Local agro-ecological knowledge of impacts of land use change on water security: impacts of eucalyptus expansion in the Ethiopian highlands

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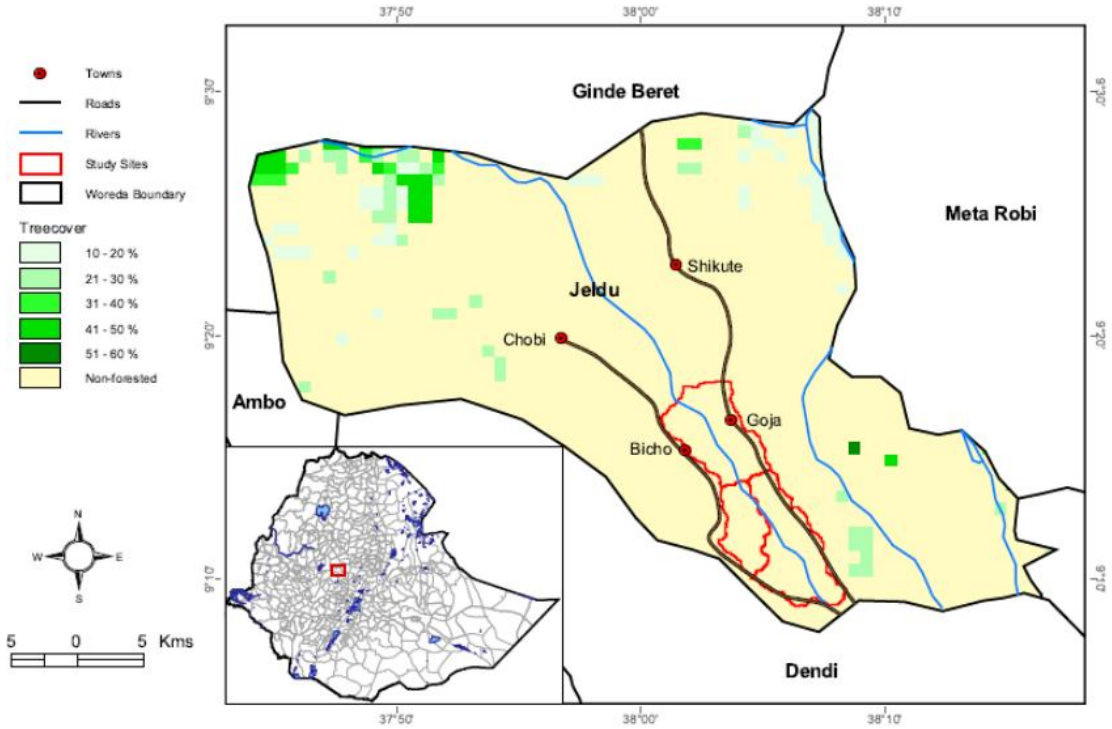
Rationale

Ethiopia is entering a period of increasing water scarcity due in part to poor water resource management and environmental degradation caused by deforestation (Tadesse, 2009). As natural vegetation is cleared for agriculture and other types of development there are often negative impacts on water regulation and sediment transport (Wood and Armitage, 1997).

Lack of long term hydrological monitoring makes it difficult to determine impacts of changing land use on the water dynamics for many catchments in Africa. Here we use local ecological knowledge (LEK) to explore the impacts of tree cover change, specifically rapid expansion of eucalyptus agroforestry on water security in a catchment area of the Ethiopian highlands.

LEK - *knowledge held by farmers and resource users concerning their daily interactions with their natural environment, based primarily on experience and observation*

Context of the study



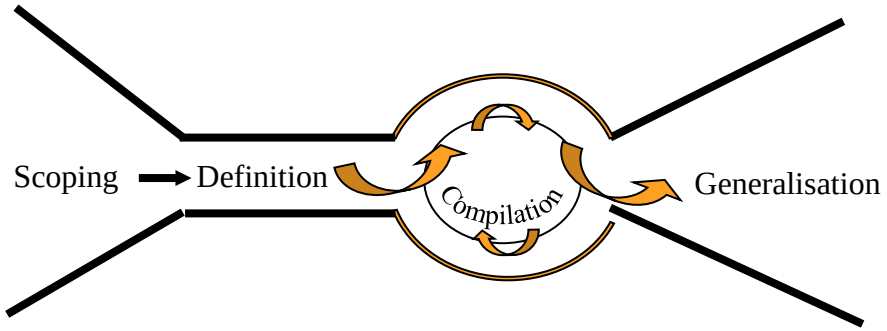
The Jeldu woreda is in the Eastern Blue Nile catchment, in Oromia Region (9°15'54"N; 38°04'54"E), and represents a high to intermediate rainfall (1,200 mm year-1), rain-fed, mixed crop-livestock system.

The most common crops are potato, wheat, and barley. Potato is the most widely grown crop both for consumption and cash generation for small households.

Study site falls mostly in the Meja watershed.

Urga Ereri	Low	2500 m - 2900m
Shukute	Mid	2600m - 2900m
Kolu Gelan	Mid	2600m - 2900m
Chilanko	High	2900m - 3200m
Sereti Denkhu	High	2900m - 3200m

Methodology



Agro-ecological knowledge toolkit (AKT) methodology

Knowledge-based systems methodology and software (Sinclair and Walker 1998)

LEK collection comprises an iterative cycle – that is eliciting knowledge from a small purposive sample of farmers and local stakeholders and returning for repeat interviews with the same informants

A knowledge base (kb) is created as findings are processed into formalised language

The kb remains a durable and accessible record of the knowledge acquired

Sampling strategy

- **Spatially explicit stratification**

Farmers

Adjacent to river (n=8)

Upper plateau (n=5)

Valley sides (n=8)

Adjacent to road (n=5)

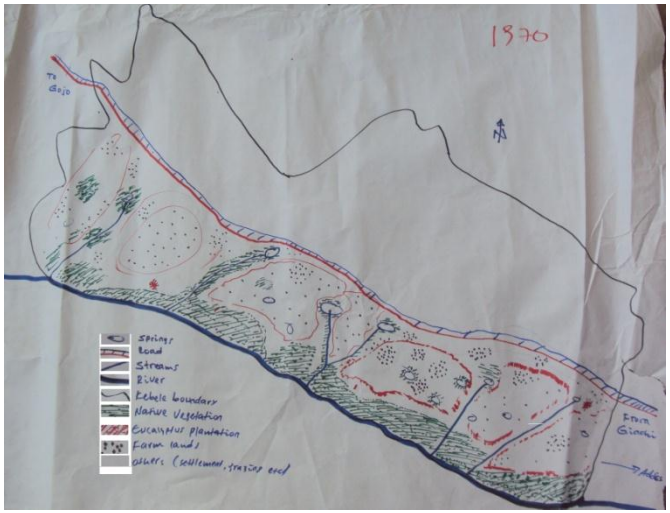
Others

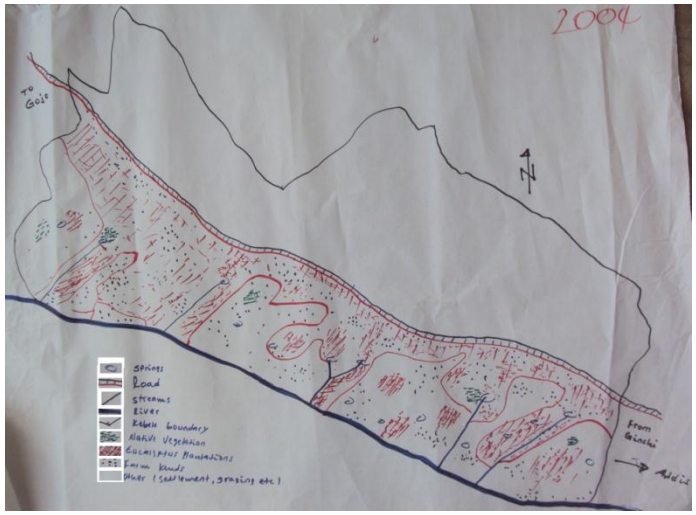
Timber merchants (n=2)

DAs (n=2)

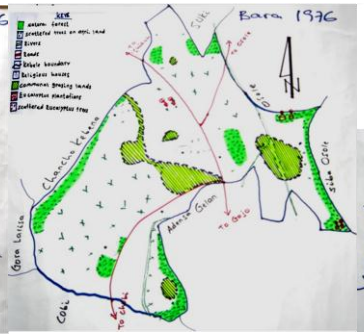
Methods - Participatory land cover change mapping

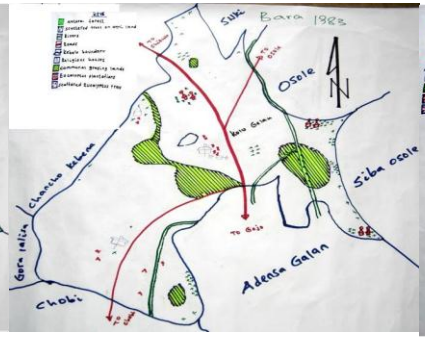
FGD Chilanko

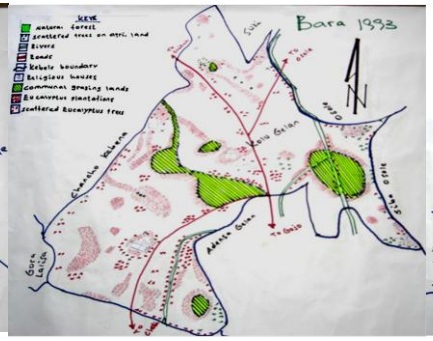


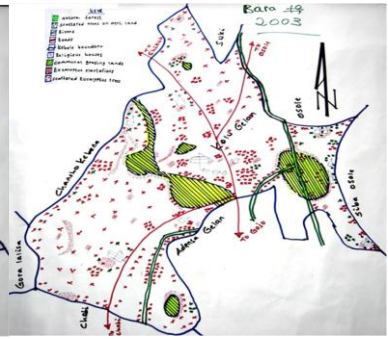


FGD Kolu Gelan



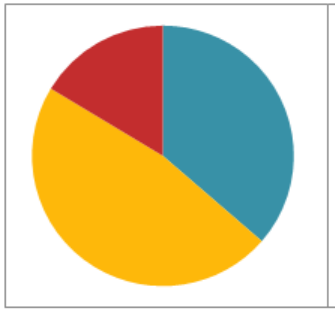
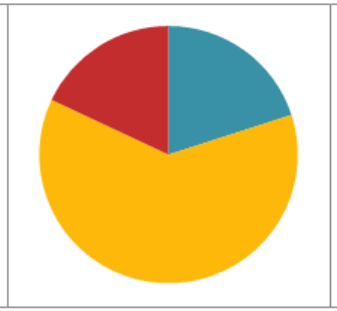
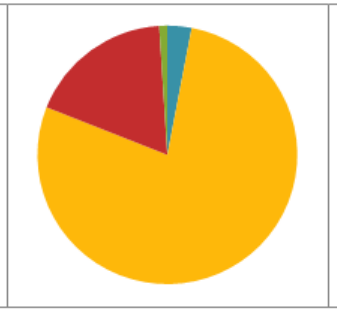
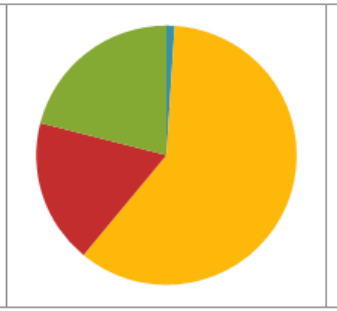
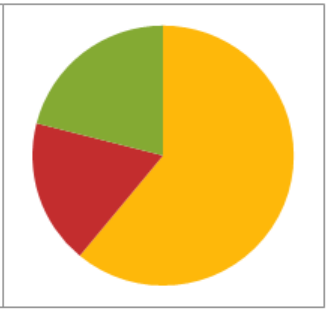






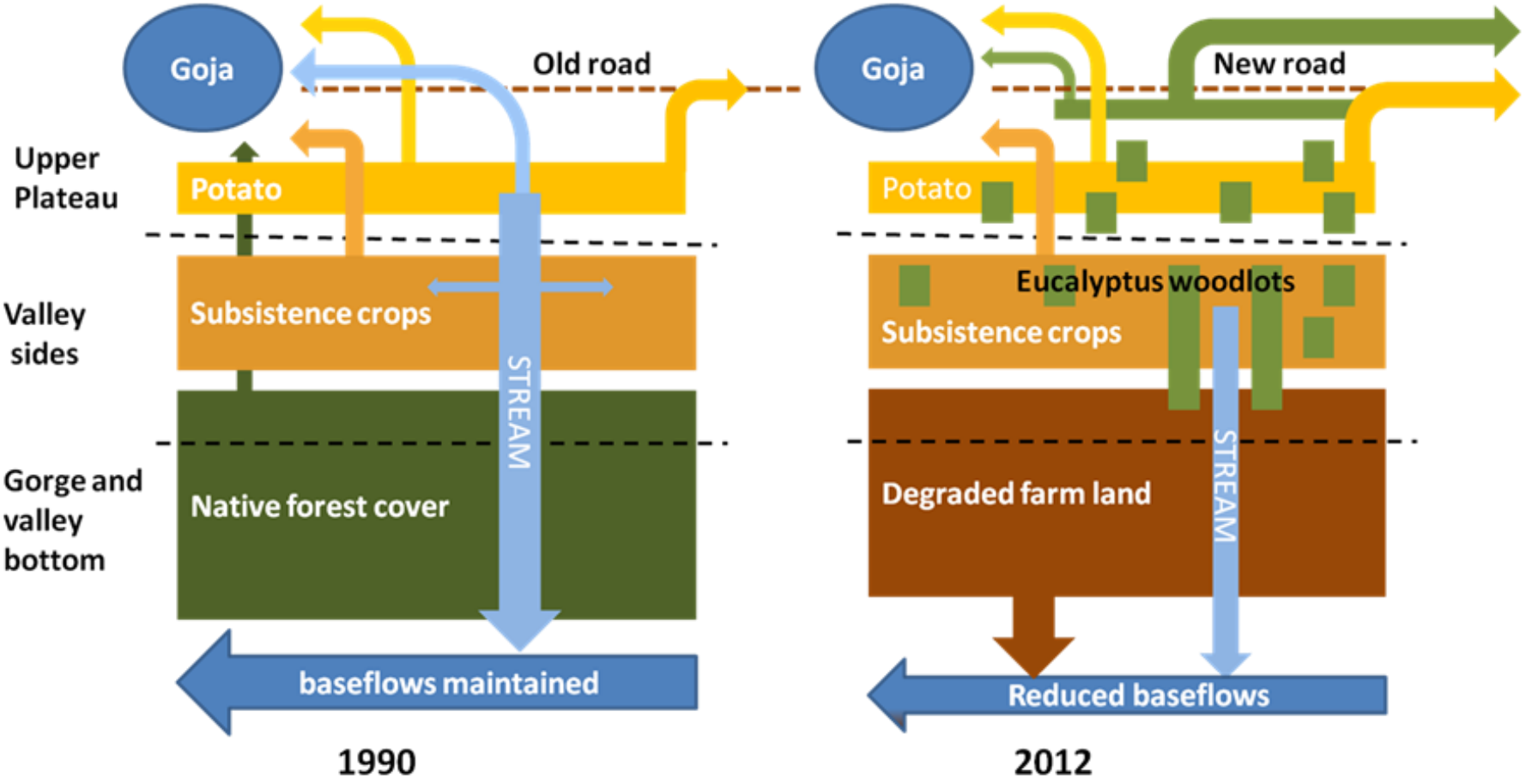
Results - Land use change

Emperor Regime | DERG Regime | FDRE Regime

Pre 1966 EC (pre 1974)	1976 EC (1984)	1983 EC (1991)	1993 EC (2001)	2003 EC (2011)
				
Valley bottoms and steep slopes had mainly forest . Ridges and flat plateaus were utilized on long fallow rotation. Livestock were grazed on natural wetlands adjacent to river	Land distributed by the Derg which includes forested land. Population begins expanding into forested areas. Fallow periods reduce.	Natural forested areas decreased. Cropland expanding as fallows become unviable. Eucalyptus is introduced into the area. Potato research begins at agricultural research station.	Natural forested areas almost lost. New road constructed to Addis and eucalyptus begins expanding to meet local needs and external needs. Improved potato seed accepted by local community and becoming dominant crop.	Remnant natural vegetation integrated into cropland. Eucalyptus plantations expanding. Cropland on steep slopes begin losing productivity. Improved potato seed dominant arable crop – farmers sell to other areas of Ethiopia.

Results - Land use change cont.

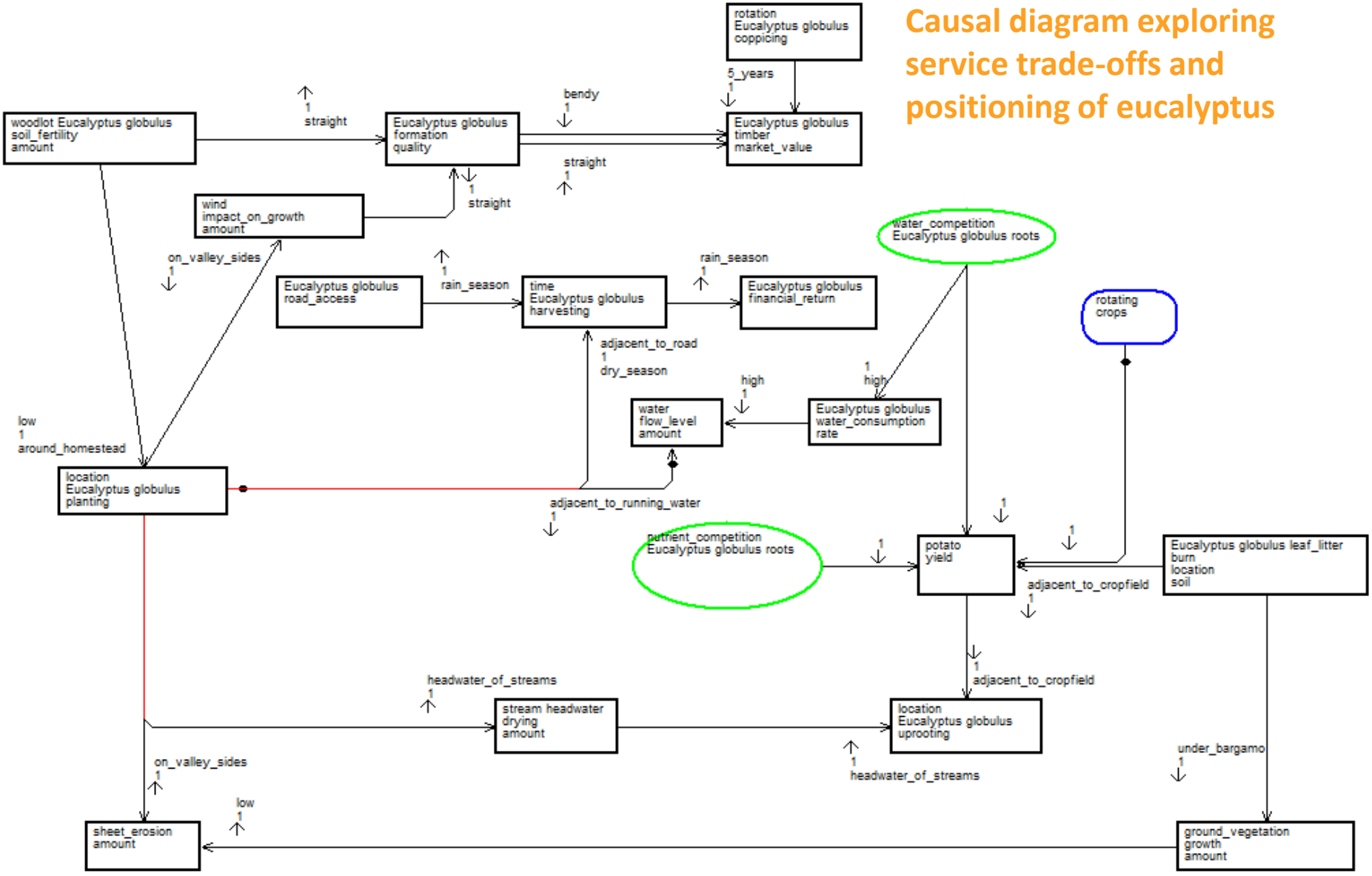
Changes in land use in the Jeldu woreda (Chilanko) between 1990 and 2012



Estimated 70-80% of the tree material leaves the system for sale as fuel or fibre

Results - Eucalyptus trade-offs

Causal diagram exploring service trade-offs and positioning of eucalyptus



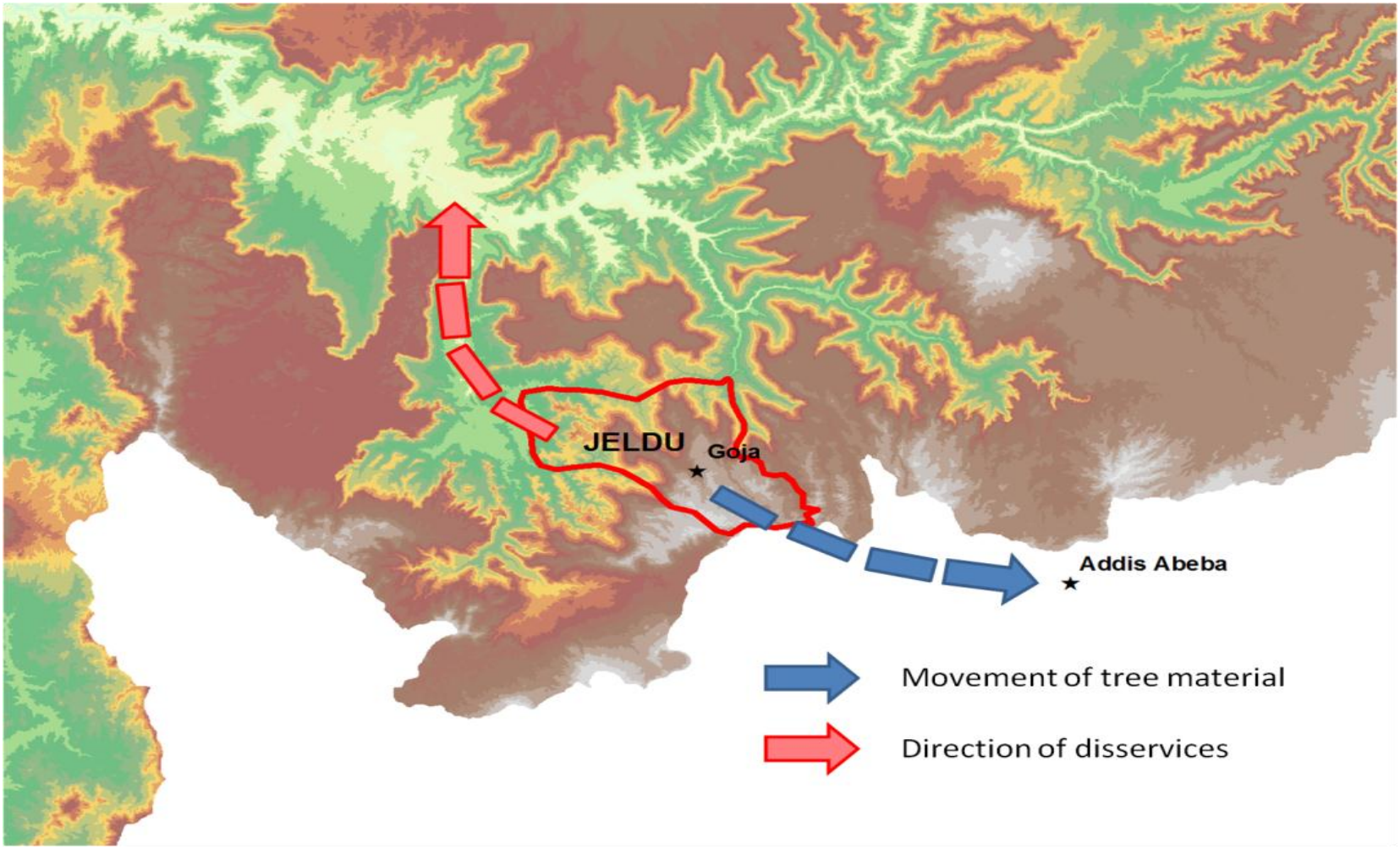
Nodes represent natural processes (ovals), or attributes of objects, processes or actions (boxes with straight edges. Arrows connecting nodes show the direction of causal influence. The first

Results – Water security indicators

- Water availability decreased 14 years ago when the water driven grinding mill in Kolu Gelan kebele closed because of insufficient water supply
- Base flow decrease has caused the water level to remain low enough for people to cross the river Meja all year round (even in heavy rain). 20 years ago could only cross the river until June
- Drying of headwaters and streams has caused a noticeable decrease in the drinking water availability in Gojo town
- A noticeable increase in sedimentation of the river in rain season has reduced water quality downstream
- Increased sedimentation has also added to destabilisation of the riverbank of Meja causing loss of agricultural land through bank collapse during the rain season
- Increased exploitation of water upstream from Kolu Gelan (in neighbouring kebele Edensa Gelan) is causing pressures on available dry season water and conflicts between irrigation committees

Scaling Up

System boundaries vary with ecosystem service



Possible solutions

Farmers knowledge of tree services and utilities

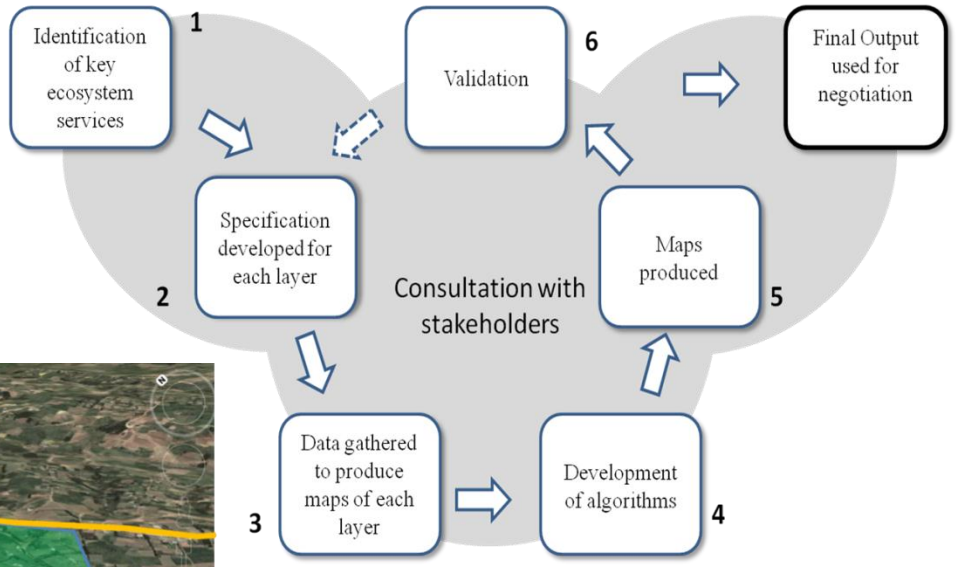
Scientific and local names	Provisioning services				Regulating services				Common position on farms			
	Fuelwood	Timber	Livestock fodder	Live fence	Gully reclamation	Stream and spring maintenance	Soil erosion regulation	Soil nutrient cycling	Riparian	Woodlot	Cropland	Home compound
Acacia spp.	x				x	x		x			x	
Buddleia polystacya	x	x	x			x		x	x			
Chamaecytisus proliferus	x		x	x								
Cordia africana		x									x	
Dombeya torrida	x	x	x			x		x			x	
Ekbergia capensis		x				x	x				x	
Eucalyptus globulus	x	x			x		x			x		x
Ficus sycomorus						x					x	
Hagenia abyssinica			x	x		x	x	x			x	x
Hypericum revolutum						x	x		x			
Maytenus spp.	x	x	x									
Myrica salicifolia	x			x							x	
Nuxia congesta	x	x	x	x		x	x	x				
Olea africana	x	x	x									
Salix mucronata	x				x	x	x		x			
Veronia amigdalina			x			x			x			

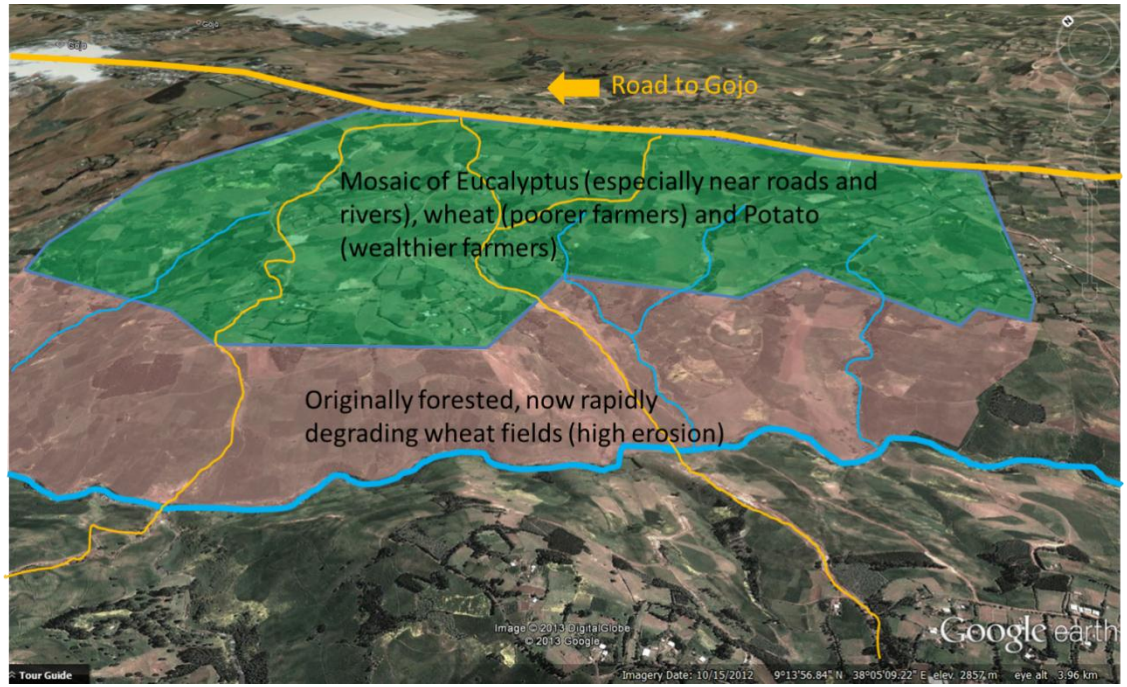
Conclusions

- The farmers interviewed had detailed explanatory knowledge of the impacts of changing tree cover on their water security.
- At an immediate landscape scale (within the sub catchment), there were clear indicators of increased water stress – caused by a combination of reduced tree cover, unplanned eucalyptus expansion and increased population.
- The beneficiaries of the eucalyptus largely lay outside the woreda in the towns on the road to Addis Ababa.
- The dis-benefits of the decreased water security flowed downstream to the west of Jeldu into the Blue Nile.
- Farmers could also identify multi-purpose tree species from the native vegetation and have knowledge of their regulating and provisioning services.

Discussion and further research

Polyscape explores trade-offs and synergies amongst ecosystem services associated with spatially explicit application of land cover interventions, including flood and sediment management measures, creating impact maps and quantifications of the effect of change on a variety of ecosystem services….





Importantly, it is designed not as a prescriptive decision making tool, but as a negotiation tool.

LEK and livelihood requirements can be integrated to allow landscape level decisions to be more acceptable to landowners. (Jackson et. Al. 2013)


Thank you …

References and Acknowledgments

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A note on Local Knowledge

- Local knowledge variables – certainty and uncertainty politics around eucalyptus has changed / need a filter (in-depth study on the policy changes around euc.) BUT knowledge most confident about is that which comes from observation – collected and triangulated – inconsistency based on the transitioning phase currently in - does not invalidate the collected knowledge though
- Dealing with complex issues
- Spatial and temporal components make judgements more uncertain but also more valuable to capture (to inform modeling