Evidence that land use interventions including Agroforestry can deliver quantifiable environmental services – case studies from Kenya and Asia

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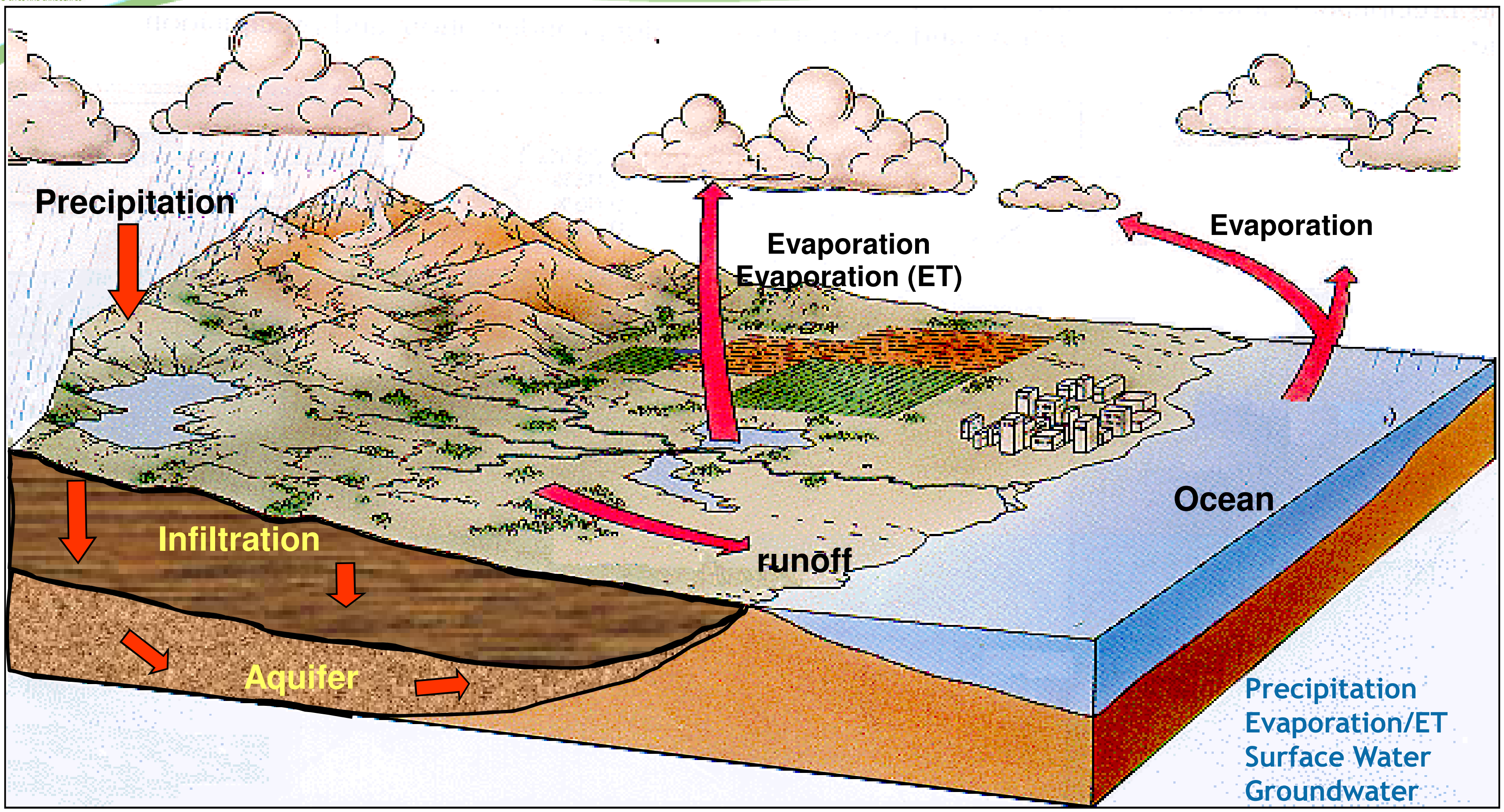
Flow at watershed outlet is determined by several factors

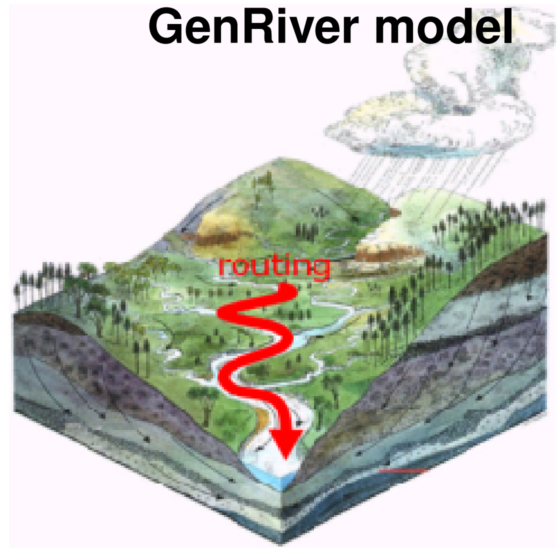


- Land cover/vegetation
- Land management
- Soils and Geology
- Rainfall
- Climate / Weather
- Topography
- Drainage pattern
- Watershed shape

Site cha-racteristics	Watershed functions	***Relevant for***
• Rainfall • Land form • Soil type • Rooting depth (natural vegetation)	1. Transmit water 2. Buffer peak rain events 3. Release gradually 4. Maintain quality 5. Reduce mass wasting	• Downstream water users, • esp. living in flood plains & river beds, • esp. without storage • or purification • **at foot of slope**

Quantifying watershed services

Application of hydrologic models



Conventional indicators:

SWAT

- Water yield, water quality

Others:

GenRiver

- Flow buffering indicators, water yield

FlowPer

- Flow persistence

Determining watershed indicators

Definitions

- Buffering capacity of a watershed is its ability to reduce variations in streamflow relative to rainfall

Can be used to study the relationship between land use and flows.

- Flow persistence is the fraction of flow on the previous day that can be expected as minimum volume of flow on a given day

Can f_p be used to indicate watershed quality?

What influences watershed services?

Non structural (Vegetative) :
Use vegetation to control erosion.
Examples:
Grass strips, hedge barriers, contour farming and agroforesty systems.

Structural:
Design and construction of erosion control structures.
Examples:
Terraces, waterways, grade stabilization structures and cut off drains

Case study: 1 Kapingazi

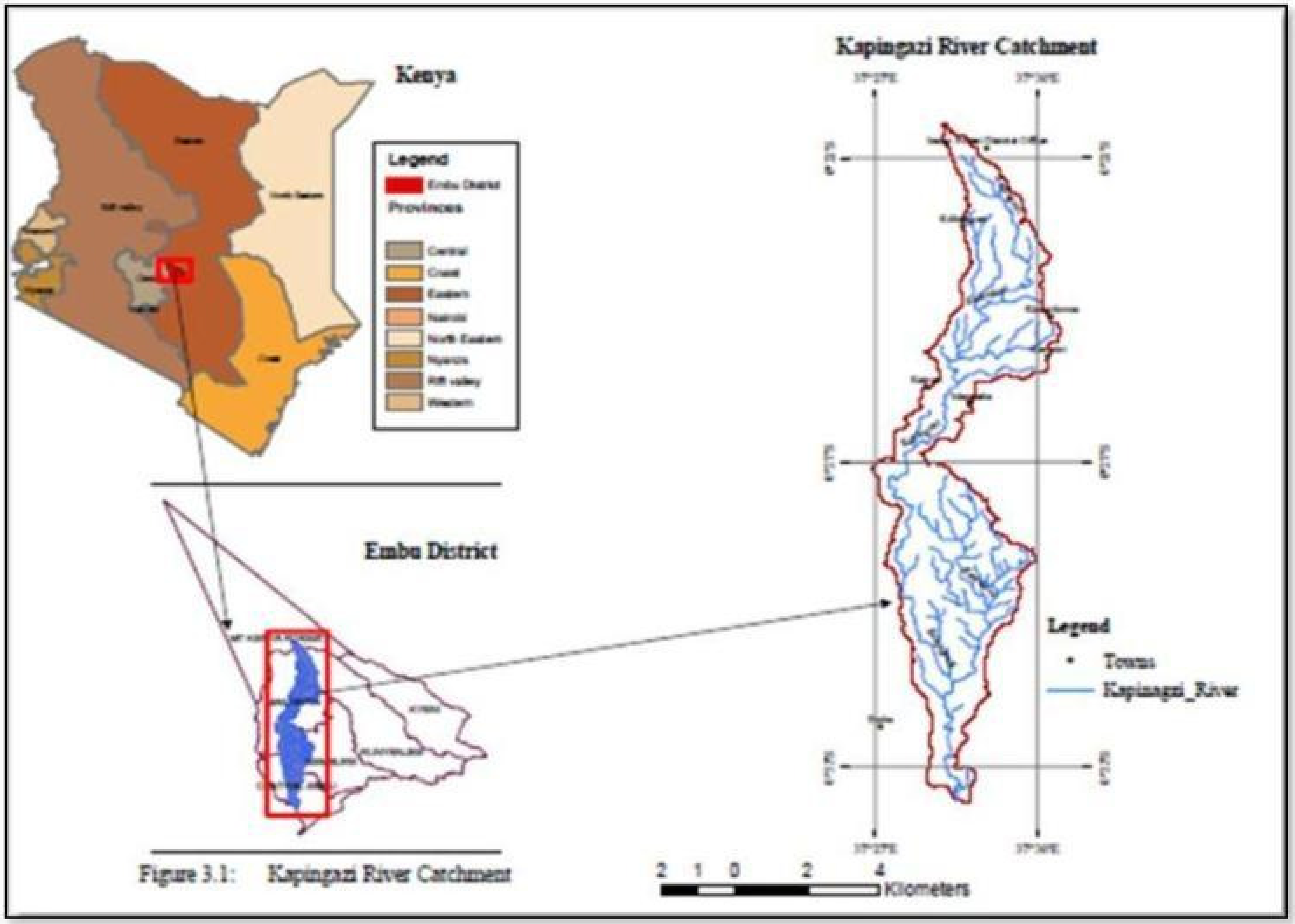
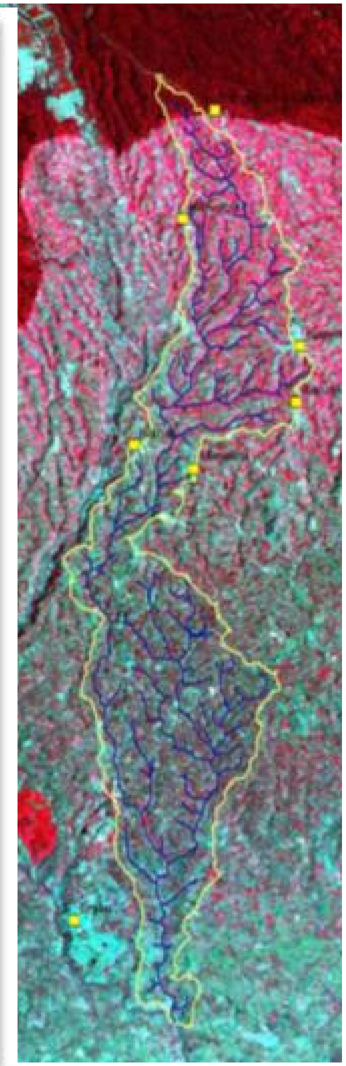


Figure 3.1: Kapingazi River Catchment



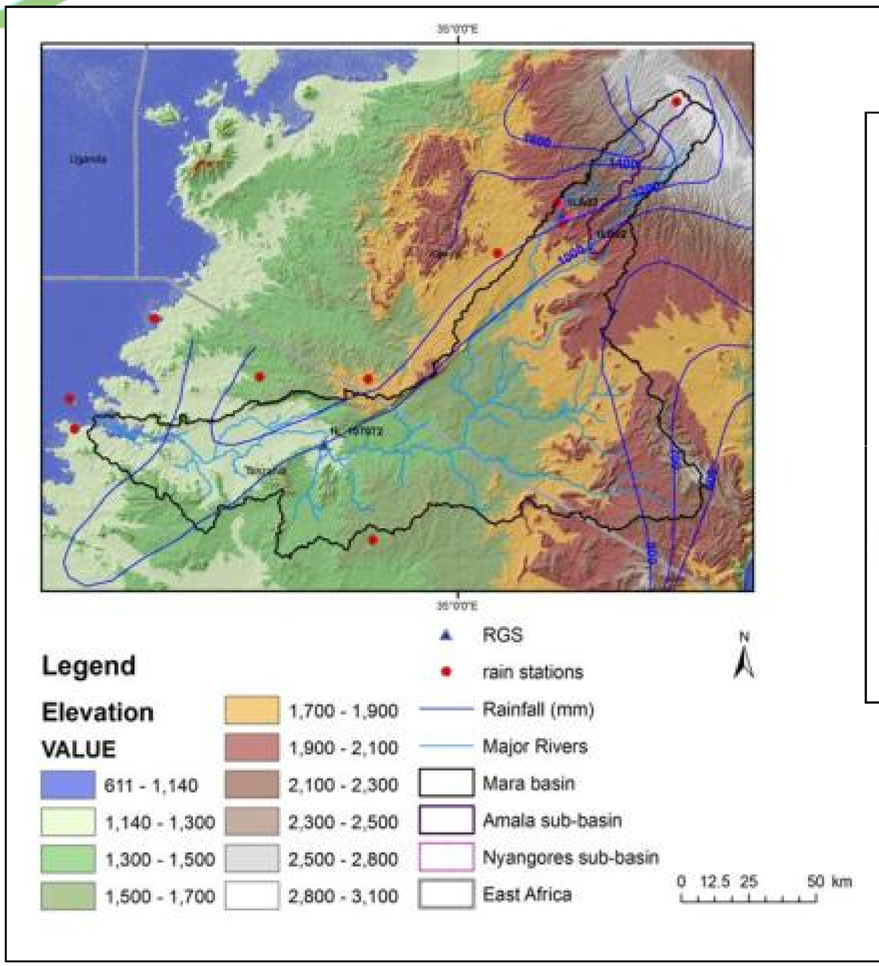
KAPINGAZI CATCHMENT

Impacts of land use change - Kapingazi

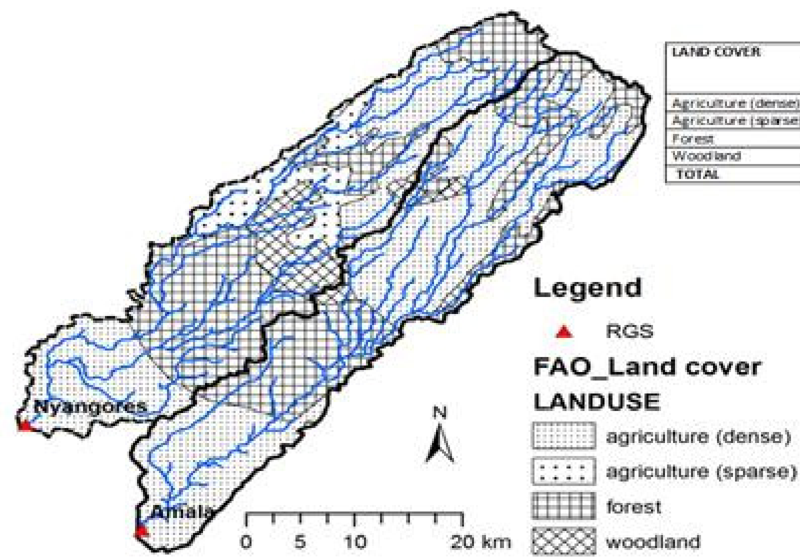
Scenario	Water yield (mm)	Surface runoff (%)	Base flow (%)
Base case	846	86	14
Conversion of tea farms to annual crops	936+(10%)	84	16
Conversion of coffee farms to annual crops	864 +(2%)	88	12
Doubling of built up areas	860 +(1.6)	86	14

Impact of land use change on water yield is generally low.

Case study 2: Mara River basin



Amala and Nyangores

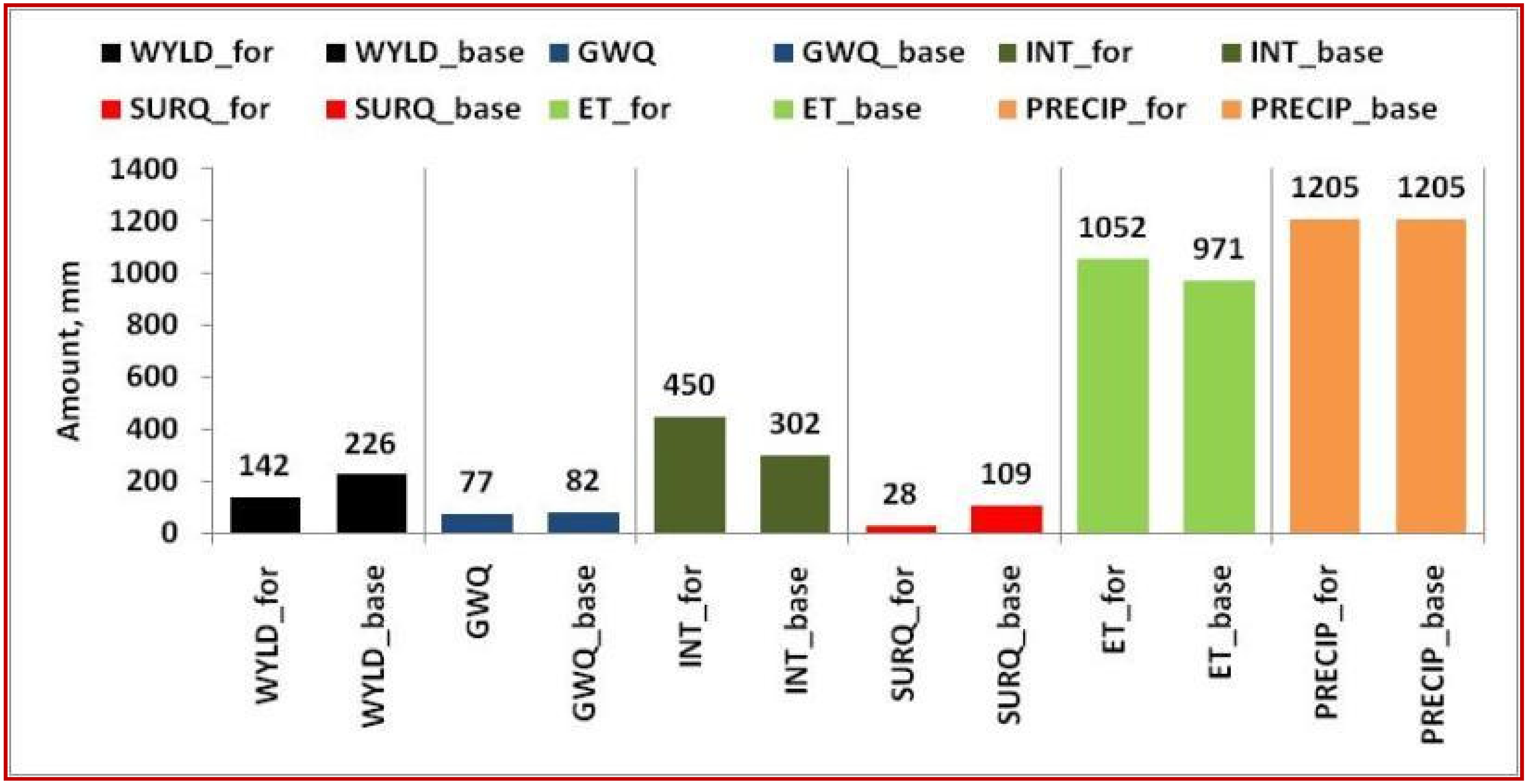


LAND COVER	AMALA AREA (%)	NYANGORES AREA %
Agriculture (dense)	88.8	88.8
Agriculture (sparse)	0.9	0.9
Forest	10.0	10.1
Woodland	0.3	0.2
TOTAL	100.0	100.0

Satellite image analysis showed forest in MRB has declined by almost 60% over the 25 years between 1975 and 1999

Mara river basin

Using Genriver, two scenarios were tested in Amala and Nyangores: 1. Base case 2. Complete forest cover



Result: Restoring forest cover may not necessarily increase water yield

Case study: 3 Kejie watershed

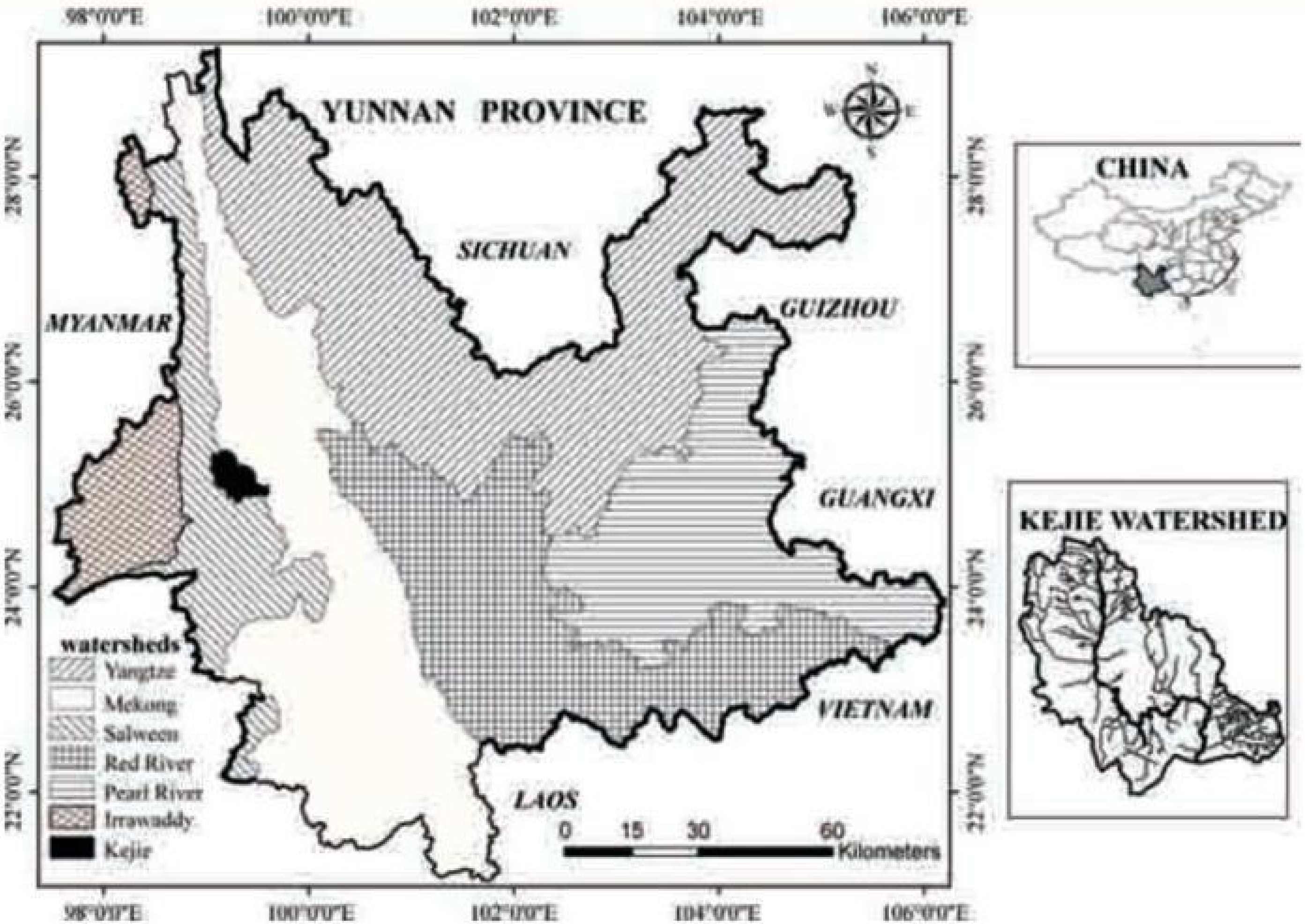


Figure 1. Location of the Kejie watershed as part of the Salween basin in Yunnan province, China

Dramatic change in land cover has occurred in the last 40 years

Land use change and water balance

Watershed scenarios

Land cover: forest+, grassland+, crop+, urban+

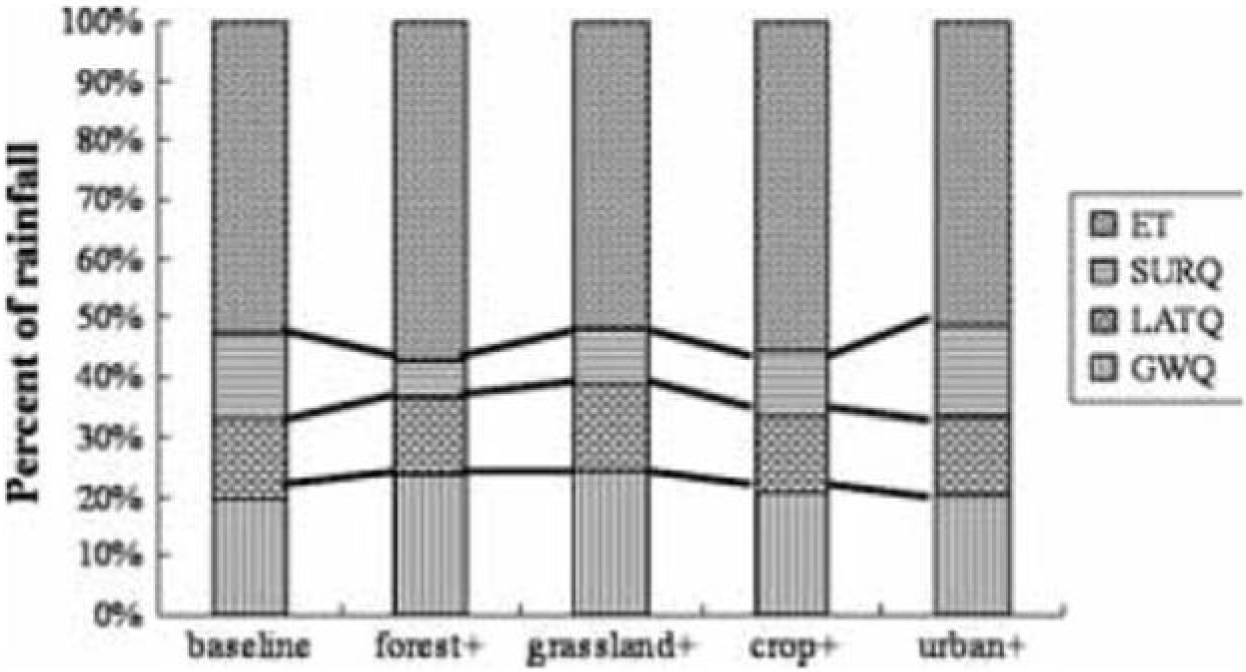
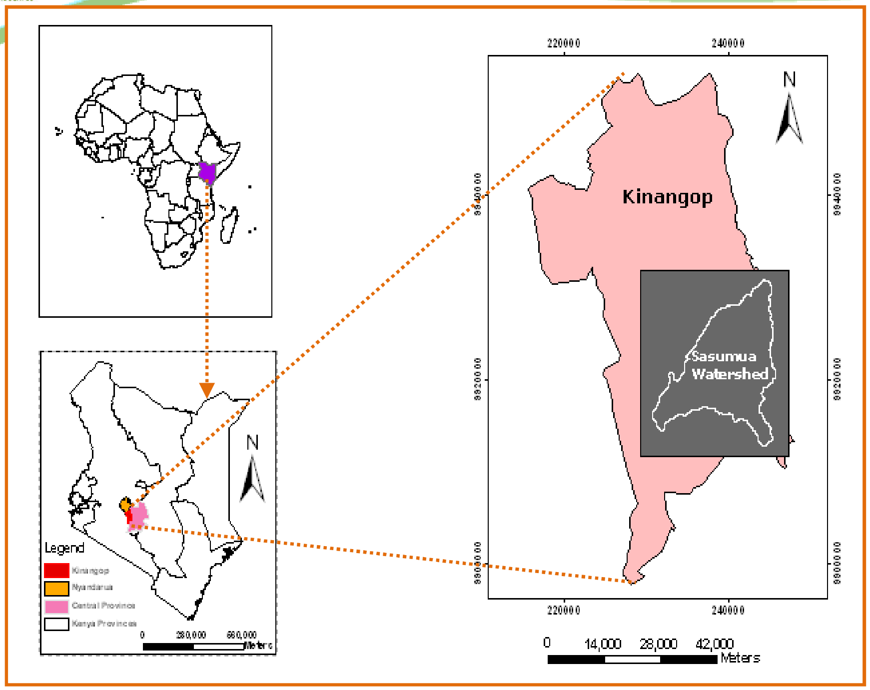
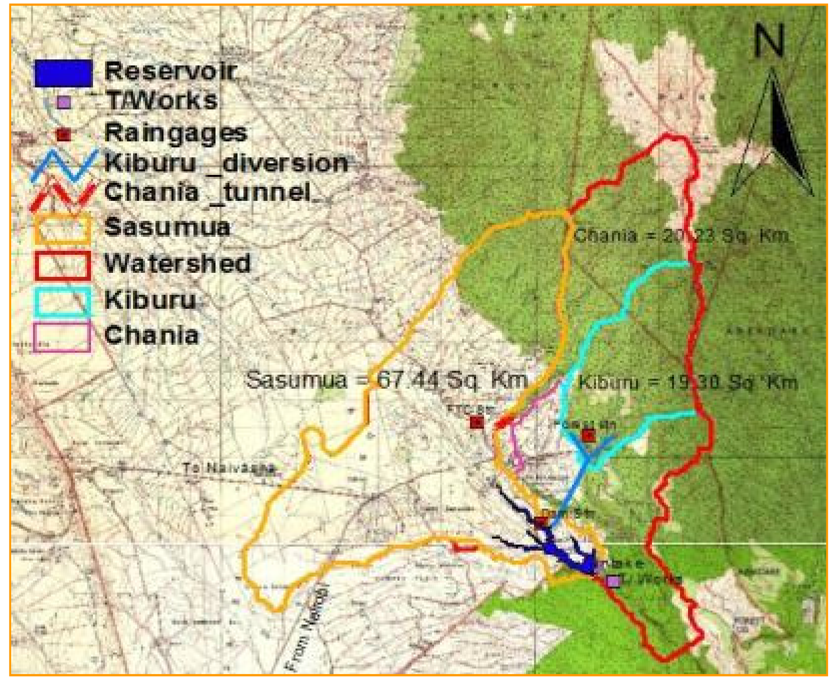


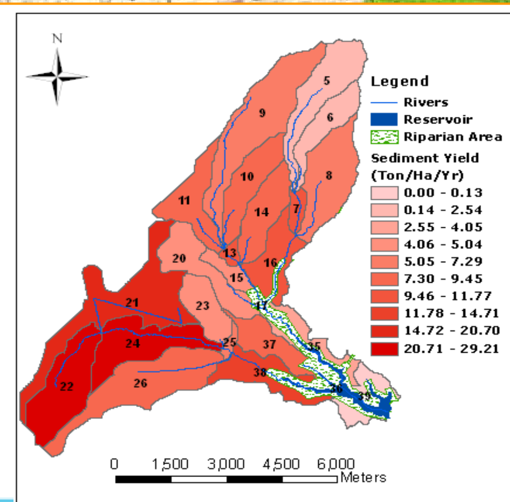
Figure 5. Relative change in average annual overland flow, groundwater release, actual ET, and streamflow as a result of land-cover changes over the period from 1961 to 1990 in the Kejie watershed

Case study: 4 Sasumua Catchment





Area = 107 km2 , 50% under agriculture
Population = 17,500 growing at 3.5%
Households ca = 3,700
Average farm size = 2.5 acres



What are the problems?

Clogging of intakes
Lowered water quality

Increased water treatment cost
Frequent de-silting of intakes

Dried up streams and rivers

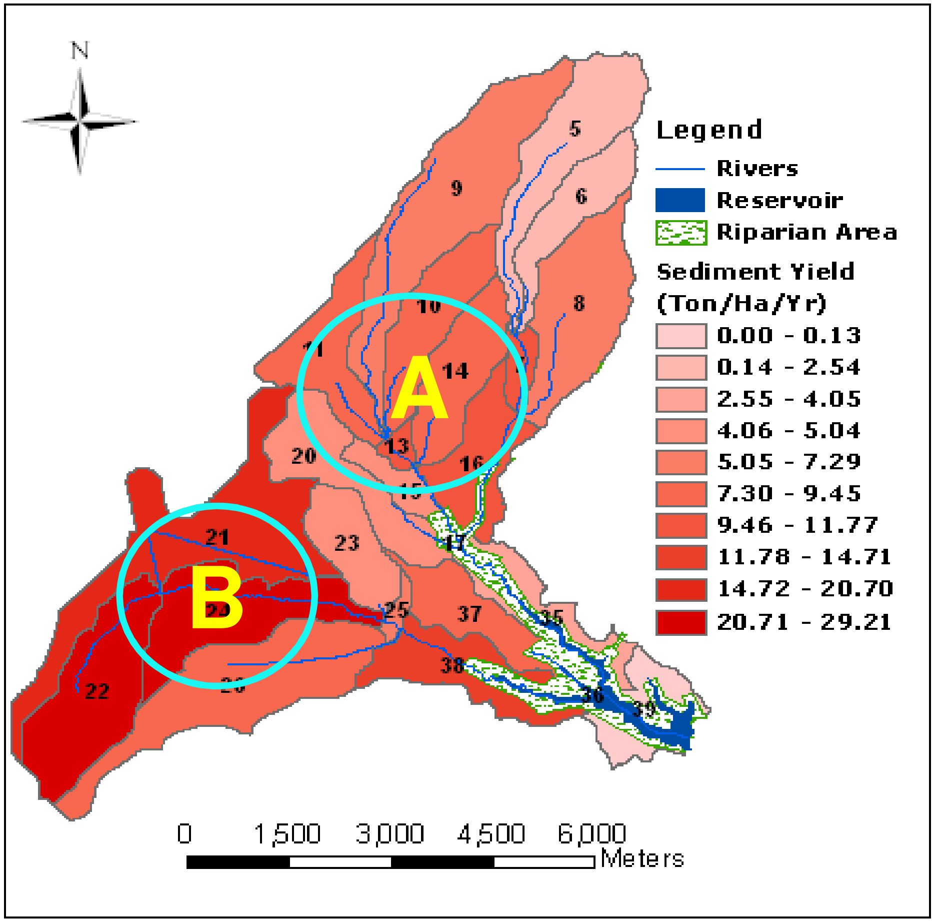
Reduced dry weather flow

Effect on water balance components

Intervention	Surface runoff (mm)	Lateral flow (mm)	Base flow (mm)	Water yield (mm)
Base Simulation	197	188	284	667
10mVFS + GWW	No effect	No effect	No effect	No effect
GWW only	No effect	No effect	No effect	No effect
Contour farming	174 –(12%)	190	302 +(6%)	664
Terracing	157 –(20%)	191	316 +(11%)	663
Contour farming + GWW	185	189	293	665
Terracing + GWW	182 –(8%)	189	295 +(4%)	665

Quality: Surface runoff reduction significant
Regulated flow: base flow increase is significant
Quantity : Impact on water yield is insignificant

Increasing impact: Targeting hotspots



Sediment sources in Sasumua

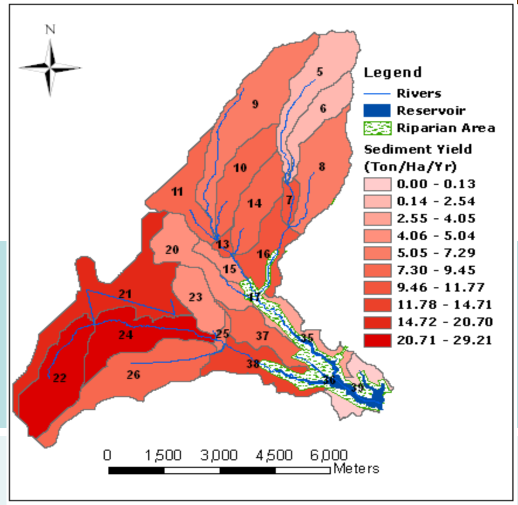
- Low erosion rates from the forest
- High rates in cultivated areas, exceeding 11.2 tons/ha per year
- A- Steep cultivated areas
- B– Flat Planosols area

Highest sediment yield comes from area B.

- Grassed waterway ideal in **B**
- Filter strips/terraces ideal in **A**

Required in Sasumua - flow regulation and improved water quality.

Sediment yield reductions at reservoir inlet (tons/year)



Order	Intervention	% sediment removal
1	30m wide filter strips and grassed waterway	80
2	Parallel terraces, 10m VFS and grassed waterway	75
3	10m wide filter strips and grassed waterway	73
4	Contour farming and grassed waterway	66
5	Grassed waterway only	54

Science and PES

- Clarify cause effect relationships
- Identify critical source areas
- Identifying appropriate land uses
- Quantifying the ES being provided
- Predict impact of interventions before / After implementation
- Monitoring impact of interventions

Monitoring impact of PES

✓Establish base line conditions
✓Monitor *environmental* impacts water quantity and quality
✓Monitor impact of payments on the community
✓Gender analysis of HH benefits
✓ Monitoring at community level

- Water quality analysis
- Sediment analysis

- Measurement of river flow
- Sediment sampling

What is required in Sasumua

ACTIONS

- Targeting of individual farmers to control water pollution
- Focus on hot spots to get maximum value for investment

OPTIONS

- Regulatory approach- get land owners to incur expenses in conservation practices – has not worked well in the past.
- Rewarding land owners to invest more in conservation

Building a business case for PES - Sasumua

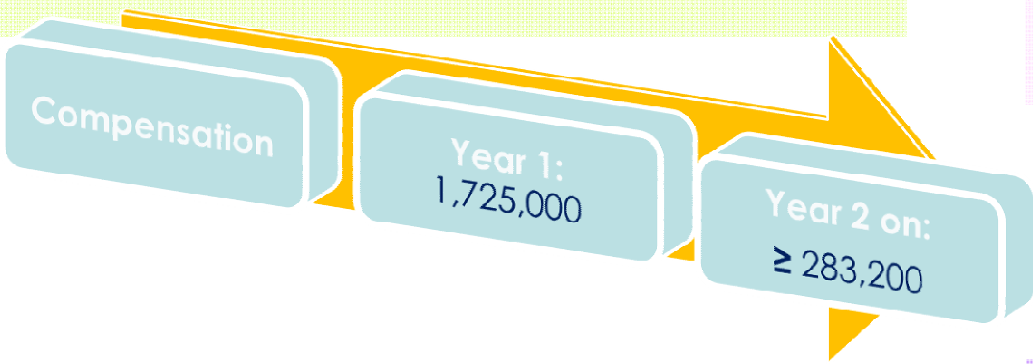
Grassed waterway (3m wide by 20 km long – approx. 6 Ha)

20% less sediment yield into Sasumua dam

Benefit to Nairobi Water Company

Reduction in cost of alum: 2,000,000

Reduction in cost of de-silting intakes



This does not include effect of other interventions

Cost to 500 households

Year 1: 1,725,000

- Annual land lease
- Labour and grass

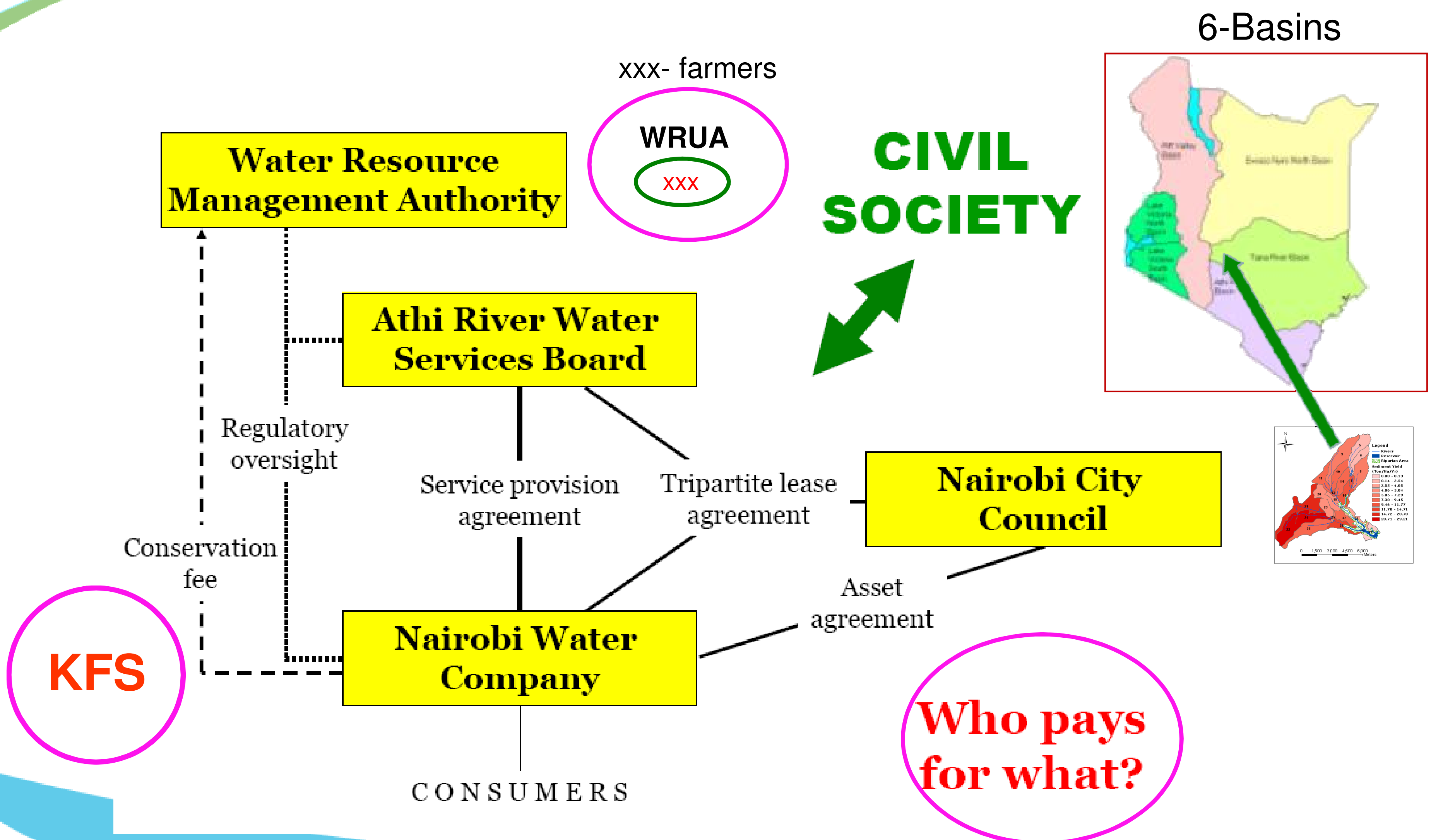
Year 2 onwards: 283,200

Maintenance only

Net annual earning per household: 566.4

(Values in Kenya Shillings)

Institutional and regulatory framework



Case for PES in Sasumua

- Potential 'hot spots' identified

Watershed services

- Regulated flow
- Improved water quality

- Identified the requisite land use practices
- Potential sellers of these watershed
- Potential buyers – basically NWC

- WTA study of sellers of ES

- Engaged sellers
- Attempting to engage buyers

Challenges:

Multiple sellers available

Lack of multiple buyers

Conclusions

Land use changes on upper catchments can:

✓Increase base flow
✓improve water quality
✓ Marginal improvement in water quantity

Role of forests and Agroforestry systems:

✓Improve amount of water in the soil
✓ retards surface runoff and reduces soil erosion
✓ Increase base flow and regulate flow.

Water quality improvement impacts are more "tangible"

Thank

You

Acknowledgement

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Web site http://presa.worldagroforestry.org.