Sedimentation and Soil Water Conservation in the Tana River basin, Kenya

Christine Omuombo

International Training Workshop on Integrated Sediment Management in River Basin

IWMI International Water Management Institute

CAPACITY BUILDING NETWORKING RESEARCH

WISE-UP to climate

WATER • INFRASTRUCTURE • ECOSYSTEMS

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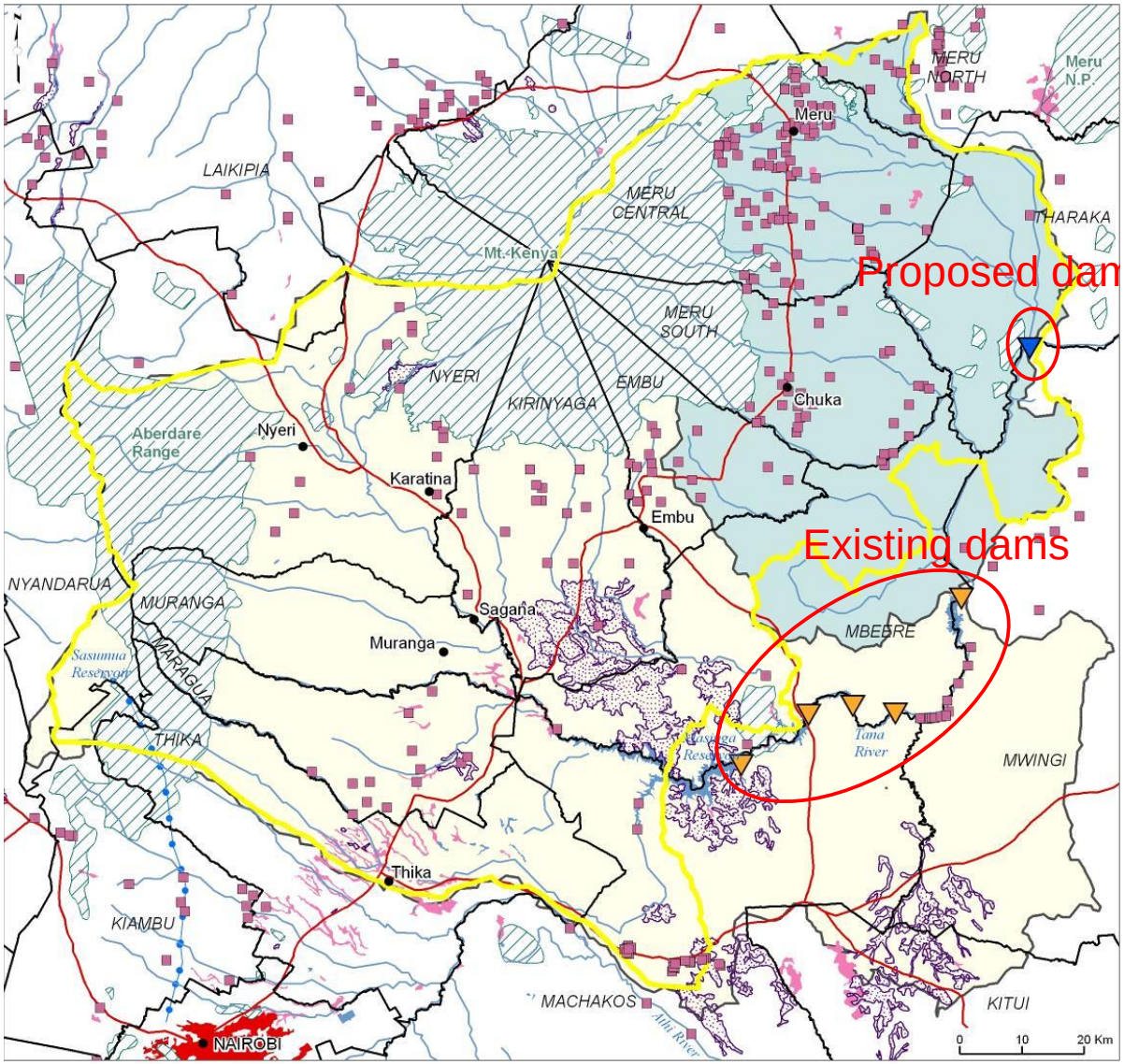
Maingi and Marsh 2002

- Longest river in Kenya approx 1000 km
- Its catchment 126, 026 km2
- Key water resource for national development – water for Nairobi, HEP production
- Upper and lower catchments receive variable rainfall: 1500 – 1000mm/yr and 600 – 700mm/yr respectively

Upper Catchment



- Upper catchment located on mount Kenya and the Aberdares ranges
- Densely populated
- Agriculturally productive
- 5 HEP dams (Masinga, Kiambere, Gitaru, kindaruma and Kamburu)
- Dams also support fishing and irrigated agriculture

WRI 2009

Lower Catchment

- Few subsistence farmers, mainly pastoral communities


Villages in the lower Tana

Pastoral child tending cattle


Lower Tana
Subsistence farming

Activities

- Wildlife conservation
- Tourism
- Livestock production
- New irrigation schemes set up at Bura and Hola

In the lower Tana, population are vulnerable to floods and droughts

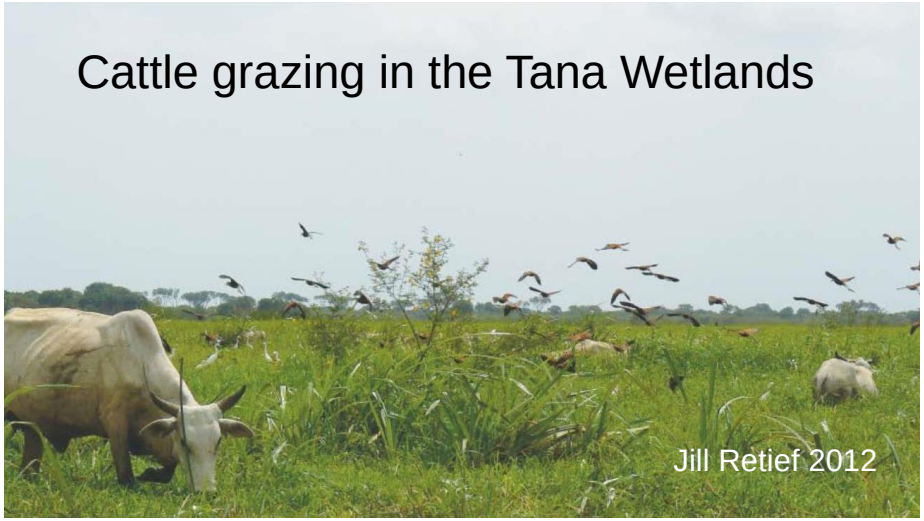

Flooded Tana

The displacement of the communities that occupy the flood plains along the Tana catchment is a recurring phenomena during intense rainy

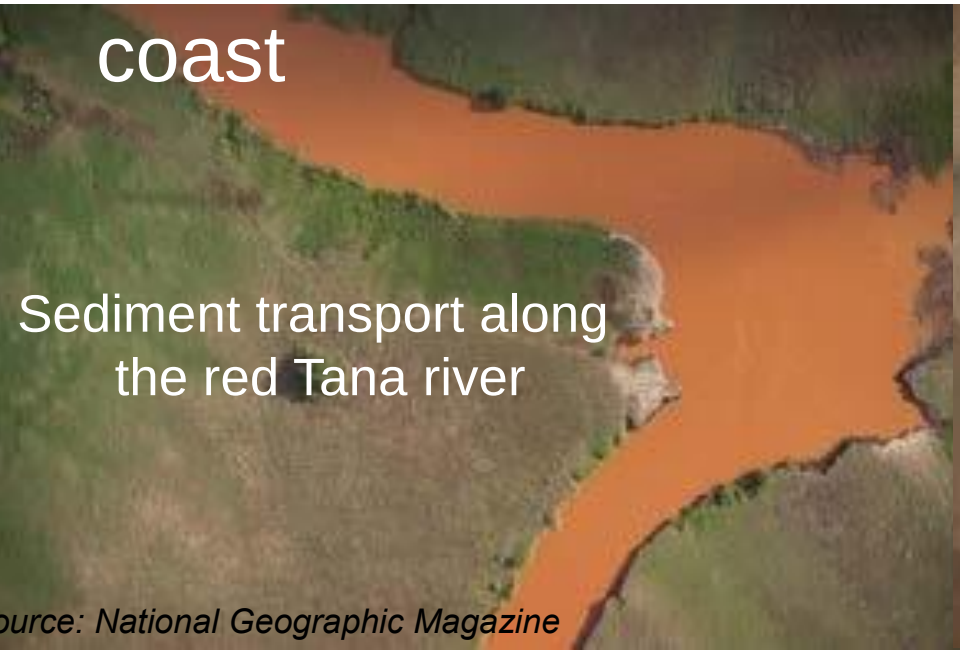
Water is a critical need in many areas within the catchment region. In times of drought, many people would face imminent death from thirst unless they got water immediately.


2006, Horn of Africa drought. Kenya Red Cross

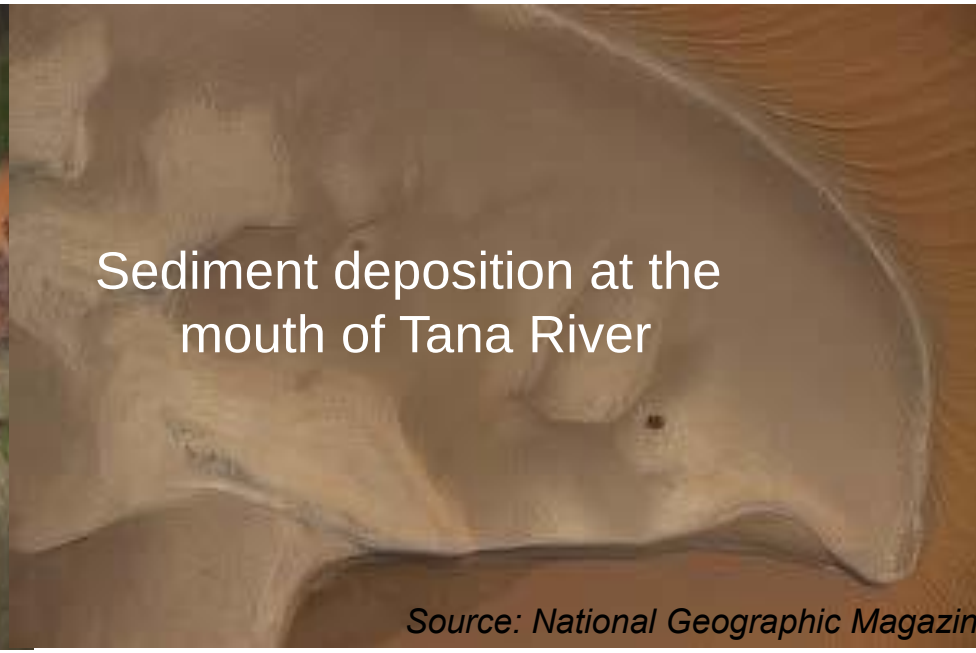
- Fishing in the Tana delta
- The wetlands, forests and mangroves are
  - important birds and wildlife site,
  - Provide faming grounds for rice and mango cultivation among other crops



Sediments as an Ecosystem service

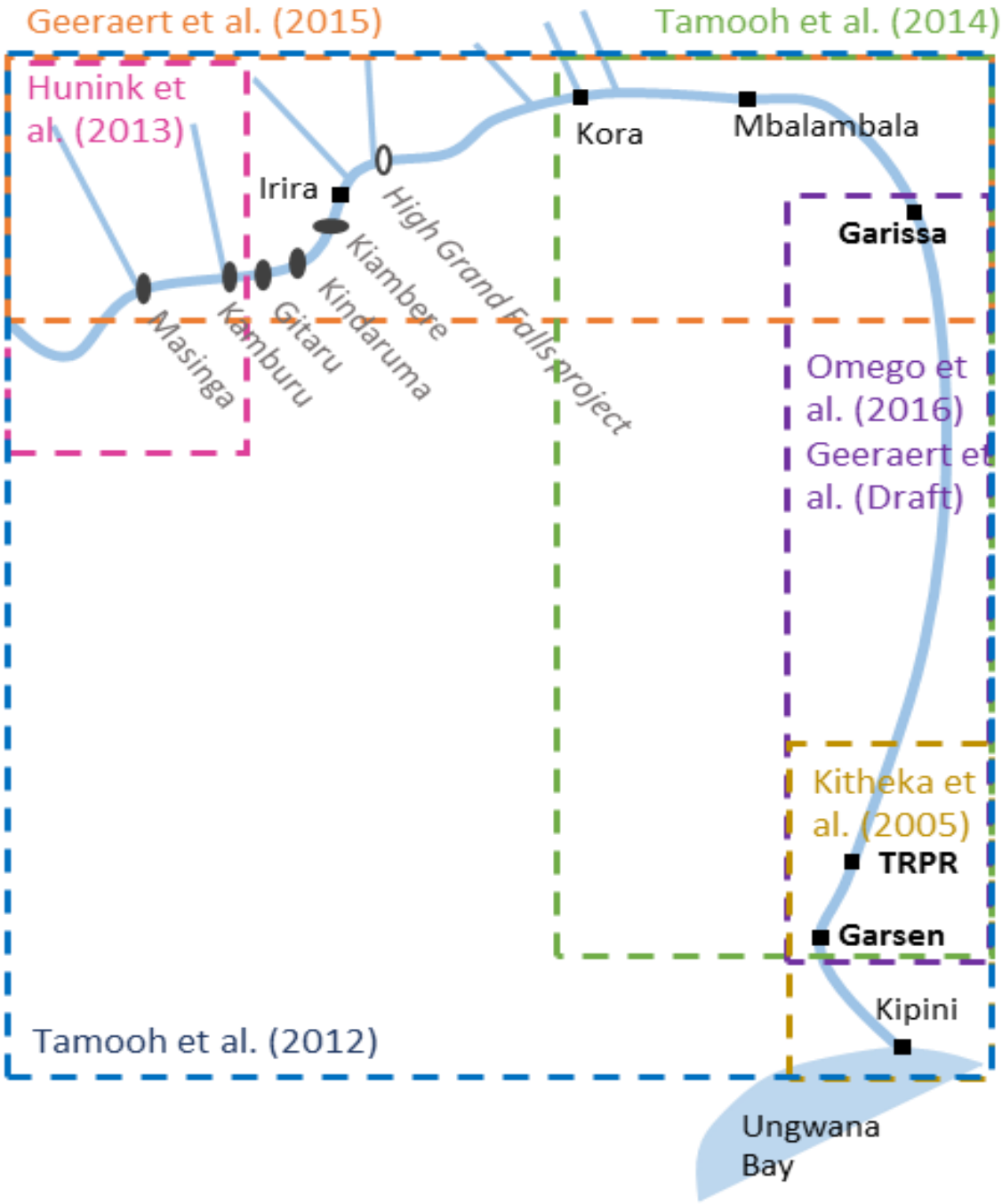


ource: National Geographic Magazine



Source: National Geographic Magazin

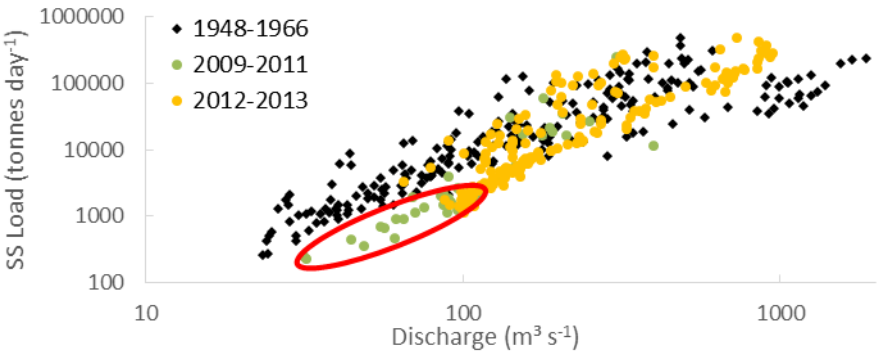
- The catchment displays the complexities and demands for water resources for human consumption, agriculture, hydropower generation and ecosystems

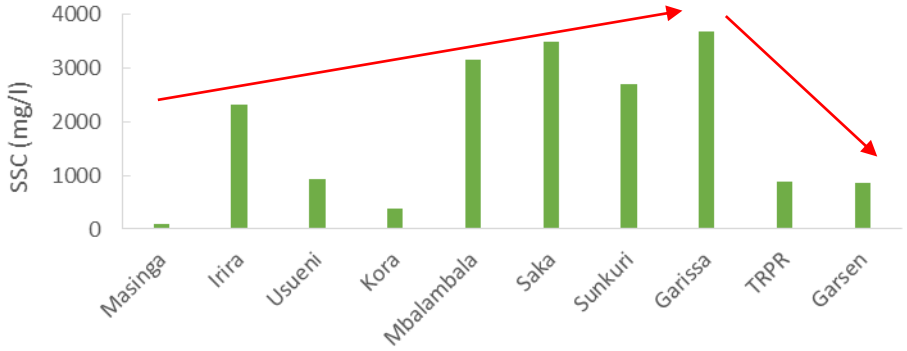


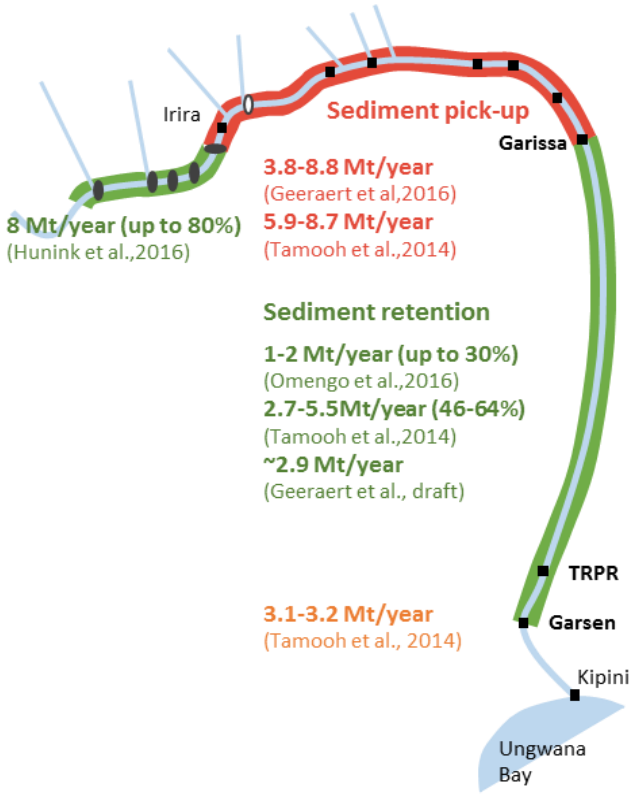
Basin scale sediment studies

- Sediment transport in the Tana River is **complex and variable** in space (along the profile) and in time (across seasons)
- Difficult to establish cause-response relationships
- Look at bigger picture
- **3 timescales**: annual, seasonal and events

Annual

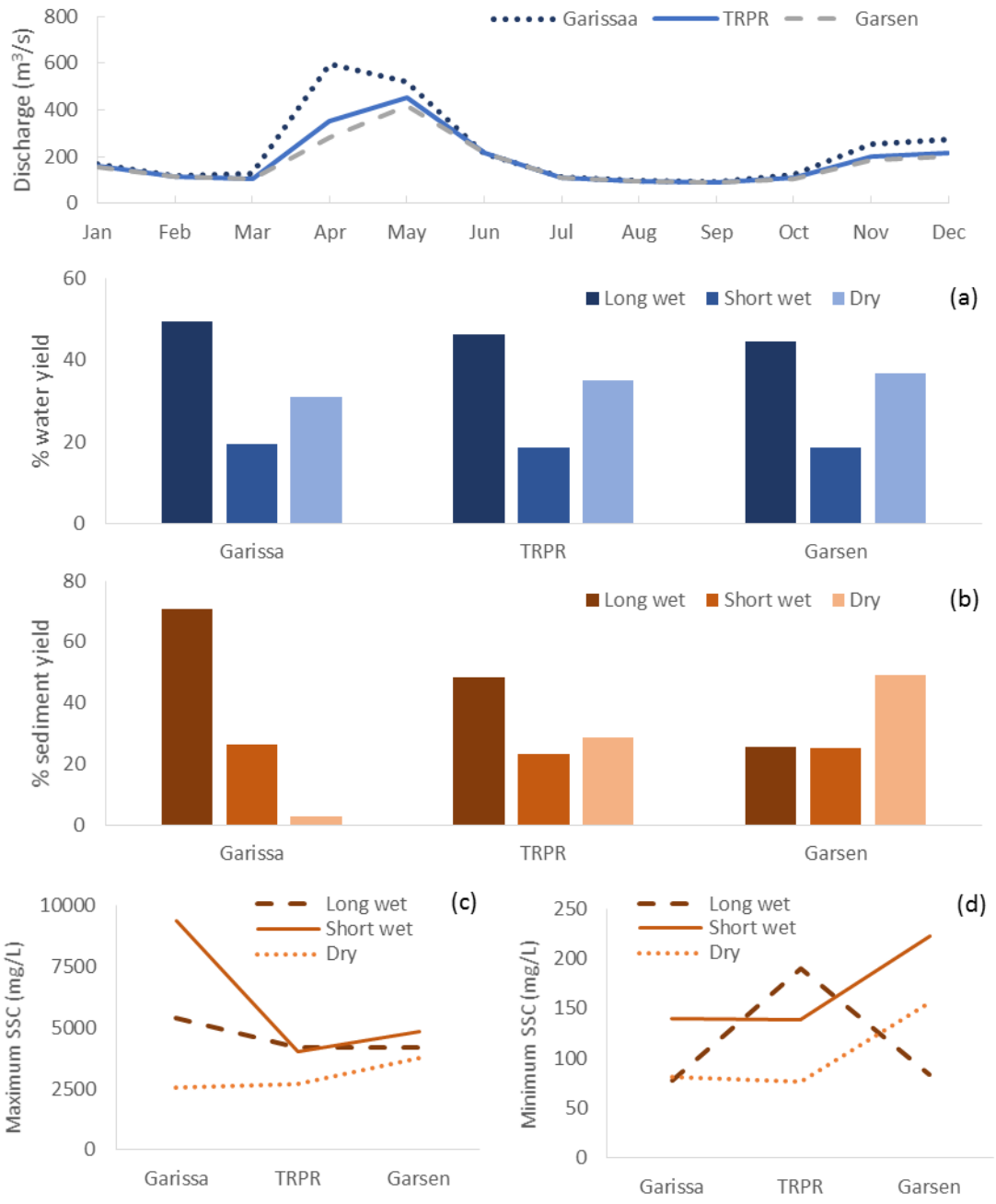






- For river flows **< 120m³/s** (~50 percentile flow), sediment load is **70% lower** after dam construction
- But, no significant changes in **annual sediment loads** at Garissa were reported in literature
- **Downstream decrease in annual sediment load** between Garissa and Garsen

- **90%** (Garissa) to **50%** (Garsen) of total sediment load is transported during **wet seasons**
- During wet seasons, sediment transport decreases downstream,
- but during **dry season**, sediment transport increases downstream



=> **Discharge not only factor** driving sediment transport, not all events with high discharges result in high sediment concentrations

=> Discharges as small as **120m^3/s** give rise to high sediment concentrations at start of rainy seasons, but there seems to be a threshold of **600 m^3/s**

Sediment (re)mobilization

Sediment trapping due to dams (i.e. > 7 Mty^{-1}) anticipated to lead to increased coastal erosion.

Total annual sediment load into the Tana estuary (Geeraert, et al. 2015):

- Pre-dam (1948-1966) = 9.4 Mt y^{-1} (2.5 – 12.2 Mt $y-^{1}$)
- Post-dam (2009-2011) = 7.2 Mt y^{-1} (3.5 – 8.7 Mt $y-^{1}$)

CONCLUSION - sediment flux to coast is NOT strongly affected by dam construction.

HYPOTHESIS – sediment retention in reservoirs is compensated for by:

- some input from d/s tributaries (lagas)/hillslopes
- alluvial sediments are remobilized downstream of the Kiambere dam due to river section expansion (lateral migration of the river channel) during the wet season

Modification of the flow regime of the lower Tana may have a significant impact on sediment transported by the river and hence consequences for the preservation of the delta

Upper Tana Catchment

Physical characteristics

- Upper !N>1300m !asl !(volcanics)!
  - Soil !erosion!
  - Quarrying!
  - Landslides!

- Mid !1300m !N500 !m !asl !(metamorphics)!
  - sand !harves* ng !and !!
  - reservoir !sedimenta* on!
- Lower !< !500m !asl !(sedimentary)!








Upper Tana-Nairobi Water Fund

A Business Case

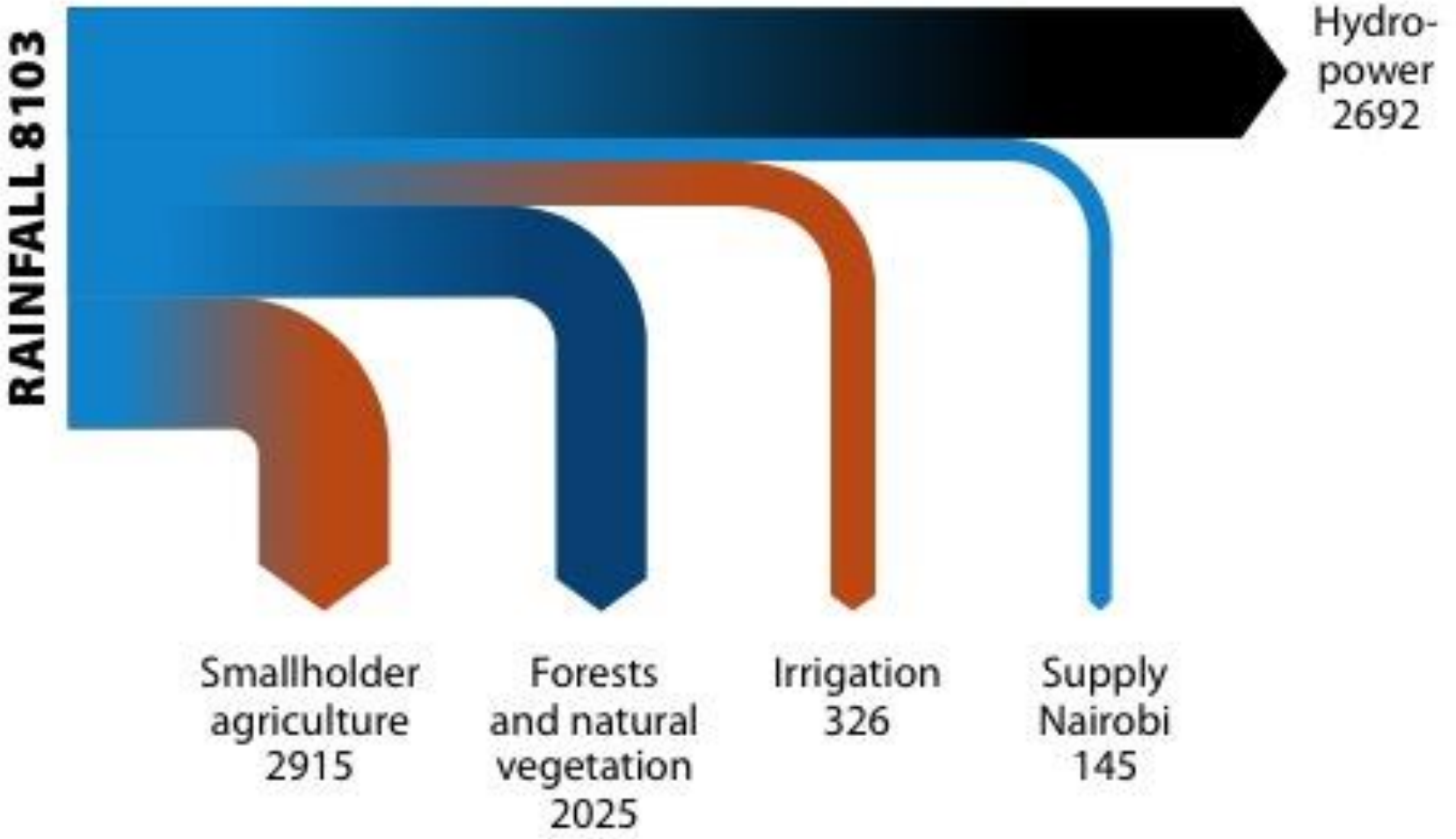
The Nature Conservancy

natural capital PROJECT

FutureWater

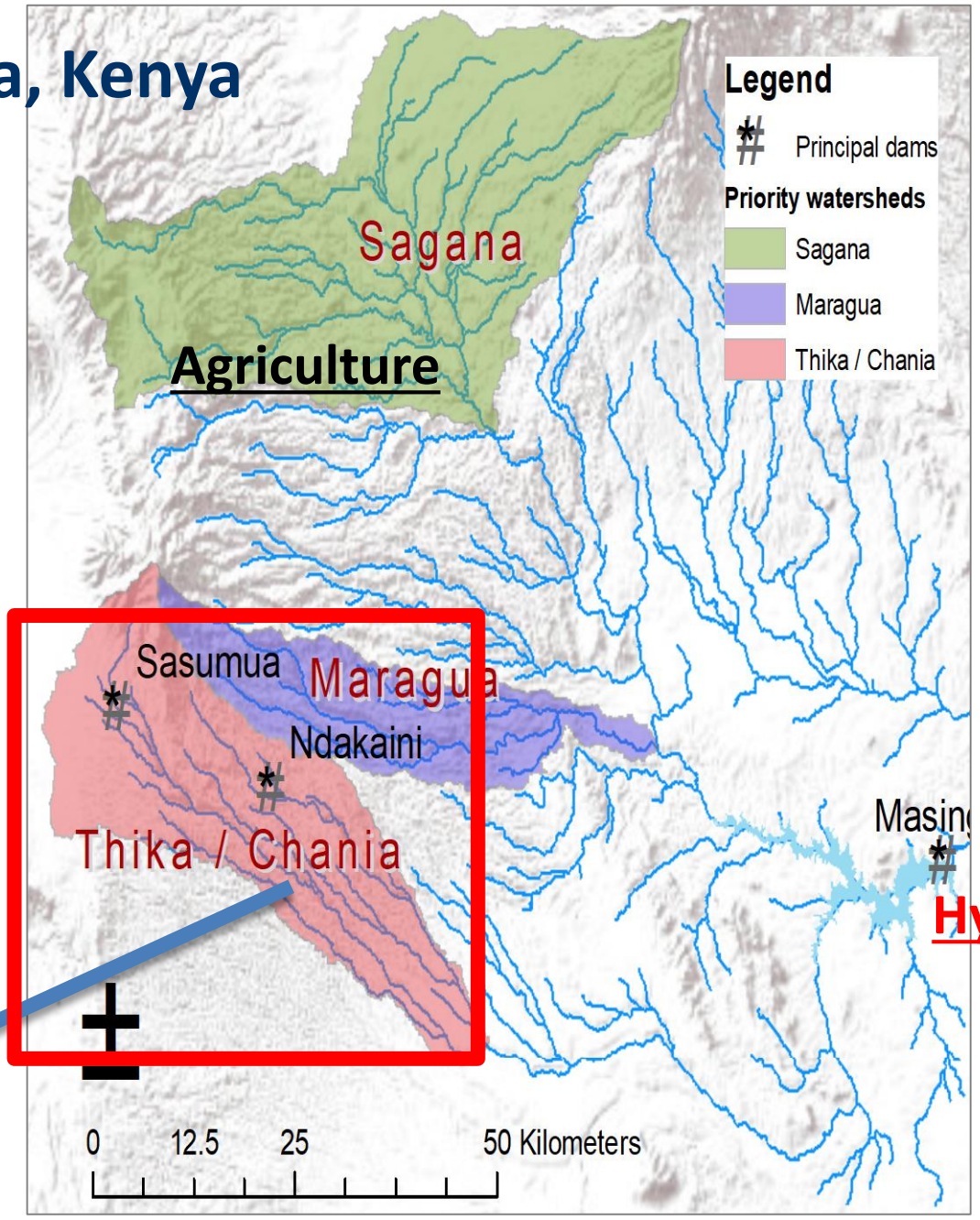
- Creation of the Upper Tana-Nairobi Water Fund to **help protect** and **restore** the quality and supply of water to one of Kenya's most productive and economically important regions.
- Upper Tana River basin covers approximately 17,000 km2 and is home to 5.3 million people.
- The water it provides is of critical importance to the Kenyan economy. It fuels one of the country's most important agricultural areas, provides half of the country's hydropower output, and supplies 95% of Nairobi's water. It is also home to areas of unique biodiversity and iconic national parks.

- Water funds are founded on the principle that it is cheaper to prevent water problems at the source than it is to address them further downstream.
- Investments in ***green infrastructure*** using natural systems to trap sediment and regulate water often provide a more cost-effective approach than relying solely on ***grey infrastructure*** such as reservoirs and treatment systems.
- Water funds have been successfully implemented elsewhere in the world to help secure the water quality and supply of major cities including Quito, Ecuador (population 1.6 million) and Rio de Janeiro, Brazil (population 6.3 million). The Upper Tana-Nairobi Water Fund is the first of its kind in Africa.



*millions of cubic meters

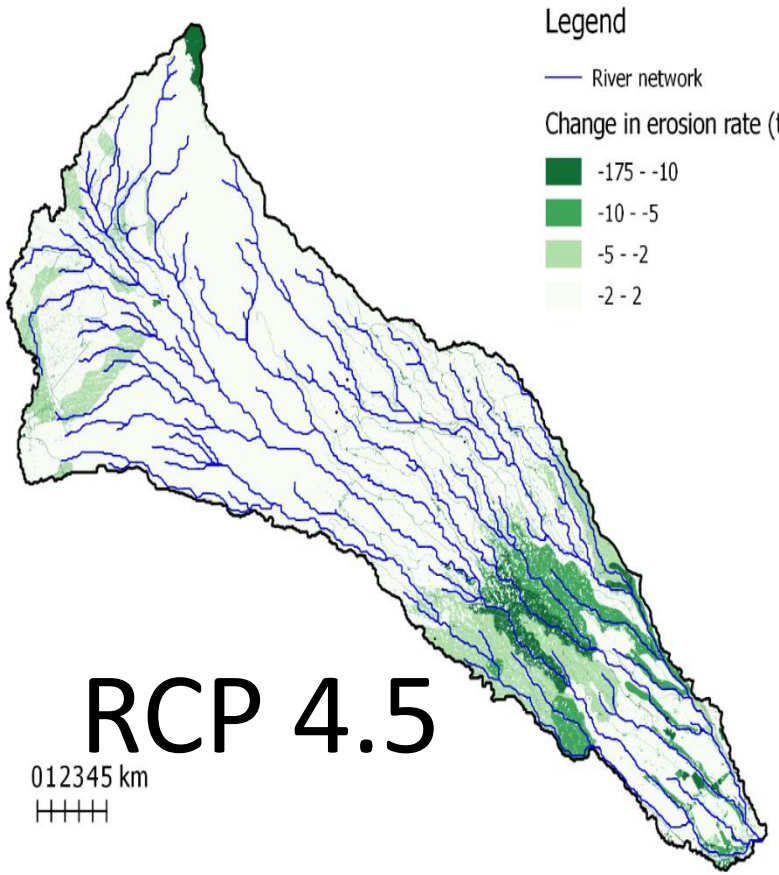
Upper Tana, Kenya



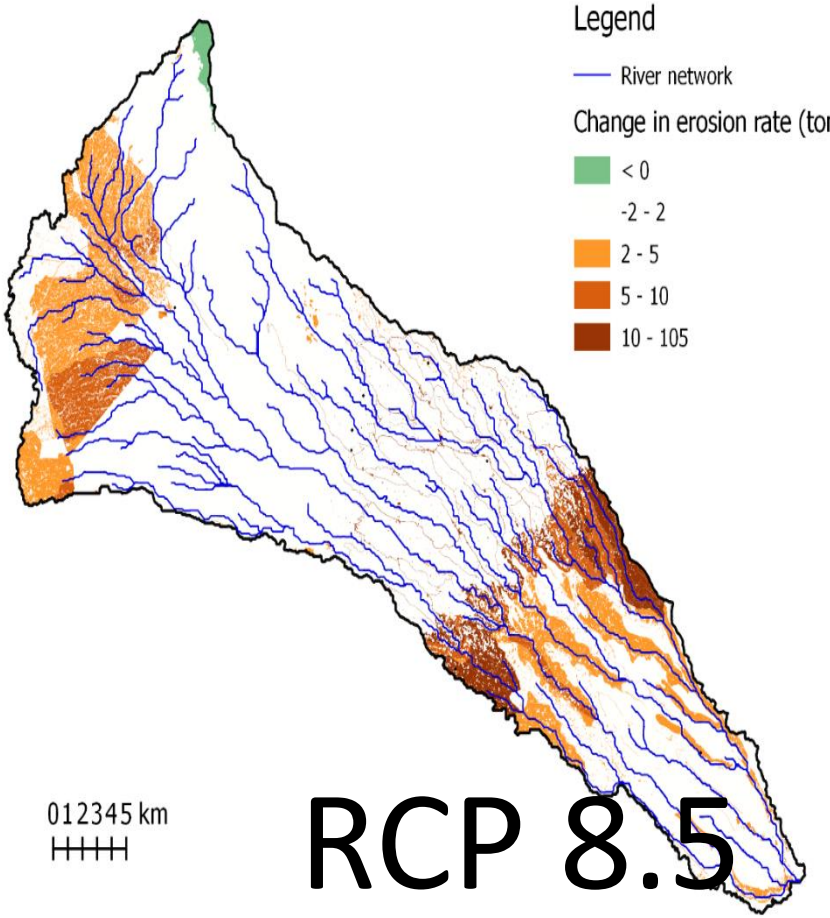
Nairobi Water Supply

Hydropower

CC Impact on erosion



RCP 4.5



RCP 8.5

- The analysis used to model the impact of a water fund combines several widely used tools:

(i) Resource Investment Optimization System (RIOS) to spatially target the investment portfolios;

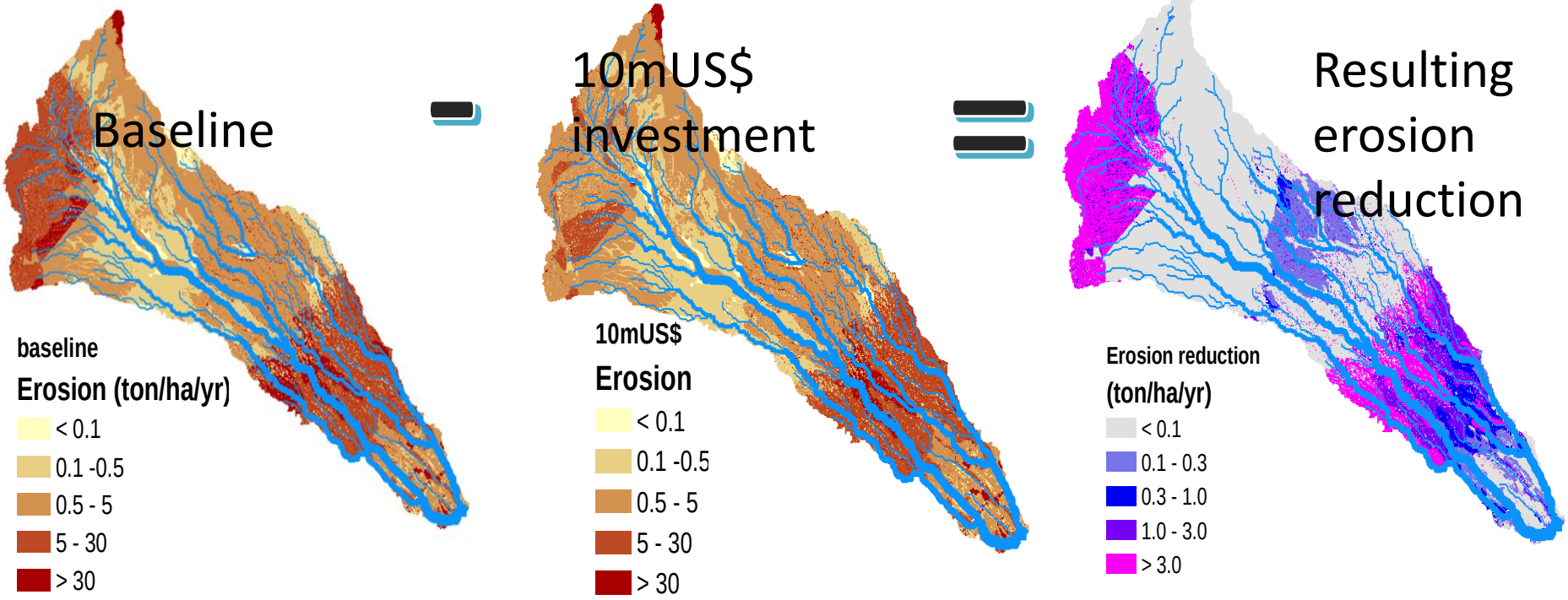
(ii) Soil & Water Assessment Tool (SWAT) to assess the biophysical impacts and benefits of the investments; and

(iii) a range of economic valuation tools to estimate the economic benefits for upstream and downstream users, ultimately informing an assessment of the Return on Investment (ROI)

Baseline versus investments in the watershed

Riparian management
Agroforestry
Terracing

Reforestation
Grass strips
Road mitigation

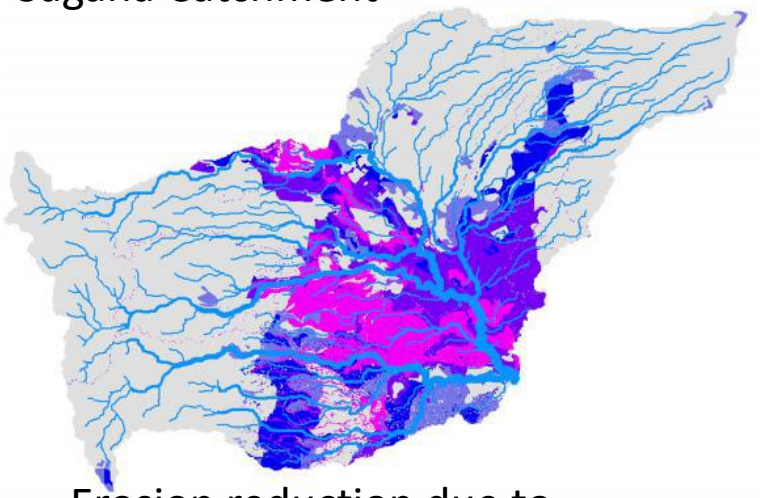


NWF analyses in the Upper Basin

Simulated interventions (SWAT (where), RIOS (impact) and RIO ($ return):

1. Riparian management: collection of activities to protect the riverine zone
2. Agroforestry: a conversion of crop lands to agroforestry
3. Terracing/*fanya juu*: similar to bench terraces/bunds along contours
4. Reforestation: a conversion of croplands to forest
5. Grass strips: the planting of grass strips along the contours.
6. Road mitigation: activities to reduce runoff/erosion from roads

Sagana Catchment



Erosion reduction due to investment

NWF analyses: benefits

Simulated economic benefits due to watershed management:

Sector	Benefits (y^{-1})	Comment
Hydropower	600,000	Increased power generation and avoided interruptions
Water Supply	40,000	Reduced treatment
Upstream farmers	1,550,000 (Coffee) 800,000 (General Ag) 250,000 (Tea)	Reduced erosion/ maintained fertility Coffee: $ 247 $ha^{-1}y^{-1}$ General ag: $61 $ha^{-1}y^{-1}$ Tea $308 $ha^{-1}y^{-1}$

Sediment yield of reservoirs reduced by around 25%

- Farmers receive support in implementing soil and water conservation structures in their farms.
  - Terracing to stabilize slopes and soil,
  - Installing water pans to collect and store runoff (water harvesting),
  - Installing drip irrigation kits to increase water-use efficiency.
- Agroforestry has also been used as a means of improving soil stability and capturing runoff before it enters a stream
- Coffee farmers have been recruited through the Green Belt Movement to adopt soil and watershed conservation practices that will prepare them to apply for certification by the Rainforest Alliance.
- The project is also engaging local women's groups in raising tree seedlings to rehabilitate two degraded forest slopes in the Mt. Kenya and Aberdare protected areas.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Coca-Cola
Africa Foundation

NAIROBI WATER

River Health Monitoring

Sample collection using the MiniSASS kits

River Health Monitoring

Water quality monitoring using a clarity tube.

Thank you