p4ges

can paying 4 global ecosystem services reduce poverty?

les paiements pour les services écosystèmiques globaux peuvent-ils réduire la pauvreté?

www.p4ges.org

P4GES WaterWorld Developments for Madagascar and the CAZ

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« L'excellence au service du développement »

UNIVERSITY OF Southampton

KING'S College LONDON

ITC UNIVERSITY OF TWENTE.

CONSERVATION INTERNATIONAL

PRIFYSGOL ABERYSTWYTH UNIVERSITY

This work is part of the p4ges project

Integrated biophysical research: Key questions

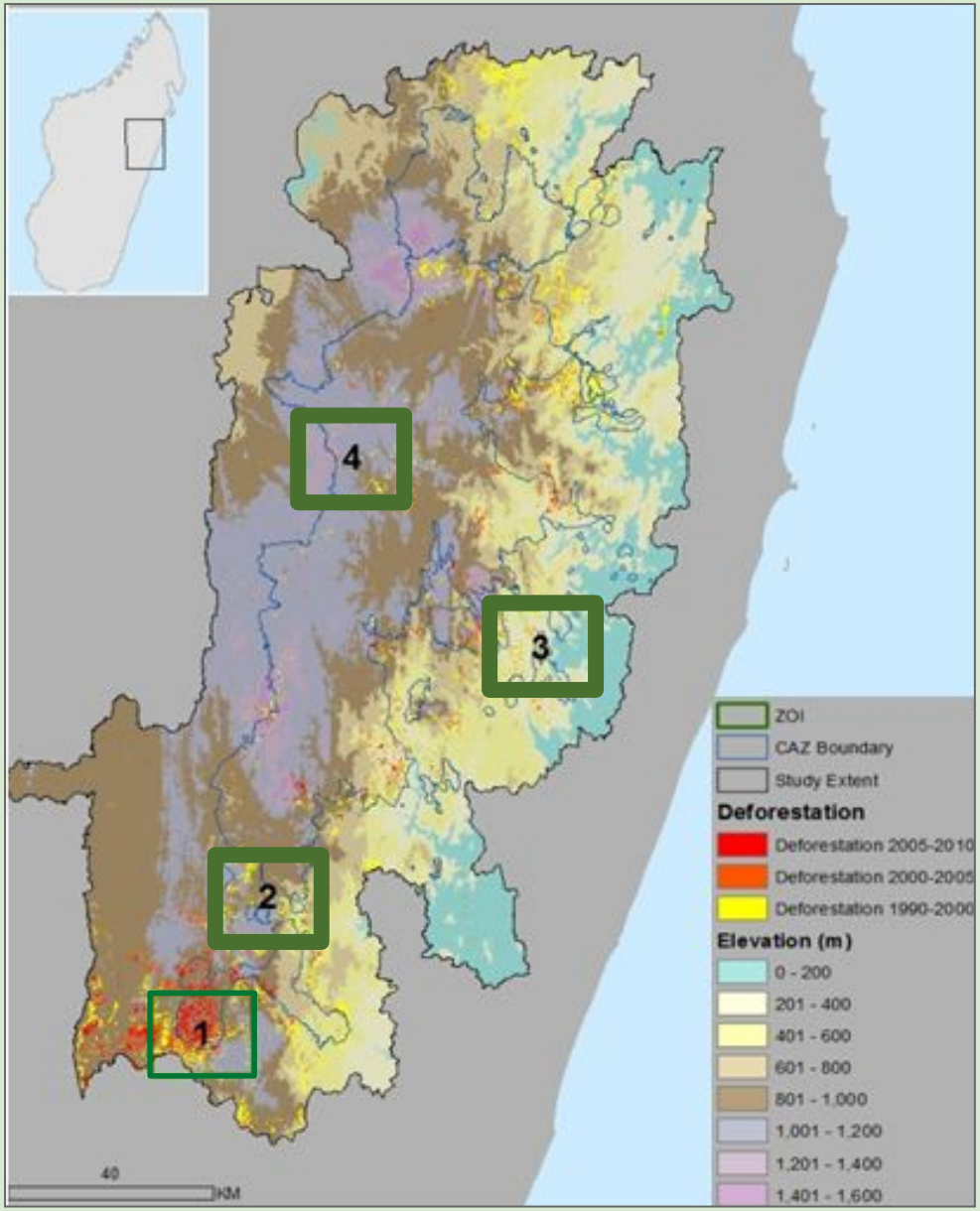
1) How does the process of loss and recovery of hydrological function, carbon stocks, biodiversity and wild harvested products differ between deforestation and restoration?
2) How can investment in avoided deforestation/restoration be optimized for delivery of Ecosystem Services?

Biodiversity

Carbon

Hydrology

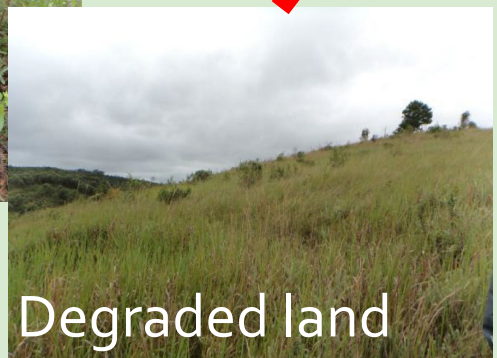
Forest products



Biophysical sites:

Hydro, biodiversity, carbon and wild harvested product measurements at 54 sites in 4 land uses

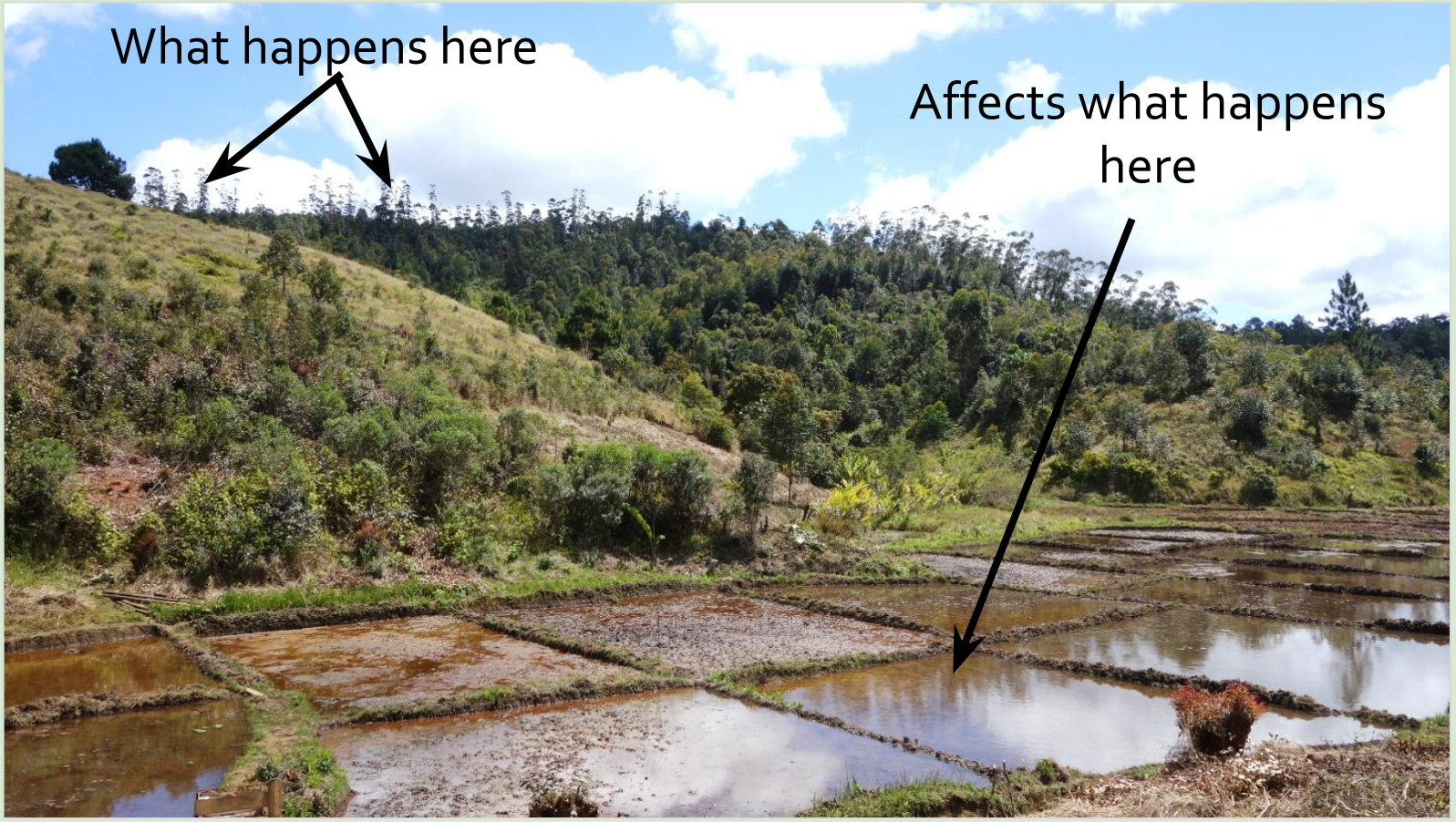
Focal land uses in the biophysical sites



degradation

restoration

Land use affects local and regional water resources



Local and regional water resources

Too much water – flooding and loss of crops

Too little water – not enough water for irrigation and rice production

P4GES Hydrological Research: Objective

To determine hydrological impacts of land-use changes incentivized under alternative PES approaches

Local and regional impacts

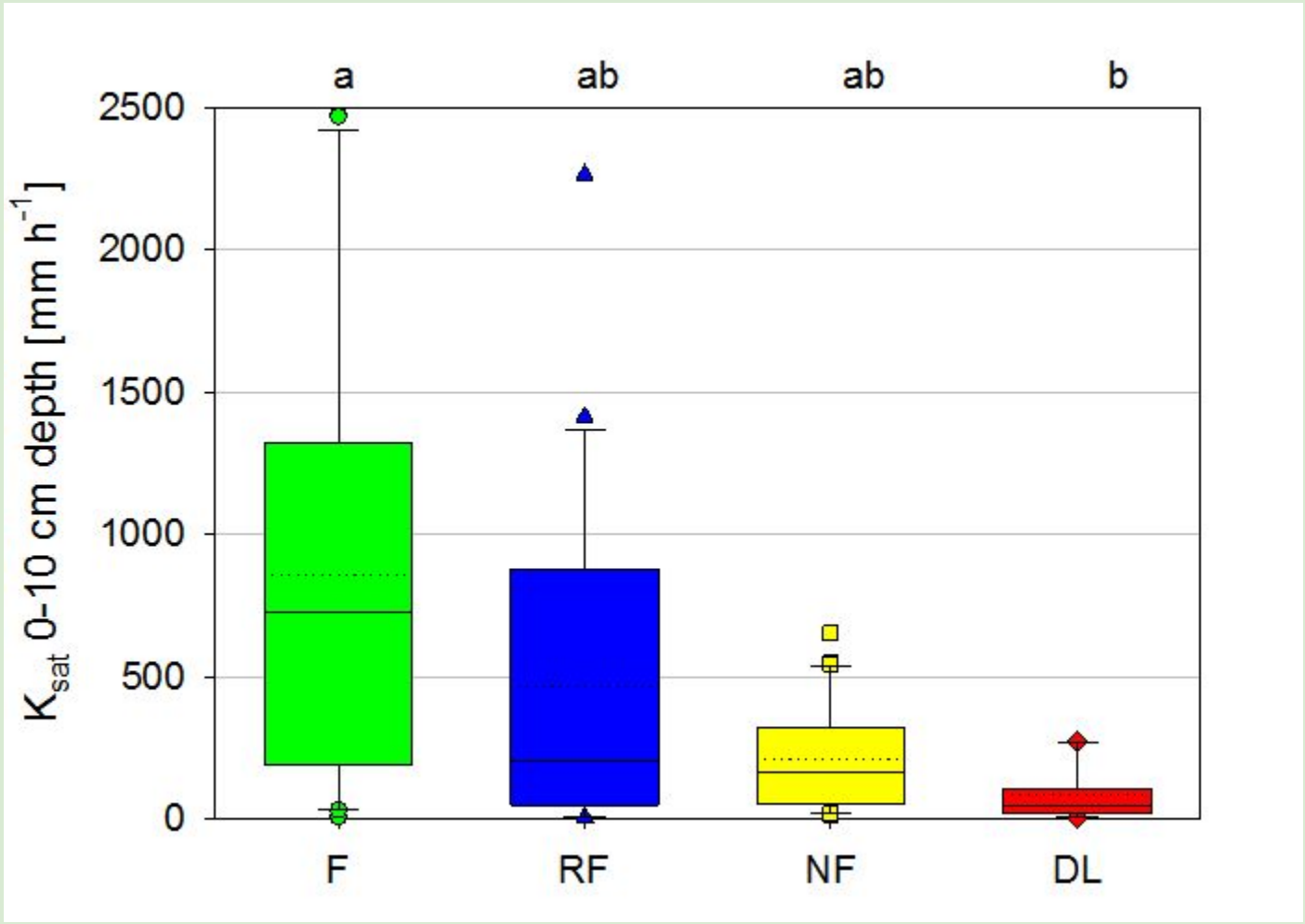
What we did (I):

Three zones of interest across CAZ

Measurements of:

- Soil properties
- Soil infiltration rates (at 3 depths)
- Preferential flow pathways

Infiltration rates



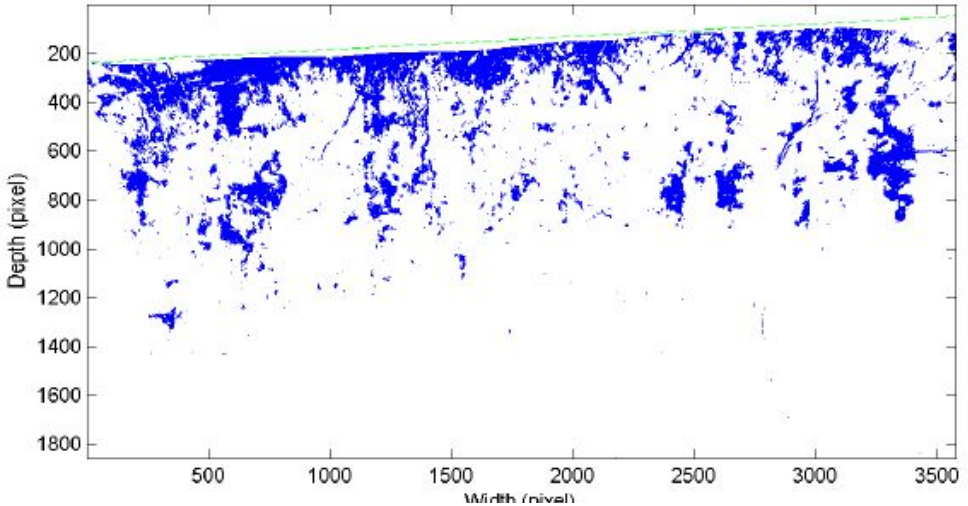
Zwartendijk et al. (in press)

Blue dye experiments
to determine how water flows into the soil

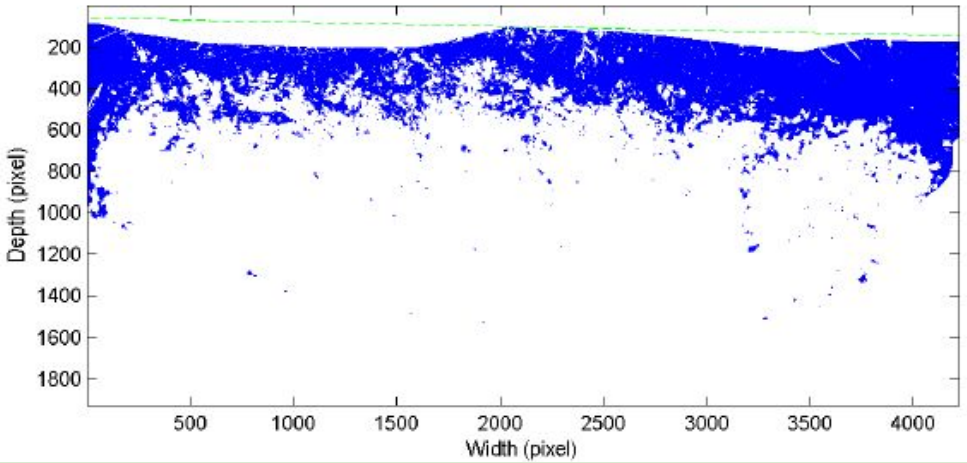
Blue dye experiments



ALM-RF1



AMT-TM Ruissellement lors des pluies



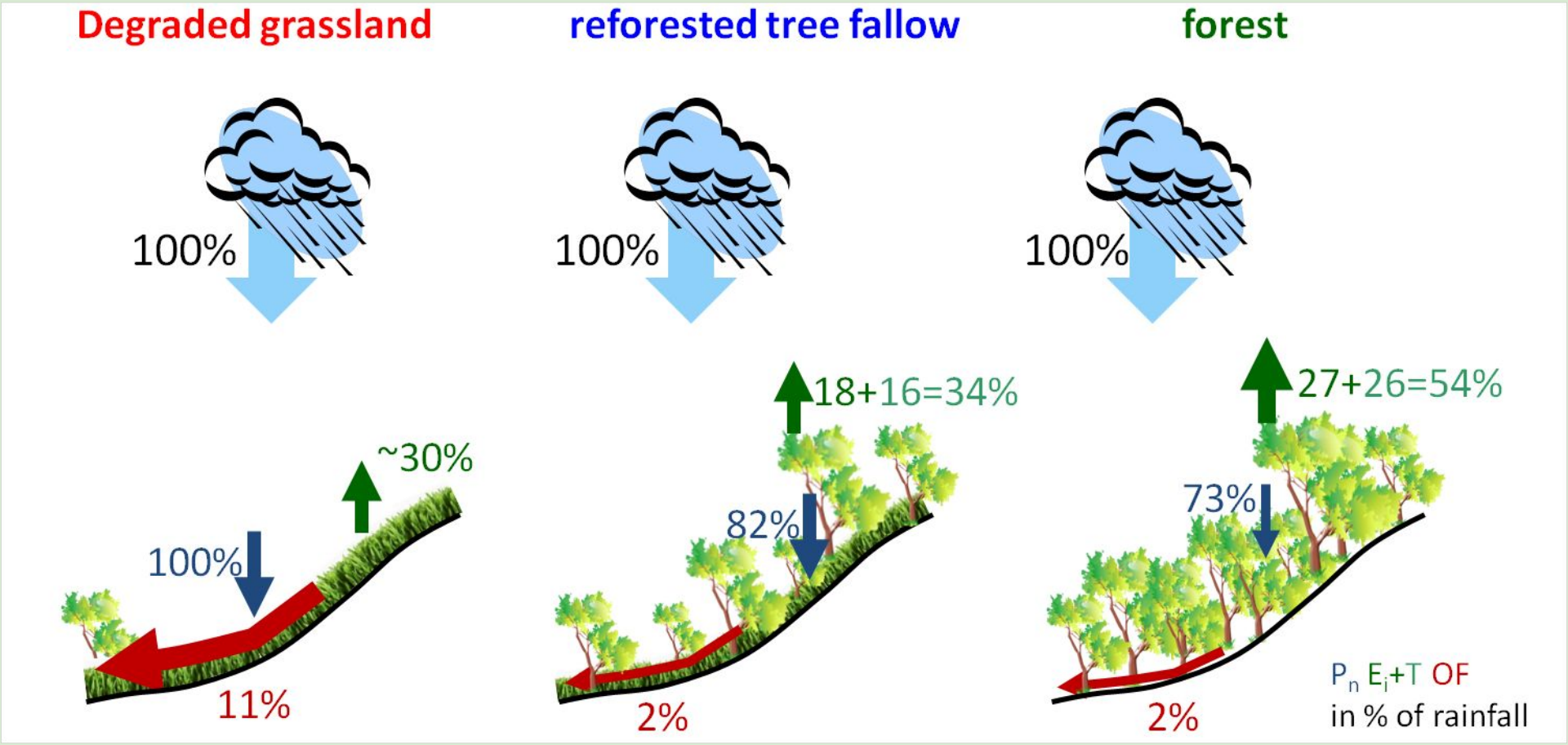
Zwartendijk et al. (in press)

What we did (II):

Three plots (forest, tree savoka and tany maty) to measure:

- Hydrological fluxes (precipitation, interception, transpiration, surface runoff)
- Changes in soil moisture and groundwater

Oct 2014-Sep 2015



Zwartendijk et al. (in press), Ghimire et al. (in press), Ghimire et al. (in prep), Zwartendijk et al. (in prep)

Conclusions

- We observed diffrerences between the different land uses
  - Increased infiltration across CAZ
  - Reduced overland flow
  - but also increased interception and evapotranspiration
- We also observed large differences between different plots → large spatial variability
- *Question*: How to upscale these small plot results to the watershed scale or all of CAZ?

Forests, water and poverty - not straightforward

Context, questions and realities of P4GES hydrological modelling

Eastern Madagascar:

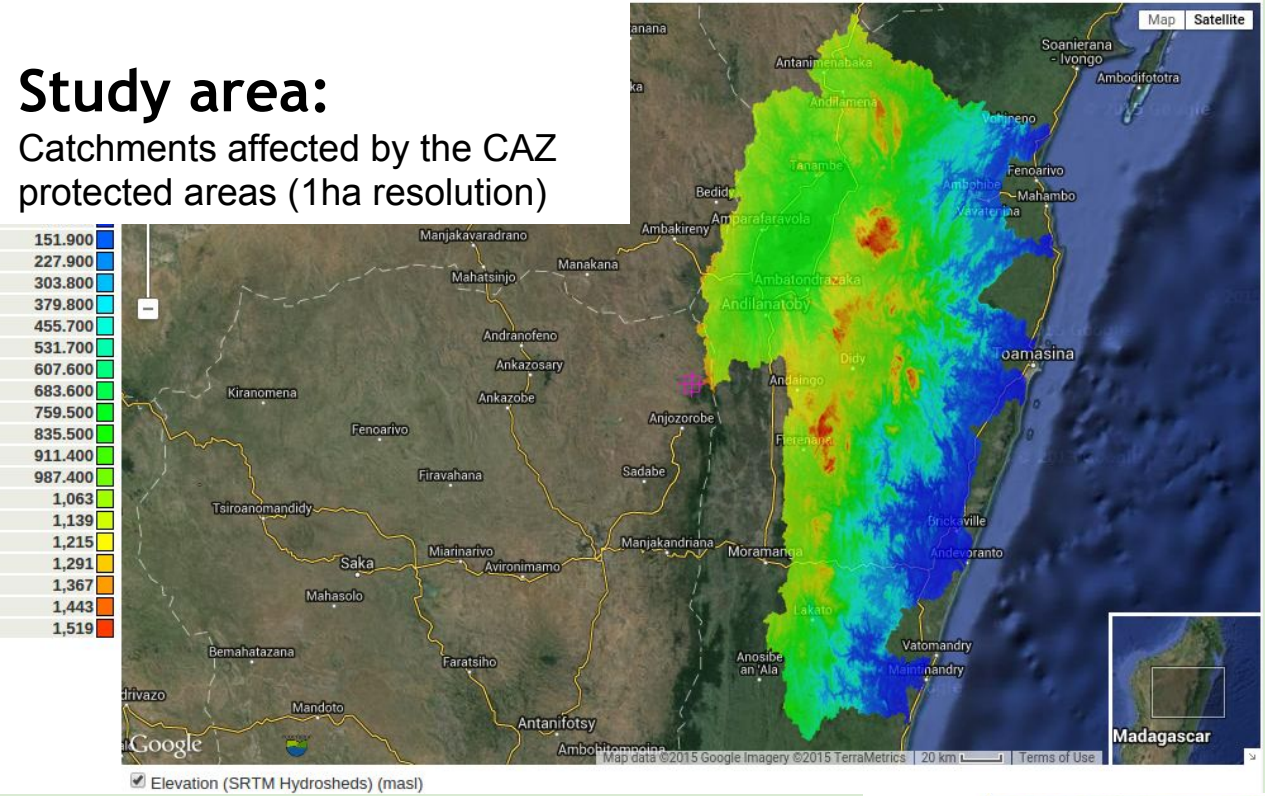
- Biologically important but a history of deforestation
- International PES schemes for carbon (and biodiversity) through protection and reforestation
- What will be the **landscape-scale** impacts on water (quantity, quality, regulation) downstream?
- Will **downstream** rice farmers lose water or get improved dry season flows and a second rice crop?
- **Where** should forest be protected and where restored, for ecosystem service win-wins?

Not all forests are good for water:

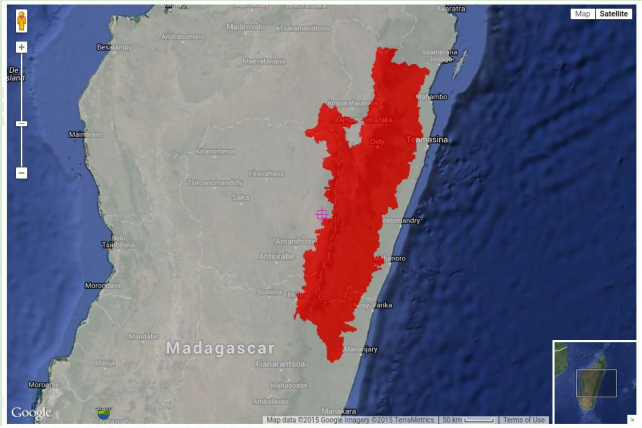
- Forests **evaporate more than many other cover types** (including rainfed agriculture). This means lower water yields to downstream
- Whether forests improve **dry season flows** depends on the balance between reduced yield and increased infiltration (facilitating increased baseflows)
- Forests may reduce soil erosion and improve water quality compared with farmland, for normal events, **but not for the largest events**
- The outcome is **highly site specific, from hillslope to hillslope. There are no rules of thumb**.

Study area:

Catchments affected by the CAZ protected areas (1ha resolution)

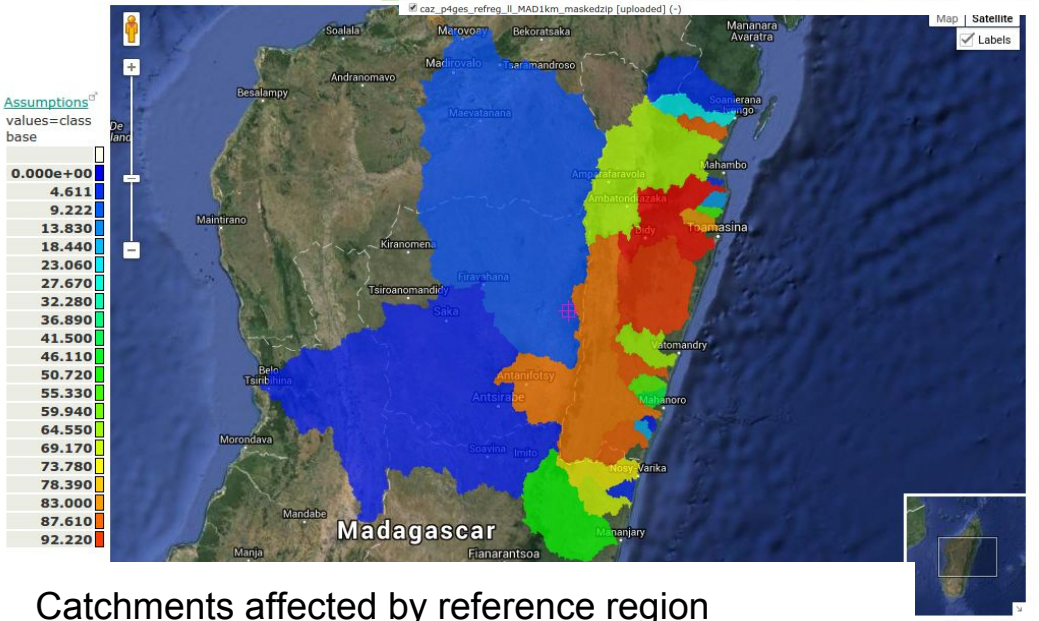


REDD Reference region:



Hydrological study area has to include all of the catchments draining into and from the CAZ protected areas, because inputs and changes in any of these areas affect the hydrological influence of the CAZ.

We choose the CAZ rather than the REDD reference region as the reference region would extend the study catchments significantly



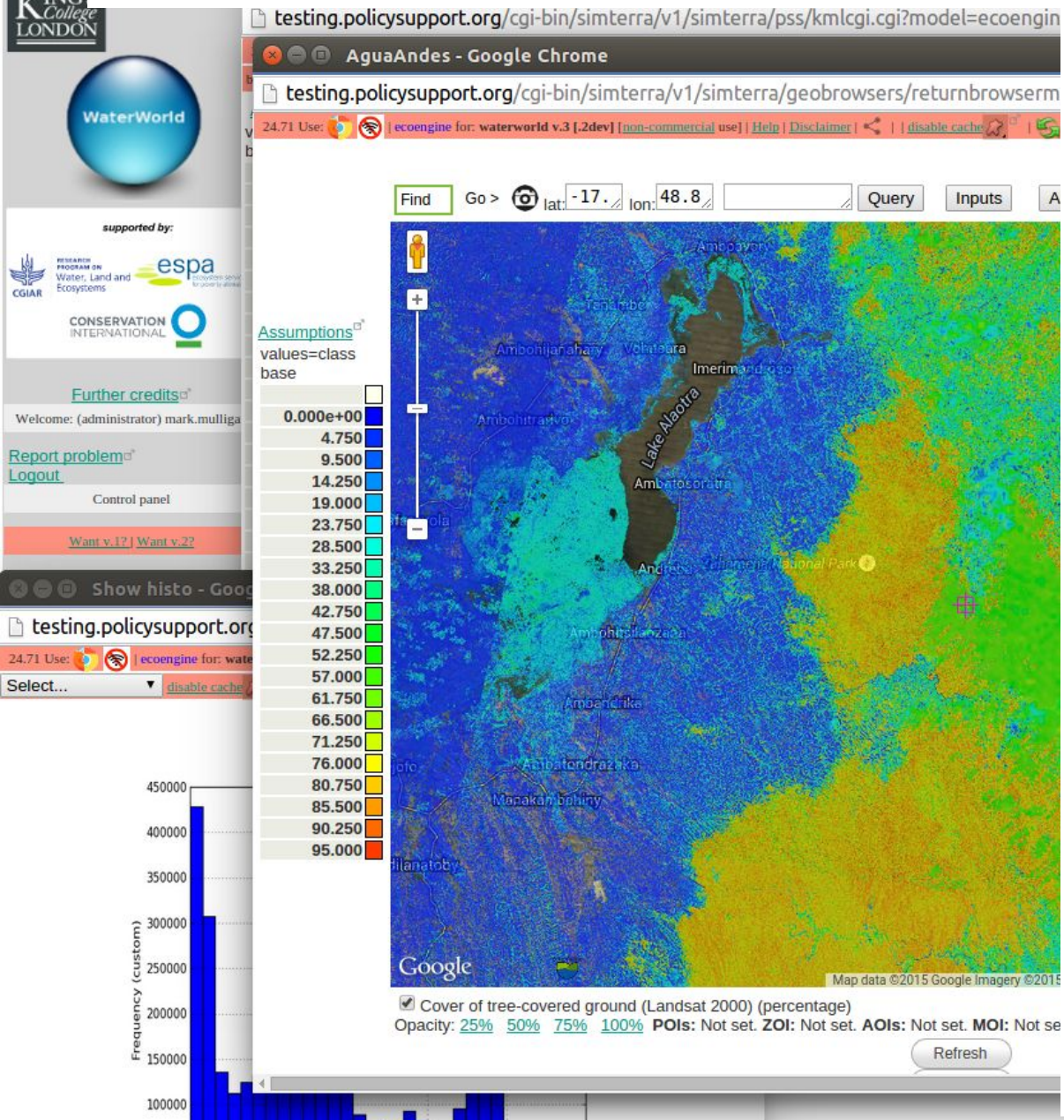
Catchments affected by reference region

P4GES hydrological modelling objectives

- To examine **basin-wide** hydrological implications of forest cover change and agriculture **for the water available to support second crop of rice**
- To **scale up processes** and properties from points and plots to more **policy-relevant scales**
- To co-develop scenarios for Business-as-Usual (BAU) change **and examine impacts**
- To co-develop scenarios representing plausible **interventions** (policy options) **and examine impacts**

- To improve WaterWorld app for Madagascar and train local stakeholders in its application to questions around REDD+/PES

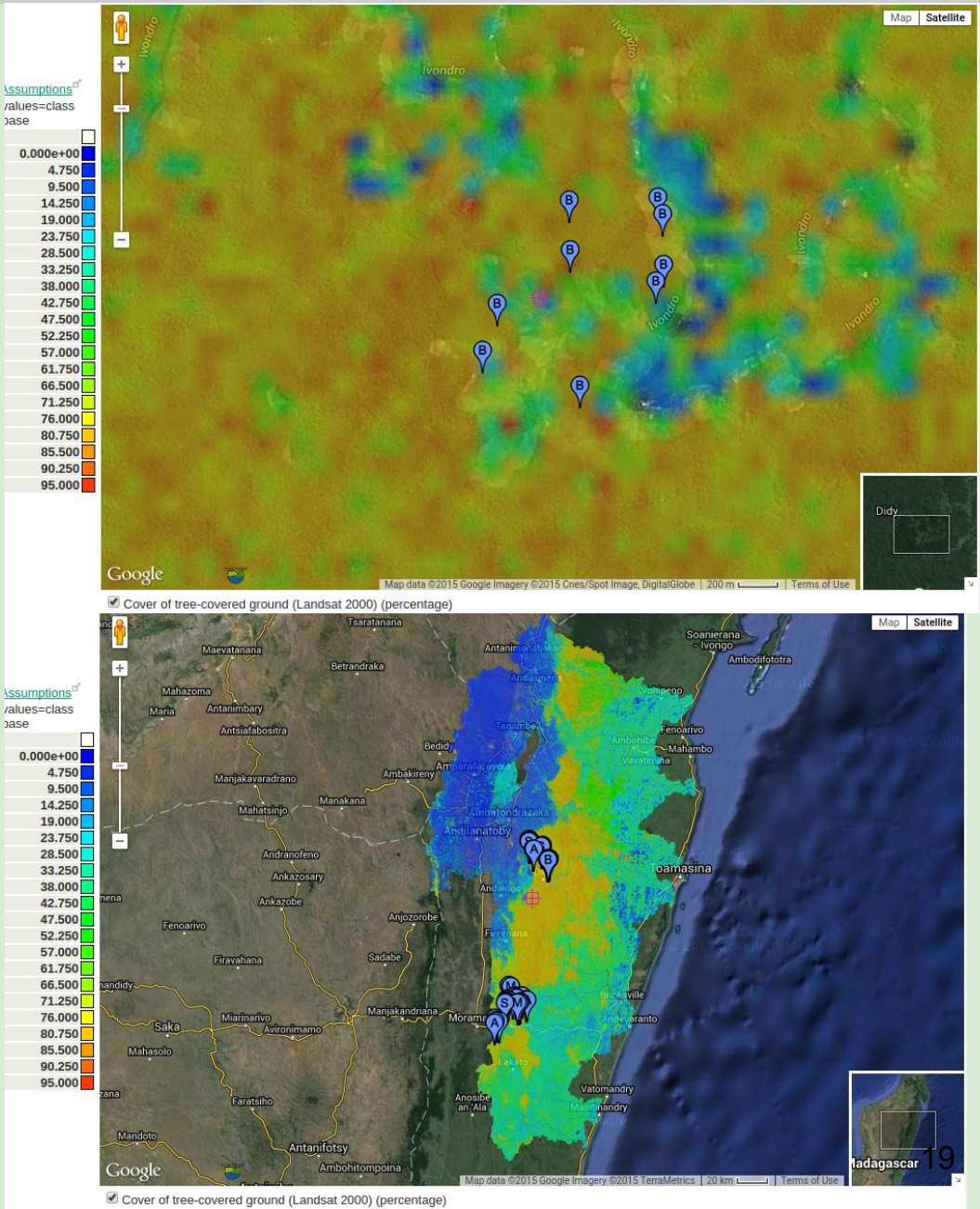
WaterWorld - turning science & big data into policy support



- Detailed, process based, since 1998
- Spatial (1ha or 1km spatial resolution)
- All required data (140 inputs) 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
- Free for non-commercial use. Free training programme.
- 1200 users, 1029 orgs. 141 countries
- Local data (e.g. that collected in p4ges) can be uploaded to improve model results

Scaling from plot to landscape with WaterWorld

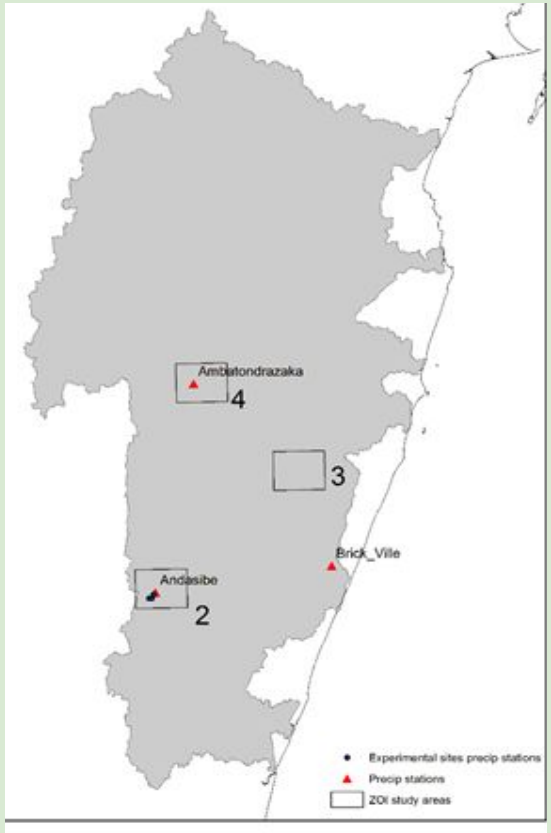
- P4GES collected sophisticated datasets **at points on the ground.**
- These help **understand the hydrological processes** (and also provide some parameters for the model)
- The data also help **verify the (global) input data** used by the WaterWorld model and the outputs of the model
- The model has to **scale up** the field science to policy relevant scales and allow the **application of scenarios and policy options to understand impacts at the landscape (watershed) scale.**
- WaterWorld is designed for this



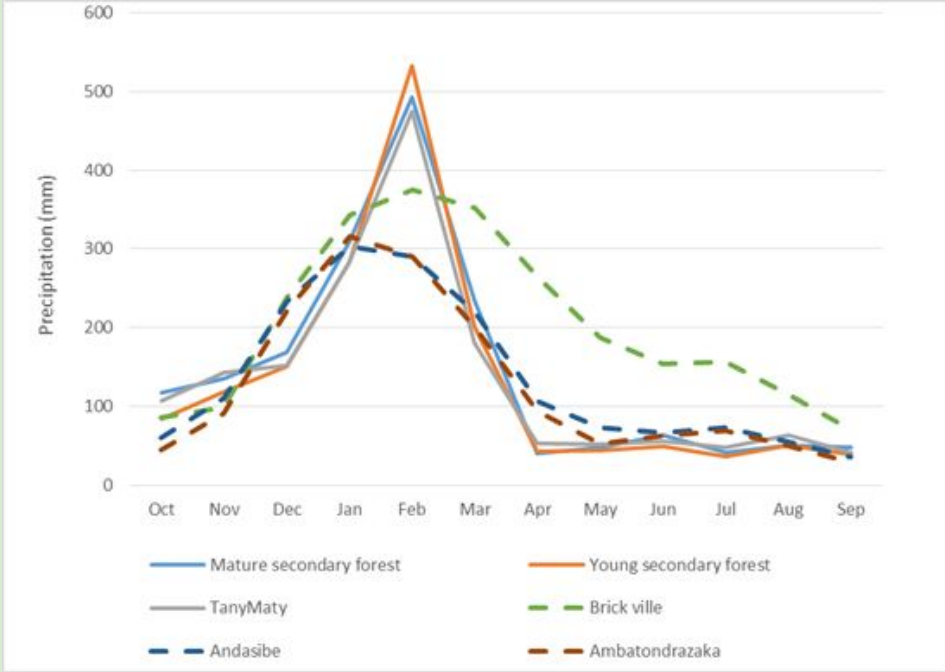
Scaling from plot to landscape with WaterWorld

Parameterising WaterWorld: rainfall

Challenges with spatial and temporal scales



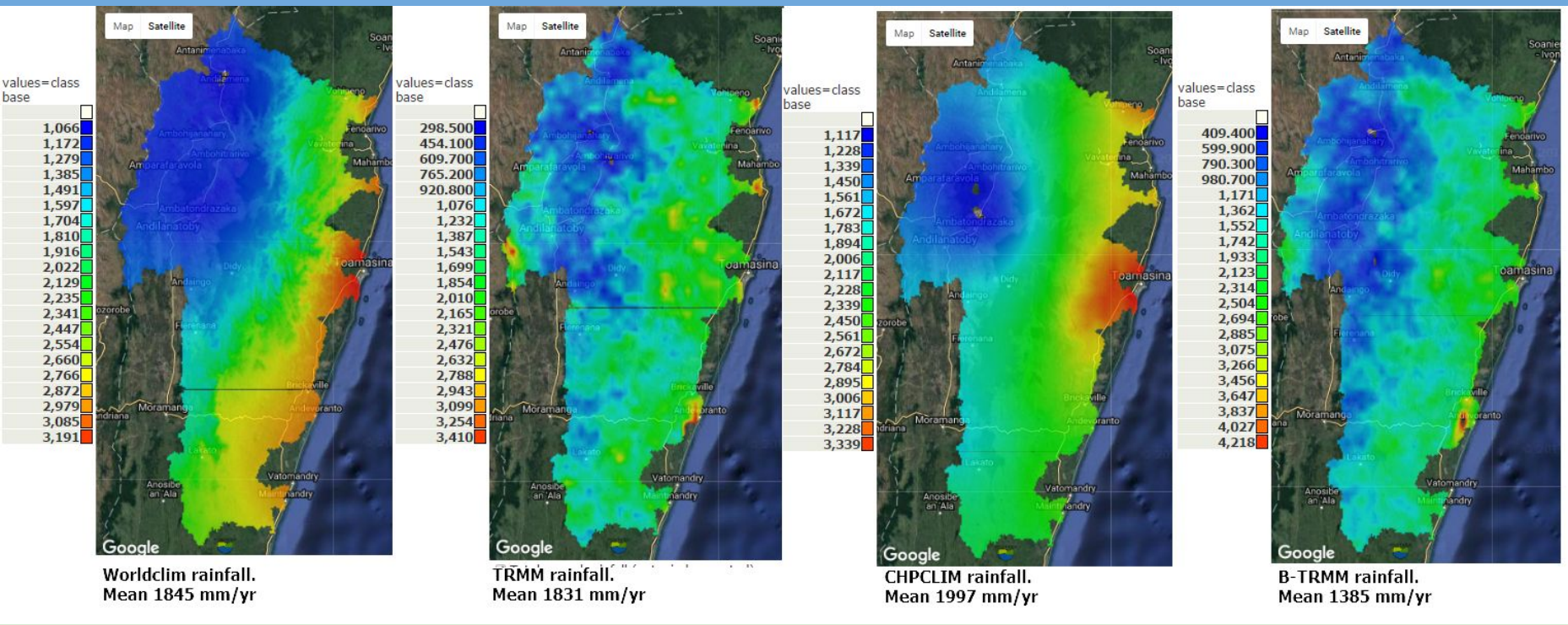
- Long term data available for only 3 stations in the CAZ (83-13). One year from P4GES study sites (in zone 2)
- Need longer term and better spatially distributed data to assess impacts on water resources at CAZ scale
- WorldClim (used by WW) is still the best ground based dataset we have



Scaling from plot to landscape with WaterWorld

Parameterising WaterWorld: uncertainty in input data

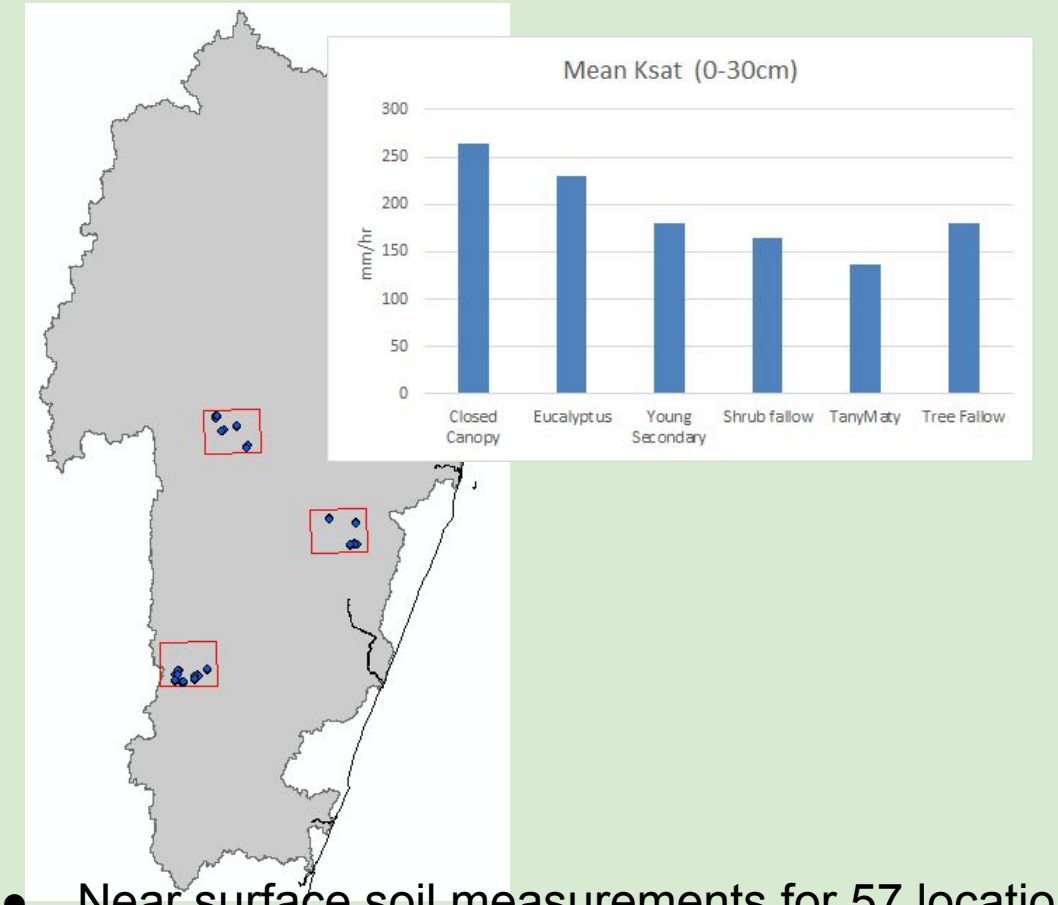
WW focuses on understanding uncertainty: *e.g.* use each of the four globally available rainfall datasets : diff's in magnitude and distribution:

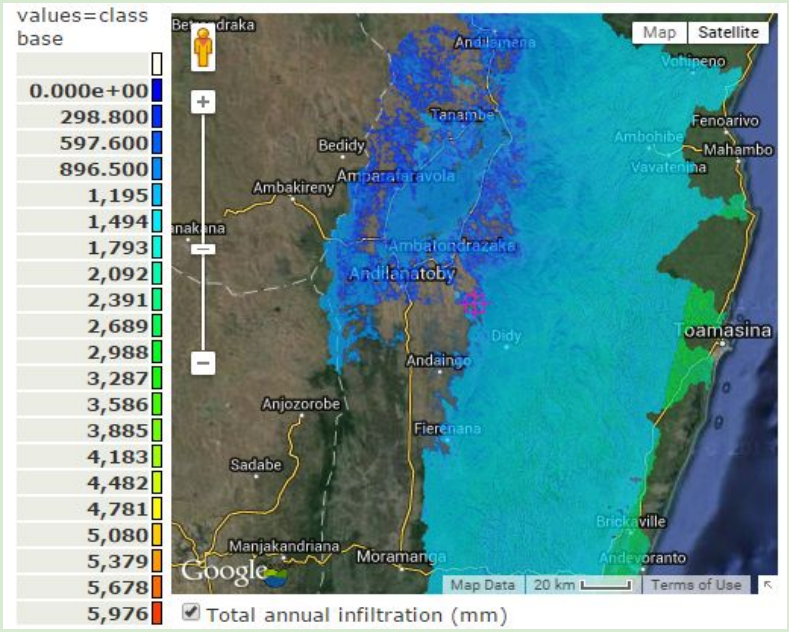


- Rainfall key input dataset for hydrological modelling
- Limited (long-term) data available for rainfall and generally poor quality

Scaling from plot to landscape with WaterWorld

Parameterising WaterWorld: infiltration (in progress)

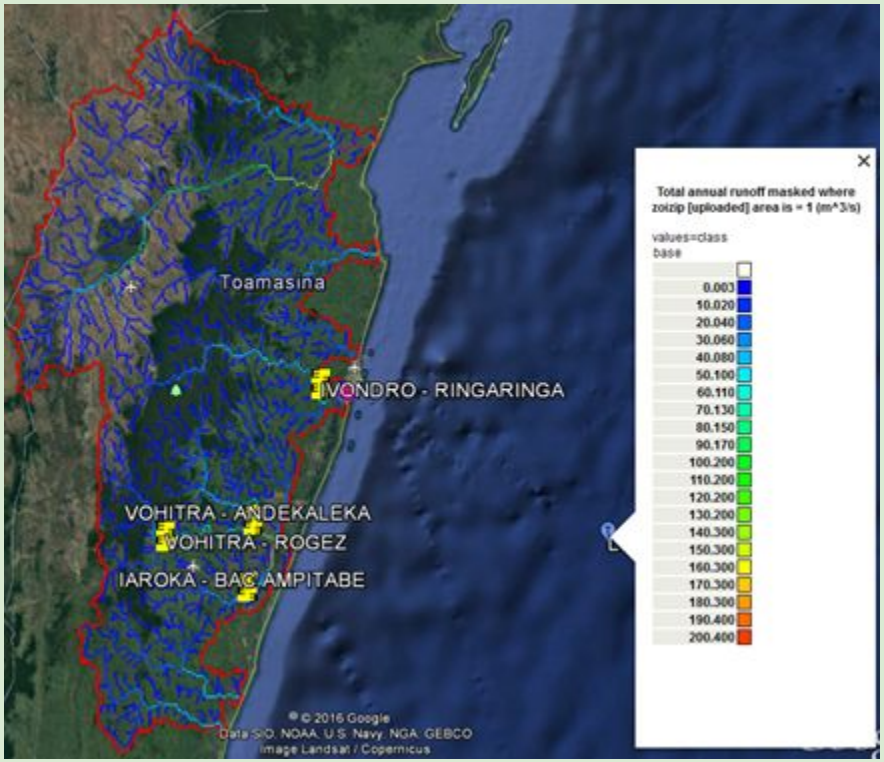




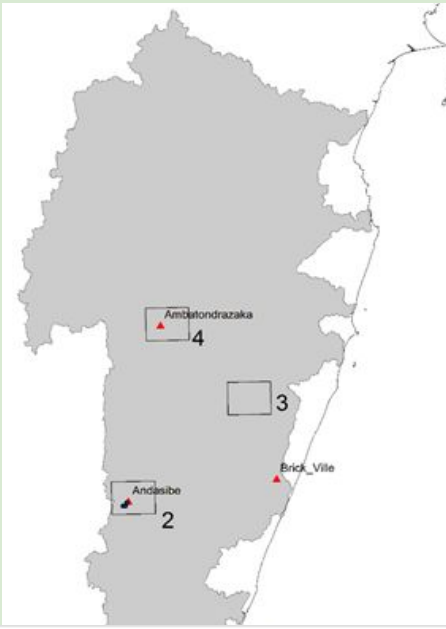
- Near surface soil measurements for 57 locations within 3 zones in the CAZ.
- WaterWorld V3 calculates infiltration based on slope and tree cover, affecting geologically determined infiltration rates. These are lower than surface rates but are more realistic for long-distance subsurface flows
- Infiltration is also influenced by land use/management

Scaling from plot to landscape with WaterWorld

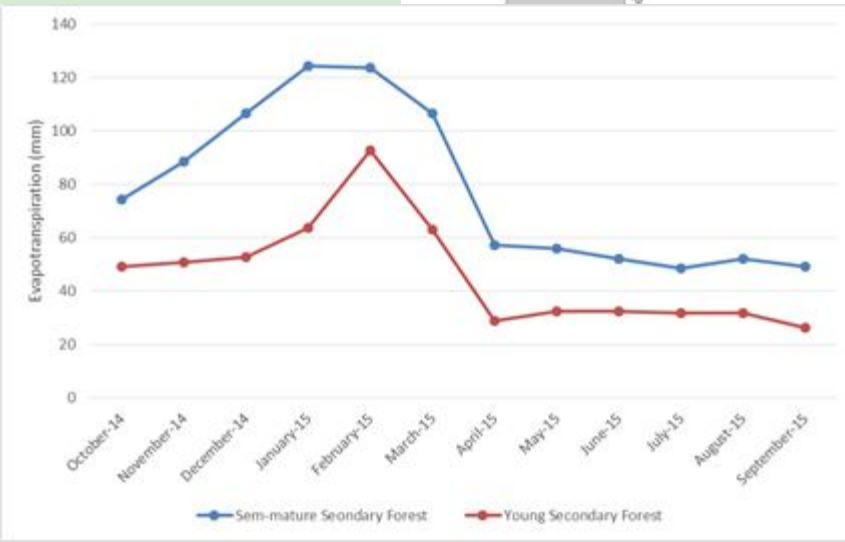
Validating WaterWorld: runoff and AET (in progress)



Measured ET data available for one year for three points in different vegetation types (Young secondary forest, semi-mature forest and Tany Maty)



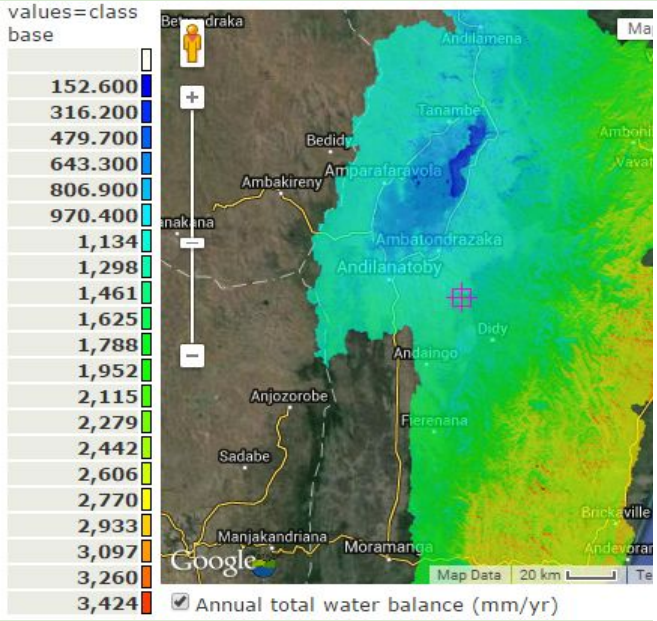
Only limited long term runoff data available for 4 stations in the CAZ from GRDC (1950s-1980s)



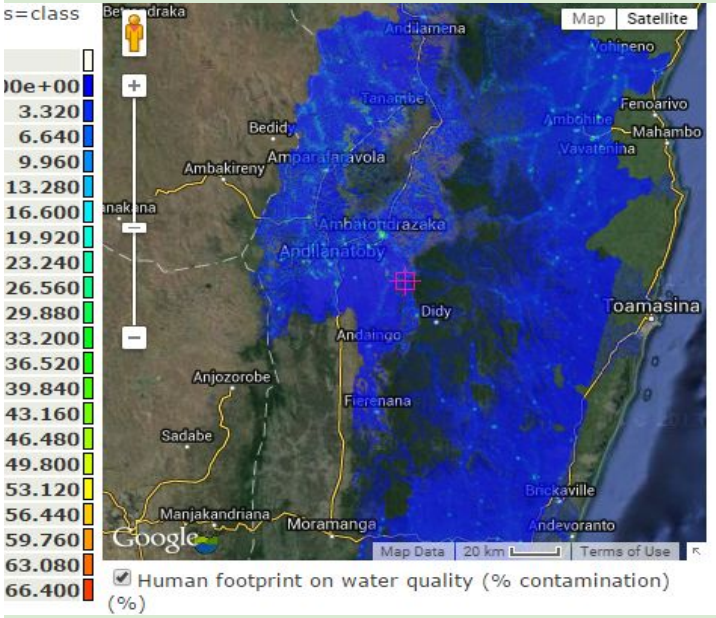
New functionality developed for P4GES

- Released WaterWorld v3 beta (includes subsurface flows, groundwater and impacts on dry season flows)
- Whole of CAZ watershed can be run at 1ha resolution (not possible on public servers - 9 million cells per calculation)
- Population distribution function from Fokotany to pixel level (1ha or 1km from any population dataset). To better identify beneficiaries
- Madagascar-relevant land use classifier from WW land cover datasets (Closed Canopy, Tree and Shrub Savoka, Tany Maty)
- Paddy rice cultivation intervention tool developed (in progress)

WaterWorld V3 results for CAZ watershed

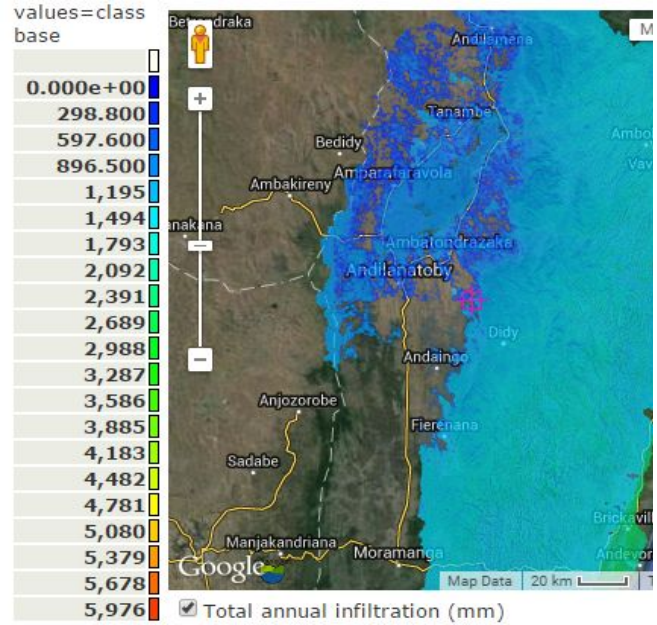


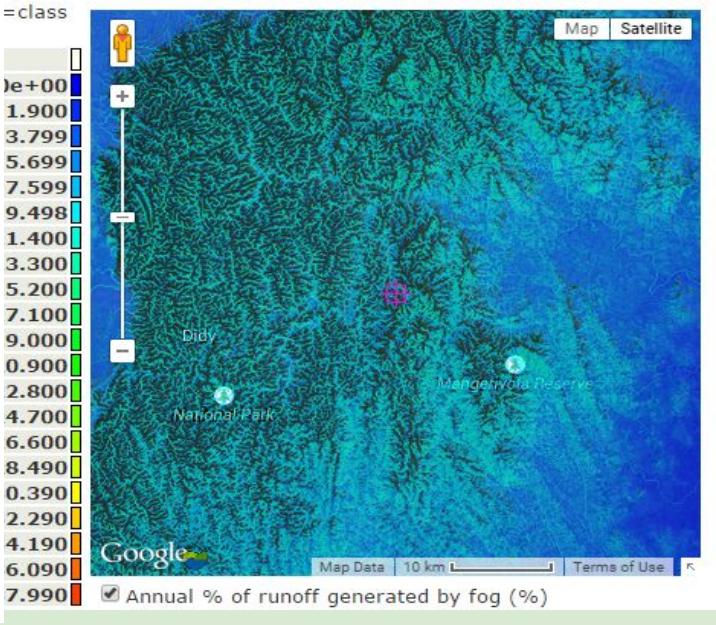
Water quality high in the CAZ, provides for some populations downstream>>>



<<<Infiltration and water balance highest on coastal plain.

Fog contribution to runoff is locally significant. This is lost on deforestation>>>





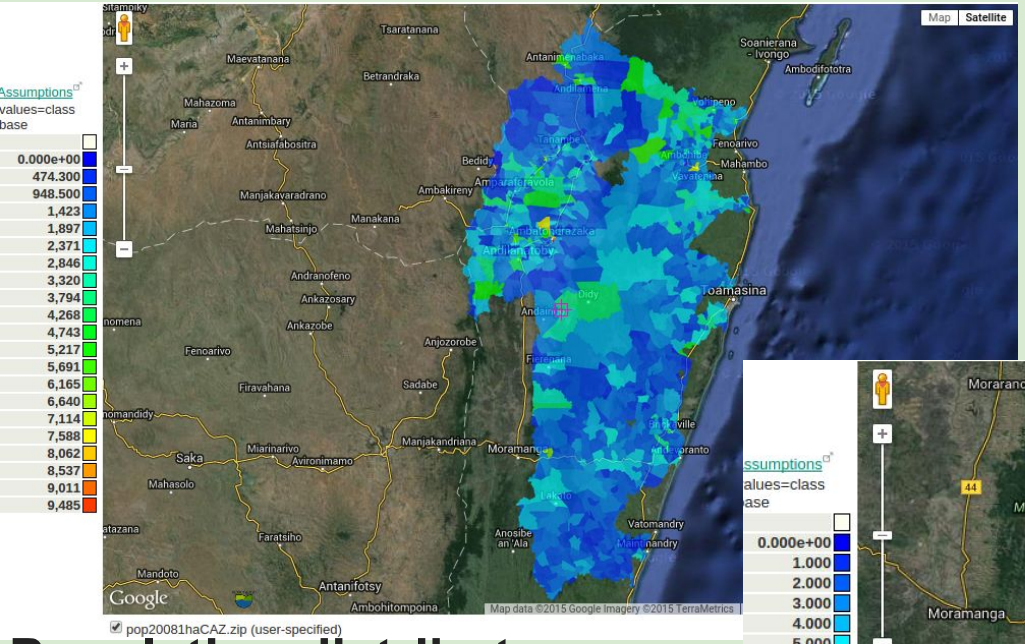
Mapping beneficiaries

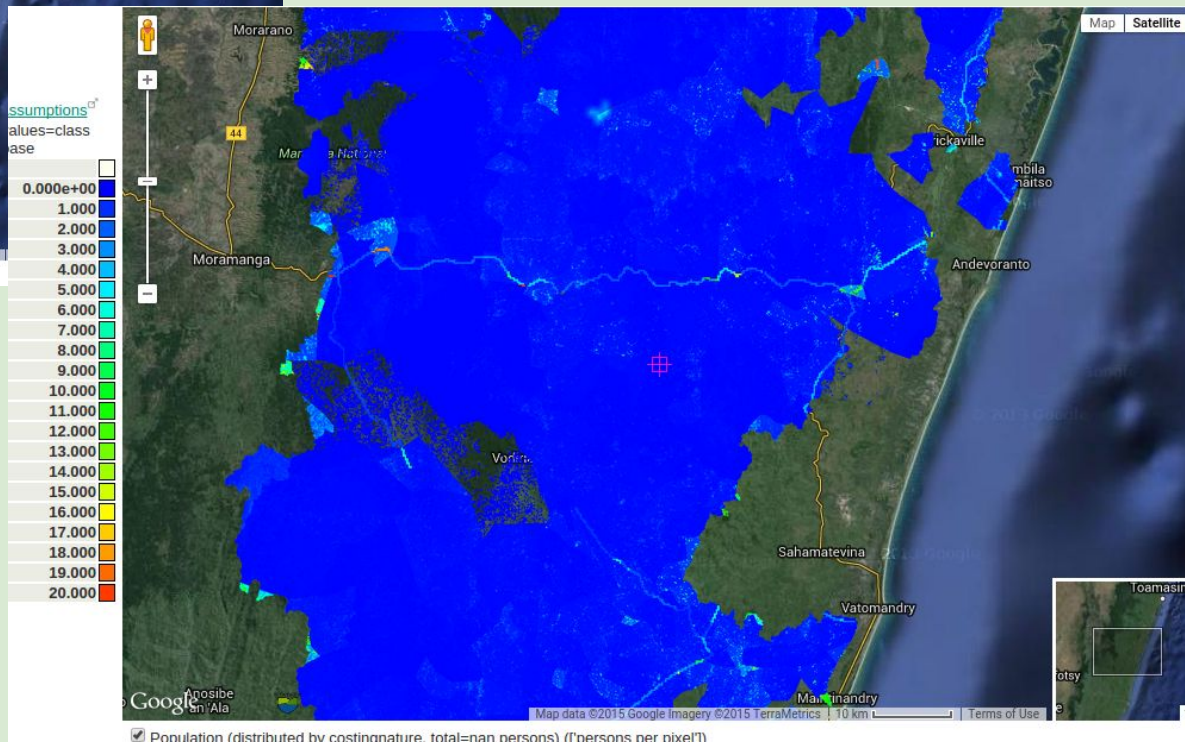
Distribute subnational population: Distribute population data based on nighttime lights, land use, deforestation and roads.

Use this function to fully distribute regional population totals based on the per-pixel values for current distribution of agriculture, nighttime lights, roads and deforestation. To use your own input map upload as an MOI first.

Choose the subnational population map: Population (2007, Landscan)

Check and Submit

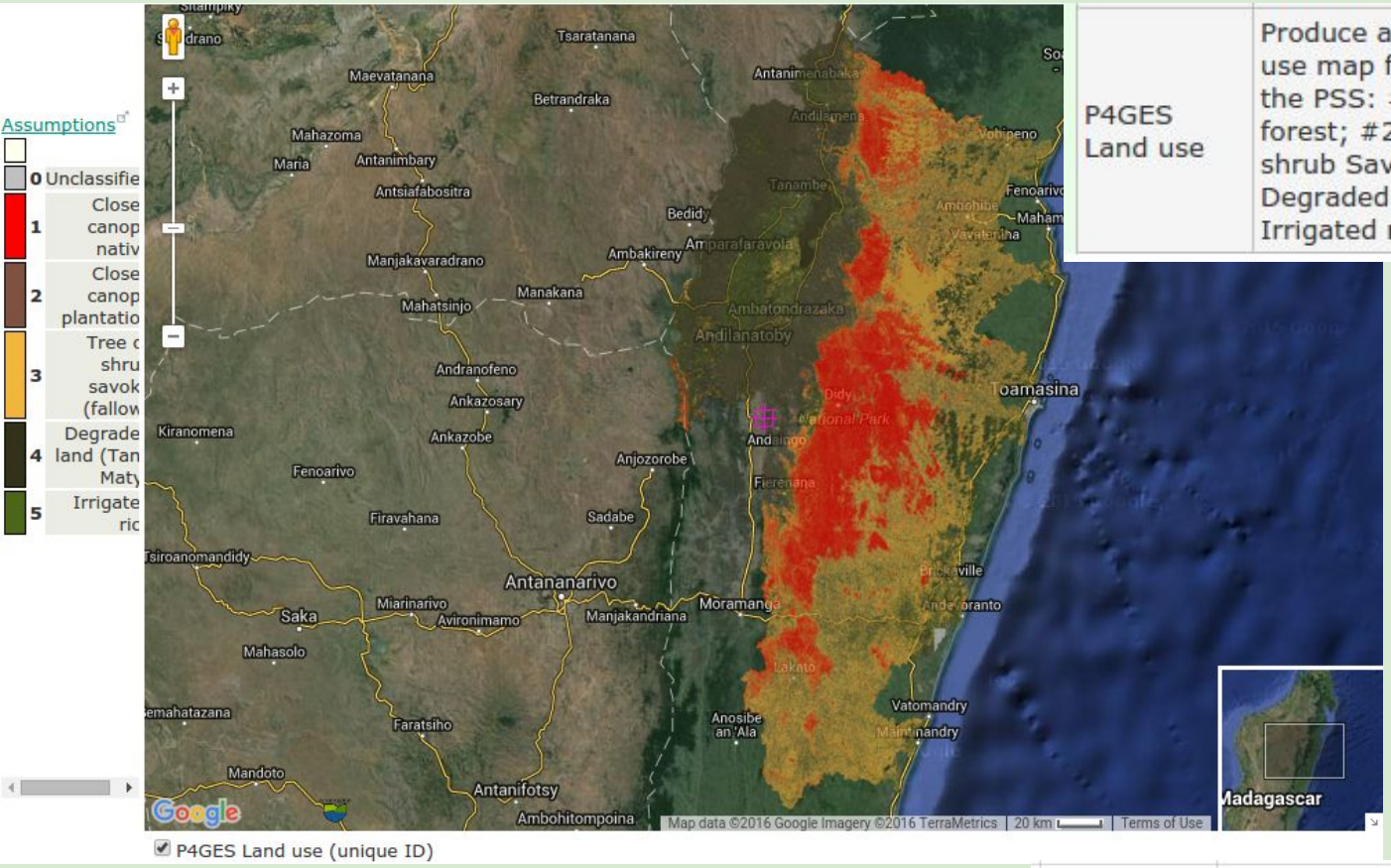




Population distributor function : distributes population by pixel according to latest nighttime lights, agriculture, roads, slope, deforestation,urban.

P4GES-relevant land use classifier

Land management as well as land cover are important so need to take into account P4GES land use types (mapped at catchment scale)



P4GES Land use	Produce a P4GES categorical land use map from the maps used by the PSS: #1 Native closed canopy forest; #2 Plantation; #3 Tree or shrub Savoka (fallow); #4 Degraded land (Tany Maty);#5 Irrigated rice	Calculate

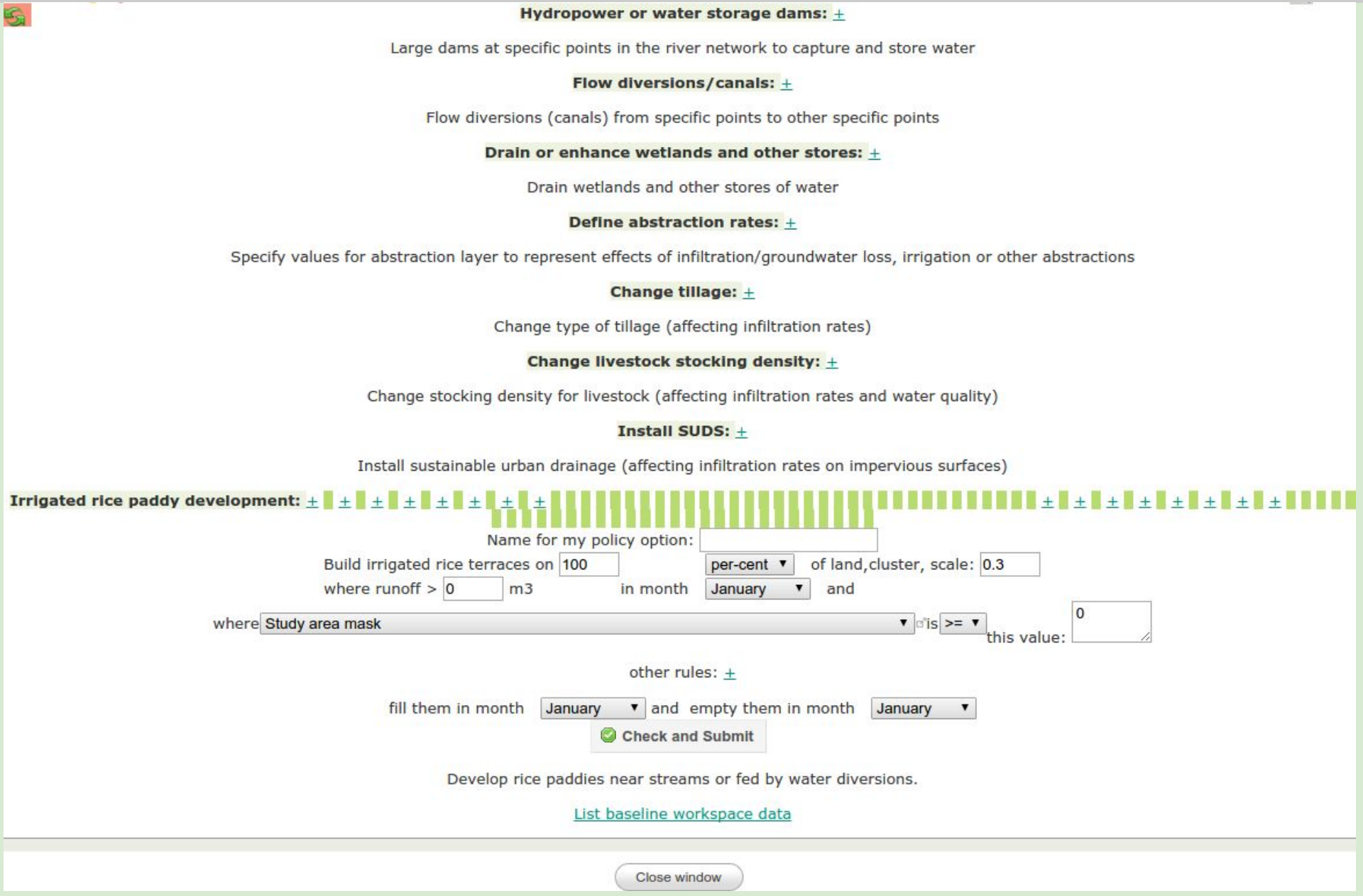
Imagery problem

Validation with field survey (not meant to replicate points but regional proportions:

Field	Field per-cent of sites	Imagery per-cent of sites	
CC	22	22	
RF	5	3	
TSA	49	53	TSA and SSA are combined in classification
SSA			
TM	24	17	

Rice cultivation intervention tool

(impacts demand for enhanced dry season flows from forests)



Thank you