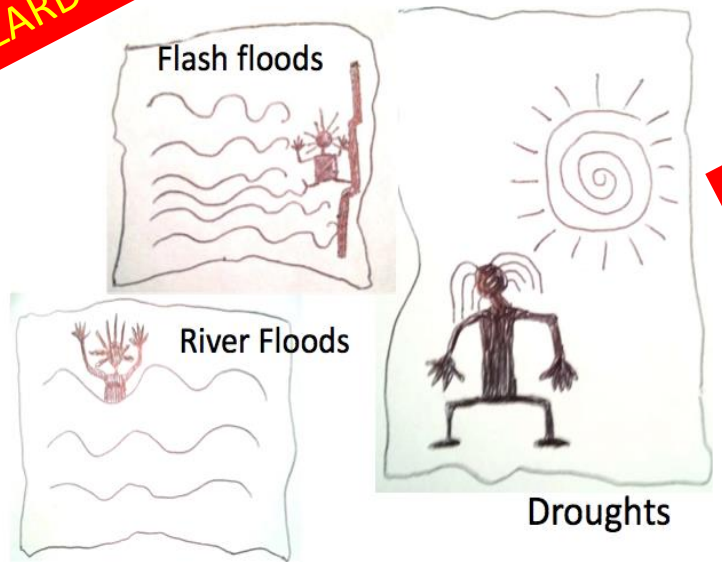


© CDKN (2014) The IPCC's Fifth Assessment Report | What's in it for Latin America?



Drivers of aging infrastructure, climate change, urbanisation and water demands call for willingness to adapt mechanisms to tradeoff water hazards on sectorial risks

HAZARDS



S.H.O.W.S
Socio-Hydrology Observatory for Water Security

RISKS

"not too little, not to much, not too dirty, not too far (unaffordable)"

Motivation: In Brazilian biomes, human exposure to hydrological extremes (i.e. floods, droughts) face risks from a crescent growth of social vulnerability, intensified by poor planning conditions and signals of climate variability and change.

Brazil 2018: 40.000 vulnerability areas with 60million people needing adaptation strategies for water security

Problems: THE BRAZILIAN HOT SPOTS

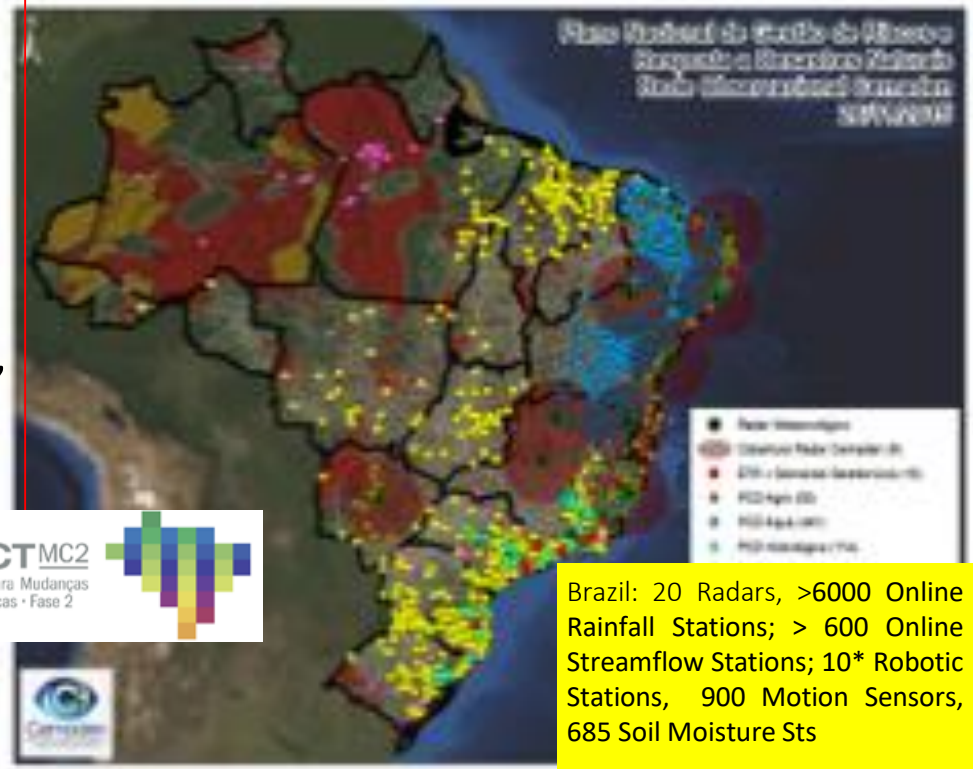
- strong social/environ. vulnerability
- > 60% of Brazilian GNP threatened by water disaster risks
- 40,000 risk areas mapped,
- approx. 6 risk areas / municipality
- 1 education station /10 rainfall st.
- 95% of risk-prone areas with time of concentration < 2 hours,
- complex patterns of land-use and socioeconomic vulnerability,

The Brazilian Socio-Hydrology gap : local, but not well documented initiatives are under progress, especially to cope with floods, landslides, droughts, progressive biodiversity losses, energy burnouts, fires and desertification

Opportunities for sociohydrology :

Low-cost technologies for disaster risk reduction in vulnerability areas:

- social media (SM)
- citizen observatories (CO)
- water security framework
- in line with Federal Acts of: Water Resources (1997), Urban Waters (2007), Climate Change Policy (2009) and Civil Protection (2012)



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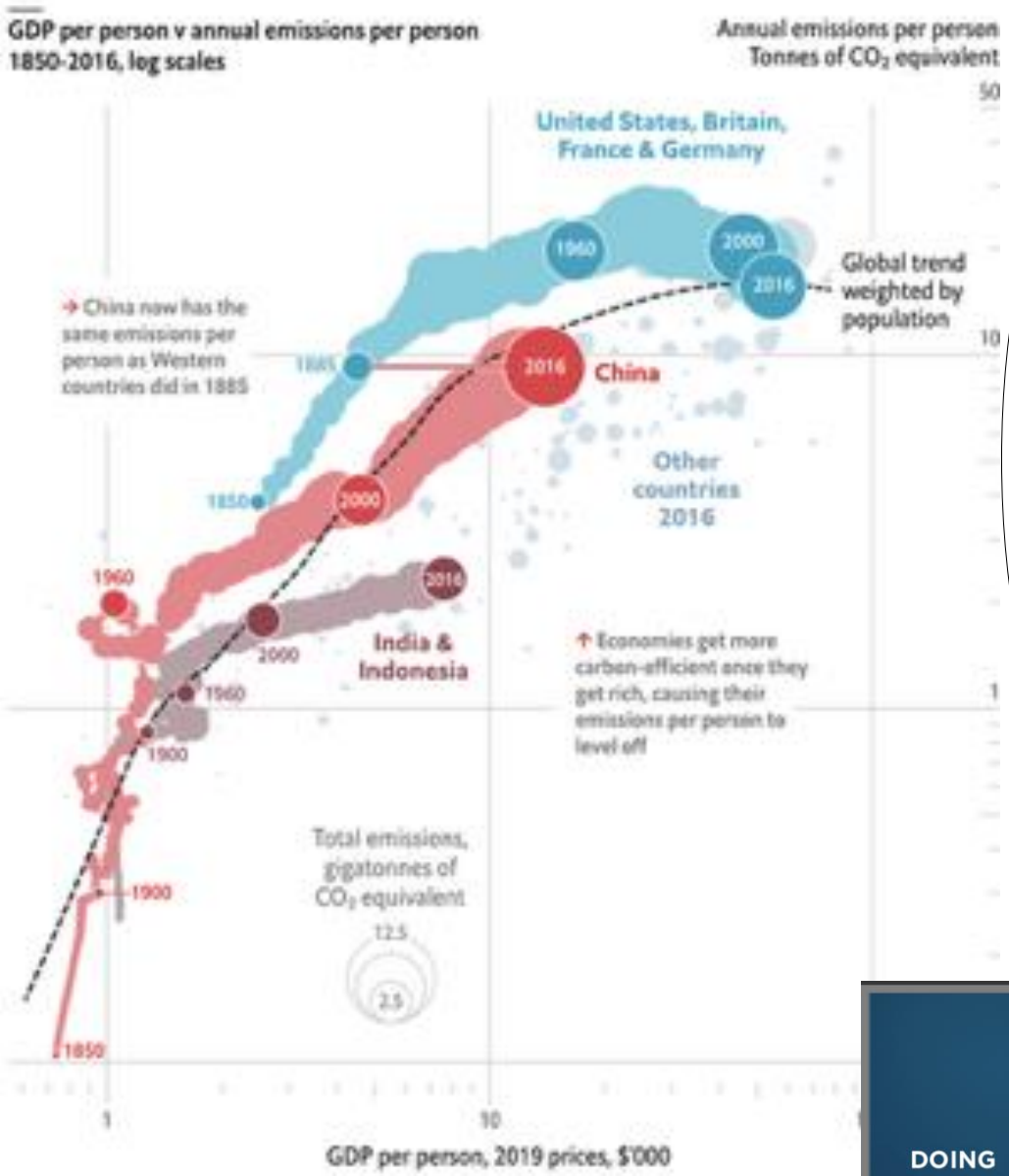
Brazil: 20 Radars, >6000 Online Rainfall Stations; > 600 Online Streamflow Stations; 10* Robotic Stations, 900 Motion Sensors, 685 Soil Moisture Sts

SocioHydrological Observatories for Water Security: Observations through Under-Represented Sensors for the Prediction in Ungauged Basins



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Contexto Legal para Segurança Hídrica:

Recursos Hídricos
(Lei Fed. 9433/97);
Saneamento Ambiental
(Lei Fed. 11.445/07)
Mudanças Climáticas
(Lei Fed. 12.127/09);
Proteção Civil a Desastres Naturais
(Lei Fed. 12.608/12)

OBJETIVOS DE DESENVOLVIMENTO SUSTENTÁVEL

Brasil:

1960: 450 m3/s; 0,6 ton CO2/cápita; U$ 3450/cápita

2016: 2000 m3/s; 2,6 ton CO2/cápita; U$ 11000/cápita

2030: 2500 m3/s; 3,5 ton CO2/cápita; U$?????/cápita

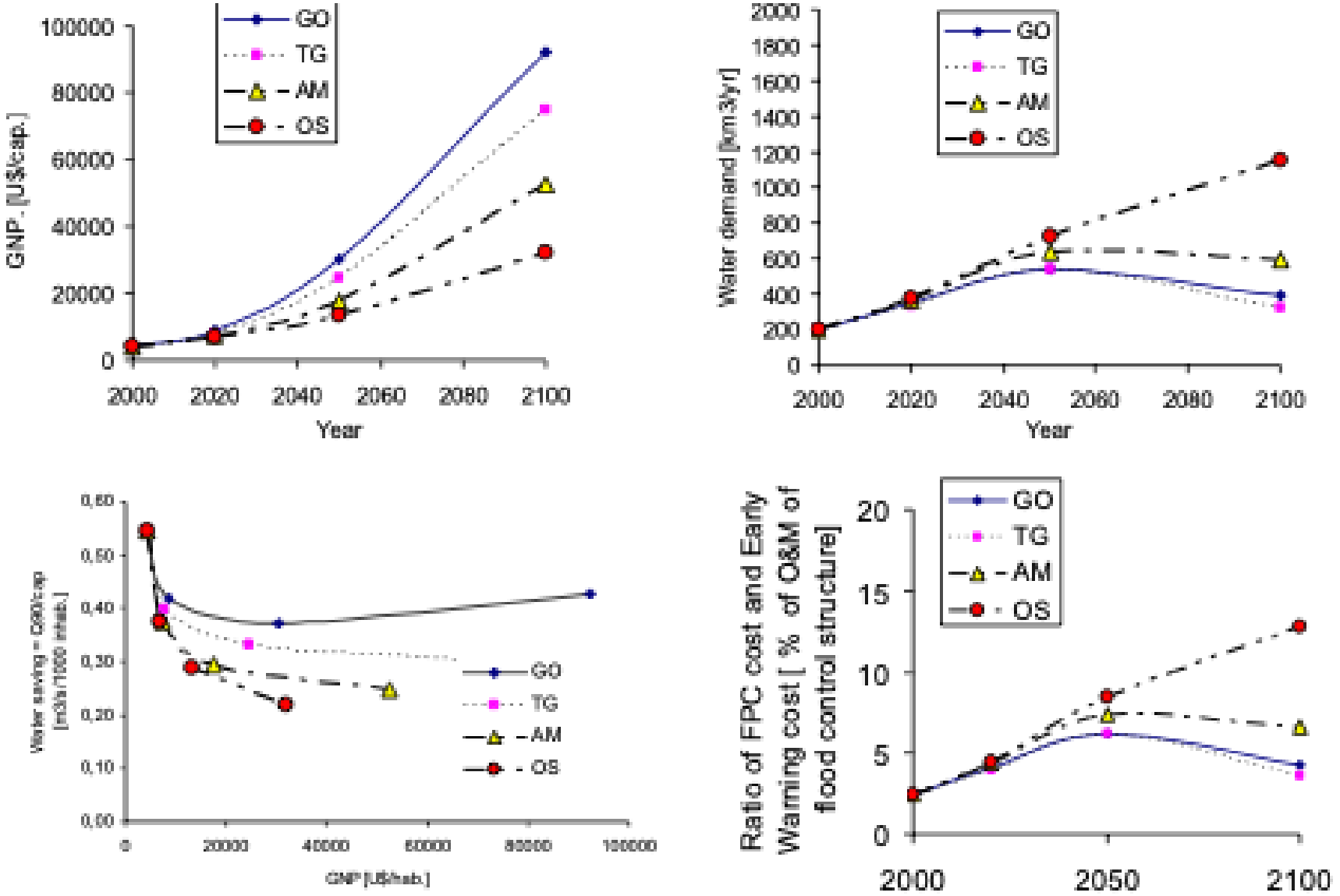

Figure 3. South America scenarios of GNP (upper, left); water demand (upper, right); relation of reuse of strategic water obtained from flood control structures versus GNP (bottom, left) and 'water compromise' represented by the ratio of 'FPC costs' and 'early warning costs'. Source: NIBH/EESC/USP (2004)

Train your brain... São Carlos, SP (Nov. 23th 2015; Drainage area= 77km2; Flood duration movie: 2h)

- NEXT STEPS: a new generation WTA insurance with PES would support of EbA for WEF+B under climate change if decision-makers do acknowledge innovative governance with more policies of Public-Private Partnerships (PPPs) planned for population empowerment at > 40,000 Brazilian Risk Prone Areas

Brazil 2018: 40.000 vulnerability areas with 60million people needing adaptation strategies for water security

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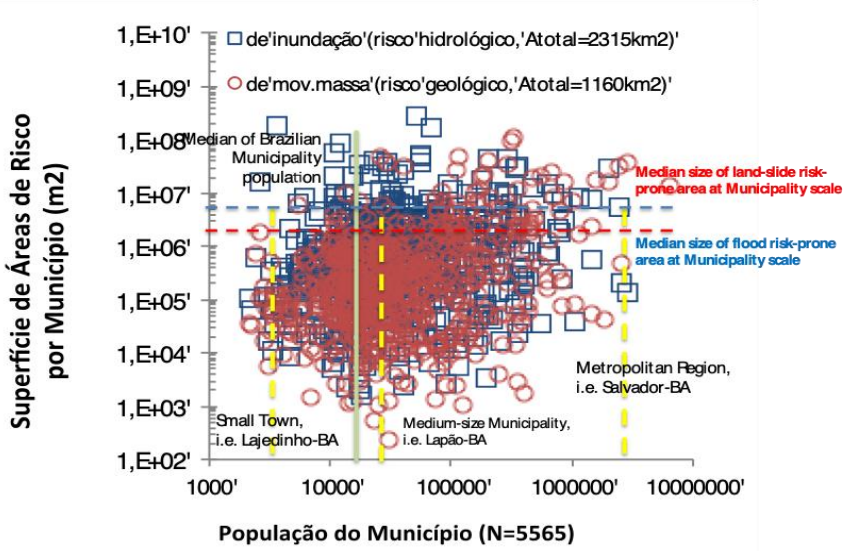

Opportunities for WTA Insurance:

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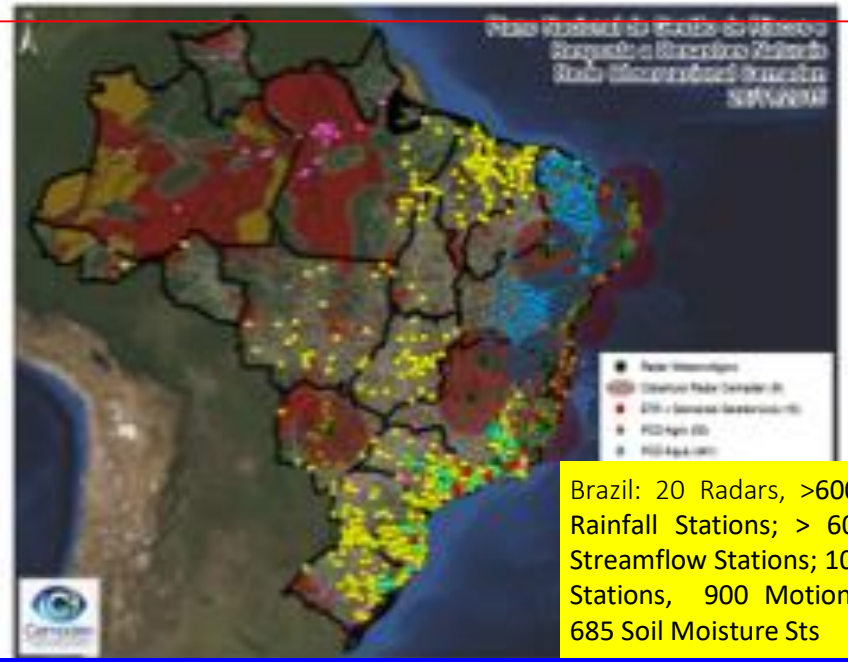
- water security framework
- in line with recent Federal Acts of: Water Resources (1997), Urban Waters (2007), Climate Change Policy (2009) and Civil Protection (2012)

The gap for insurance: these initiatives are still under progress, especially to cope with floods, landslides, droughts, progressive biodiversity losses, energy burnouts, fires and desertification.



Brazil: 20 Radars, >6000 Online Rainfall Stations; > 600 Online Streamflow Stations; 10* Robotic Stations, 900 Motion Sensors, 685 Soil Moisture Sts

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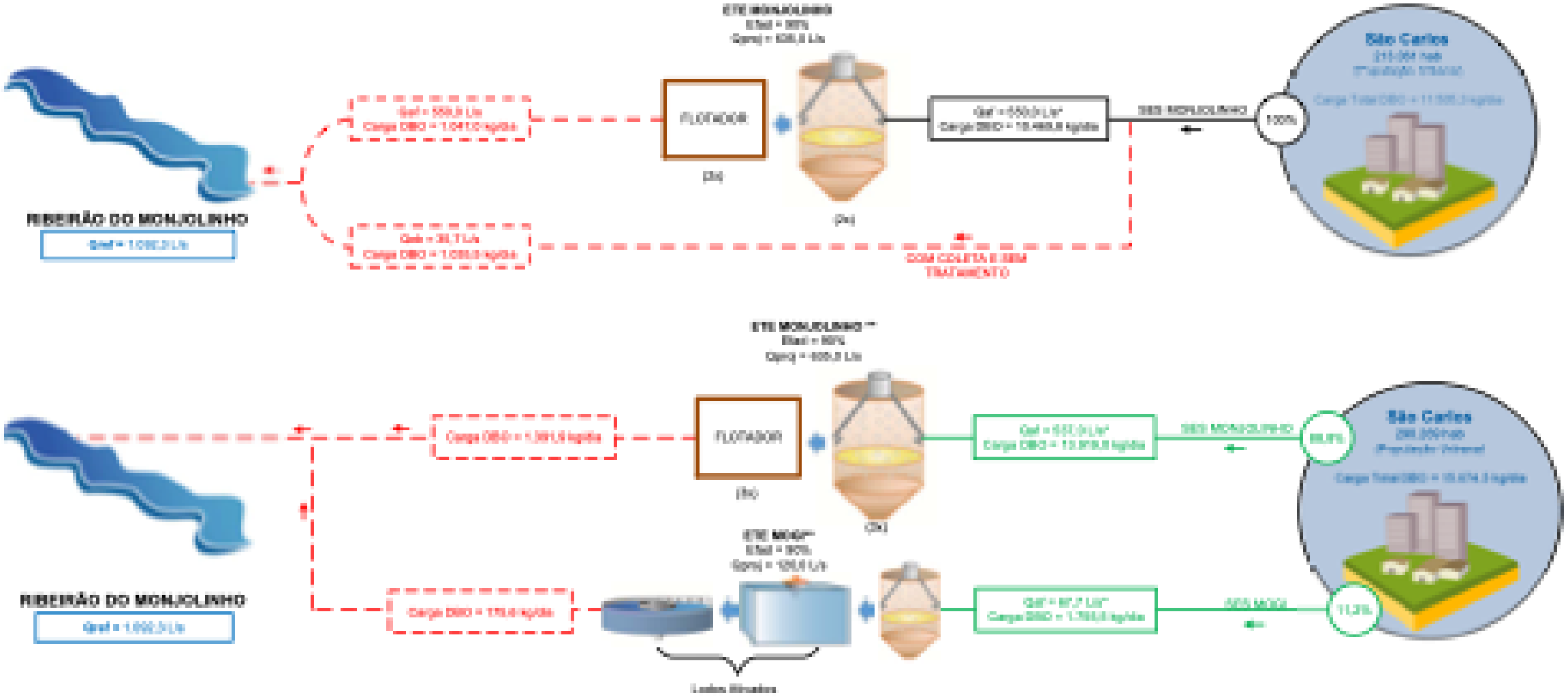
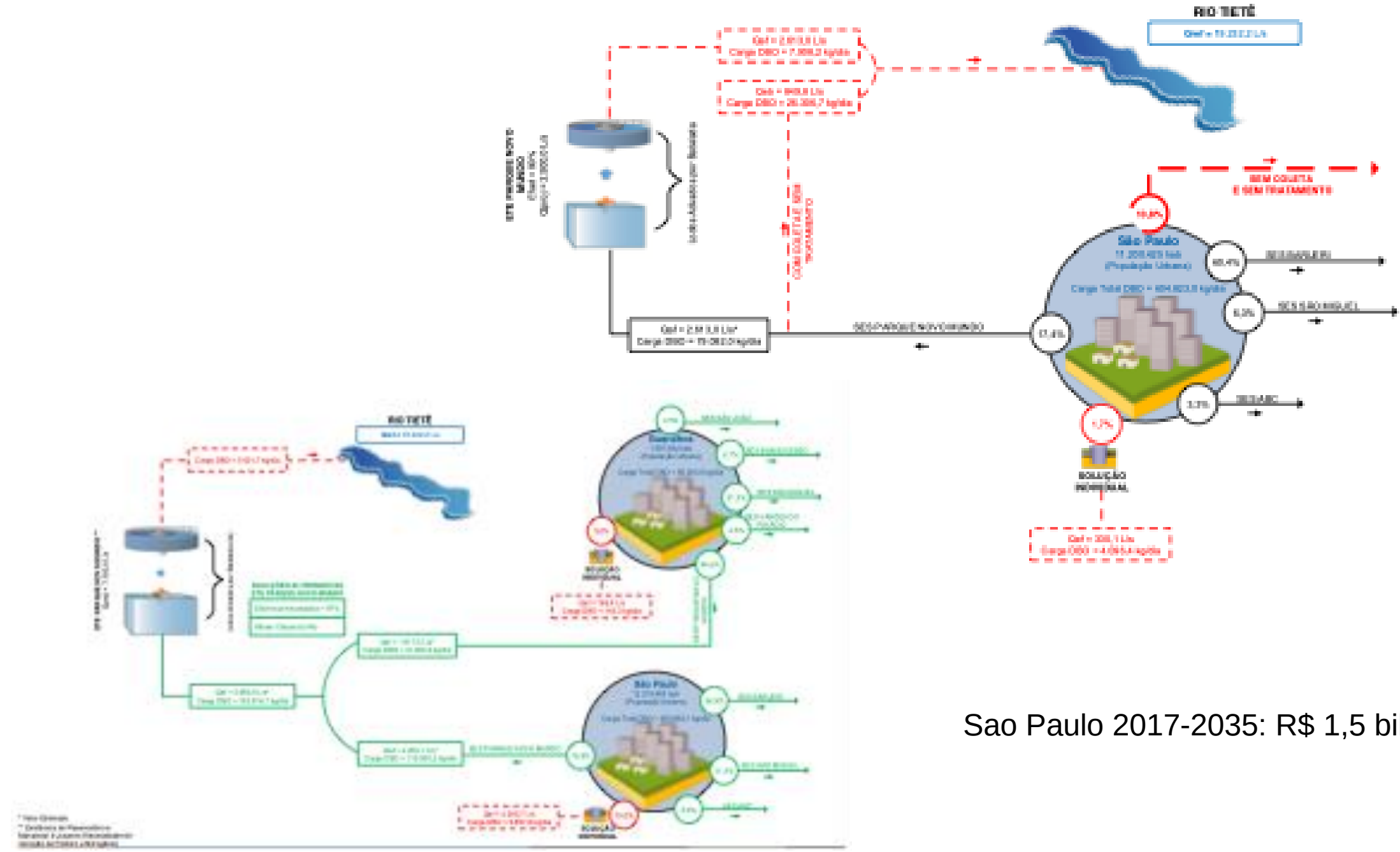
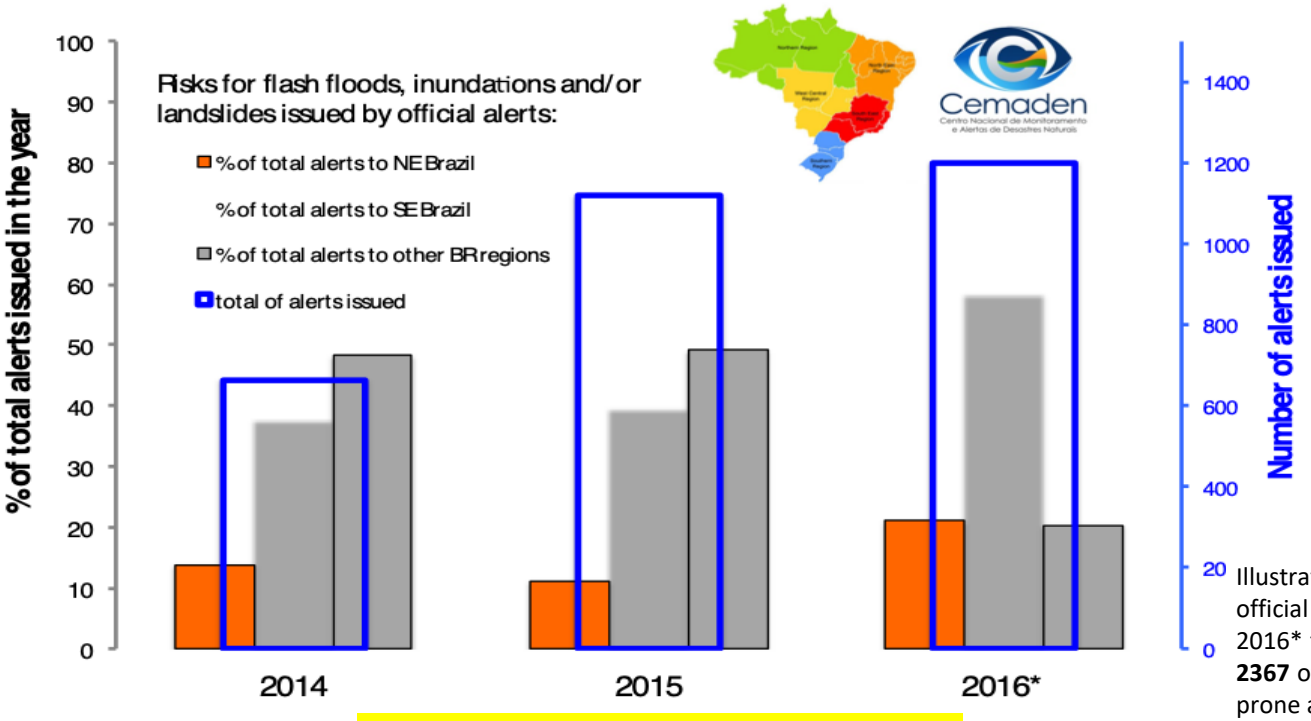


Sao Carlos 2017-2035: R$ 260 milhões



Sao Paulo 2017-2035: R$ 1,5 bilhão

The Brazilian Socio-Hydrology Gap: flood warnings are issued at national and states' scales under institutional protocols* (ANA/CEMADEN/CENAD/CPRM+States, Brazilian Law of Civil Protection #12.208/2012). But more than 90% of critical flood prone areas (with people) has runoff time of concentration below 2 hours!!!



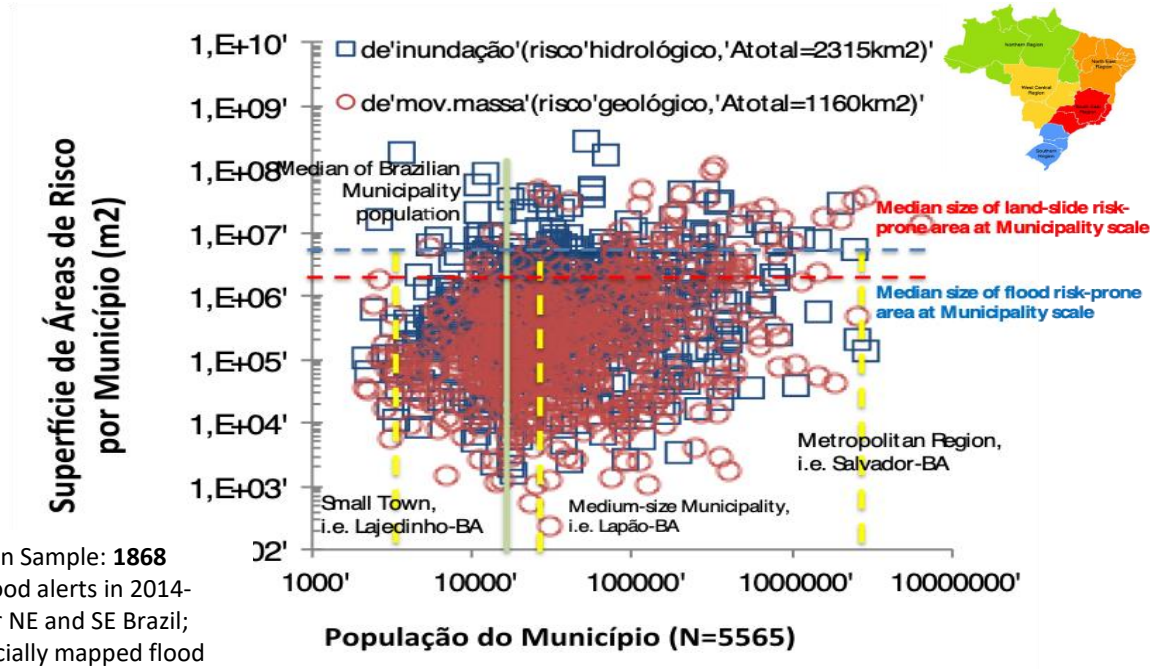
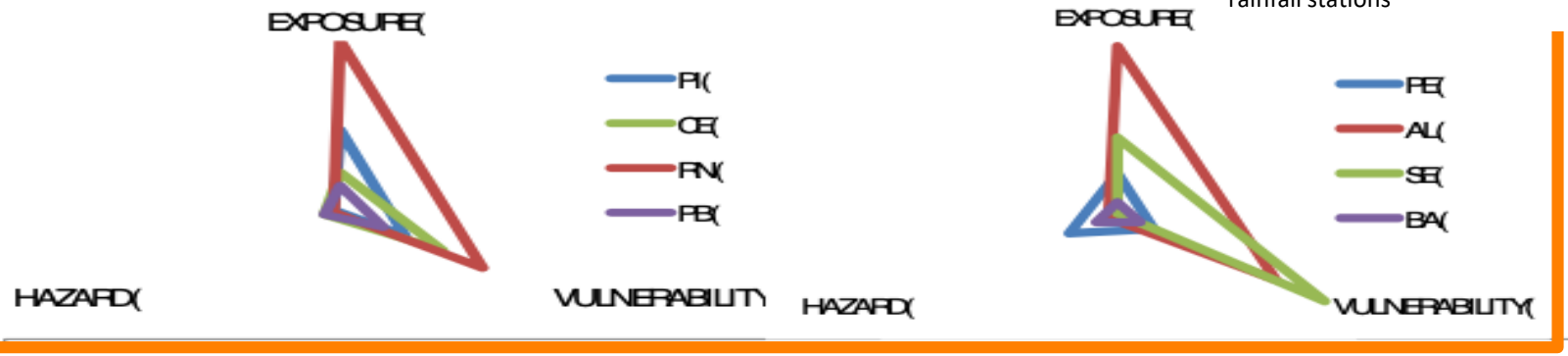


Illustration Sample: **1868** official flood alerts in 2014-2016* for NE and SE Brazil; **2367** officially mapped flood prone areas in NE + SE Brazil; **50.1** million people living in NE+SE municipalities; **1275** own rainfall stations

States of NE Brazil



States of SE Brazil

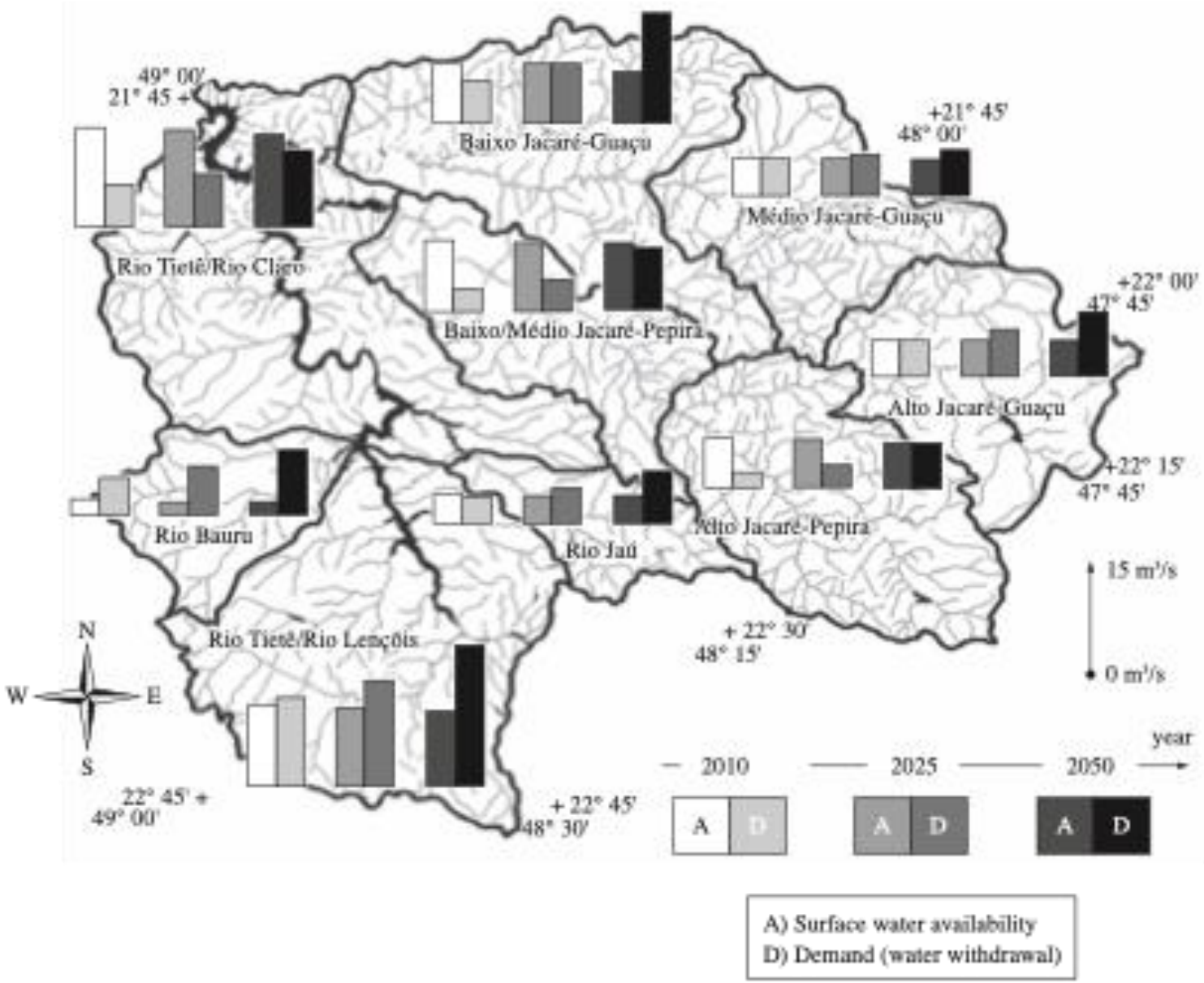
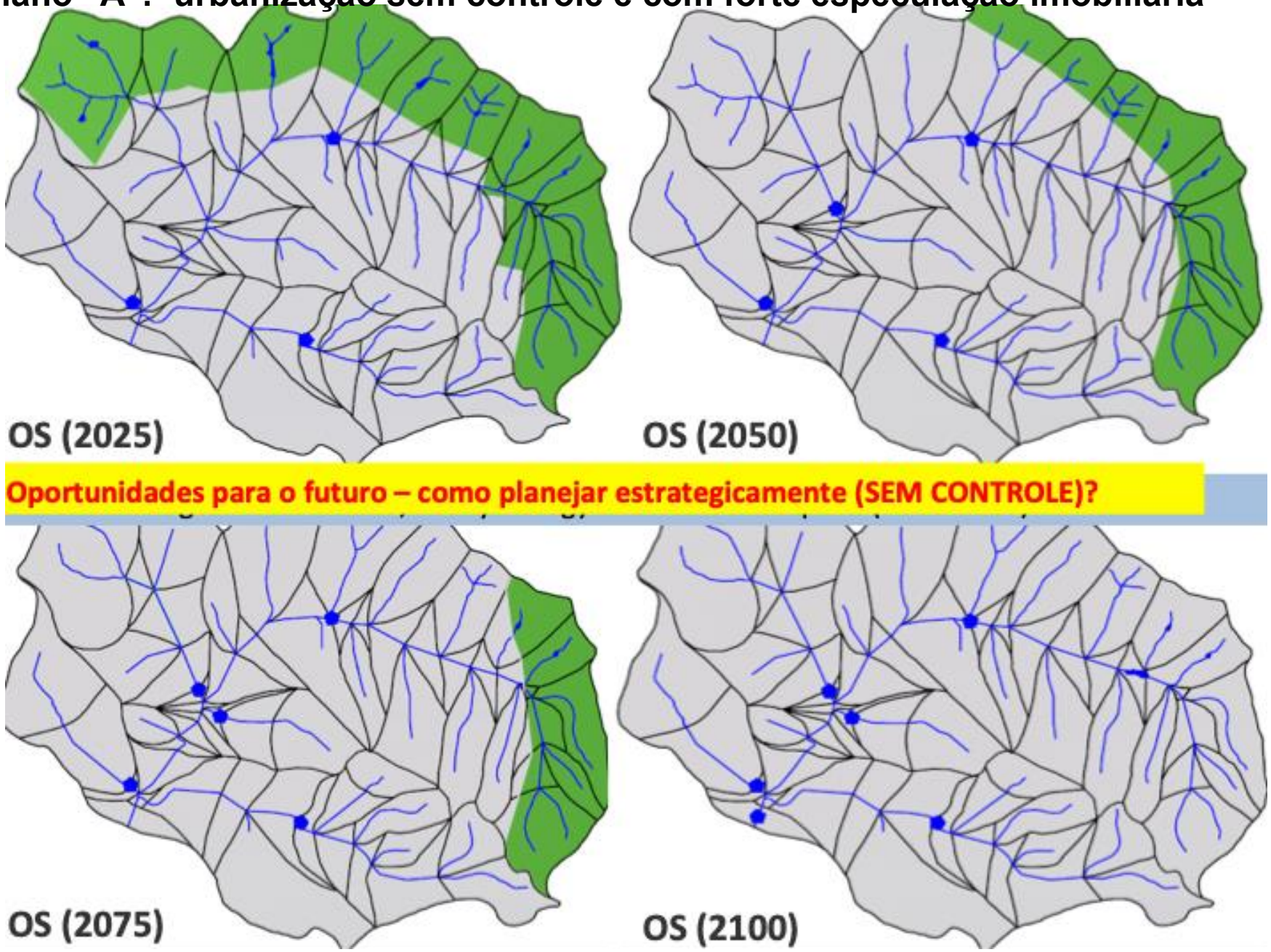


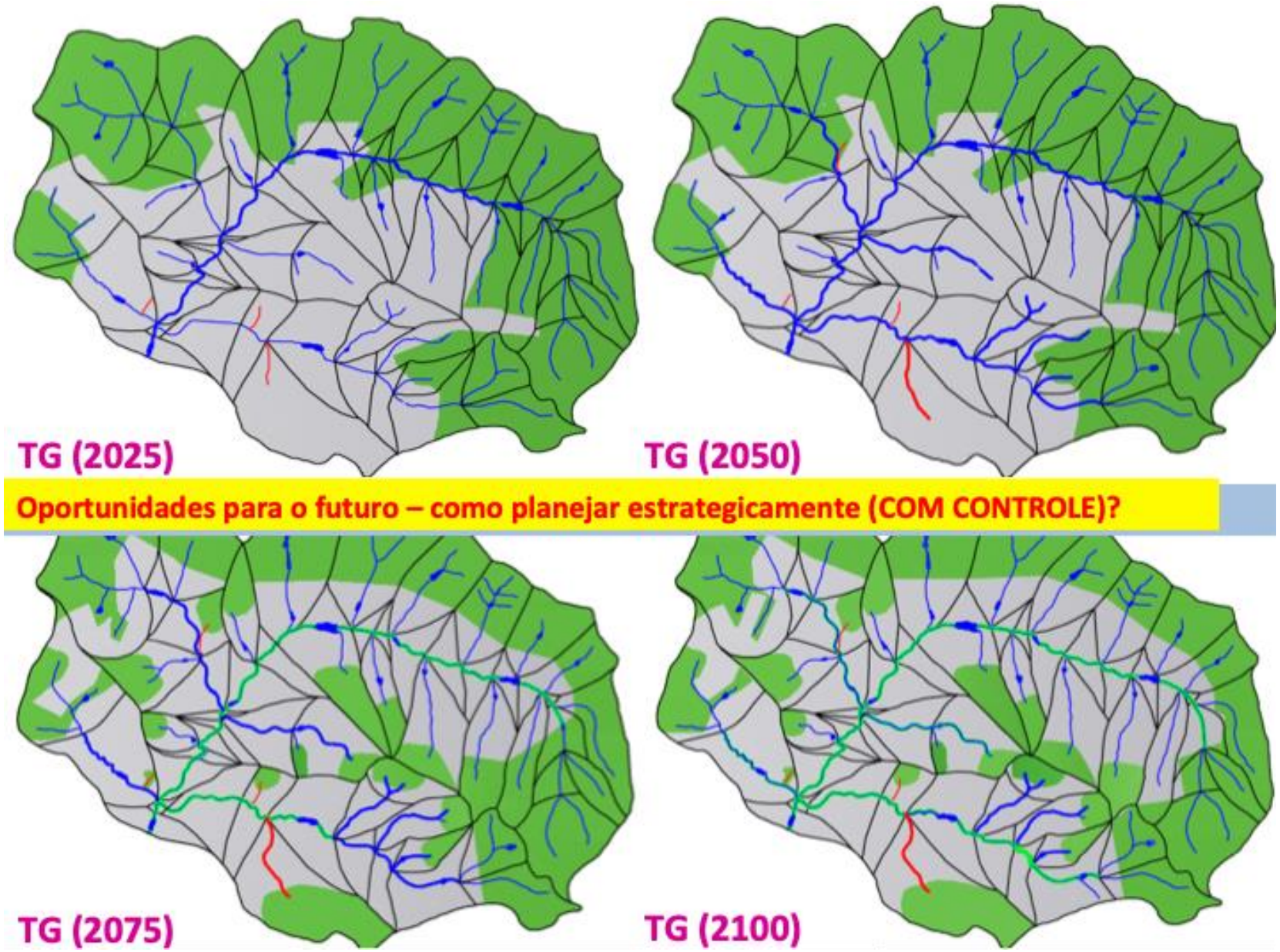
Figure 12. Impacts of urban biodiversity should be related to water availability and to multi-sector water withdrawal for the period of 2010 and 2050 at river basins of Tiete Jacare River Basin (11,400 km^2) at Sao Paulo State, Brazil (Mendiondo and Macedo, 2007).

Plano “A”: urbanização sem controle e com forte especulação imobiliária



nagem urbana sob cenários de longo prazo visando incentivos ambientais, Diss. Mestrado PPGSHS, EESC-USP; disponível em: http://www.teses.usp.br/teses/disponiveis/18/18138/tde-

Plano “B”: com Serviços Ecossistêmicos, ODSs, SIMI e Observatório Cidadão



- Initial publications considering EbA, climate services, willingness-to-adapt and insurance for the WEF+B nexus of subtropical catchments in Brazil.

Climate Services 8 (2017) 1–16

Contents lists available at ScienceDirect

Climate Services

journal homepage: www.elsevier.com/locate/cliser

Hydrological services in the Atlantic Forest, Brazil: An ecosystem-based adaptation using ecohydrological monitoring

Denise Taffarello[a,*], Maria do Carmo Calijuri[a], Ricardo A. Gorne Viani[b], José A. Marengo[c], Eduardo Mario Mendiondo[a]

Ecological Economics 140 (2017) 66–78

Contents lists available at ScienceDirect

Ecological Economics

journal homepage: www.elsevier.com/locate/ecolecon

Economic indicators of hydrologic drought insurance under water demand and climate change scenarios in a Brazilian context

Guilherme Samprogna Mohor *, Eduardo Mario Mendiondo

Hydrol. Earth Syst. Sci. Discuss., https://doi.org/10.5194/hess-2017-615
Manuscript under review for journal Hydrol. Earth Syst. Sci.
Discussion started: 20 November 2017

Hydrology and Earth System Sciences Discussions

Economic impacts of drought risks for water utilities through Severity-Duration-Frequency framework under climate change scenarios

Diego A. Guzmán[1-2], Guilherme S. Mohor[1], Denise Taffarello[1] and Eduardo M. Mendiondo[1]

Hydrol. Earth Syst. Sci., 22, 4699–4723, 2018
https://doi.org/10.5194/hess-22-4699-2018

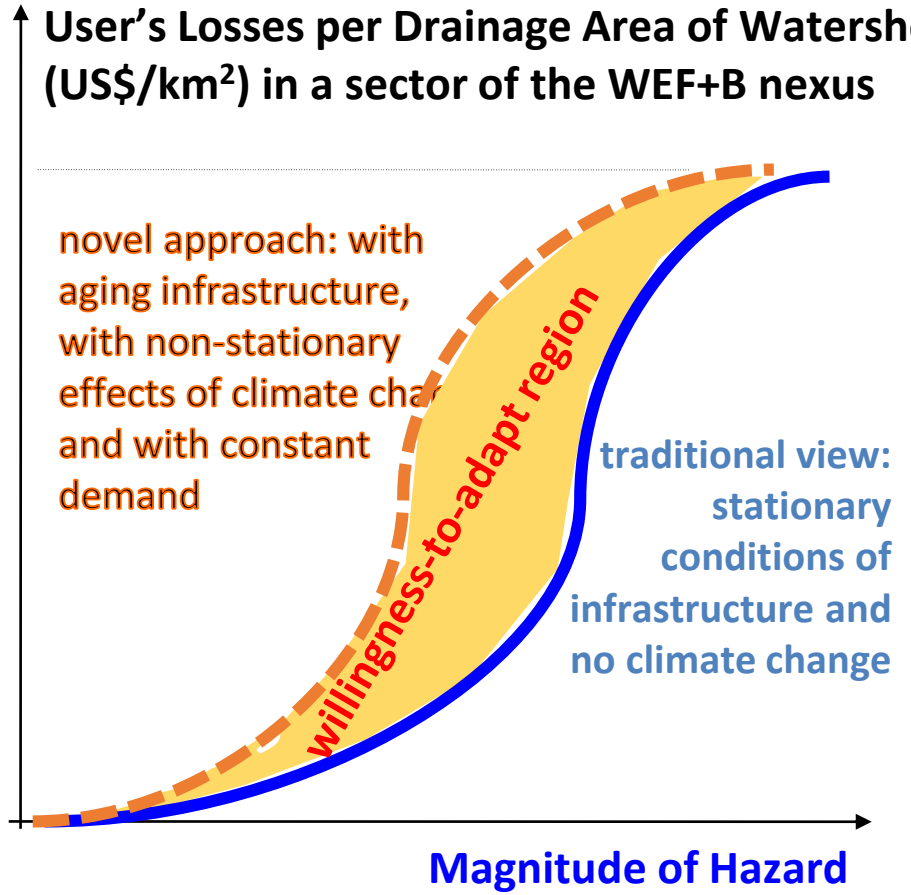
Hydrology and Earth System Sciences

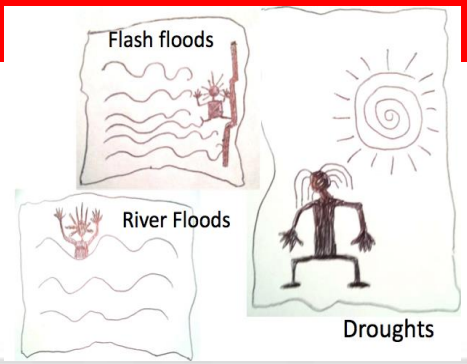
Modeling freshwater quality scenarios with ecosystem-based adaptation in the headwaters of the Cantareira system, Brazil

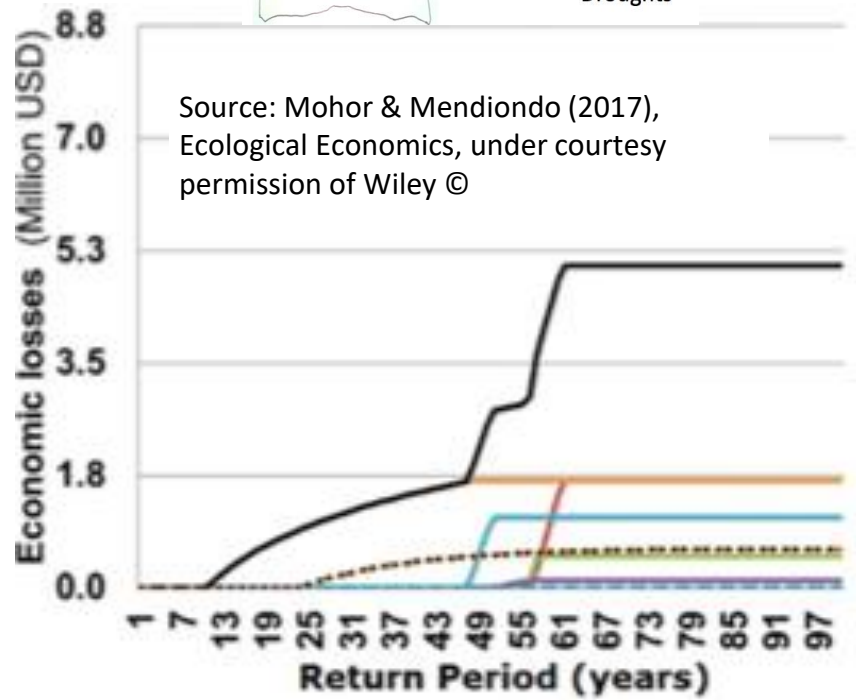
Denise Taffarello[1], Raghavan Srinivasan[2], Guilherme Samprogna Mohor[1,3], João Luis Bittencourt Guimarães[4], Maria do Carmo Calijuri[1], and Eduardo Mario Mendiondo[1]

- Fundamentals for a “willingness-to-adapt” (WTA) insurance to cope with risks on aging infrastructure and climate services using Multi-Hazard, Multi-Risk under Change (non-stationary) mechanisms.

Continuous lines represent time-stationary conditions for HAZARDS acting on each sectorial loss risk. Dotted lines outline non-stationary conditions for HAZARDS acting on aging infrastructure under climate change. All sectorial loss risks can be assessed through economic metrics of damage (US$) per drainage area of the studied river basin(km^2).

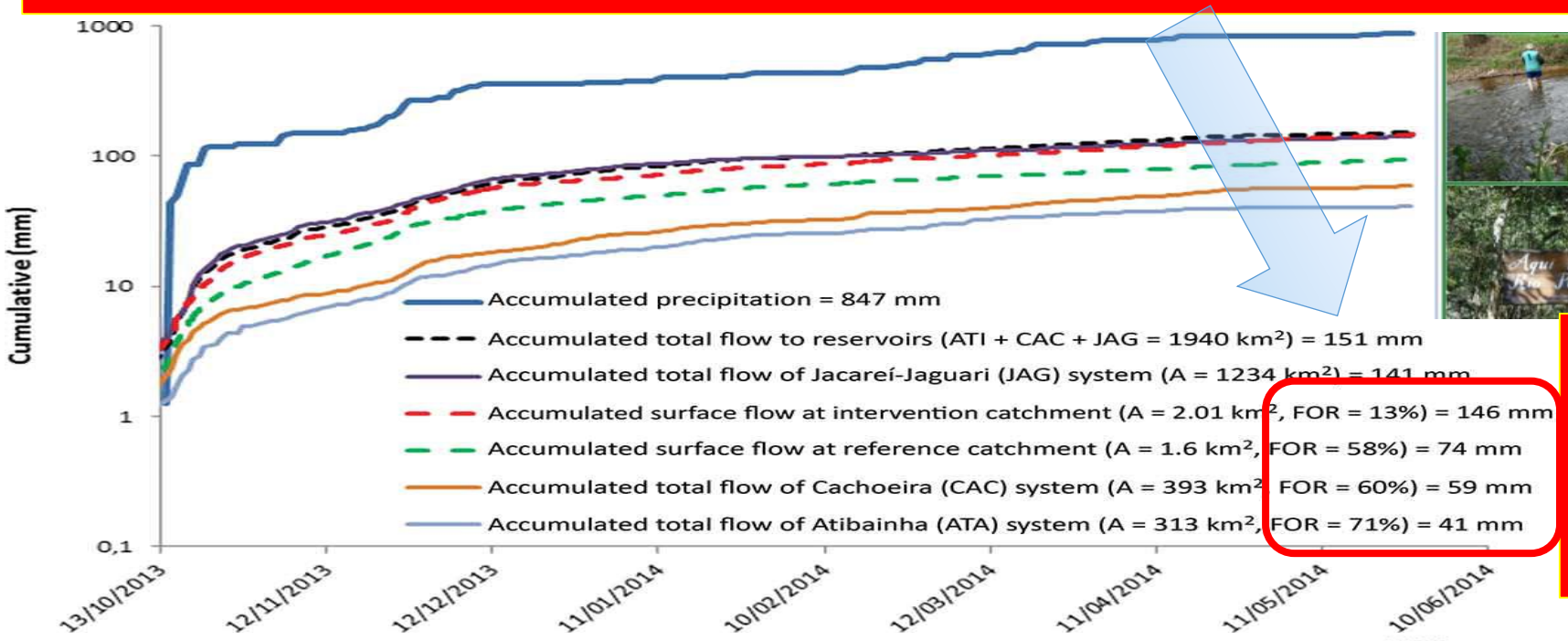






Source: Mohor & Mendiondo (2017), Ecological Economics, under courtesy permission of Wiley ©

WTA insurance also acknowledges EbA mechanisms under extreme water hazards. From the 'cover-water yield demand-side' approach, experimental monitoring under Brazilian 2013/2014 drought showed that forested-prioritized catchments (with stronger green water footprint) produced lowest water yield …



…and WTA insurance could help forested catchments to support regional biogeochemical fluxes across spatial scales*, accepting the 'cover-water yield supply-side' approach

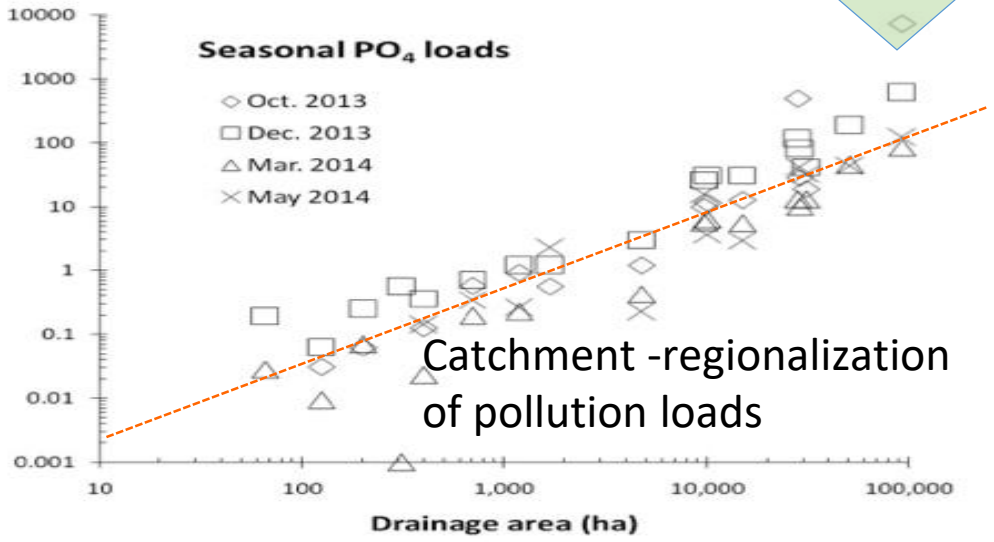
Water International

Routledge
Taylor & Francis Group

ISSN: 0250-8060 (Print) 1941-1707 (Online) Journal homepage: http://www.tandfonline.com/loi/rwin20

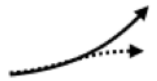
Field investigations of the 2013–14 drought through quali-quantitative freshwater monitoring at the headwaters of the Cantareira System, Brazil

Denise Taffarello, Guilherme Samprogna Mohor, Maria do Carmo Calijuri & Eduardo Mario Mendiondo



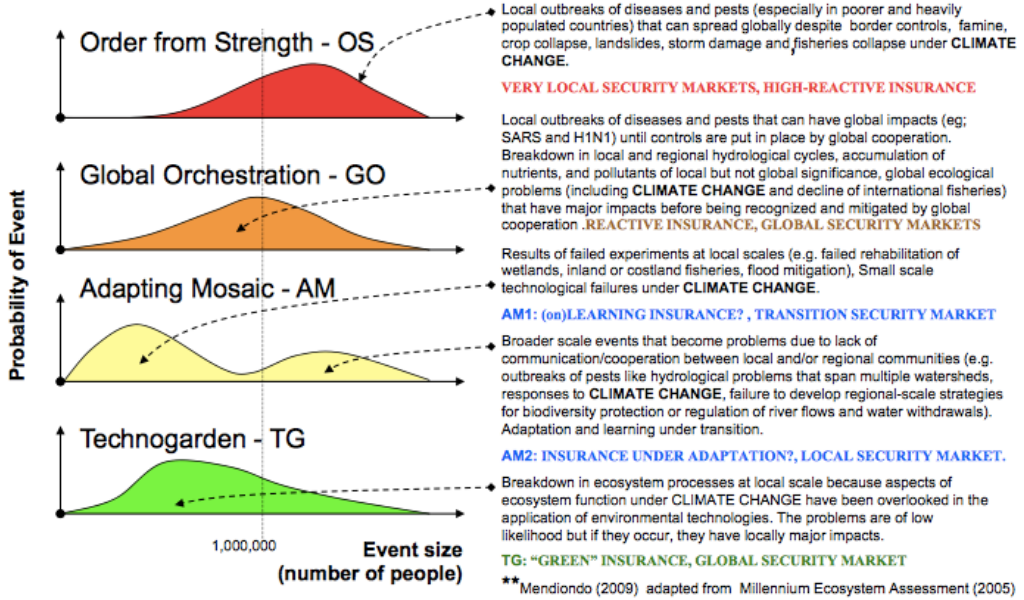
Catchment -regionalization of pollution loads

- We point WTA-resilient metrics better merge the hydrologic cycle with the life cycle of aging water services. We tested this WTA hypothesis using freshwater flows in current and future climate scenarios.

Component	Global Orchestration	Technogarden	Order from Strength	Adapting Mosaic
	Scenario development for period 2010-2100 (horizontal axis)			
Flood prone areas impacted (total area degraded)				
Direct Drivers:				
Hard Flood Control	++	+ → 0	0	0 → -
Risk Exposure	+	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	+

HRTMs used for water extremes *and insurance options* across governance policy scenarios under climate change**

The **x-axis** is the magnitude of the disturbance of ecosystem services, measured by the number of people affected.
The **y-axis** is the likelihood of an extreme ecosystem event of a given magnitude.
The **total area under each curve** is the same (for each scenario the probabilities of all event magnitudes must sum to one 1).



Local outbreaks of diseases and pests (especially in poorer and heavily populated countries) that can spread globally despite border controls, famine, crop collapse, landslides, storm damage and fisheries collapse under **CLIMATE CHANGE**.

VERY LOCAL SECURITY MARKETS, HIGH-REACTIVE INSURANCE

Local outbreaks of diseases and pests that can have global impacts (eg; SARS and H1N1) until controls are put in place by global cooperation. Breakdown in local and regional hydrological cycles, accumulation of nutrients, and pollutants of local but not global significance, global ecological problems (including **CLIMATE CHANGE** and decline of international fisheries) that have major impacts before being recognized and mitigated by global cooperation .REACTIVE INSURANCE, GLOBAL SECURITY MARKETS

Results of failed experiments at local scales (e.g. failed rehabilitation of wetlands, inland or costland fisheries, flood mitigation), Small scale technological failures under **CLIMATE CHANGE**.

AM1: (on)LEARNING INSURANCE? , TRANSITION SECURITY MARKET

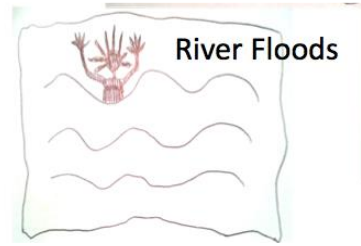
Broader scale events that become problems due to lack of communication/cooperation between local and/or regional communities (e.g. outbreaks of pests like hydrological problems that span multiple watersheds, responses to **CLIMATE CHANGE**, failure to develop regional-scale strategies for biodiversity protection or regulation of river flows and water withdrawals). Adaptation and learning under transition.

AM2: INSURANCE UNDER ADAPTATION?, LOCAL SECURITY MARKET.

Breakdown in ecosystem processes at local scale because aspects of ecosystem function under CLIMATE CHANGE have been overlooked in the application of environmental technologies. The problems are of low likelihood but if they occur, they have locally major impacts.

TG: "GREEN" INSURANCE, GLOBAL SECURITY MARKET

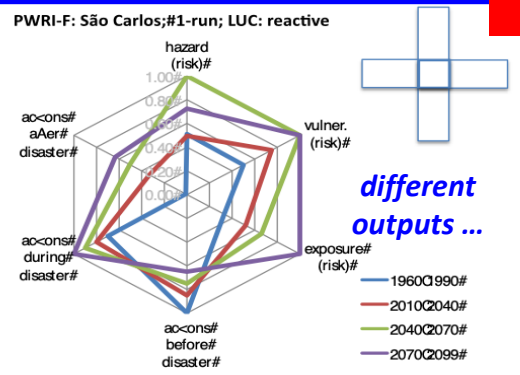
**Mendiondo (2009) adapted from Millennium Ecosystem Assessment (2005)

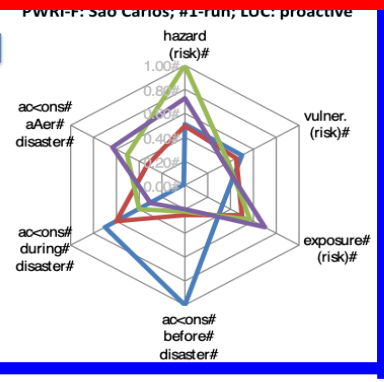


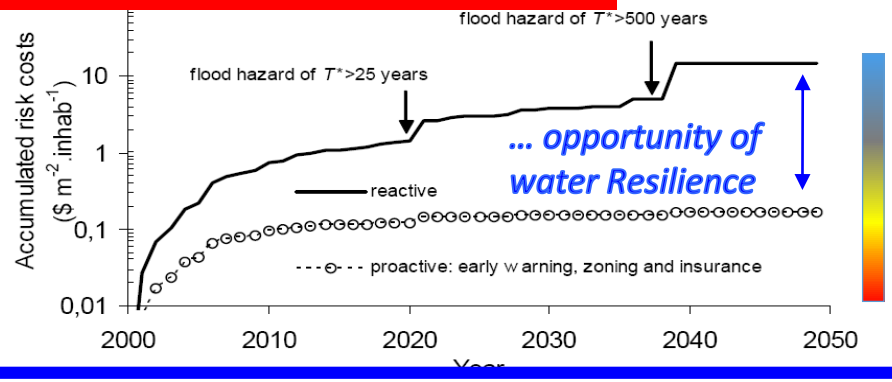
Participatory Water Resilience Index (PWRI) under long-term policies of urban risk aversion to floods. Source: Mendiondo (2010)* and FAPESP-IVA (Marengo, 2014)**

Participatory Water Resilience Index linked to Insurance

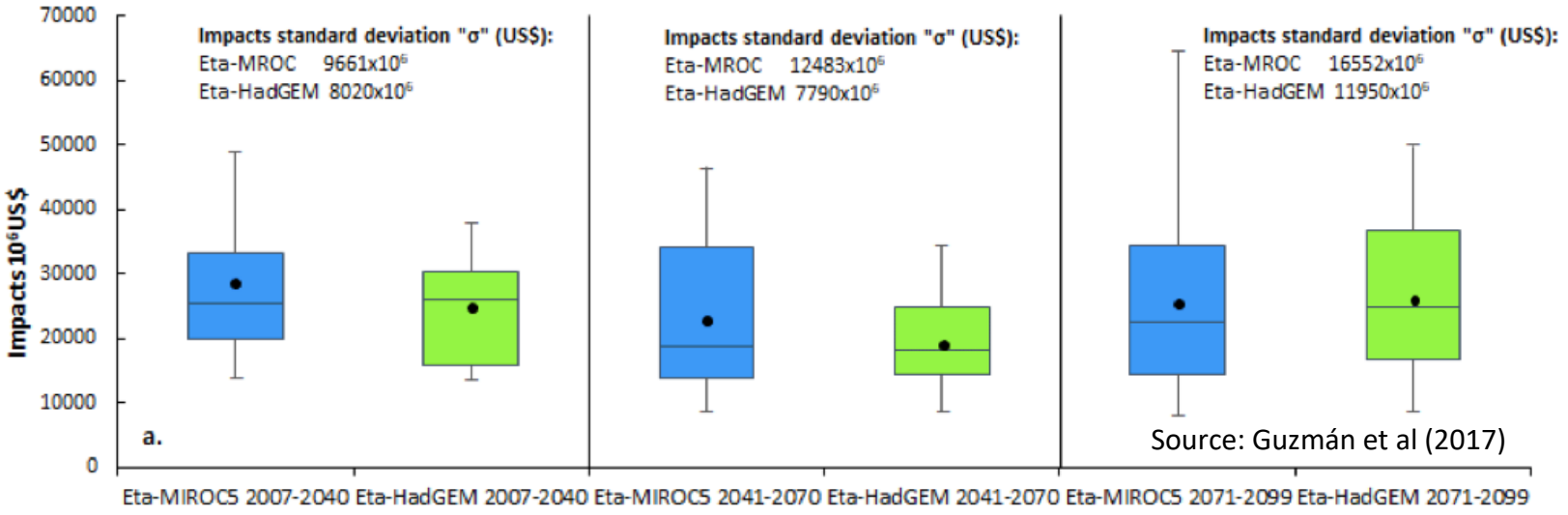
Marengo, J. (2014) Assessment of Impacts and Vulnerability to Climate Change in Brazil and Strategies for Adaptation Options, FAPESP 2008/58161-1, Final Report (www.fapesp.br)
Mendiondo, E M (2010) Reducing Vulnerability to Water-Related Disasters in Urban Areas of Humid Tropics, In: J. Parkinson et al (eds) Integrated Urban Water Management: Humid Tropics, Chapter 6, UNESCO-IHP Series







- With WTA concept, we addressed insurance premiums to cover users' losses as mitigation mechanisms on climate change** and aging infrastructure, extending works to strategic, but vulnerable river basins strongly dependant on water footprints for hydropower, food production and water supply in Southeast Brazil



Source: Guzmán et al (2017)

Hydrological Processes

RESEARCH ARTICLE

Season-based rainfall–runoff modelling using the probability-distributed model (PDM) for large basins in southeastern Brazil

Rong Zhang, Luz Adriana Cuartas, Luiz Valerio de Castro Carvalho, Karinne Reis Deusdará Leal, Eduardo Mário Mendiondo, Narumi Abe, Stephen Birkinshaw, Guilherme Samprogna Mohor, Marcelo Enrique Seluchi, Carlos Afonso Nobre

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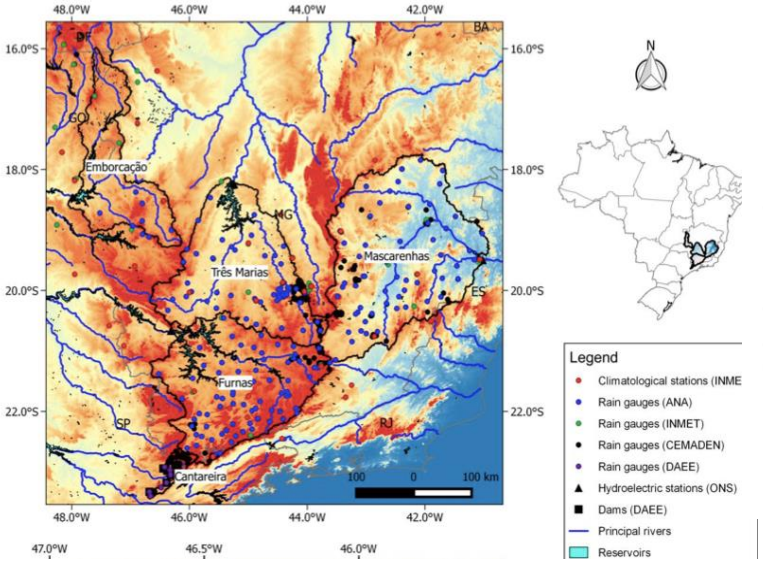
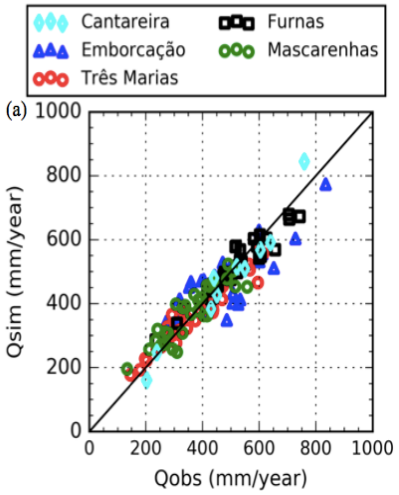
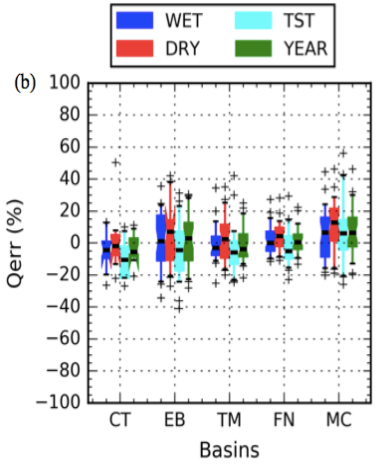
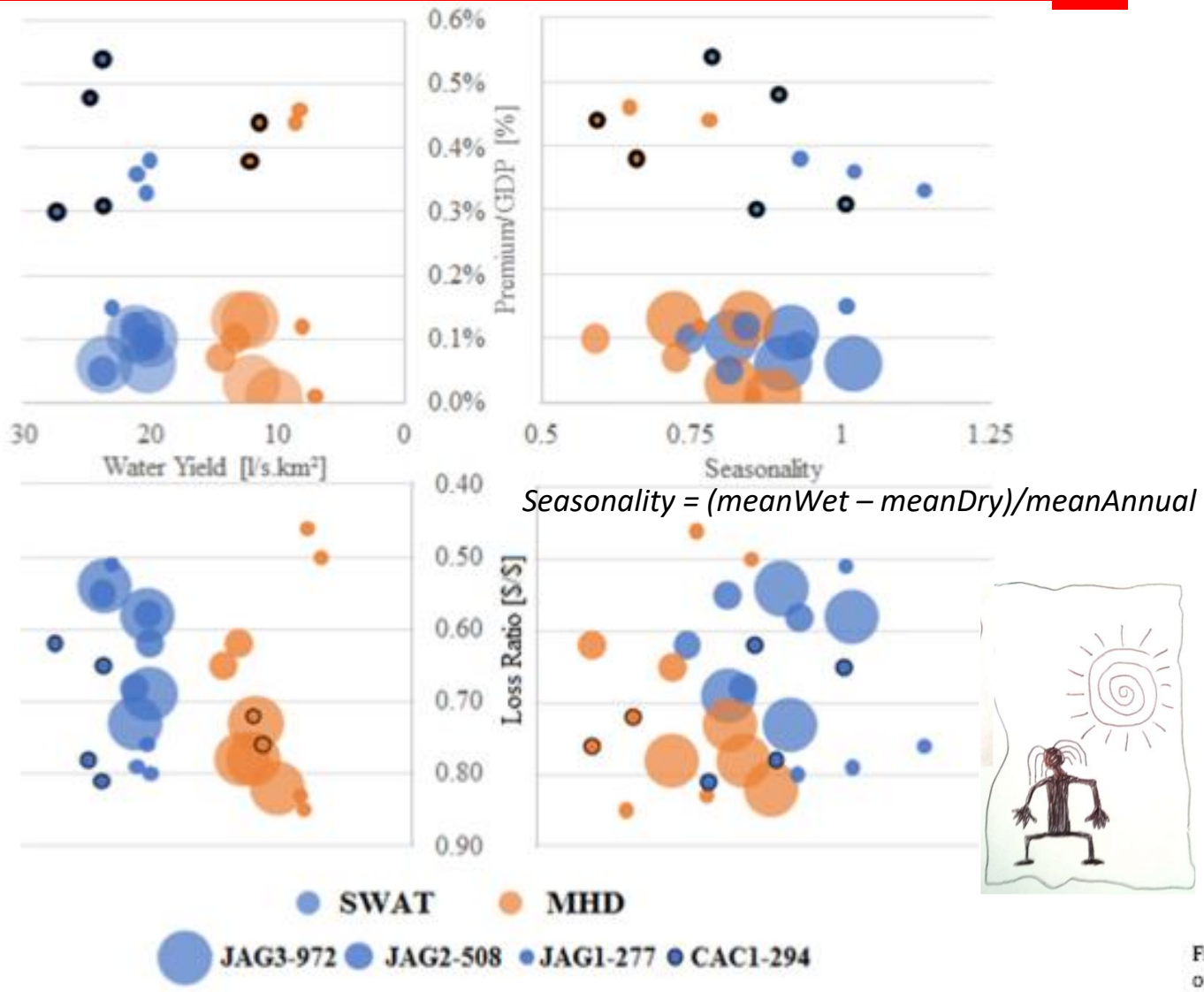




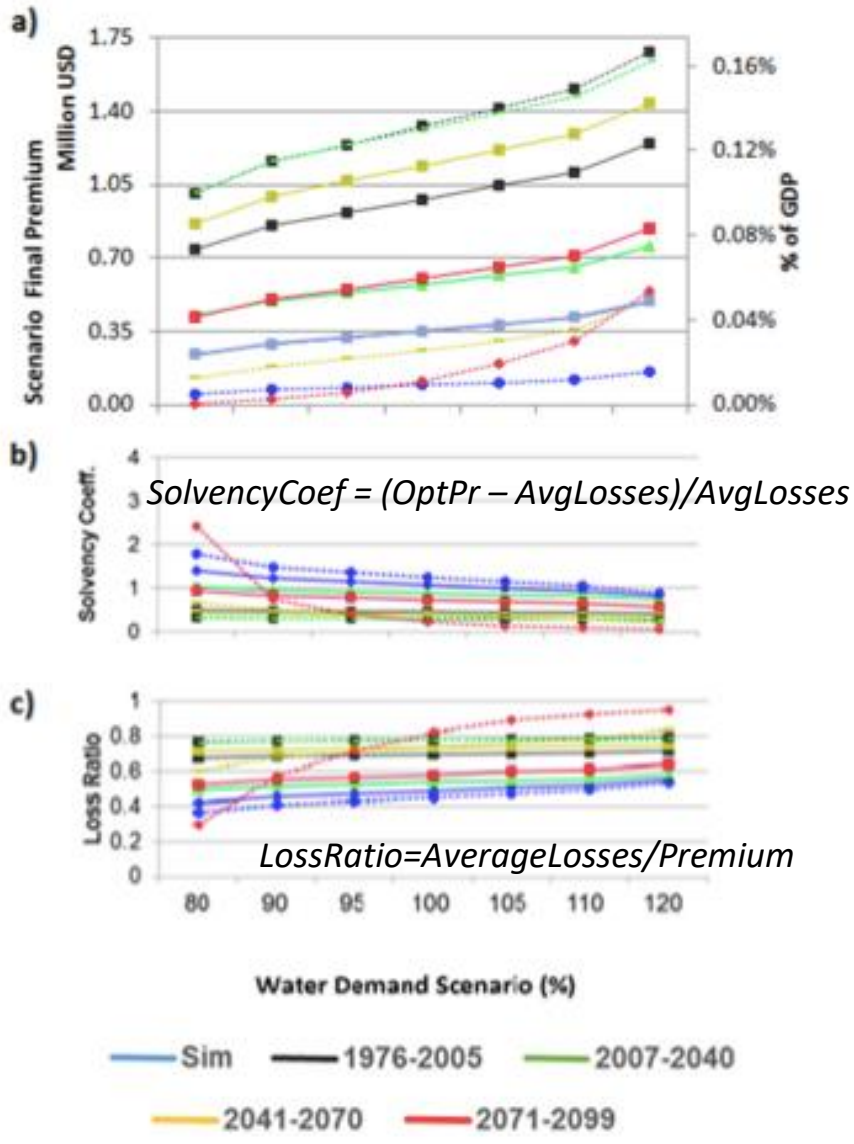


** Projected economical impacts of climate change on water utility company revenue from a 2800-km2 supply system, in Southeast Brazil (Sao Paulo Metropolitan Region), show great range of possibilities for trading off and for developing adaptation strategies of Ecosystem-based Adaptation (EbA) with Payment for Ecosystem Services (PES) supporting WTA insurance.

- Scenarios with MTRH-SHS assess what aging water services could benefit of setting premiums as proxies of WTA.



Seasonality = (meanWet – meanDry)/meanAnnual



SolvencyCoef = (OptPr – AvgLosses)/AvgLosses

LossRatio=AverageLosses/Premium

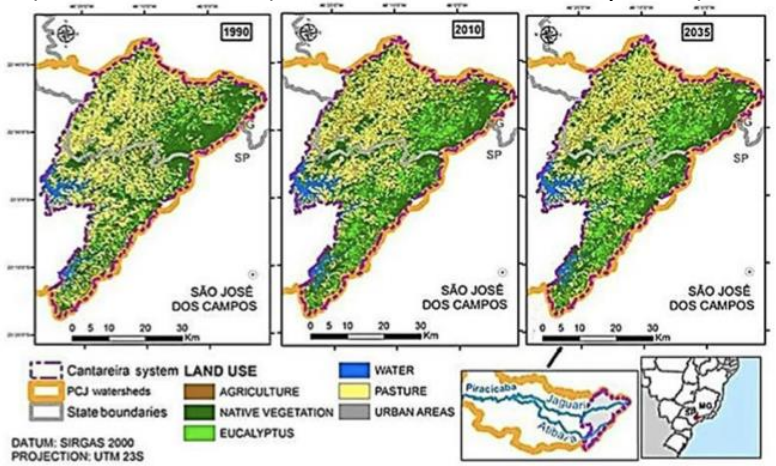
Fig. 6. a) Optimized premiums, b) solvency coefficient, and c) loss ratio for JAG3-972 outlet from SWAT (solid lines) and MHD (dashed lines) outputs.

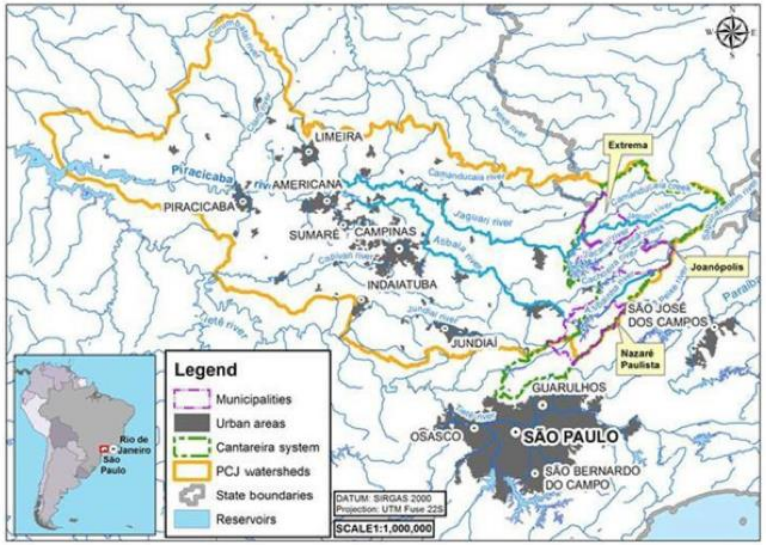
Optimized premiums and loss ratios under hydrologic scenarios driven by climate projections, under current (100%) water demand. Circles area are proportional do sub-basins' areas.

Source: Mohor & Mendiondo (2017), under courtesy permission of Wiley©

Water Yield Uncertainty: Brazilian nested catchments* draining to water supply utilities under climate change scenarios between 2010-2099 show more dependence on outputs from different hydrological models (i.e. SWAT/TAMU and MHD/INPE) than on scales….

Land-use change during 1990 (scenario S1), 2010 (scenario S2) and 2035 (scenario S2 + EbA) in the Cantareira water system (Taffarello et al, 2018)



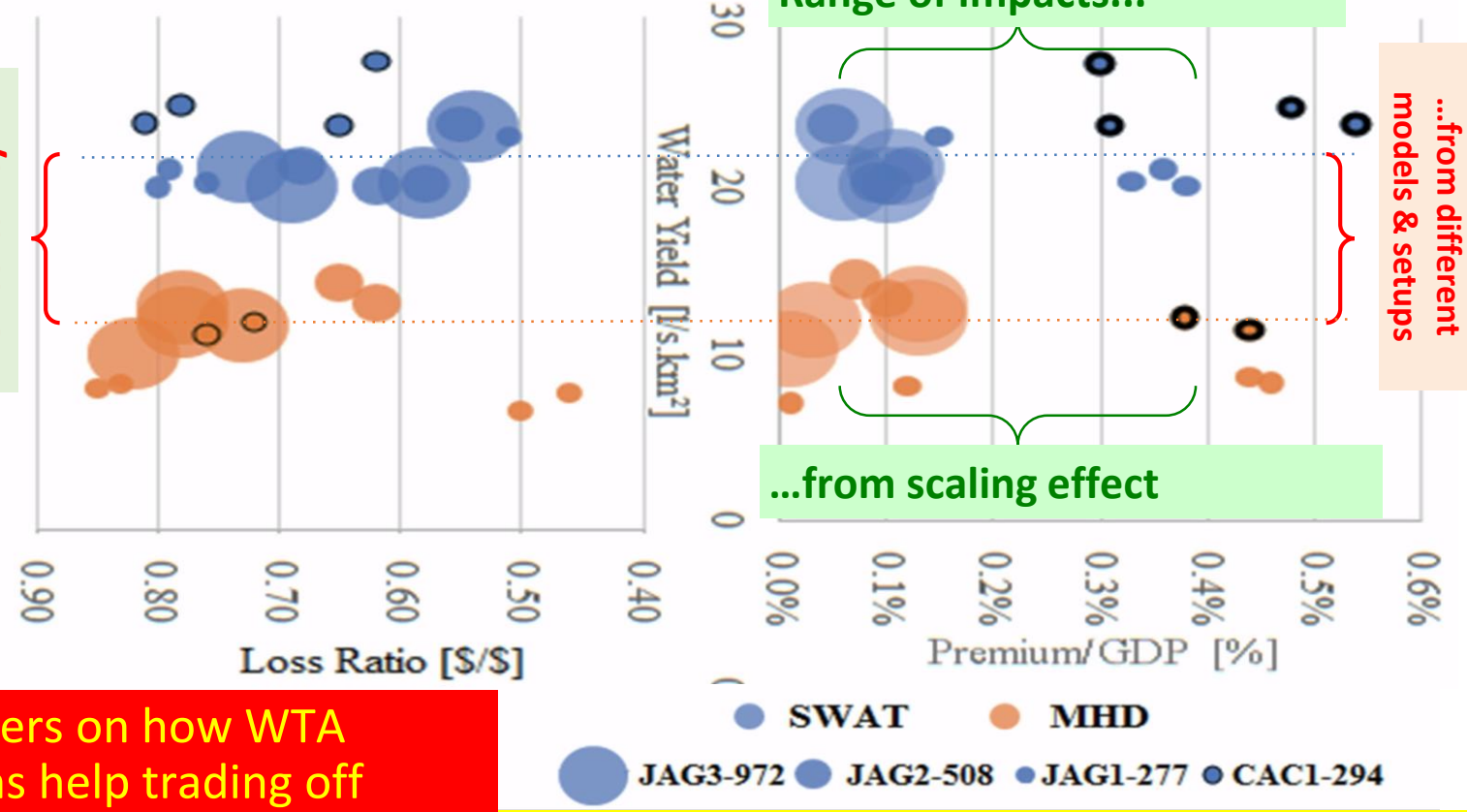


Range of impacts...

Water Yield Uncertainty...

...from different models & setups

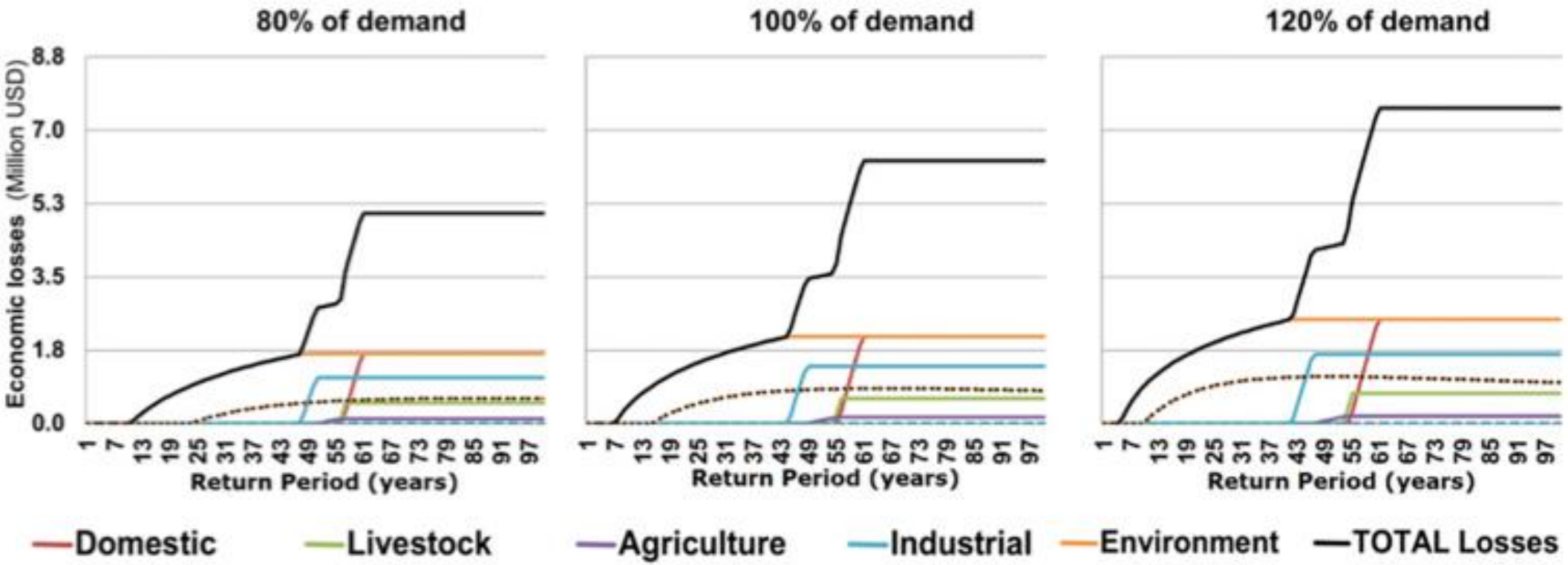
...from scaling effect



EbA centers on how WTA premiums help trading off drought crises as kind of Payment for Ecosystem Services (PES) impacting 20 million people of the Brazilian biggest metropolitan area.

…but **resilient mechanisms** (i.e. insurance) depict evidences of heavy influence of different spatial scales* (areas of: 294, 277, 508 and 972 km^2)

- A 20% increase in water demand, which elevates the pressure of aging infrastructure, elevates the premium up to only 0.1% of the local GDP.



. Source: Mohor & Mendiondo (2017), under courtesy permission of Wiley©

- Indeed, even under current and future water demands, premiums assessed by WaterPES may surpass 1-2% of GDP because of people's changes of WTA, not only due to water regime but also because of institutional governance or techno-trends.

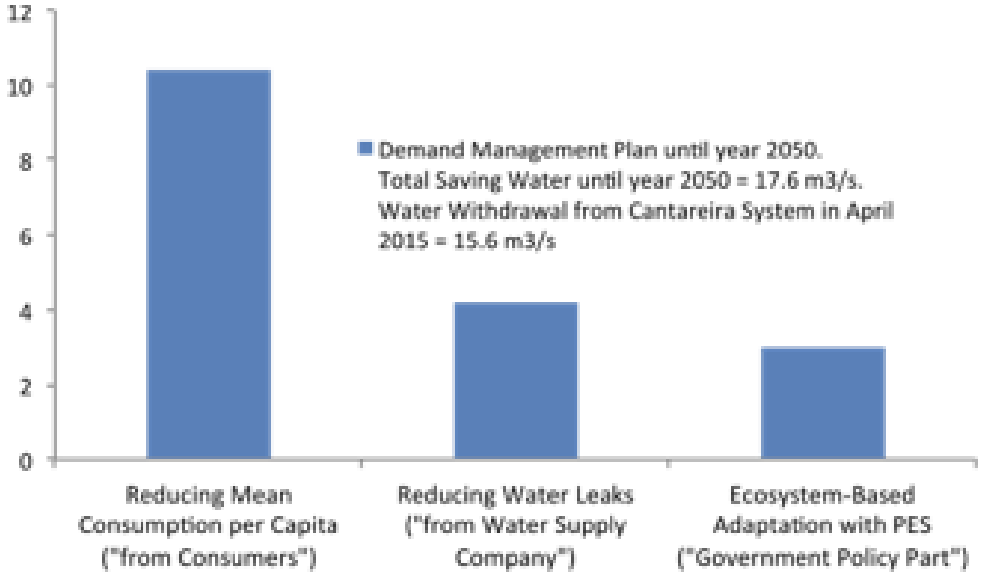
Para Região Metropolitana de São Paulo (RMSP):

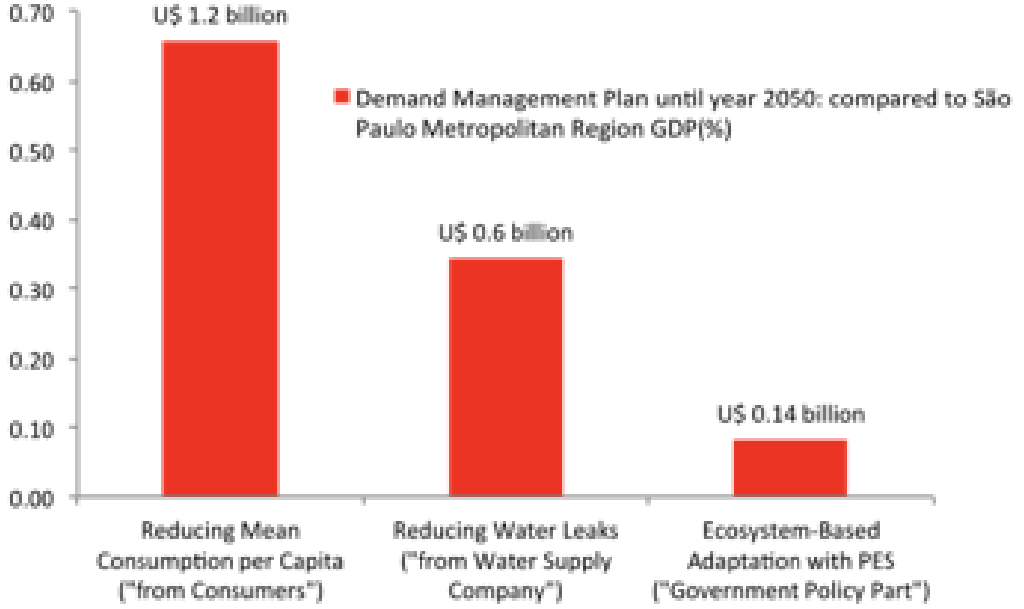
É possível poupar quase um SistemaCantareira com
Gestão de Demanda, através de
Parcerias-Público Privadas (PPPs), com aprox.
1,5 % do PIB da Região Metropolitana de São Paulo (RMSP).

Ao mesmo tempo, os investimentos em infraestrutura hídrica,
hoje contabilizados de até R$ 1,5 bilhão para RMSP,
Não incorporam elementos de saneamento como:
- Novo tratamento da poluição difusa (+ R$ 2,3 bi),
- Infraestrutura resiliente a mudanças climáticas (+ R$ 4,5 bi)
- outros

Seguros ambientais e transferência de riscos são necessários
Incluindo bancos, EBTs, institutos, centros especializados,
Empresas de saneamento básico (públicas-privadas)

Nicho de oportunidade de investimento 2020-2035: + R$ 180 bi





Thank you

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Water Footprint Working Group