

# AN INTRODUCTION TO WATERWORLD

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## Hydrological services provided by forests

- Assumption of the past was that more forest = more water yield
- Highly contested topic in the scientific community: Question of scale
- Demand-side: Forests use a lot of water:
  - Intercept precipitation, evaporation and transpiration
  - Forest vegetation may remove water from the local water cycle, therefore decreasing downstream yields
- Supply-side: Forests may intensify water cycle at broader scales



## Hydrological services provided by forests



- Regulate seasonal discharge
- Reduce flooding at local scales
  - Large-scale flooding is influenced by basin-wide relationships between topography, runoff, regulation of water storage (e.g. lakes), discharge, groundwater tables tides etc.



# Hydrological services provided by forests

## Maintain water quality

- Regulate soil erosion and reduce sediment loading
  - » Stabilization of slopes
  - » Roots trap sediments
  - » Lower canopy leaves and ground litter reduce splash force from precipitation
- Trap and filter water pollutants
  - » Generally no use of fertilisers or pesticides in natural forests
  - » Act as buffer zones between agricultural or industrial development and water bodies



## What is WaterWorld?

- Free web-based spatial modelling tool
- Models hydrology and soil erosion
- Complete set of data included, but possible to use own data to refine analysis
- Annual and monthly output maps downloadable in GIS formats
- Runs and compares scenarios of land use change and climate change fast (full analysis in 30 mins)
- Simple to use: Chrome or Firefox
- Includes free training programme



## What WaterWorld does?

Provides a spatially detailed and quantitative estimates of baseline hydrological values, as well as understanding of likely hydrological outcomes of scenarios (e.g. land use, climate change)





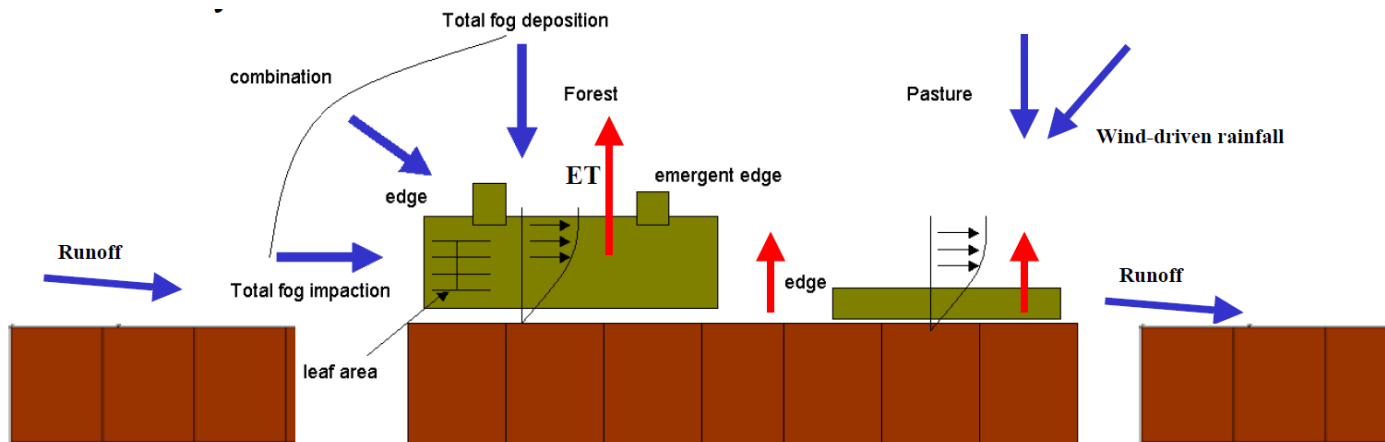
## What WaterWorld does?

- For anywhere in the world, produces a **hydrological baseline** for a 1950-2000 baseline using more than 140 input maps.
- Does this at **1-hectare or 1-square-km** spatial resolution and monthly temporal resolution.
- Provides **scenario tools** for climate change and land use change
- Allows visualisation, analysis and GIS download of some **46 output variables**
- Allows summary of outputs according to watersheds, administrative areas, etc.



## Scientific principles

- Based on FIESTA model (Mulligan and Burke, 2005; Bruijnzeel et al, 2011)
- Process-based (rather than empirical)
- Not calibrated (e.g. to observed measured flows)
- Gridded representation of water balance (wind-driven rainfall + fog minus evapotranspiration) (See Mulligan 2013).
- Changes in climate or land cover/use change water balances locally and downstream
- Erosion according to Thornes (1990).

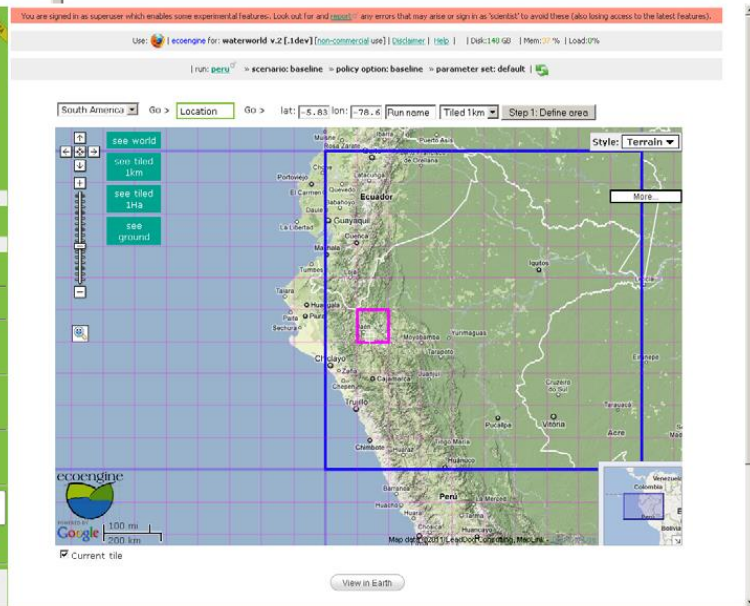
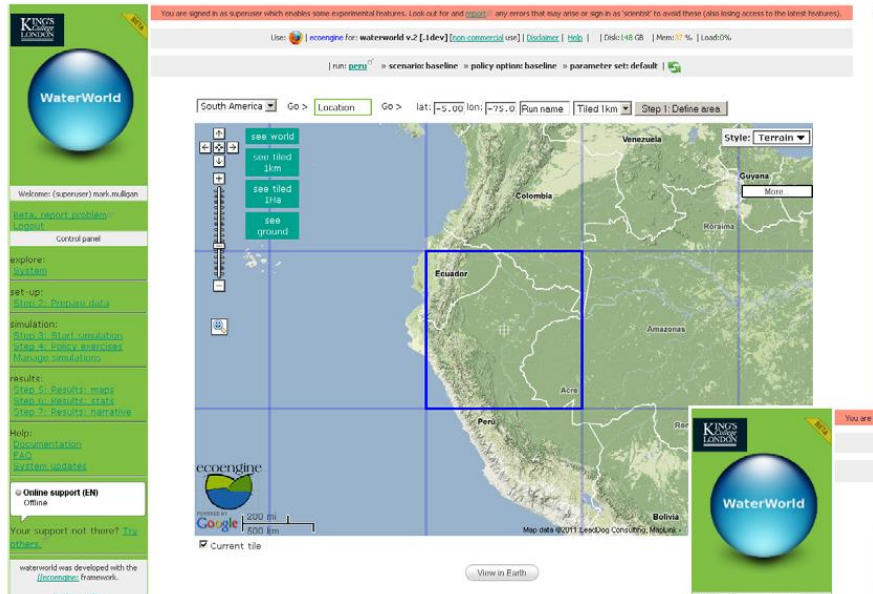




## How to use WaterWorld

### Step 1 Define area

Run anywhere globally for  
1 degree (100km) tiles at  
1-hectare grain,  
OR 10 degree (1000km)  
tiles at 1-square-km grain.



The screenshot shows a web browser window with the URL `http://192.168.0.248/cgi-bin/simterra/v1/simterra/ctrl/file_mgt.cgi?model=ecoengine&username=drmarkmulligan_gmail.com&language=en_gb&currenttrmdir=%2Fvar%2Fwww%2Fmodelling%2Fuserdata%2Fdrmarkmulligan%2Fworkspace`. The page title is "ecoengine - spatial policy support on the web - Mozilla Firefox". The main content area displays a list of data layers under the heading "show workspace data". The list includes:

- Presence of mines (unique id)?
- Boundary layer wind direction January (degrees from N)?
- Boundary layer wind direction February (degrees from N)?
- Boundary layer wind direction March (degrees from N)?
- Boundary layer wind direction April (degrees from N)?
- Boundary layer wind direction May (degrees from N)?
- Boundary layer wind direction June (degrees from N)?
- Boundary layer wind direction July (degrees from N)?
- Boundary layer wind direction August (degrees from N)?
- Boundary layer wind direction September (degrees from N)?
- Boundary layer wind direction October (degrees from N)?
- Boundary layer wind direction November (degrees from N)?
- Boundary layer wind direction December (degrees from N)?
- Cell area (fraction\*100000)?
- Study area (?)
- Croplands (2000) (fraction)?
- Dams (unique id)?
- Mean sea level pressure January (mb)?
- Mean sea level pressure February (mb)?
- Mean sea level pressure March (mb)?
- Mean sea level pressure April (mb)?
- Mean sea level pressure May (mb)?
- Mean sea level pressure June (mb)?
- Mean sea level pressure July (mb)?
- Mean sea level pressure August (mb)?
- Mean sea level pressure September (mb)?
- Mean sea level pressure October (mb)?
- Mean sea level pressure November (mb)?

Each item in the list has a "download+" button and a small grid icon to its right. The left sidebar contains navigation links for "Beta\_report problem", "Logout", "Control panel", "explore: System", "set-up: Step 2: Prepare data", "simulation: Step 3: Start simulation, Step 4: Policy exercises, Manage simulations", "results: Step 5: Results: maps, Step 6: Results: stats, Step 7: Results: narrative", "Help: Documentation, FAQ, System updates", and "Online Support (ES, EN) Available".

## Step 2 Prepare data

All data required for operation available globally (either new datasets or datasets homogenized from existing sources).

>140 maps required

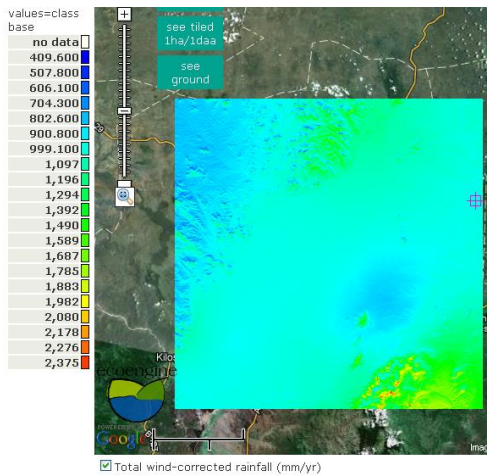
**If you have better data for a site you can use those instead**

**Step 3 Start simulation**  
Users first run a baseline simulation to produce mean 1950-2000 baseline. This is then used as comparator for running scenario or policy option 'alternatives'

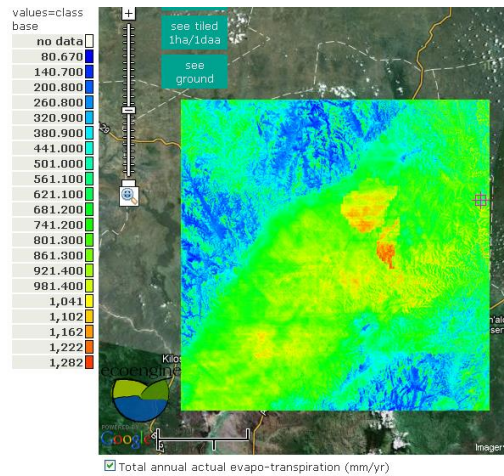


## Key outputs: Hydrology

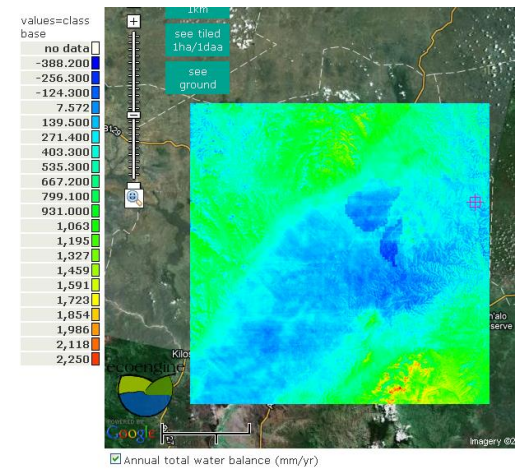
- Process based spatial hydrological model



Wind driven precipitation  
(based on WorldClim)



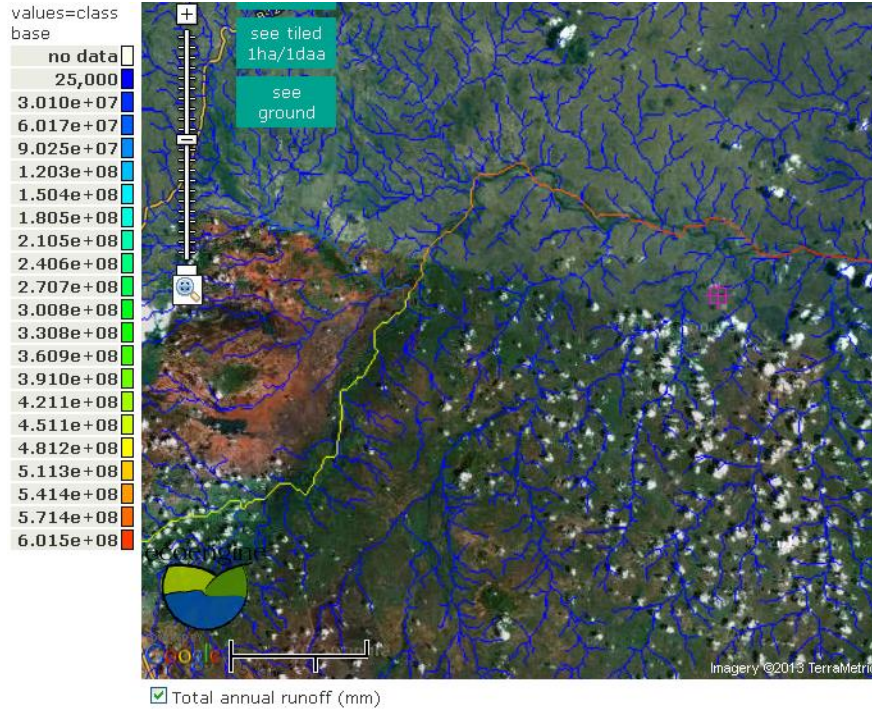
Actual evapo-transpiration



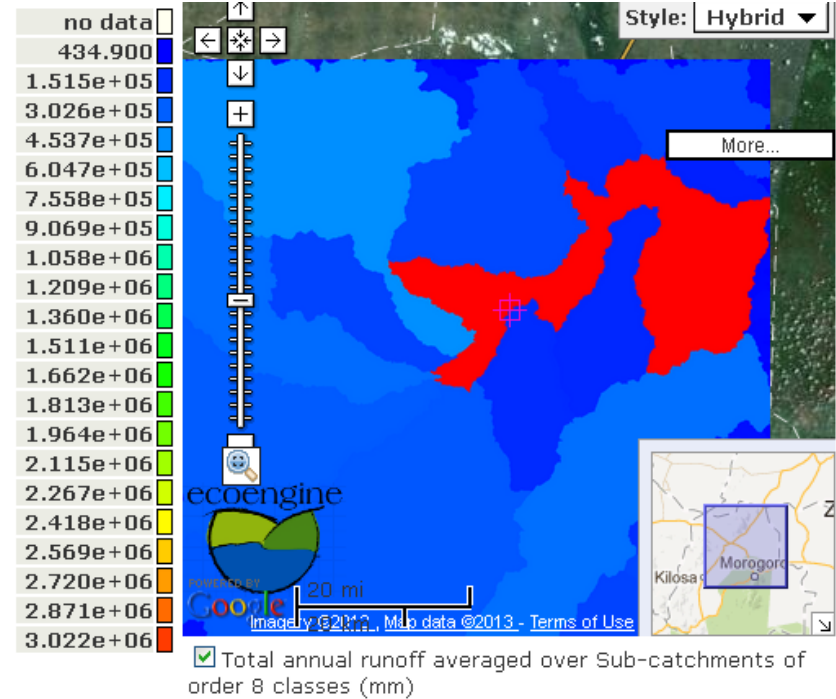
Pixel based water balance  
(Prec – ActEvap + Fog inputs)



## Key outputs: Hydrology



Annual runoff



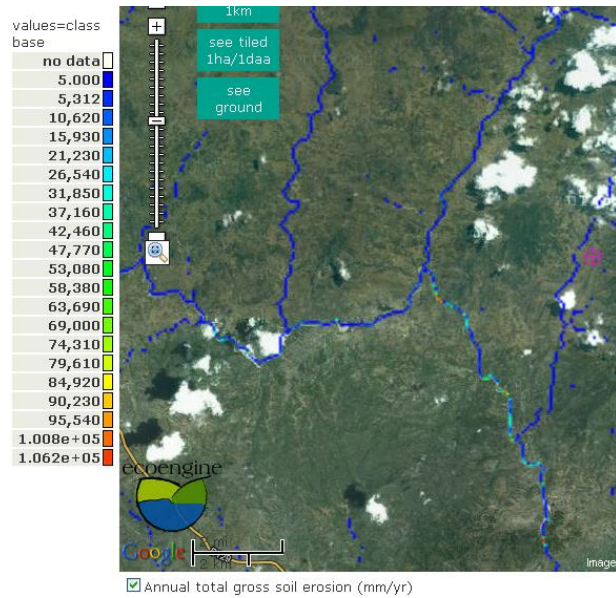
Runoff (water yield) averaged by sub-catchments



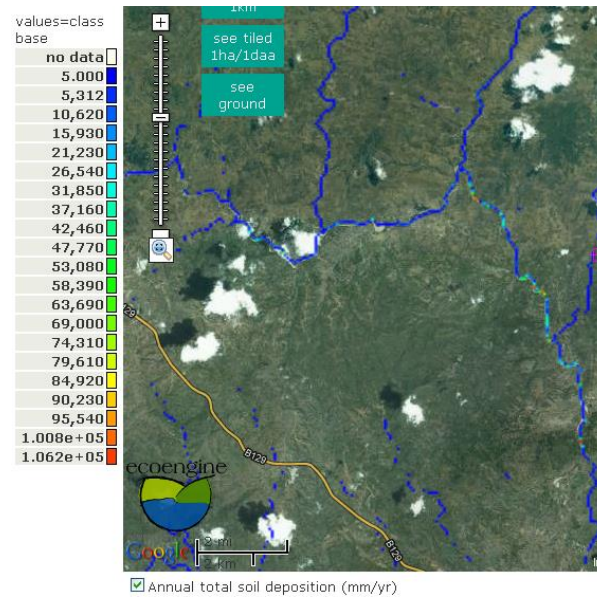


## Key outputs: Soil erosion

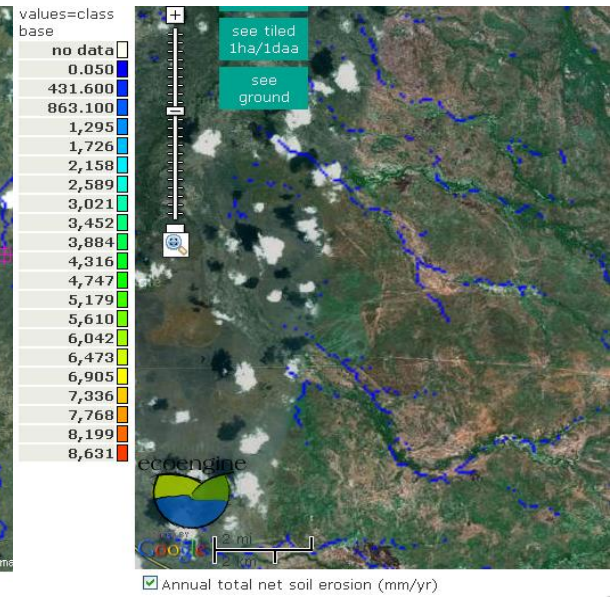
### Full wash erosion model



Gross soil erosion: detachment of soil based on runoff, vegetation, slope



Soil deposition: detached soil that gets deposited



Net soil erosion





Click the intervention tool you would like to use

- Climate Change : assess impacts of climate change
- Land Cover and Use Change : assess impacts of land use change
- Land and water management : implement land management policy options
- Change input maps : replace one or more of the input maps
- Extractives : examine impacts of mining or oil & gas
- Population : examine impacts of changes in population and demography

Submit choice

Close window

### Scenarios for Climate Change and Land cover and use available

**FOREST TO HERBACEOUS and HERBACEOUS TO FOREST:** Changing forest cover replaces forest (tree cover) with pasture or cropland (herb cover). Changes of between -99% and 99% represent selective deforestation and afforestation respectively. Deforest a given percentage per pixel of trees with e.g. -15 or reforest by a given percentage per pixel of trees e.g. 15. Specify where and by what percentage (per pixel) deforestation or reforestation should occur:

Use a pre-defined rule:

These are applied additively in the order in which they appear so that, for example deforesting land outside of protected areas by 100% then deforesting mid elevations by 50% will result in a scenario in which all areas outside of protected areas are totally deforested but mid elevations (including those inside protected areas) are deforested by 50%

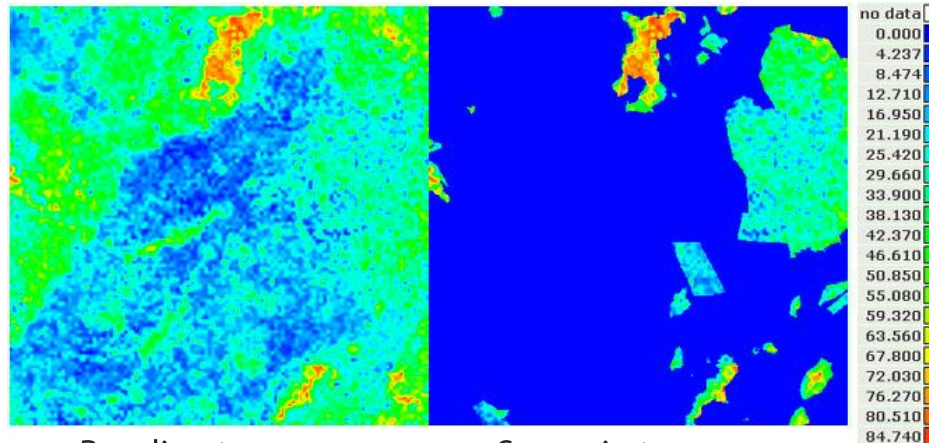
Deforest(-)/Reforest(+) each pixel by (..

Name for my scenario	<input type="text" value="Deforest_all"/>	
Land outside <u>protected areas</u> <sup>af</sup> (%)	<input type="text" value="-100"/>	
Land inside <u>protected areas</u> <sup>af</sup> (%)	<input type="text" value="0"/>	
Land near <sup>2</sup> <u>roads</u> <sup>af</sup> and rivers (%)	<input type="text" value="0"/>	
Land near <sup>2</sup> existing <u>deforested</u> <sup>af</sup> areas (%)	<input type="text" value="0"/>	
Land at Low <sup>2</sup> <u>elevations</u> <sup>af</sup> (%)	<input type="text" value="0"/>	e.g. for lowland forests
Land at Mid <sup>2</sup> <u>elevations</u> <sup>af</sup> (%)	<input type="text" value="0"/>	e.g. for montane forests
Land at High <sup>2</sup> <u>elevations</u> <sup>af</sup> (%)	<input type="text" value="0"/>	
All land (%)	<input type="text" value="0"/>	

Define converted areas as:  Land use intensity:

Check and Submit

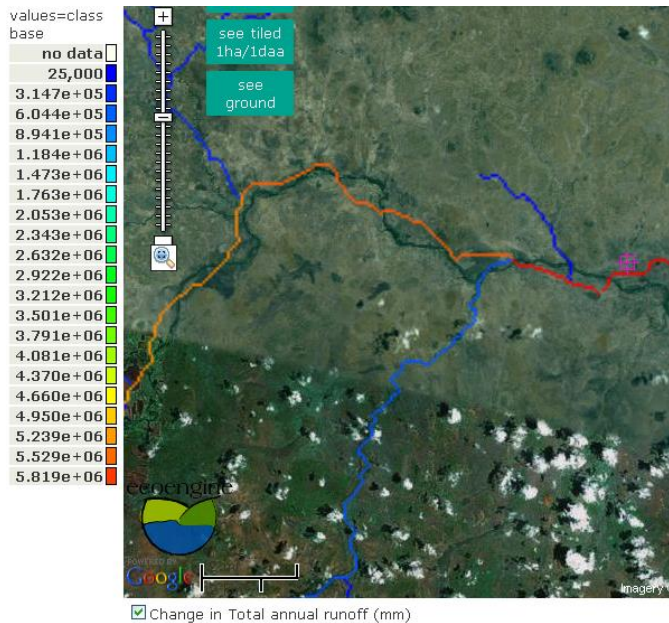
For example deforest all land outside PAs



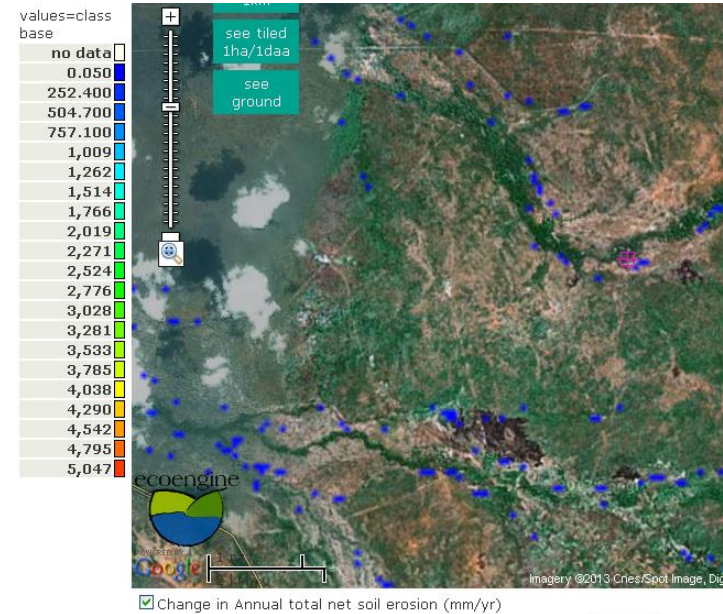
Baseline tree cover

Scenario tree cover

### Results deforestation outside protected areas scenario



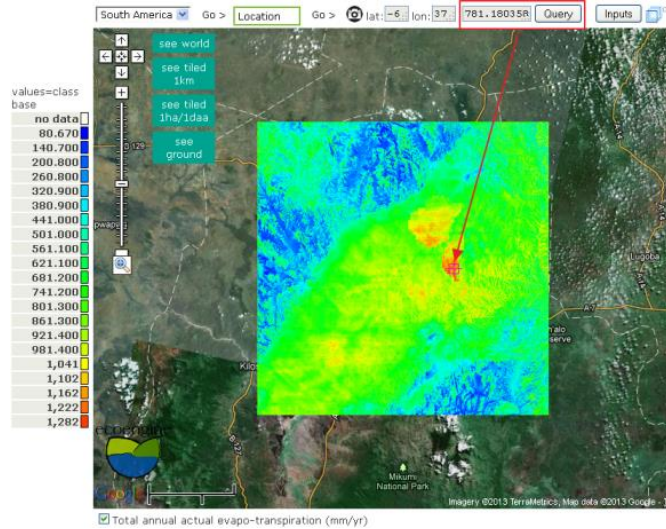
Deforestation leads to increased runoff  
(less water use by trees)



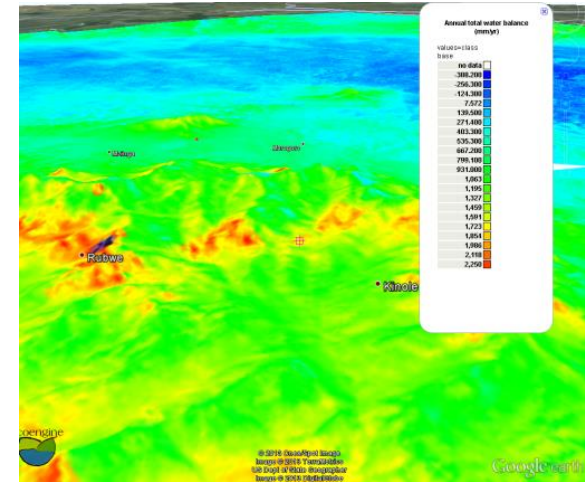
And increased erosion mainly visible around  
channels which leads to increased sedimentation



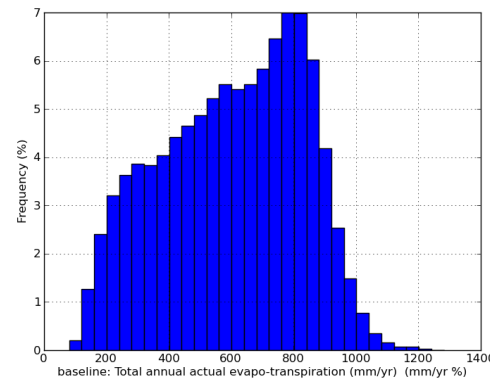
## Analyse, visualise and/or download GIS maps



View in Google maps and query map at points



Overlay in Google Earth

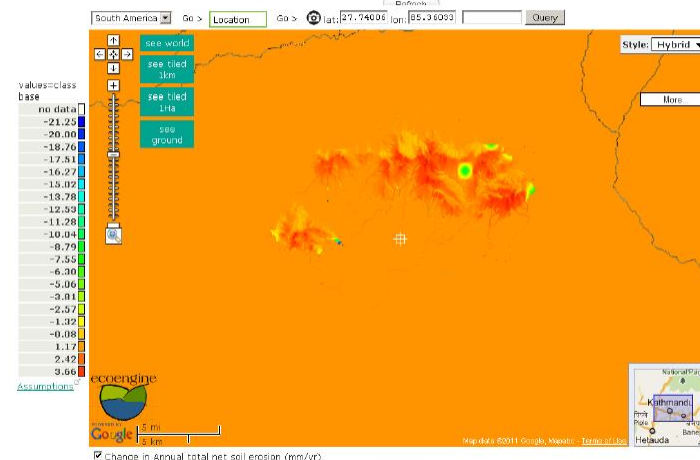
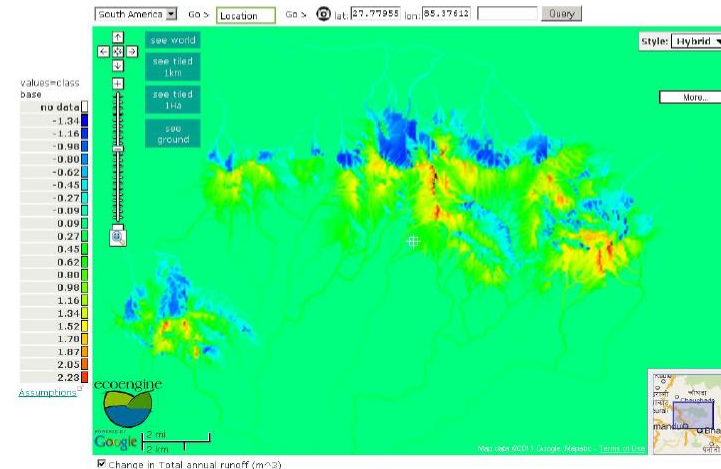
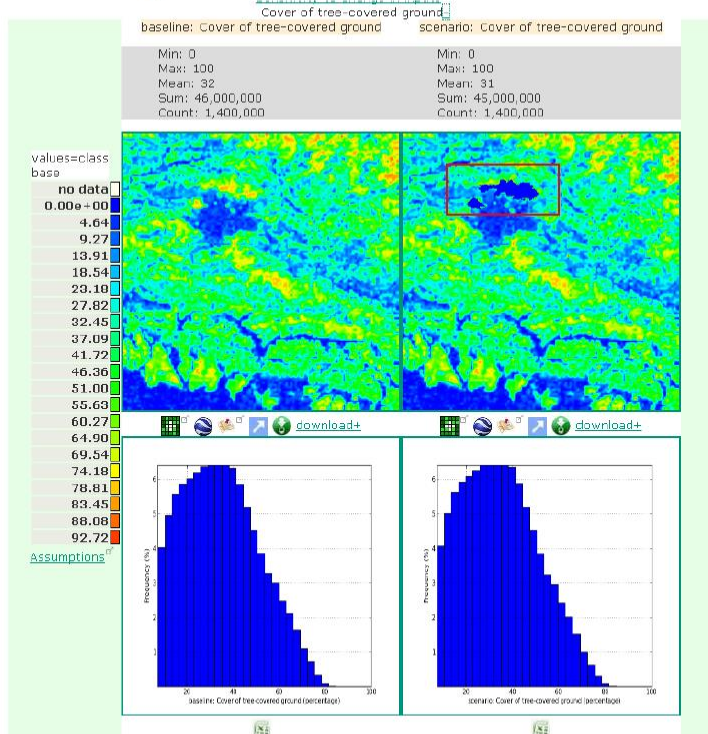


Analyse map histogram



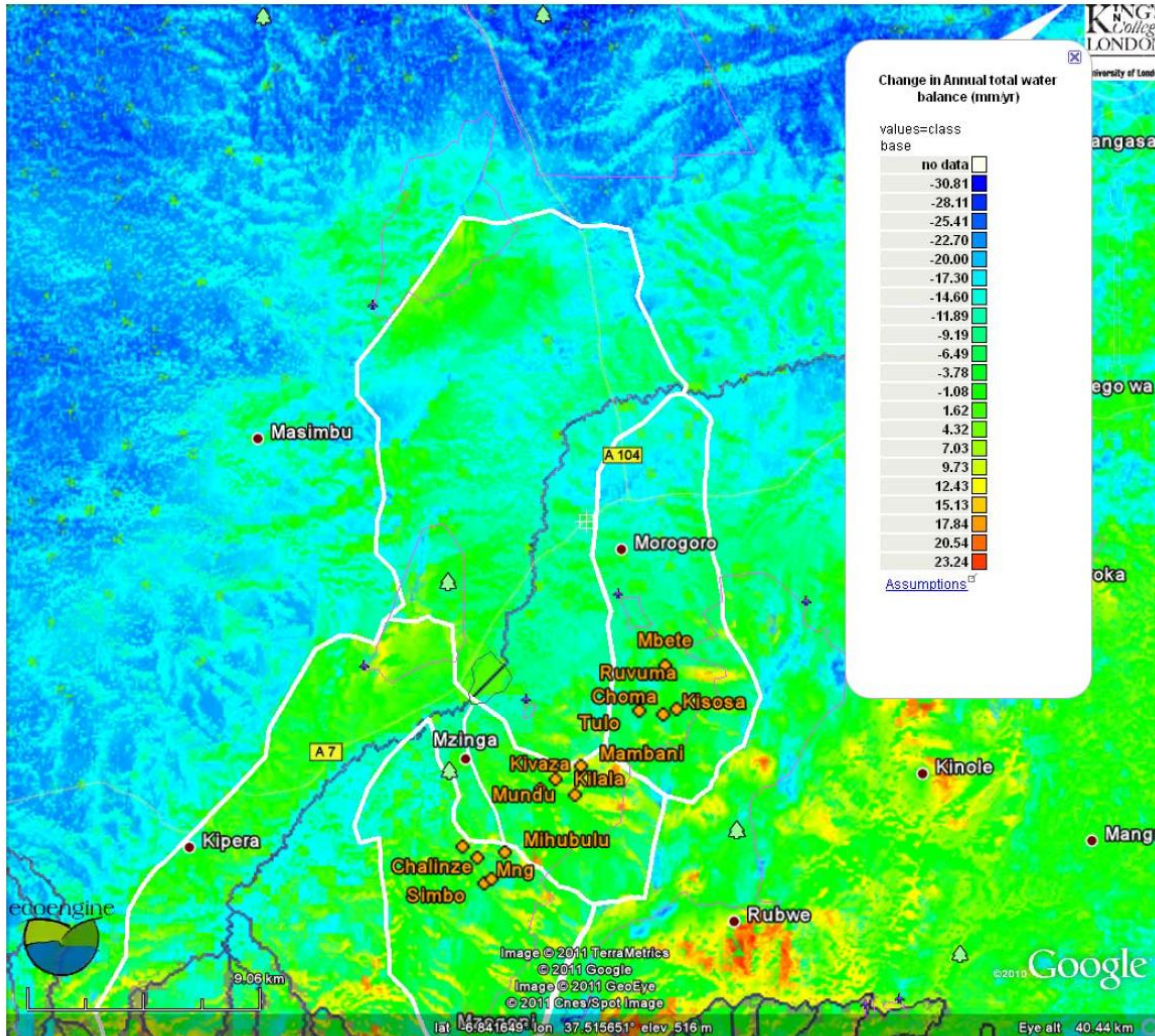
## WaterWorld – case studies

### Shivapuri, Nepal – Deforestation of IBA



Deforested protected area and replaced with herbaceous cover. Results in decreases in water on the forested cloudy N slopes but increases in the already sparse S slopes (towards Kathmandu). Impacts on erosion also variable

## Ulugurus – Sensitivity to deforestation



Where to  
afforest with  
10% woodlots  
to increase  
water flows.



## Limitations

- Provides estimates of hydrology per pixel, for erosion especially, local (sub-pixel) level characteristics can have a large impact
- Uses global datasets and assumptions which are not calibrated locally
- If your catchment crosses two tiles you need to run both separately and stitch a GIS software.
- You run on WaterWorld's servers so only a limited number of simulations can be stored. *Download results and delete simulation to start a new one*





# Thank you!

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UNEP



WCMC