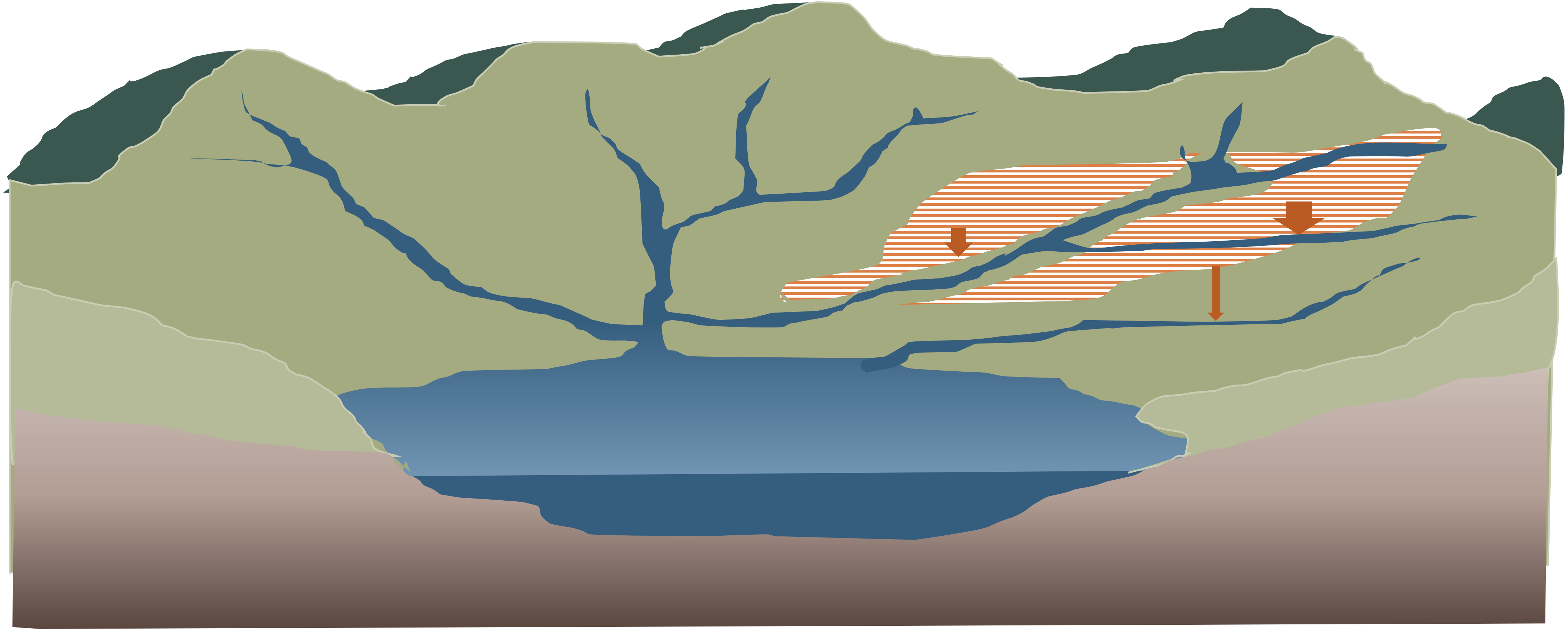
Water quality amelioration



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Service & Benefits

Service

1. Limiting the area of polluting land uses

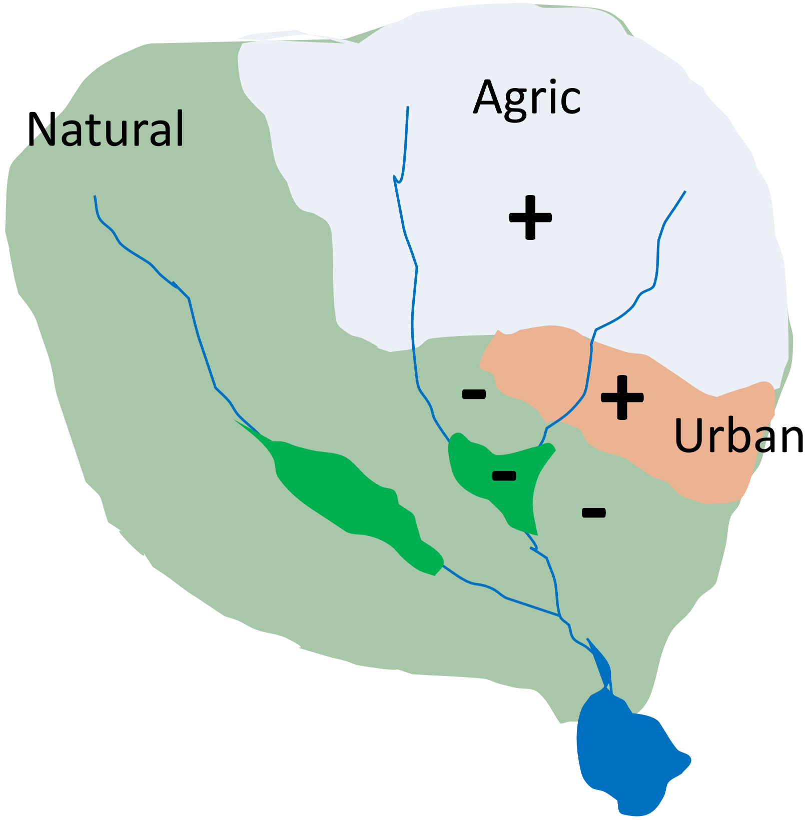
the passive service

1/disservice of degradation

2. Assimilating some of the loads generated

the active service

+ = generates excess nutrients
- = removes excess nutrients



Downstream ecosystem/ reservoir

Benefits

1. Reduced impacts on water treatment costs or health costs

final service

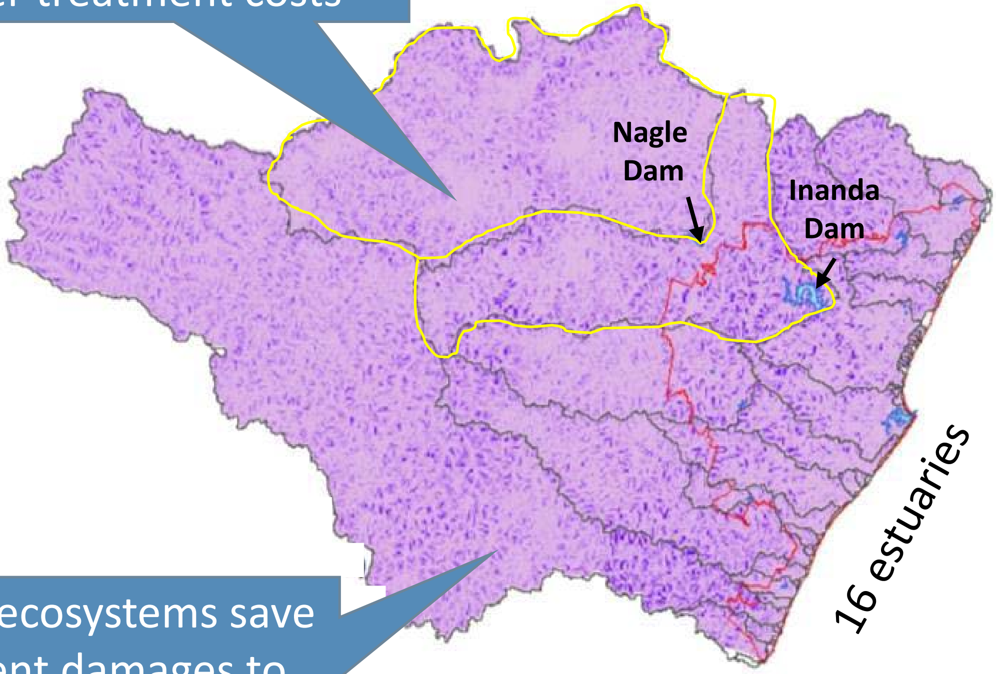
2. Reduced impacts on other downstream aquatic ecosystem services

intermediate service

Durban case study (eThekwini Municipality)

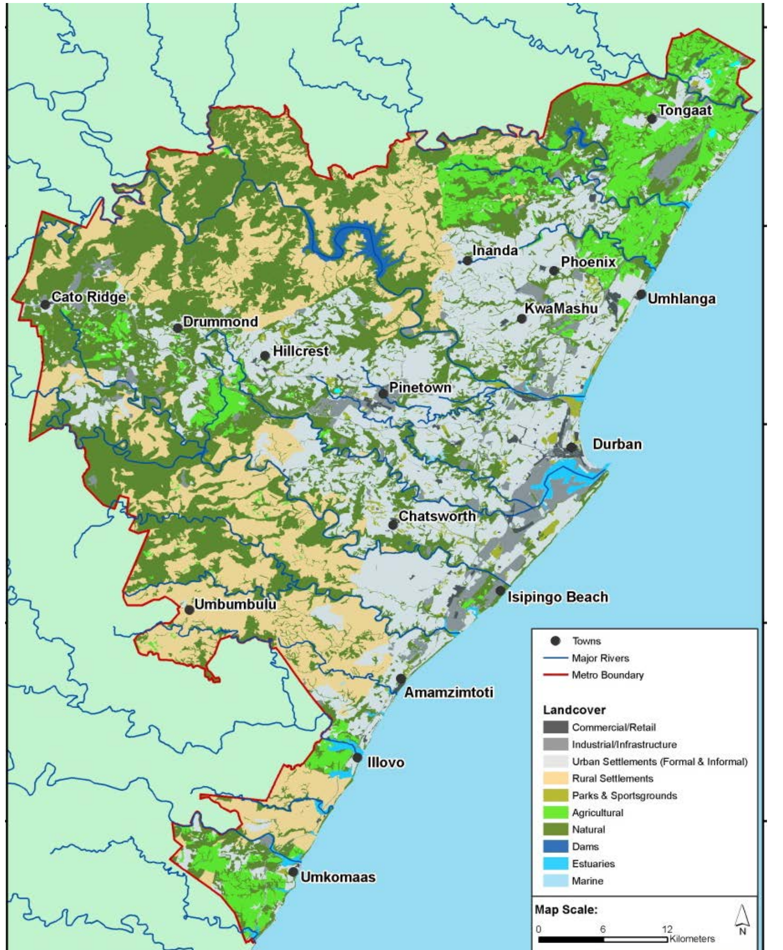
- Included active (nutrient assimilation) and passive (no LULC change) aspects;
- Included final (treatment cost) and intermediate (estuary ES) values

These ecosystems save on water treatment costs

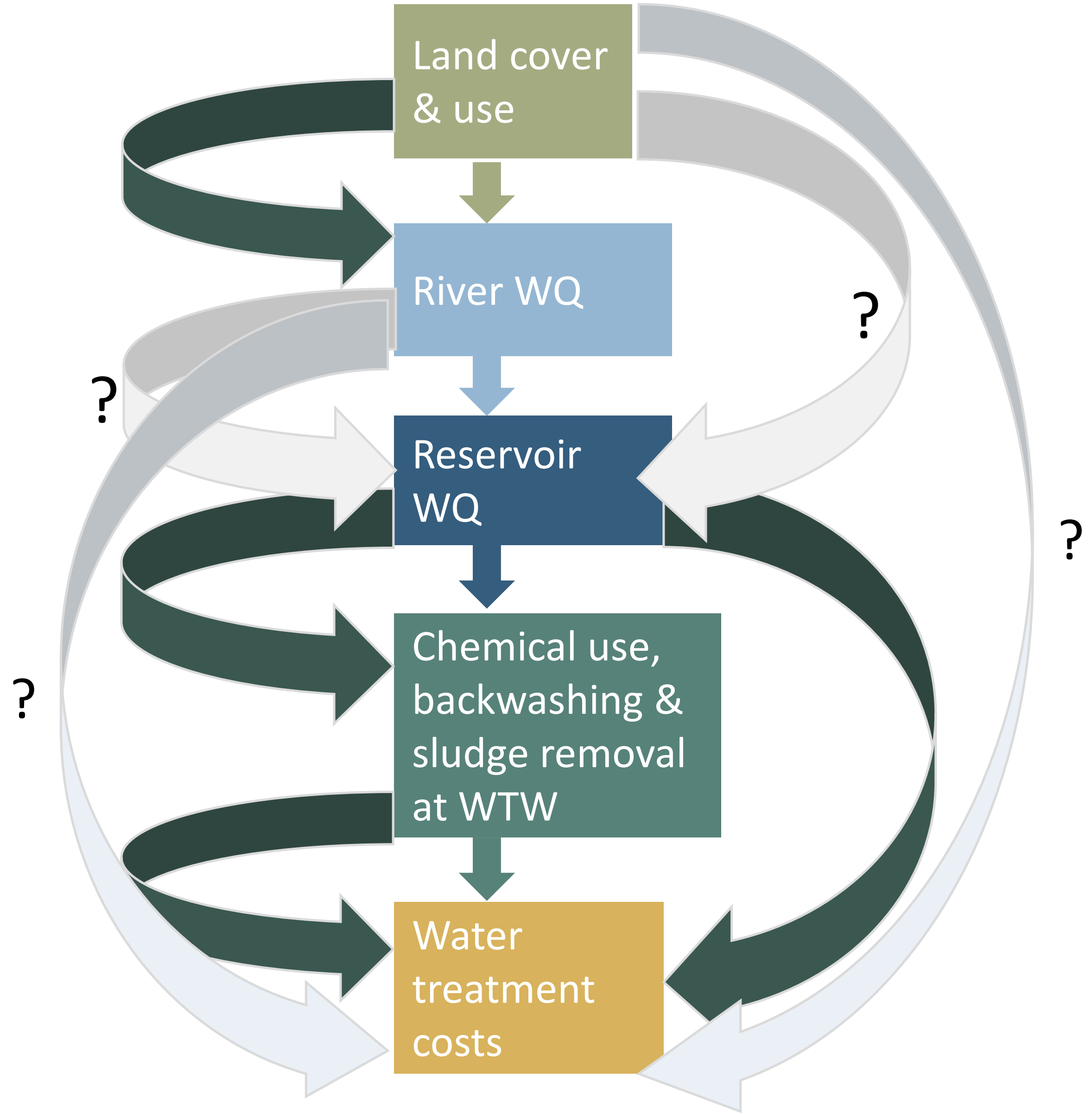


16 estuaries

These ecosystems save prevent damages to downstream rivers and estuaries

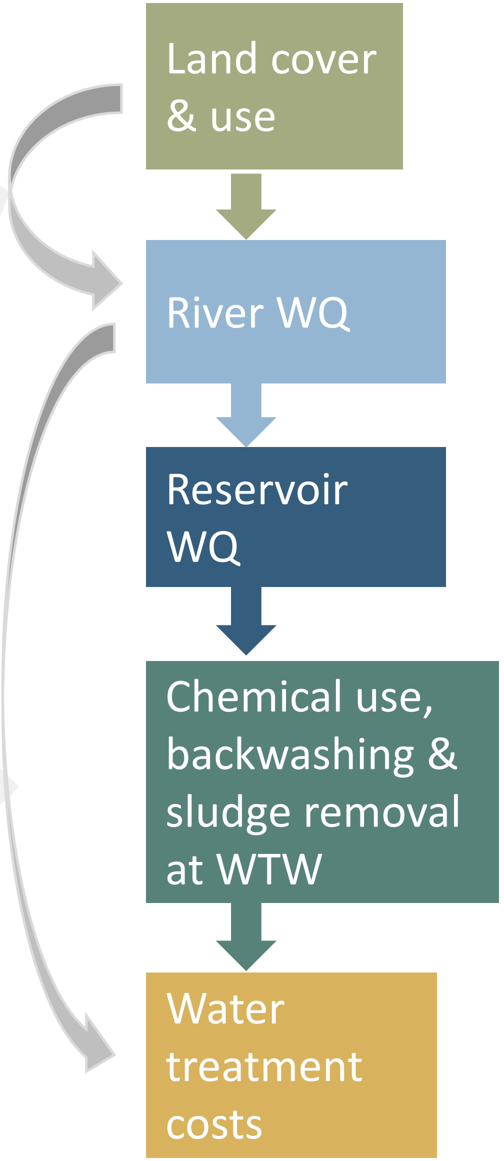


Understanding of treatment costs avoided

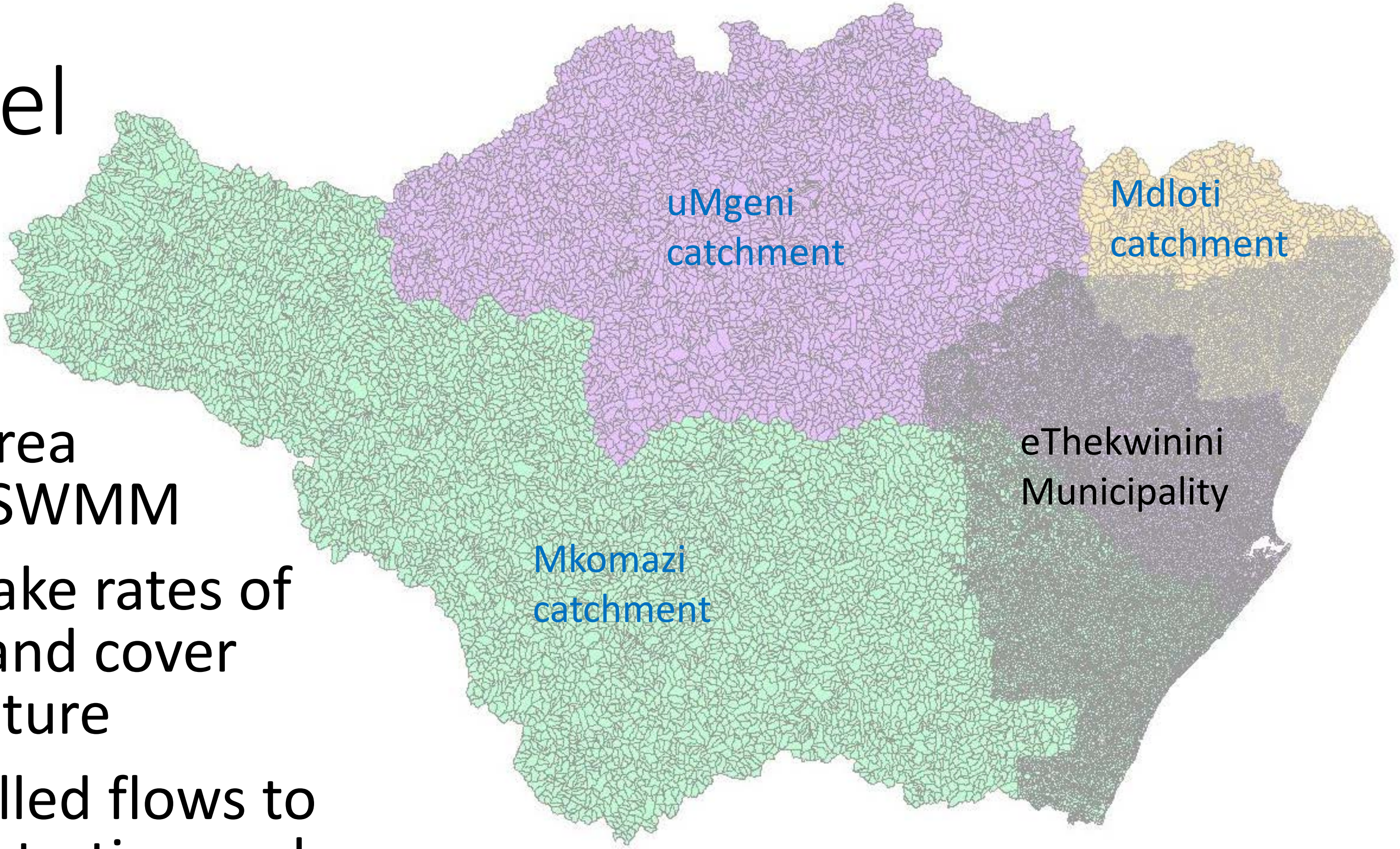


Two-stage valuation process

- Physical modelling
  - Change in nutrient load at each point of interest (m^3/year)
  - Mapping the removal back to service areas (m^3/ha/year) based on model coefficients
- Valuation
  - Avoided treatment costs at each treatment plant based on empirical model – treatment costs = f(N, P entering dams)
  - Map value to source areas based on removal rate ($/ha/year)



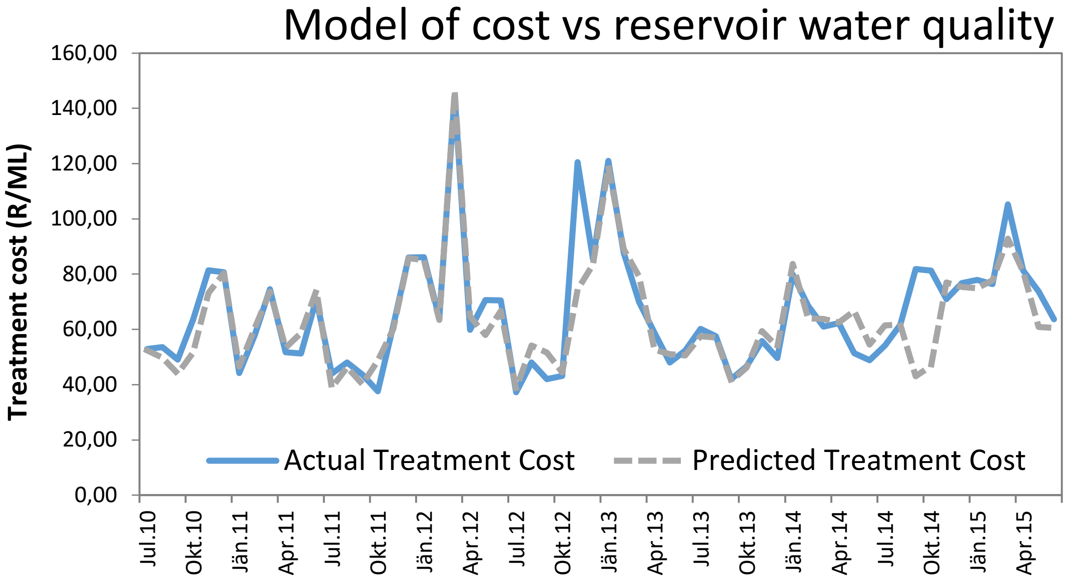
Physical model



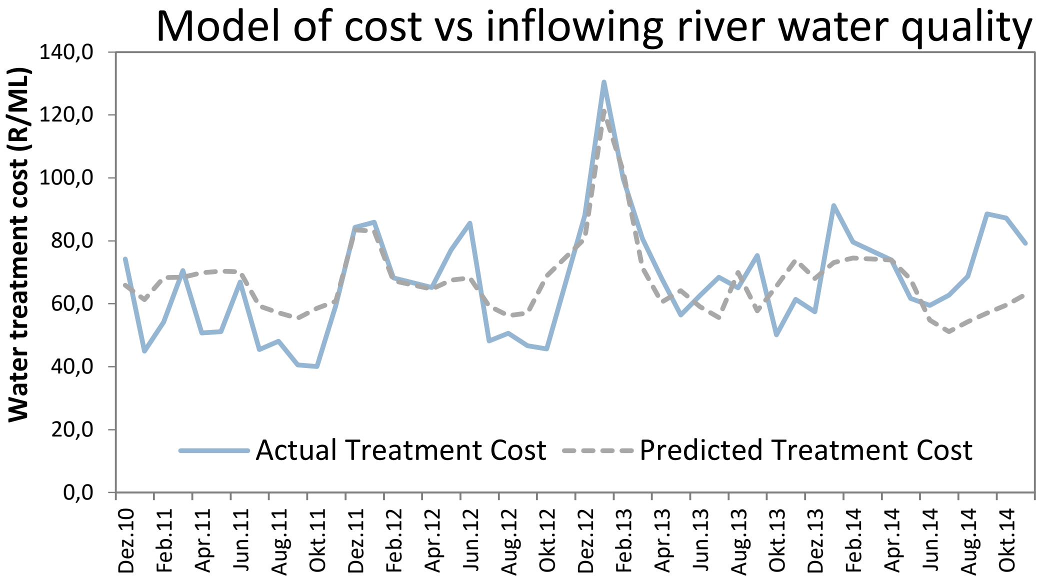
- Whole catchment area modelled using PC-SWMM
- Production and uptake rates of nutrients for each land cover type based on literature
- Coupled with modelled flows to estimate the concentration and total load of N & P at relevant points
- Calibrated with WQ data from >40 monitoring stations.

Valuation model

- Treatment cost vs reservoir WQ: model had good fit



- However, physical model predicts inflowing river water quality
- (Too complex to model reservoir response)
- So used slightly weaker model of cost against river water quality



Defining the baseline

- Two scenarios were used to estimate service provided:

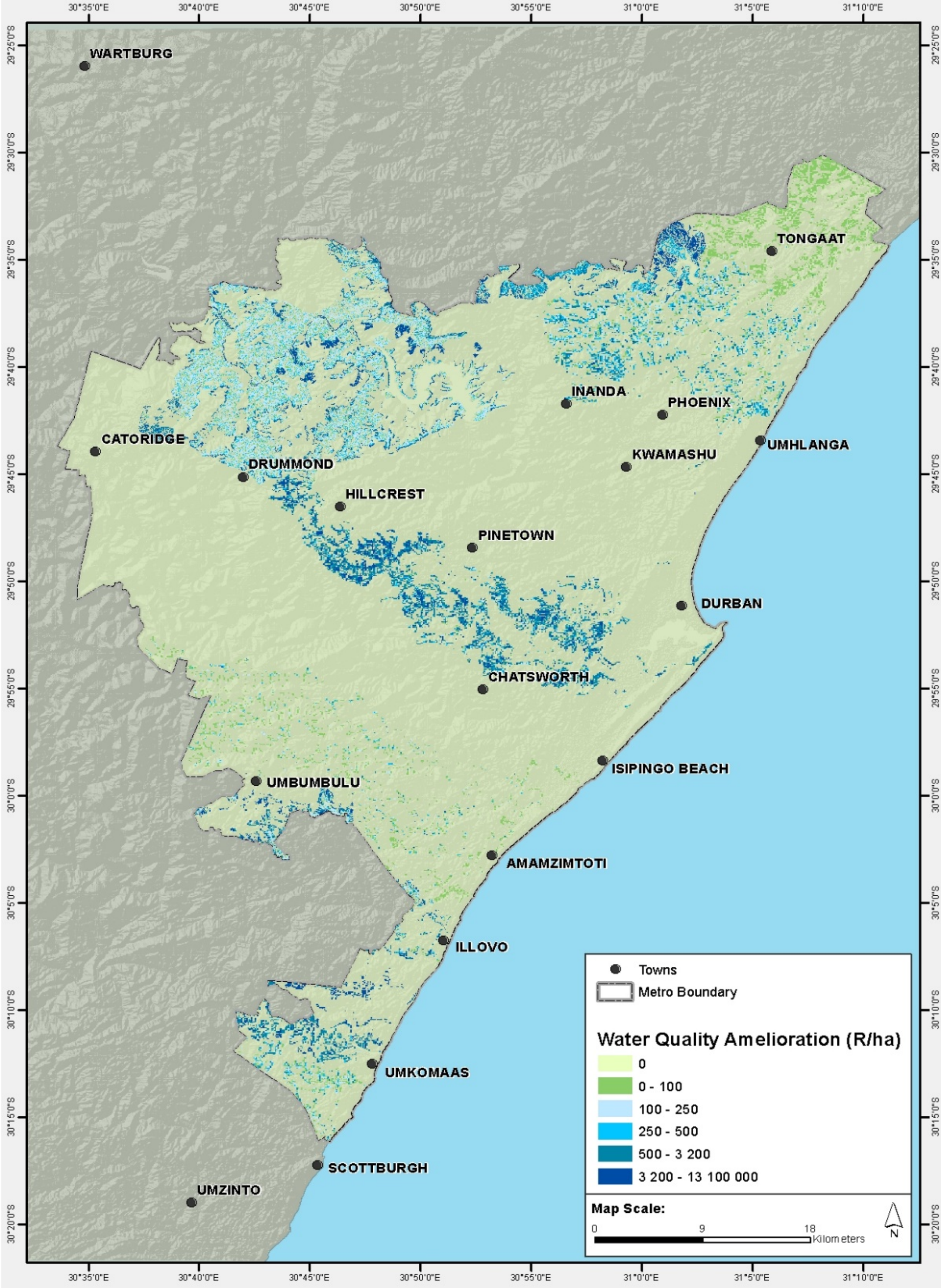
1: removal of uptake capacity of natural habitats (a hypothetical construct) — quantifies the active service

2: replacing natural habitats with dense rural settlement as a likely alternative land use — quantifies the active + passive services

- These provided lower and upper bound estimates of the magnitude of the service, depending on what is considered as the service

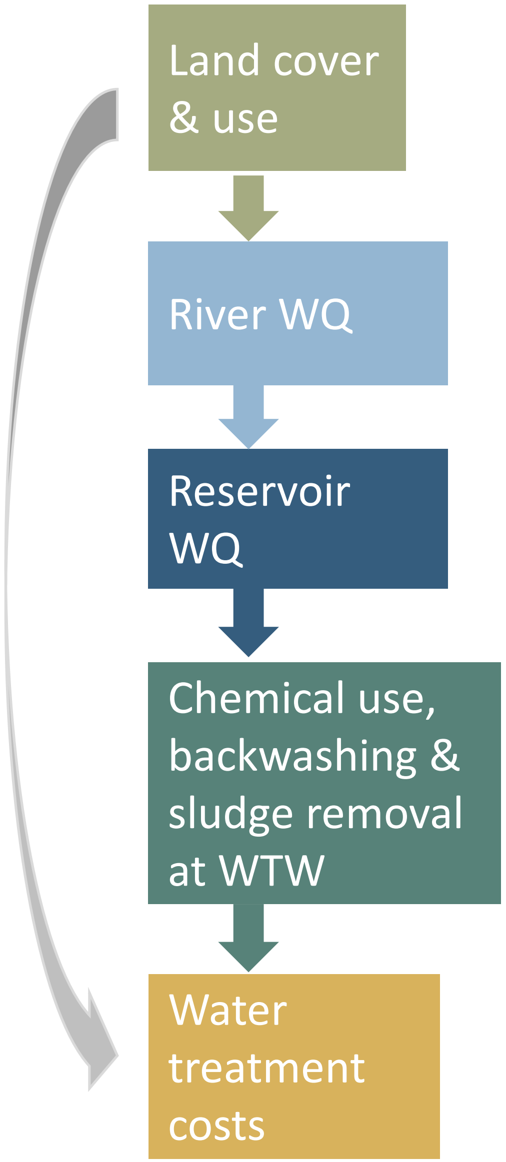
Results

- Big increases in P loads entering dams
  - 193%-319% for Inanda Dam,
  - 193%-968% for Hazelmere and
  - 200%-509% for Nungwane Dam
- Estimated water treatment cost savings of R1 - R8.7 million per annum
- Large range of uncertainty, mainly from physical modelling and service definition



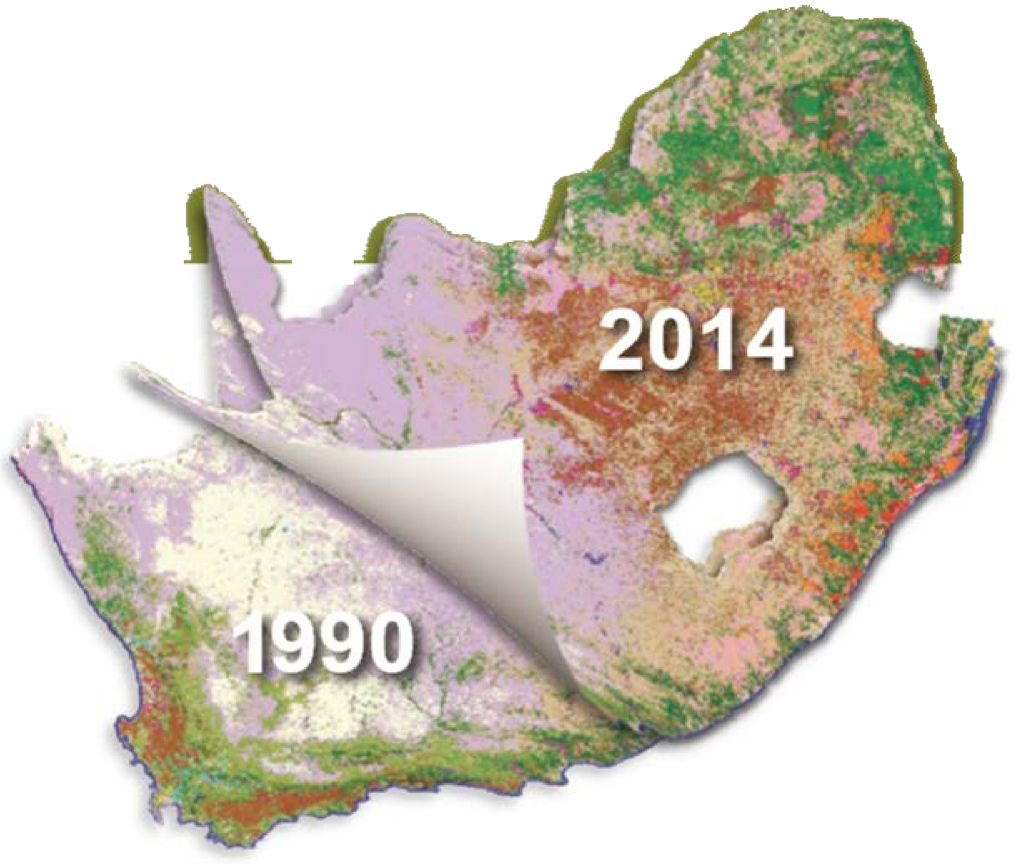
Empirical valuation based on land cover/use

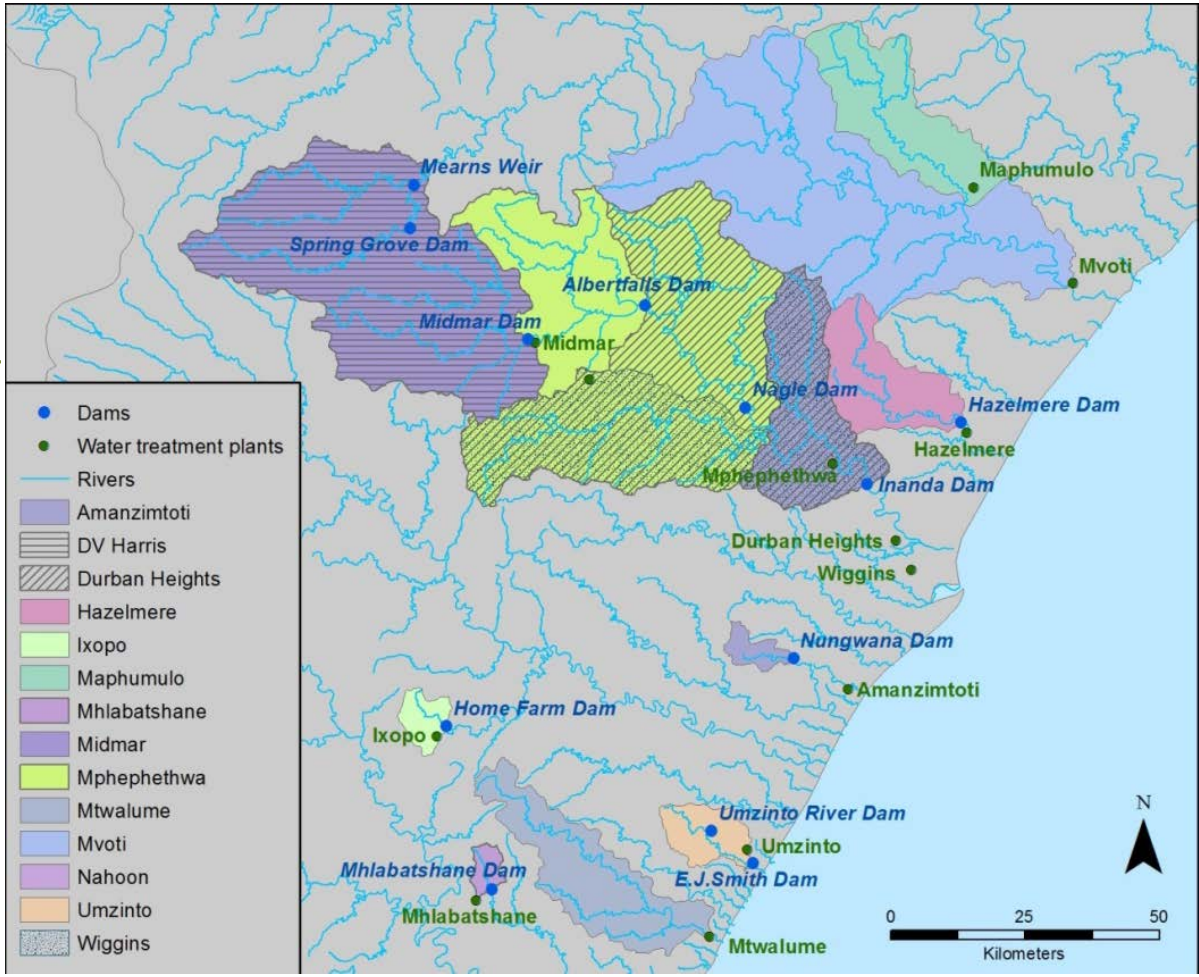
- Few studies directly relate catchment land cover to water treatment costs
  - Many anecdotal reports, but little empirical evidence
  - Some early studies have been criticized
- Vincent et al. 2015 analysed effect of forest cover on water treatment cost
  - Rigorous approach using fixed effects and instrumental variable (IV) models
  - 1% increase in virgin forest reduces costs by 1.16%
- ESAforD study used this approach to value water quality amelioration in South Africa, Sweden, Costa Rica, China, Kenya, Ethiopia & Tanzania



RSA study

- Panel data analysis 2008-2014
- Cost and output data from 14 treatment plants (TPs)
- Climate and land cover data extracted each catchment





Model results

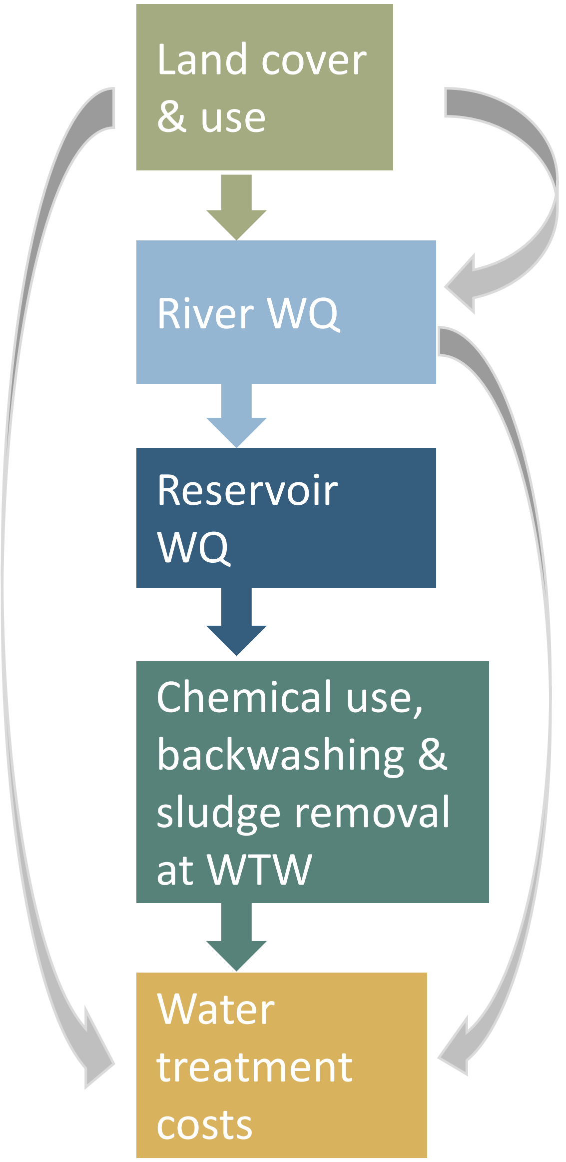
Variables	Random Effects	Fixed Effects	Mundlak
Constant	740,405	-6.339e+07***	-1.273e+07***
TP_capacity	15,690***		15,395***
Volume treated	0.156*	0.235***	0.421***
Rainfall	5,243*	-521.1	300.9
Rain sqr	-8.5**	2.075	0.602
Settlmnt	-309.3	-18,543***	-450.6**
Settlmnt sqr	0.00218	0.772***	0.00335
Subsistence	2,011***	14,901***	2,626***
Orchards	659.5**	53,021***	1,098***
Plantations	**-350.9*** **	**-8,599*** **	**-622.2*** **
Grasslands	5.882	1,215**	65.02*
Natural_forest	**-2,830*** **	**-39,942** **	**-4,937*** **
Woodland	-1,252	**-9,200*** **	463.2
Wetland	**-936.3** **	**-4,133*** **	**-2,243*** **
Observations	92	92	92
Number of TP	14	14	14
R-squared		0.757	

- Co-efficients translate to cost savings in R/ha/year
- Sensitive to model choice
- Some unexpected signs
- Lack of data on ecosystem condition

Discussion

- Improving confidence
  - More empirical modelling needed to refine modeling assumptions
    - Needs larger datasets, more detailed land use
  - Empirical modelling may better isolate the active from the overall service
  - Two/multi-stage empirical approach may be more practical, achieve higher confidence

- Defining service
  - Should only assign active service value to ecosystems,
  - but should also assign negative (disservice) value to polluting land uses (when added to production, this internalizes the externality)



Discussion

- Double counting?
  - run-of-river water – provisioning - maybe
  - treatment costs – sedimentation – no
  - if extrapolated to areas not serving users – yes – ie. Check demand
- Possibility of scaling up
  - Yes, but rigorous modelling will take time; must take spatial variation in demand into account.
  - Once set up, highly repeatable.

- Thank you!

WQ amelioration by ecosystems

- In landscape before reaching river systems, especially riparian zone
- Within drainage system, particularly in wetlands