Policy support systems in the development of benefit-sharing mechanisms for water-related ecosystem services

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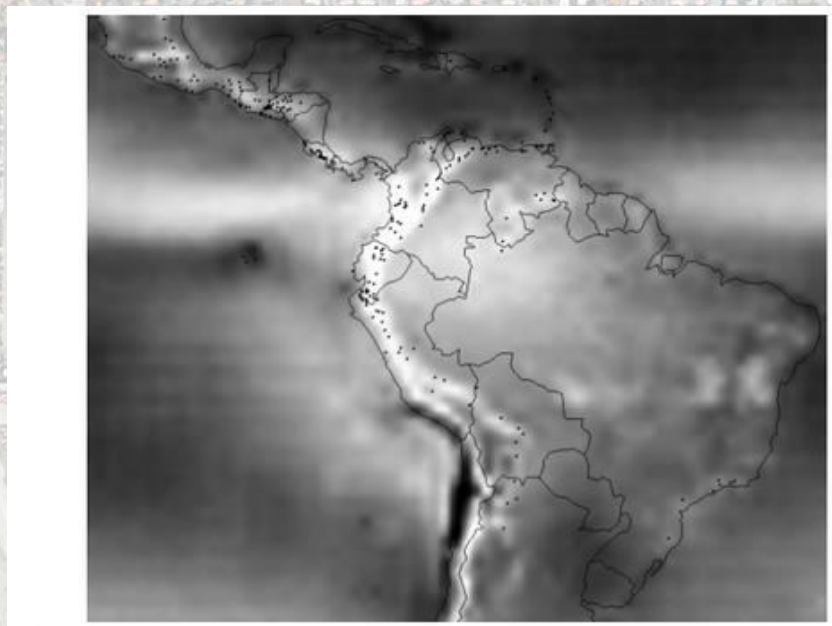
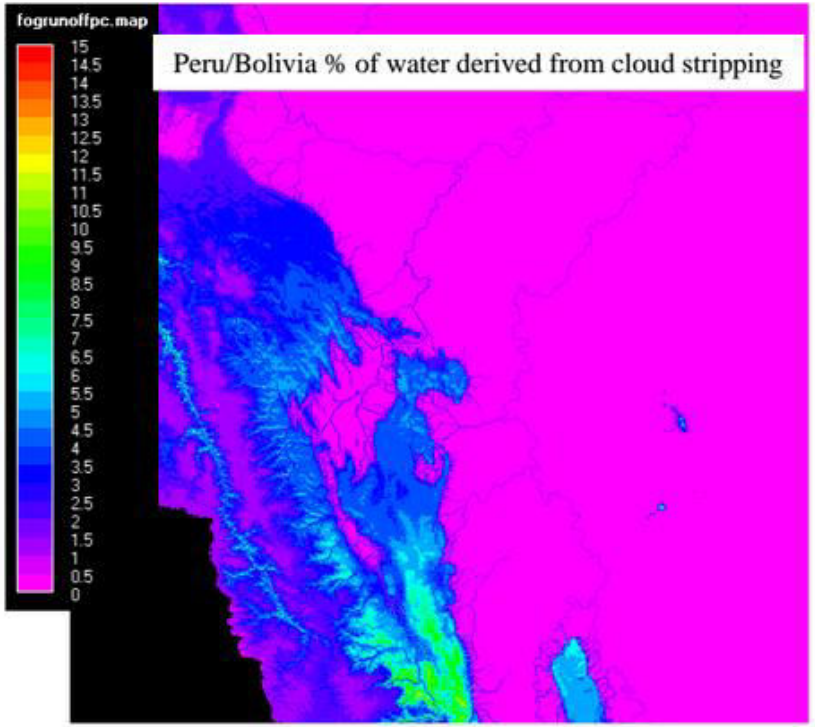
Environmental *vs* ecosystem services

- ***Environmental services*** - a function of broader environment (including climate and terrain) and thus not manageable at the local and regional scale of interventions
- ***Ecosystem services*** - a service provided by the ecosystem on the ground (vegetation, soil, wetlands) and can thus be managed for positive and negative outcomes
- *eg* cloud forests are **wet environments** (high precip, low evap. because of cloud) much of the water they produce is thus an **environmental service**
- Cloudwater (fog) inputs are an **ecosystem service** as they are dependent on trapping by forest. No forest, no trapping.





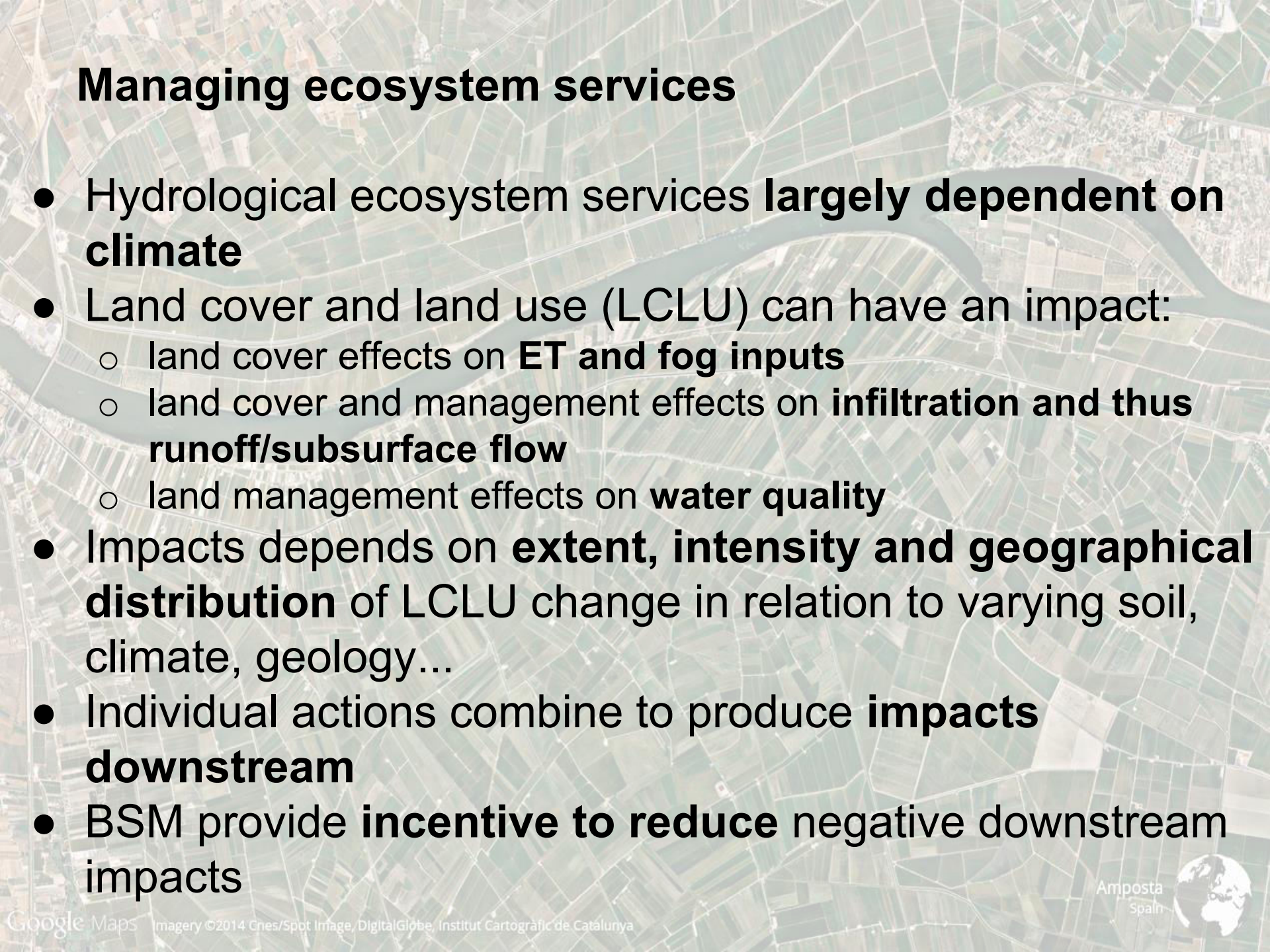
Hydrological ecosystem services

- Provisioning of water **quantity and quality**
- **Regulating** of flow peaks and troughs (floods and droughts)
- Role in some **hazards and hazard mitigation**
- Other cultural, spiritual and recreational
- Water **supports** other services *eg* plant production

- **Oversimplifications**: *forests generate more water, forests prevent floods, forests sustain dry season flows,forests improve water quality*
- ***Depends*** *on landscape and climate, type of forest, relative to what land use, distribution of beneficiaries.* ***The geography is key.***

Managing ecosystem services

- Hydrological ecosystem services **largely dependent on climate**
- Land cover and land use (LCLU) can have an impact:
  - land cover effects on **ET and fog inputs**
  - land cover and management effects on **infiltration and thus runoff/subsurface flow**
  - land management effects on **water quality**
- Impacts depends on **extent, intensity and geographical distribution** of LCLU change in relation to varying soil, climate, geology...
- Individual actions combine to produce **impacts downstream**
- BSM provide **incentive to reduce** negative downstream impacts



Site-scale, water-relevant tools for mapping and modelling ecosystem services

- **ARIES** - data-based surface and subsurface water calculations. Bayesian.
- **INVEST** - simple annual water balance model, tradeoffs with many other ES, valuation. **RIOS** investment optimisation
- **WEAP** - water allocation/distribution model with simple water balance
- **SWAT** - sophisticated process model, detailed parameterisation required.
- **WATERWORLD** - sophisticated, process based model of surface and subsurface stores and flows including snow and ice, fog. Climate, land use and land management scenarios. All data supplied for application globally.

ARIES
ARtificial Intelligence for Ecosystem Services

InVEST
integrated valuation of ecosystem services and tradeoffs

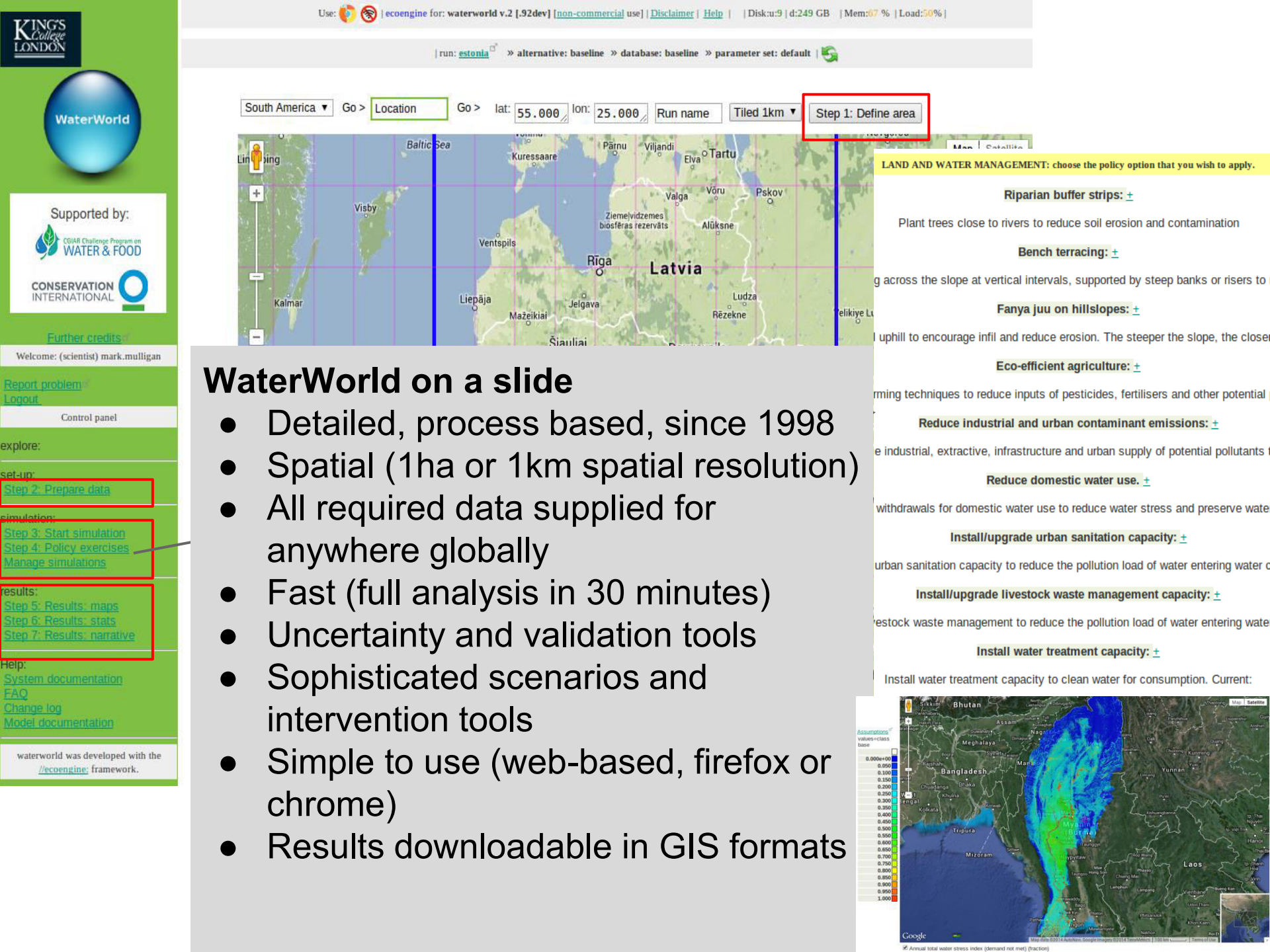
WEAP

SWAT Soil & Water Assessment Tool

WaterWorld

Tools & metrics - are like toothbrushes!

Everybody wants one but nobody wants to use anyone else's!



WaterWorld on a slide

- Detailed, process based, since 1998
- Spatial (1ha or 1km spatial resolution)
- All required data supplied for anywhere globally
- Fast (full analysis in 30 minutes)
- Uncertainty and validation tools
- Sophisticated scenarios and intervention tools
- Simple to use (web-based, firefox or chrome)
- Results downloadable in GIS formats

RIOS

resource investment optimization system

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RIOS on a slide

- Prioritises areas for investment portfolio based on a set of ES objectives in order to obtain the highest return on investment
- Uses input layers on any relevant biophysical, socio-economic or other properties
- Produces maps of where each investment should be prioritised up to a specific budget
- These maps can be used for scenario testing in ES tools eg INVEST, WaterWorld

The Latin American Water Funds

- BSMs in which water users such as hydropower, municipal water and industry provide **funds to be invested in ES management** upstream of their water intakes
- Need to know:
  - **what to invest in**
  - **where to invest**

  ...for **maximum water ES benefits return**

WF_NAME	Stage	Country
SAO PAULO STATE PES PROGRAM	1. Evaluate potential	BRAZIL
LA PAZ WATER FUND	1. Evaluate potential	BOLIVIA
SANTIAGO VALPARAISO WATER FUND	1. Evaluate potential	CHILE
AREQUIPA WATER FUND	1. Evaluate potential	PERU
TRUJILLO WATER FUND	1. Evaluate potential	PERU
SIERRA NEVADA WATERFUND	1. Evaluate potential	COLOMBIA
TEGUCIGALPA WATER FUND	1. Evaluate potential	HONDURAS
BARRANQUILLA WATER FUND	1. Evaluate potential	COLOMBIA
MERIDA WATER FUND	1. Evaluate potential	VENEZUELA
CALI WATER FUND	1. Evaluate potential	COLOMBIA
SANTA CATARINA STATE PES PROGRAM	1. Evaluate potential	BRAZIL
CANAL DE PANAMA WATER FUND	1. Evaluate potential	PANAMA
SUCUMBIOS	1. Evaluate potential	ECUADOR
SAN MARTIN	1. Evaluate potential	PERU
DOCE WATERSHED WATER FUND	1. Evaluate potential	BRAZIL
PARAIBA DO SUL WATERSHED	2. In design	BRAZIL
TAQUARUSU WATERSHED PALMAS	2. In design	BRAZIL
CAMBORIU WATERSHED	2. In design	BRAZIL
CARTAGENA WATER FUND	2. In design	COLOMBIA
MEDELLIN WATER FUND	2. In design	COLOMBIA
MONTERREY WATER FUND	2. In design	MEXICO
AYAMPE PUERTO LOPEZ	2. In design	ECUADOR
UPPER TIETE WATERSHED SAO PAULO	2. In design	BRAZIL
CANCUN, QUINTANA ROO WATER FUND	2. In design	MEXICO
SIXAOLA WATER FUND	2. In design	PANAMA
FONCAGUA GUATEMALA CITY	2. In design	GUATEMALA
PIURA WATER FUND	2. In design	PERU
GUAYAS GUAYAQUIL	2. In design	ECUADOR
TERRABA WATER FUND	2. In design	COSTA RICA
SANTO DOMINGO WATER FUND	2. In design	DOMINICAN REPUBLIC
RIO YAQUE DEL NORTE WATER FUND	2. In design	DOMINICAN REPUBLIC
ESPIRITO SANTO PES STATE PROGRAM	3. Created and operating	BRAZIL
PROCUENCAS ZAMORA	3. Created and operating	ECUADOR
TUNGURAHUA AMBATO	3. Created and operating	ECUADOR
AGUA SOMOS	3. Created and operating	COLOMBIA
FONAPA CUENCA AZOGUES	3. Created and operating	ECUADOR
AGUA POR LA VIDA Y LA SOSTENIBILIDAD	3. Created and operating	COLOMBIA
AQUAFONDO	3. Created and operating	PERU
GUANDU WATERSHED RIO DE JANEIRO	3. Created and operating	BRAZIL
PCJ WATERSHED CANTAREIRA SYSTEM SAO PAULO	3. Created and operating	BRAZIL
PIPIRIPAU WATERSHED BRASILIA	3. Created and operating	BRAZIL
SEMILLA DE AGUA	3. Created and operating	MEXICO
FONAG QUITO	4. Mature	ECUADOR

The Guayaquil Water Fund: Ecuador (operating June 2015)

Geography:

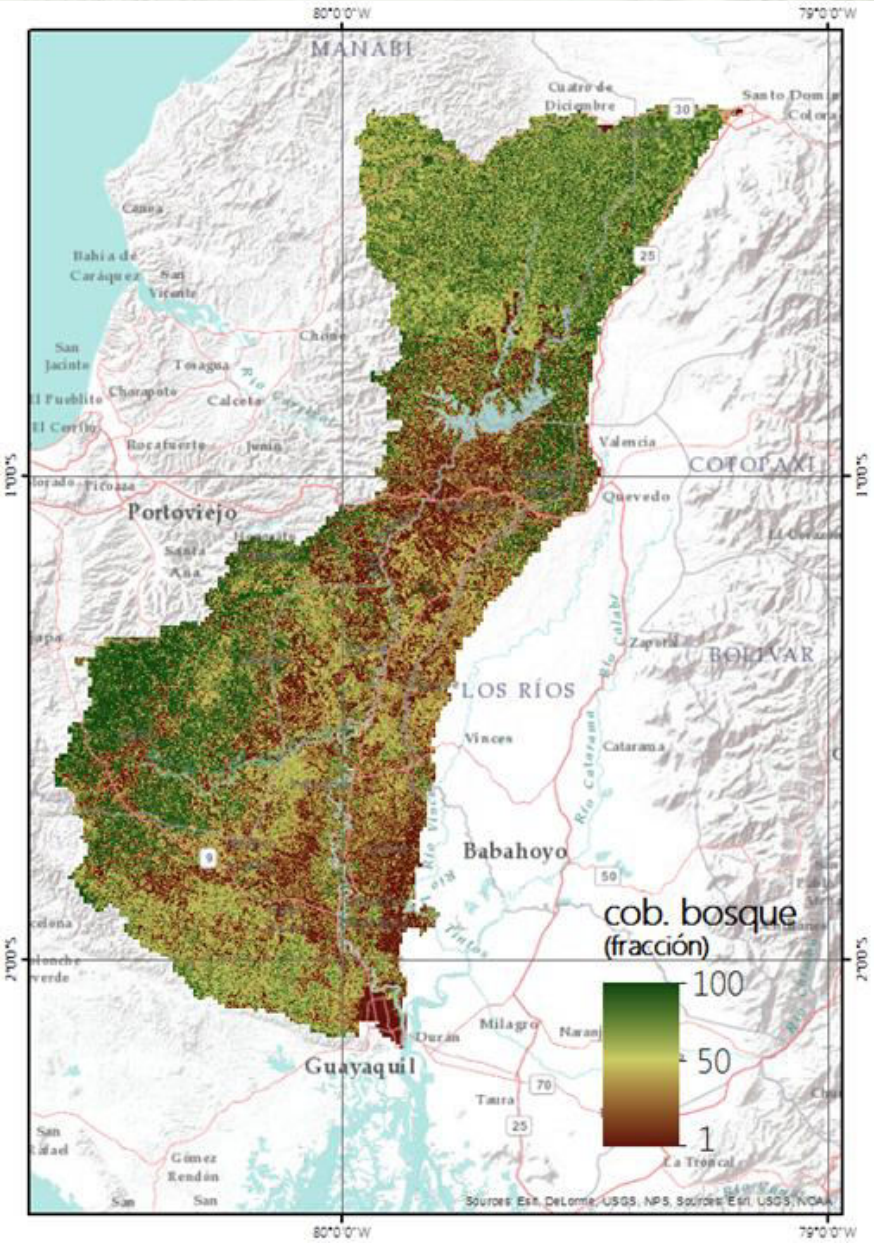
- Daule basin flows to Guayaquil, Ecuador's second city
- Montane areas and Pacific coastal plair
- 19-630 masl, 1300-2900 mm/yr, 26 to 23℃
- *For chapter: area upstream of Peripa reservoir only*

Context:

Significant and continuing deforestation and agriculturalisation of lowlands and hillslopes

Key water Issues:

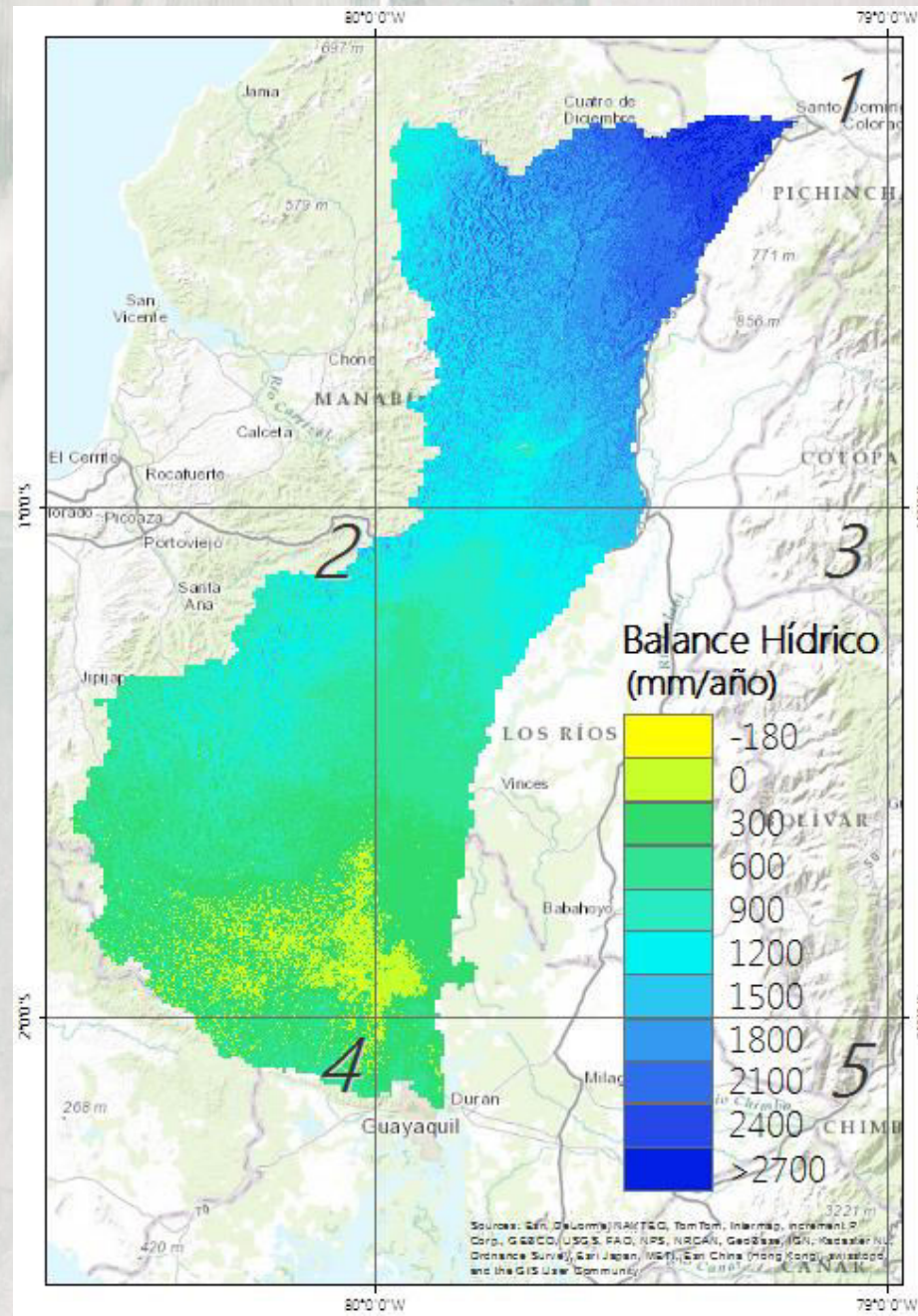
- Soil erosion on deforested hillslopes
- Navigation problems because of Daule river sedimentation
- Poor water quality at water intakes



Assessment strategy

- Run **WaterWorld** hydrological baseline
- Decide on **ES intervention types:**
  - Business as usual (no intervention) (BAU) (7% land)
  - Forest protection on steep, wet slopes (PROT) (33% land)
  - Eco-efficient agriculture in steep, wet slopes (33% land)
  - Rural sanitation (9.8% land)
- Apply interventions
- Examine impacts on key ES over whole basin and spatially:
  - areas improving
  - areas degrading
  - people with improved services
  - people with reduced services

Use RIOS to assign priority [not shown]



Hydrological baseline and BAU

Baseline (now):

- 27% forest cover, 24% cropland
- Water balance: 210-3300 mm/yr, mean=1900
- Water quality: average 40% human footprint

BAU deforestation to 2050:

- to 20% forest cover (-7%), to 31% cropland (+7%)

Impacts:

- *Gross erosion:* 19% of basin with mean +0.14mm/yr (+270%). +50% over entire basin.
- *Sediment deposition:* +3% over 62% of main channel but decreases in deforested areas (more runoff)

Protecting steep, wet slopes

- **BAU to 2050 but with protection for steep** (>5°), wet (>1500mm/yr) slopes, 33% of catchment
- Forest cover to 24% (*cf* 20).Cropland to to 29% (*cf* 31)
- Much less deforestation than BAU in steep, wet parts

Impacts:

- *Gross erosion: +29% increase over basin (cf +50%)*
- *Sediment deposition:* +3% over 64% of main channel (cf +3% over 62%) i.e. PROT leads to > sedimentation! Seems counter-intuitive but because DEF leads to increases in erosion AND in runoff (and thus transport capacity). Protecting the steep, wet slopes reduces runoff and increases deposition!

Eco-efficient agriculture and rural sanitation

Eco-efficient agric. on steep, wet slopes

- Recognising that BAU agriculturalization is a powerful force for change, reduce human footprint for all agricultural land by 50%, reflecting investment on eco-efficient techniques.

Impacts: Human footprint (HF): -23% over 28% of basin (-6.5% basin mean). -17% decrease in number of people exposed to poor quality water. HF at reservoir -7%.

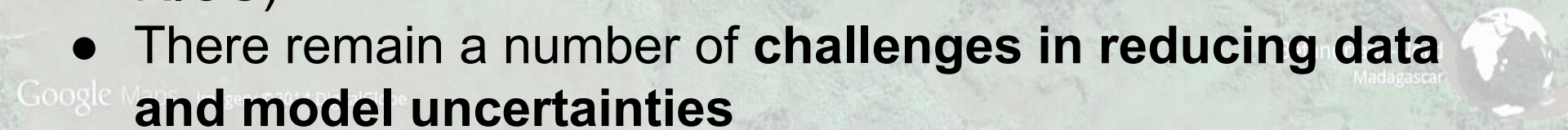
Rural sanitation

- Treat 100% of effluent for all non-urban areas (urban already treated) in which pop/km^2>100. Sanitation area 0.19% to 6.2%.

Impacts: No change in HF over 90% of basin. -2.3% over 9.8% of basin (-0.2 mean for basin) but decreases the number of people exposed to poor quality water by 35%. HF at reservoir -0.35%

Key messages for policy makers and practitioners

- Environments are geographically heterogeneous and hydrological feedbacks are complex: **interventions may have the opposite effects to that anticipated!**
- Some interventions **improve ES in parts** of the catchment **while degrading them on others**
- Some interventions **affect more land, other affect more people!**
- **Tools are available** for ES baseline and scenario assessment (*e.g.* WaterWorld). You can run these and other interventions for your own basin at www.policysupport.org
- These can be coupled with tools for the **optimisation of investments**, spatially and across multiple objectives (*e.g.* RIOS)
- There remain a number of **challenges in reducing data and model uncertainties**



Thank you

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