Local knowledge training using the AKT5 software and methodology at Mekelle University, funded by the AfricaRISING project: A report on a two week research study in the village of Abreha We Atsbeha in Tigray Region, northern Ethiopia

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During the period 11th-22nd June, 2012, local knowledge training was carried out at Mekelle University and at the field site of Abreha We Atsbeha in a semi-arid area of the Tigray Region. The training and research carried out by the students was funded by the AfricaRISING project and led by ICRAF, with a trainer brought in from Bangor University. The focus was on tree-crop-livestock interactions on farms within the field site, to assess drivers influencing incorporation of trees on farms and constraints and opportunities for increasing tree cover through agroforestry interventions. The team of eight researchers was split into four groups to conduct interviews with farmers, each with a different topic and some similar areas to cover; this enabled us to get a quick glimpse into the farming systems present in the field site within a short time frame. The four topics were: drivers of tree cover change over the last 50 years, positioning of trees on farms (in terms of what grows well next to what and environmental impact), ecosystem service provisioning of trees (in terms of domestic use, marketability, and environmental impact), and livestock fodder (in terms of palatability and seasonal availability). All researchers also questioned farmers about soil types found on farms to assess the potential or limitations for growing certain agricultural crops and trees in particular areas.

A scoping trip was first undertaken with three DAs (Development Agents) who showed us around the field site and gave a broad overview of the local environmental conditions and farming context. This provided the researchers with a good insight into how national and regional policies have been implemented locally in the field site with regards to the natural resource base, and the challenges that farmers are facing in the area.

The day after our 'scoping' with the DAs, semi-structured interviews were carried out with a total of eight farmers (two per group) and second interviews were held with seven of them in the second week of training; this added value to the knowledge elicited in the first interviews and allowed for clarification of certain points that researchers were unclear about. Participatory research methods were carried out with the farmers to draw land cover changes and farm layout diagrams, and a feedback session was conducted with all the farmers in attendance on the last day of the training; this gave the researchers an opportunity to make sure that they had understood what the farmers had told them, and it gave the farmers an opportunity to discuss the findings as a group.

The sections below have been broken down according to the scoping trip, the four groups of researchers, on-farm soil resources, and the feedback session, but they should not be taken as separate pieces – rather as a whole to demonstrate the integrated farming systems represented. There are crossovers in places where the same questions were asked by interviewers to the different farmers. The training followed the AKT (Agro-ecological Knowledge Toolkit) methodology as closely as possible in the two-week period – including the 'scoping', 'definition of domain' and 'compilation' stages (refer to the website for more information: akt.bangor.ac.uk). To test the representativeness of the knowledge collected, we would want to carry out a further 'generalisation' stage in which a wider sample of the population would be included as this was not possible to do within the timeframe of the training course.

Scoping trip: Context of field site

The first day in the field was our 'scoping visit', aimed at exploring the research site and talking to major stakeholders to get a good contextual overview before beginning to interview farmers in Abreha We Atsbeha village. The Village Administrator and local Development Agents explained to us about the development of the village over the past 10-20 years and detailed explanations were made whilst walking through common land areas and farms, where we were able to ask plenty of questions.

The village was said to consist of 911 households and a population of about 5030 people. From 100% food insecurity, 85% of the population is now food-secure as a result of the aggressive watershed management done within the past 8 years. The rehabilitation of the watershed was initiated by community members who were concerned about the increased deterioration of the soil and the tree population as a result of deforestation and consequent erosion and flooding of their crop fields and grazing areas. The community members then experimented with initiatives to rehabilitate the watershed, and once these proved to show some positive outcomes, they were soon backed by the support of the government extension system. Development groups were then formed (in a form of 25 people per group) and 500 people were managed by one foreman. 10 watershed committee members were elected by the community to deal with the different issues related to the watershed development.

Treatments to the watershed include:

1. Traditional check dams and percolation ponds
2. Soil/stone bunds
3. Planting of tree and grass species (trees – grevillea, sesbania, acacia, mytenus, cordia, leucaena; grasses – napier, vetiver). Trees are used for soil rehabilitation, fodder, bee forages whereas grasses are used for soil rehabilitation and livestock fodder
4. Area closure to livestock and restrictions on harvesting

The choice of tree species was said to be made through discussion between experts and community members. Management of the common land closure areas was initially through guarding by paid people and then, once enough support had been generated in the village, by community members taking turns. Currently there is no need for guarding as awareness of the community is so high that no one touches the property of the common land and if anyone is found touching anything there is a monetary fine which has been set by the community itself.

Sharing of benefit from the communal land

There was a by-law established for sharing of grasses from the closed area initially so that everyone could have an equal share. However, currently there is plenty of grass under trees so anyone can harvest the amount they need. There are restrictions on harvesting of tree products and even if a tree has fallen it is not allowed to be taken from the common land. Due to exclusion of livestock, restrictions on harvesting and the improvements made by building physical structures for halting heavy water flow and soil erosion, it took only two years to see changes in the flora rehabilitation and the resultant benefits.

Faidherbia albida (momona tree) is praised much by the community for its huge contribution towards soil conservation, livestock fodder and soil nutrient restoration. People who do not have the momona tree on their farms can rent from farmers who have it abundantly or from those without livestock so do not need it for fodder. The normal rental rate is Eth Birr 150.00/tree for one season (3-4 months). One momona tree can provide supplemental feeding to 10 sheep for 3 months.

The main benefits said to be obtained so far from the watershed development work were:

- Spring development - the farmers call it "water bank". Treating steep hills and gullies in the upper landscape ensures water at the bottom of the watershed through better capture and infiltration (so investing in the top of the watershed enables them to collect the 'cheque' at the bottom in the form of usable water). The DAs stated that 350 hectares of land are now cultivated for fruits and vegetables using the spring water for irrigation, and family feeding habits have changed drastically - people who did not include fruits and vegetables in their diets are now adding these items to their meals.

- Grass harvest for livestock - cattle and sheep fattening became a practice using the grass. Reducing livestock number, stall feeding and careful selection of the best producing animals is being adopted by the community.

- Milk quantity and quality increased by feeding momona tree pods and leaves of other trees like sesbania.

- Crop production on the lower areas of the watershed increased as a result of decreased siltation on crop fields due to measures undertaken to control the floods that were bringing unfertile soils from the upper catchment. Farmers are now motivated to use cow dung manure and green manure in their crop fields to increase the harvest of their crops.

- Bee keeping – youth groups (including university graduates) and women groups are organized in associations with support from the government to raise income and improve livelihoods. There is enhanced sense of ownership of the trees and other flora by all sectors of the community as all are benefiting from them; this means they are now taking better care of them. They also believe that bees contribute to the increase in production and diversifying varieties of crops through pollination. 11 University graduates organized themselves initially into a bee keeping group and now 80 modern beehives and produce up to 800 kg of honey/year and sell it at the rate of Birr 150.00/kg – the practice then spread to other youth groups. 52 women from women headed households have a total of 140 bee hives out of which 30 have bee colonies at the moment.

- Changes in livelihoods – farmers now have TV sets and mobile telephones; more children are attending school instead of herding livestock. All farmers are said to be benefiting from the development in one way or the other.

The main challenges mentioned were:

- Community initially resisted until model practices were done with volunteers and demonstrated to the rest of the farmers
- Need for incentives initially but awareness creation work continued and later on people realized that the long term benefit is for all
- Problem of theft of hives
- Problem of pests and wildlife attacking bees and honey
- Shortage of appropriate stone and transportation for shallow well construction
- Fruit and other crop varieties need to be diversified. Currently it is only guava fruits which are distributed at large in the irrigated areas
- Survival rate of exotic tree species was low initially and was better on private farms than in communal land

Group 1: Temporal elements influencing tree cover in landscape and on farms (Habtamu, Emiru and Tesfaye)

Scope of interviews:

- *Species names of trees that used to be in landscape from 50yrs ago up until the present time species*
- *Drivers of tree cover change*
- *Other uses of these species in relation to livelihoods and impacts on environment (soil, water climate)*

Habtamu, Emiru and Tesfaye interviewed two farmers (the first was a 74 yr old male and the second was a 50 yr old female) with a focus on drivers of tree cover change over the past 50 years and the changes in species composition, as well as their uses. The first farm visited was 0.5 ha in size whilst the second farm was 0.75 ha.

The main crops grown were teff, millet, maize, wheat, barley and pulses (based on rain availability) and the uses of these crops were said to be for food at the household level and for selling on the market, as well as residues for animal feed.

The first farm had two oxen and one cow, whilst the second farm had two oxen, one cow, two sheep, two donkeys and six chickens.

Both farms had a range of tree species, with the first farm having many more fruit trees and the second farm focusing more on eucalyptus due to their irrigation site being far from the homestead which limited fruit production. Table 1 shows the trees present on the two farms with their positioning and uses, whilst Figure 1 shows the vegetation cover change from pre-1991 to post-1991 according to the farmers. Figures 2 and 3 are diagrammatic representations of the drivers of tree cover change after processing the interviews and entering into a knowledge base using the AKT5 software.

Table 1. Trees and their uses on interviewed farms.

Mentioned by	Tree species	Position	Uses and comments
Farm 1	*Faidherbia albida* (momona), cha'a, *D. abyssinica*	Natural regeneration on farmland	Soil fertility, shade, animal forage, farm implements, fuel wood, soil and water conservation. If planted too densely (more than 3 trees/timad), momona tree roots will hinder proper farming – on the farm boundary it is possible to plant more.
	Mango, orange, avocado, lemon, gesho, casmir, trungo, cactus	Orchards	Food, shade, income, soil and water conservation, medicinal. Water ponds and micro basins constructed to hold water for irrigating fruit trees.
	Eucalypus camaldulensis	Homestead	Farm implements, construction wood, fuel wood, income, saves other species for conservation, soil and water conservation. Leaves do not decompose easily which can cause soil fertility and land productivity to decline. If planted in

			an appropriate site it can grow tall and strong (likened to the 'eldest son').
	Faidherbia albida, cha'a, cactus, *D. abyssinica,* phonex, ere (argisa)	On boundary hedgerows	
Farm 2	*Faidherbia albida*	Natural regeneration on farm	Soil fertility, shade, animal forage, farm implements, fuel wood, soil and water conservation. Should not be more dense than 10-15/timad. Fertilises land.
	Eucalyptus camaldulensis	Woodlot	Farm implements, construction wood, fuel wood, income, saves other species for conservation, soil and water conservation, shade. Leaves do not decompose easily so this tree is not even kept on boundaries.
	Olea, neem	Homestead	Farm implements, construction wood, fuel wood, income, saves other species for conservation, soil and water conservation, shade.

When asked about drivers of land cover change over the last 50 years, the first farmer interviewed (Hintsa Siyum) stated the following as the main drivers:

- Land ownership
- Poverty
- Political instability
- Drought
- Awareness level

The second farmer interviewed (Hiwot Alemayehu) stated 'awareness level' as the main driver of land cover change.

Changes in land cover over the last 50 years were directly linked with political regime changes and the impact that these regimes had on the environment. Plate 1 shows an interview being carried out with a farmer and Figure 1 shows changes in vegetation cover pre-1991 to post-1991, according to the farmers interviewed.

Land cover change

- **Before 50 years**

First farmer: Barren land, not any vegetation cover
Second farmer: Barren land, drought

- **Before 1974**

First farmer: 1. Land holding: limited landlords
2. Productivity: better due to higher rainfall and higher land cover with some trees such as *Olea europe*, *C.africana*, *F. vasta*, *F.albida*, Cha'a, and others.

Second farmer: No comment

- **1974 -1991**

First farmer: 1. Period when severe land and resources degradation occurred

2. Instability, limited involvement in development activities
3. Severe forest resources degradation for subsistence need

Second farmer: A time of severe resources degradation.

- **1991 – present**

First farmer: 1. Land cover increased due to:
- Increased area closure
- SWC activities (biological and physical)
- Zero grazing both in closed area and agricultural land
- Plantations of fast growing trees such as eucalyptus for different wood purpose
- Ground water increased, irrigation and other water and forest services available within limited distance, livelihoods status changed

2. Drivers of change: awareness and involvement in every intervention

Second farmer: 1. Land cover increased due to:
- Increased area closure
- SWC activities (biological and physical)
- Zero grazing both in closed area and agricultural land
- Plantations of fast growing trees such as eucalyptus for different wood purpose.

2. Drivers of change: awareness but change is not uniform due to awareness level being variable.

Plate 1. Emiru interviewing a farmer on his land and being shown his water pond. Photograph taken on 13th June 2012.

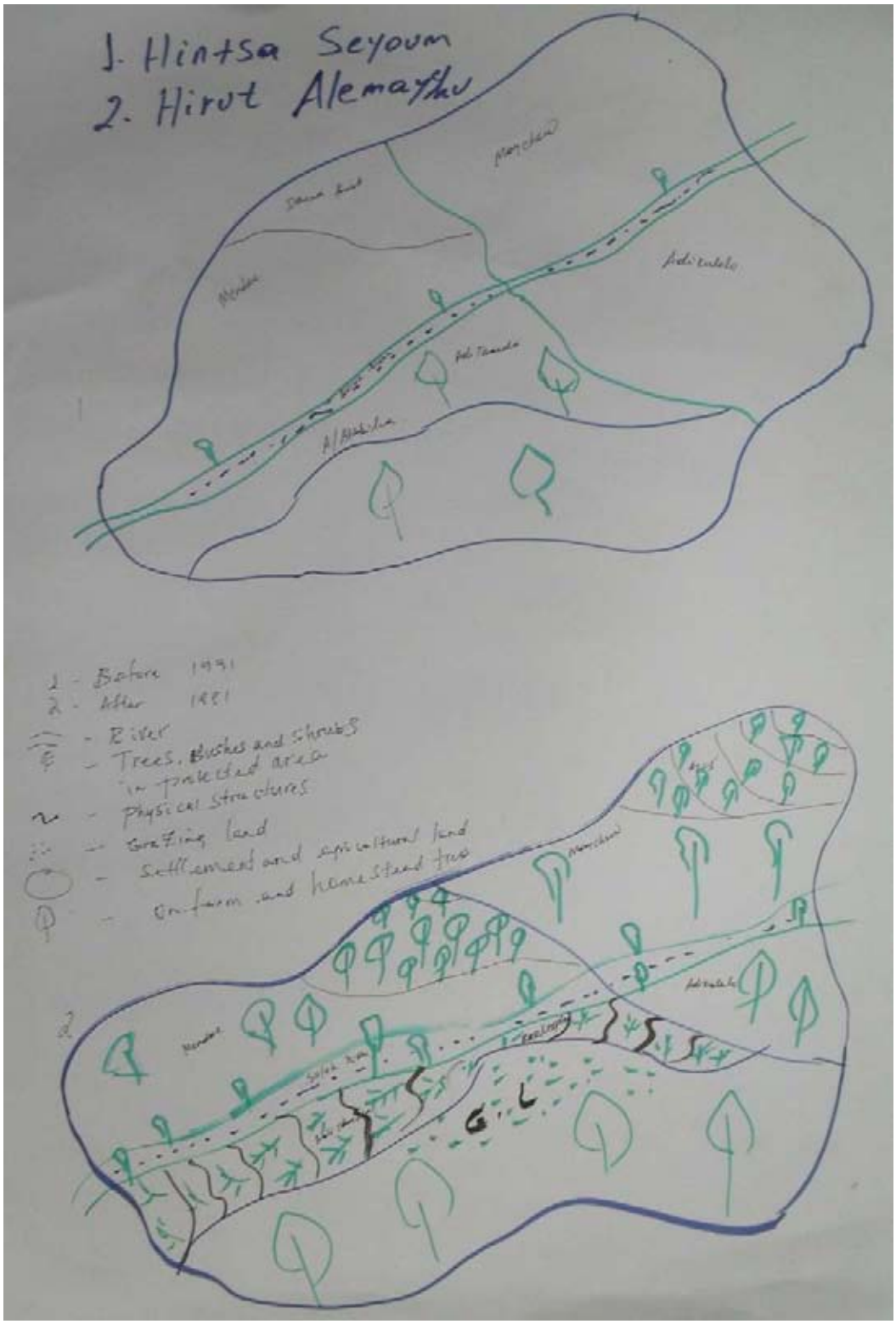

Figure 1. Land cover change pre-1991 (top) and post-1991 (bottom) according to two farmers in Abreha We Atsebha.

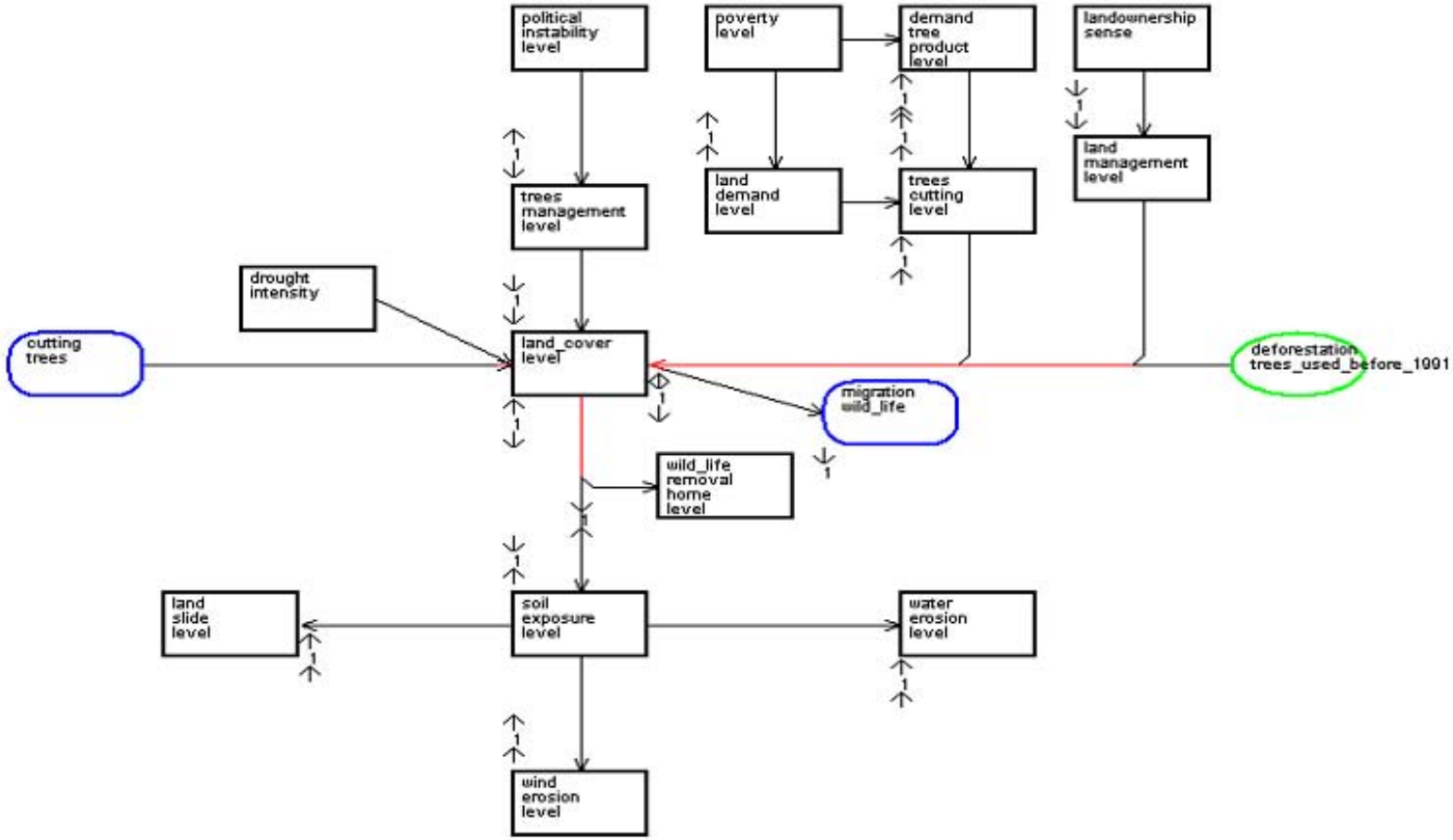

Figure 2. AKT5 causal diagram generated in knowledge base showing land cover pre-1991 (a time of severe natural resource exploitation). Created by Habtamu, Emiru and Tesfaye from their two interviews.

Legend: Nodes represent human actions (boxes with rounded corners), natural processes (ovals), or attributes of objects, processes or actions (boxes with straight edges). Arrows connecting nodes denote the direction of causal influence. The first small arrow on a link indicates either an increase (↑) or decrease (↓) in the causal node, and the second arrow on a link refers to an increase (↑) or decrease (↓) in the effect node. Numbers between small arrows indicate whether the relationship is two-way (2), in which case ↑A causing ↓B also implies ↓A causing ↑B, or one-way (1), which indicates that this reversibility does not apply. Words instead of small arrows denote a value of the node other than increase or decrease.

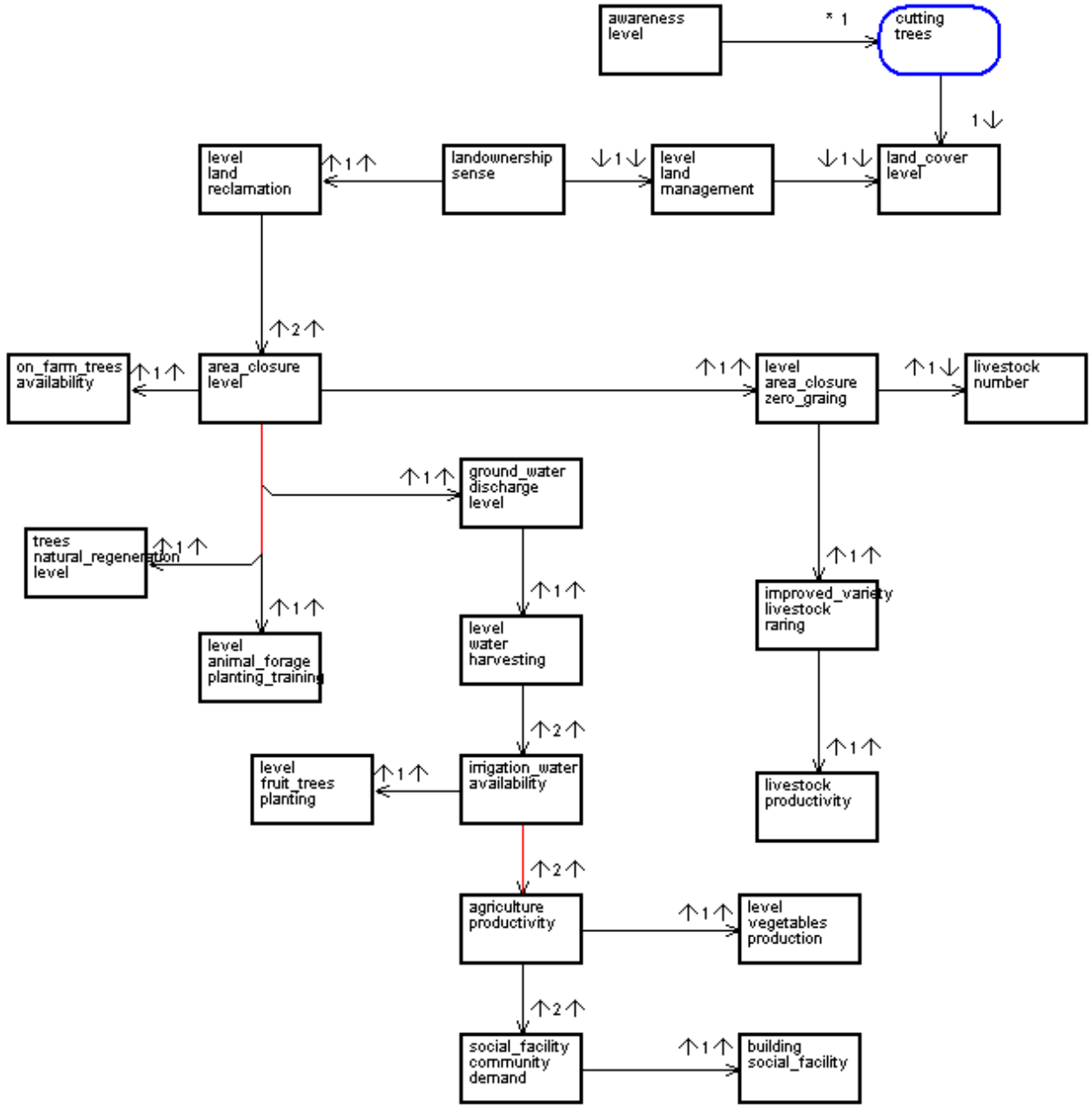

Figure 3. AKT5 causal diagram generated in knowledge base showing transition of land cover from 1991 to the present day. Created by Habtamu, Emiru and Tesfaye from their two interviews.

Legend: Diagrammatic symbols are the same as explained in Figure 3.

Group 2: Positioning of trees on farms, their livelihood uses and impacts on the environment (Nuraini and Hoa)

Scope of interviews:

- *Species names*
- *Position found in landscape/on farms, reasons for position, and whether planted or naturally regenerated*
- *Other uses of these species in relation to livelihoods and impacts on environment (soil, water climate)*
- *Overall tree-crop-livestock interactions: what grows well with what and how they interact at the farm/landscape level*

Nuraini and Hoa interviewed two farmers (the first was a female farmer aged 40 yrs old and the second was a male farmer aged 47 yrs old). The focus of their interviews was the positioning of trees on the farms and the reasons underlying it. Trees and other vegetative species grown on boundaries, in fields, and around the homestead were discussed and any interactions they were having with the rest of the farming system were explored. Two farm sketches were drawn by the researchers and are shown below along with photos of interviews on the farms.

They both had integrated farming systems, with a mix of cereal crops, fruits, vegetables, trees for fuel wood, fodder and timber, and livestock.

The main crops that were grown on the farms and were mentioned during the interviews were: maize, wheat, teff, barley and millet. The cereals planted depended on amount of rainfall/available water and season. Vegetable crops included tomato, green chilli and cauliflower but these were said to be heavily dependent on water availability. The first farmer had two farmlands; one by the household compound and the other a bit far but near to a stream where it was easier to grow vegetables. She had one pond on her farm which was the main source of water for the farmland around the household compound and within the household. Using the pond water, she was able to grow a range of vegetables, fruits and some cereal crops. The second farmer had his farmland just near his household compound and had a well that was used for irrigation purposes and household use.

The first farmer had two cows kept separately because of their different breeds and uses (one for meat production and the other for milk) and she kept bees, whilst the second farmer had cattle, goats, sheep, chickens and a donkey.

Both farms had a range of tree species on their farms, with the first farm having more boundary species and fruit orchards and the second farm having a woodlot of eucalyptus, clusters of fruit trees and some scattered *Faidherbia albida* on the fields (although the main cereal crop fields were bare of trees). Table 2 and Figure 4 represent the knowledge elicited about species present on the farms and their positioning, whilst Figure 5 is a visual representation of both farms using sketches drawn by the researchers.

It was evident from talking to the farmers that there was a direct interaction between most of their trees (excluding eucalyptus), crops and livestock. Manure was being used to fertilise the crops and trees, whilst trees and grasses were providing a vital source of fodder for the livestock as well as compost material to put back into the soil. Although livestock were being kept off the farmland and were either being zero grazed or put on the common grazing land, they were an integral part of the farming system along with its other components.

Table 2. Plant species and their positions on the two farms visited.

Plant species	Position on farm	Reasons why
Sesbania sesban, *Leucaena leucocephala*, *Faidherbia albida*, *Euphorbia tirucalli* (locally known as 'qinchib'), 'gaba', 'gosho', cactus, elephant grass, dried eucalyptus branches	Boundaries	Most of the boundary species were being used as fodder as well as protecting farmland from roaming livestock. Sesbania and leucaena were mostly valued for providing a source of fodder. Euphorbia was valued because it is fast growing and protects against soil erosion due to its dense stems; the only downside is its lack of thorns so a fence only made of this specie would be easily damaged by livestock. Cactus was valued because it is easy to propagate, it's spiky so protects the area from livestock, and it is used as fodder. Elephant grass was said to help protect against soil erosion, especially on sloping land, and it is used during coffee ceremonies. Dried eucalyptus branches were being used by one of the farmers for a section of her boundary because the neighbouring farmer had refused green fencing to be put there due to the competition with their crops and trees for water and nutrients; the dry branches of eucalyptus need to be changed every year due to natural degradation.
Faidherbia albida	On fields	Just a few naturally regenerated – some would be transplanted to the boundaries rather than left in field.
Orange, mango, avocado, coffee, apple, papaya, grape, tringo, guava, some vegetable crops	In orchards	There was some intercropping of vegetables in the under storey of fruit trees and this was said to benefit the trees because they could take advantage of the compost and water applied to the vegetable crops. It was said to be better to grow vegetables next to small trees rather than the big ones for better production due to the shading effect. It saves on space as well as inputs.
Eucalyptus camaldulensis	In woodlots	Eucalyptus was kept in a separate woodlot due to its competitiveness with crops and the fact that its leaves do not decompose easily – he likened them to plastic.

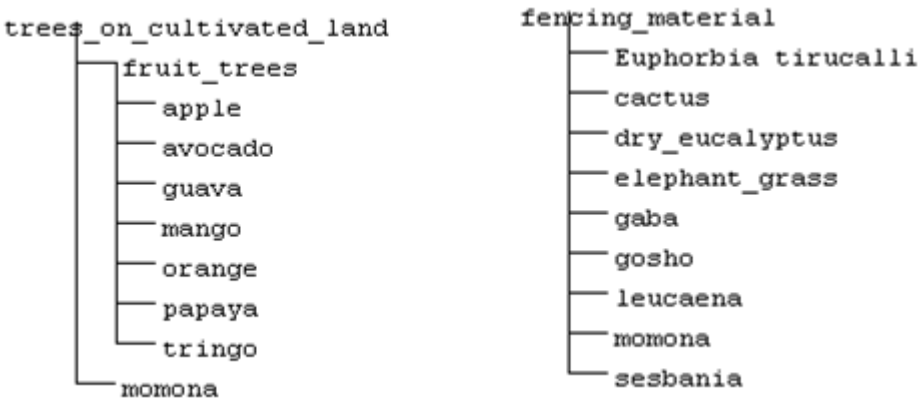

Figure 4. AKT5 object hierarchies showing trees that were present on cultivated land and species used as boundary fencing, created by Hoa and Nuraini from their two interviews.

Figure 5. Farm sketches drawn by the researchers of the two farms visited by Nuraini and Hoa. The first farm of Askual Halfeom (top) and the second farm of G/Selsse Rata (bottom) are represented.

Plate 2. The farm of Askual Halfeom, interviewed by Nuraini and Hoa. Photographs taken on 13th June, 2012.

Plate 3. The farm of G/Selsee Rata, interviewed by Nuraini and Hoa. Photographs taken on 13th June, 2012.

Group 3: Utilities of trees found on farms and in landscape both for direct household benefits (cash income or use in household) and environmental benefits (Emelda and Muluberhan)

Scope of interviews:

- *Species names of trees on the farms*
- *Uses of these species in relation to livelihoods and impacts on environment (soil, water climate)*
- *Phenology of these trees (flowering, fruiting times)*
- *What trees farmers would want to plant more of and why?*
- *Overall tree-crop-livestock interactions: what grows well with what and how they interact at the farm/landscape level*

Emelda and Muluberhan interviewed two farmers (the first was a female farmer in her early thirties whilst the second farmer was a male in his late seventies) with a focus on tree utilities. The first farm was said to be made up of three parcels totalling 1 ha and the second was four parcels totalling 0.75 ha. Both household's livelihood depended mainly on their integrated farming systems, including cereals, fruits and vegetables, livestock, trees and shrub components.

Major cereal crops grown by the two farmers included: teff, barley, finger millet, maize, sorghum and 'qerqaeti'. Teff was the main crop for both households visited and was used for household consumption and sold on the market when in excess (yield was said to be 2.5 quintals per ha). Vegetable crops were tomato, chilli pepper and potatoes. There were also a wide range of fruits: guava, orange, papaya, mango, lemon, avocado and banana. The vegetable and fruit crops were grown using irrigation, whilst the cereal crops tended to be rain-fed. Trees and shrubs were present on both farms and were explained as providing both direct benefits to the household in terms of products such as timber and fuel wood, and to the land in terms of soil and water conservation.

In terms of livestock, both farmers had cows, oxen, sheep, donkeys and chickens. The livestock were not kept on the same area of land as the crops or trees, rather they were fed using the cut and carry system.

As well as looking at tree species that appeared on the farms and their utilities in relation to livelihood needs and environmental impact (Tables 3 and 4), questions were asked about the phenology of these species, what species the farmers would be interested in having on their farms in the future that they do not currently have, and observed interactions between trees, crops and livestock. Farmers were also asked about which trees they planted and which naturally regenerated (Table 5).

The main drivers to integrating more trees on farms were given as:

- Available seedlings that are cheap to buy
- Generation of additional income
- Soil conservation (e.g. stabilising steep gullies)

The main barriers to integrating more trees on farms were given as:

- Small size of land so there are limitations to where more trees could be planted without interfering too much with crop cultivation, e.g. boundary areas would have the most potential.
- Adverse impact of certain trees on crop productivity, e.g. eucalyptus.

Table 3. Trees, shrubs and herbs found on the two farms visited and their utilities.

Tree species	Utility	Other comments
Banana	Fruit	
Guava (locally known as 'zeithun')	Fruits for income generation	Guava flowers all year round if there is water available. Fruit trees are planted in rows with careful spacing so that they do not affect the productivity of one another.
Lemon (locally known as 'lomi')	Fruit	
Mango	Fruit	
Orange (locally known as 'aranshi' or 'birtukan')	Fruits for income generation	Orange flowers in June, during the rainy season. If well maintained, after planting it starts flowering after 2 years – otherwise, it will be after 5 years.
Papaya	Fruits	If well maintained, papaya will flower 3 years after planting.
Cactus	Fruit, fodder, fencing, soil conservation	Cactus flowers from January-May and fruits in May-August. Planted in gullies to reclaim the land and combat soil erosion.
Coffea arabica		
Arundinaria alpine (locally known as 'arqai' or 'qerqeha')		
Acacia abyssinica (locally known as 'che-a' or 'bazra grar')		
Acacia seyal		
Carissa edulis (locally known as 'agam')	Fencing	
Cassia singueanea (locally known as 'hamba hambo' or 'gufa')		
Dovyalis abyssinica (locally known as 'koshim')	Fencing	
Eucalyptus camaldulensis (locally known as 'qeyih qelamitos' or 'qey bahir zaf')	Reclamation of land, timber for income generation and fuel wood	Eucalyptus is only planted on the edges of the farm rather than in fields because it reduces the productivity of crops (the leaves are not good). Planted in gullies to reclaim the land and combat soil erosion. At the beginning of soil and water conservation activities, eucalyptus is very useful because of its deep rooting ability which leads to quick stabilisation of steep gullies. It flowers once a year between April and June. It starts producing timber 5-6 years after planting. It is evergreen and needs very little maintenance.
Euphorbia tirucalli (locally known as 'qinchib')	Reclamation of land and fencing	Planted in gullies to reclaim the land and combat soil erosion.
Faidherbia albida (locally known as 'momona')	Good for soil fertility, fencing, pods for livestock fodder	Faidherbia does not provide direct monetary benefits but she keeps it on the farm when it naturally regenerates there (she does not plant it). Crops are more productive under this tree compared with other trees. It takes 10 years to flower and start having fruits. It loses its leaves once a year during February-April and grows its leaves again between April-May. The second farmer was practising transplanting some of the natural regenerated seedlings from the fields to the boundaries of his farm, during the rainy

		season because it needs a high amount of water when transplanted. Maintenance involved harvesting the pods; if these are not removed then it does not produce more leaves on those branches.
Ficus carica (locally known as 'beles')	Food for human consumption and livestock fodder	
Ficus sycomorus (locally known as 'sagla' or 'bamba' or 'shola')		
Leucaena leucocephala		
Olea europea var. africana (locally known as 'awli-e')	Used to make ploughing implements	
Rhamnus prinoides (locally known as 'gesho')	Used to prepare local beer 'siwa'	
Rumex nervosus (locally known as 'machicho' or 'hohot')	Fuel wood, fodder for goats, eaten by children, good for soil and water conservation	It can be cut year after year but it grows back.
'Chihang'	Human consumption and construction timber	This tree used to be in the area but has now disappeared.

Table 4. AKT5 hierarchic objects usage tool output showing tree utilities according to the two farmers interviewed by Emelda and Muluberhan and represented in their knowledge base.

Multiple usage of the same object within different hierarchies					
OBJECTS	Fodder trees	Shade trees	Trees for soil and water conservation	Trees planted in woodlots	Fruit trees
Faidherbia albida	x	x	x		
Acacia etbaica		x			
Acacia saligna	x		x		
Acacia seyal			x		
Acacia spp	x				
Carica papaya					x
Citrus sinensis					x
Cordia africana		x			x
Dichrostachys cenearea			x		
Dodonaea angustifolia			x		
Eucalyptus camaldulensis			x	x	
Euclea schimperi			x		
Ficus carica					x
Grevillea robusta			x		
Leucaena leucocephala	x				
Mangifera indica					x
Maytenus senegalensis	x		x		

Moringa oleifera	x				
Persea americana					x
Pisdium gaujava					x
Rhamnus prinoides				x	
Sesbania sesban	x				

Table 5. AKT5 hierarchic objects usage tool output showing the trees that natural regenerate or are planted on farms according to the two farmers interviewed by Emelda and Muluberhan.

Multiple usage of the same object within different hierarchies		
OBJECTS	natural regenerating tree species	planted trees
Faidherbia albida	x	
Acacia saligna		x
Acacia seyal	x	
Acacia spp	x	
Carica papaya		x
Citrus aurantifolia		x
Dichrostachys cenearea	x	
Dodonaea angustifolia	x	
Euclea schimperi	x	
Grevillea robusta		x
Leucaena leucocephala		x
Mangifera indica		x
Maytenus senegalensis	x	
Moringa oleifera		x
Persea americana		x
Pisdium gaujava		x
Sesbania sesban		x

Plate 4. The farm of Medhin Haileselassie, interviewed by Muluberhan and Emelda. Photographs taken on 13th and 19th June, 2012.

Plate 5. The farm of Gebregziabher Gebru, interviewed by Muluberhan and Emelda. Photographs taken on 13th June, 2012.

Group 4: Livestock fodder from trees and grasses (Aberra and Addisu)

Scope of interviews:

- *Main fodder species names and details of unpalatable tree and grass species*
- *Fodder qualities (e.g. palatability for different livestock)*
- *Seasonal availability*
- *Other uses of these species in relation to livelihoods and impacts on environment (soil, water climate)*

Aberra and Addisu interviewed two female farmers with a focus on livestock fodder sourced from both farm and common land. The first farm was said to be 1 ha and the second was 0.75 ha. Both farmers were illiterate but were managing integrated farming systems with successful outcomes for their household food security; this was attributed to the efforts of the community leader Ato Aba Hawi to rehabilitate the local environment and improve farming practices.

Major crops grown by the two farmers included: barley, wheat, teff, millet, finger millet, sorghum, maize and chickpea. Cash crops were sugar cane, coffee and gesho (*Rhamnus prenoides*). Vegetable crops were tomato, chilli pepper and onions. There were also a range of fruits: mango, avocado, papaya, apple, orange, grape and cactus.

Both farmers had been provided with poultry via extension packages, and other livestock kept were local breeds of cow, oxen, sheep and donkey.

As well as looking at livestock resources and their seasonal availability (Tables 6 and 8), questions were asked about trees and grasses that do not provide suitable fodder for livestock and the reasons why (Table 7), and what species the farmers would be interested in having on their farms in the future that they do not currently have (Table 9).

Table 6. Specific livestock feed resources and seasonal availability according to the two farmers interviewed.

Feed resource		Livestock type fed on it	Feeding season/months	Feeding habit	Other comments
Crop residues (teff, wheat, barley)		Farmer 1: for all except poultry and sheep Farmer 2: for all except poultry and sheep	Jan – June Drought season	Basal Supplement	Barley straw is easier to digest compared with wheat straw.
Cactus		Farmer 2: cattle			The cactus stems are burned to remove the spines, then they are chopped and mixed with crop residues. It cause diarrhea if fed on its own. The fruit of cactus is used for human consumption.
Naturally occurring grasses	Sugar grass (locally known as 'netsa' grass)	For all	September	Basal	It is particularly good for milk quality and quantity when fed to milking animals. Good for hay making.

	Senbelt grass	Oxen and cow	September	Basal	Used for roof coverage
Cultivated grasses	Vetiver grass	For all	September (cut and carry)	Basal	Soil conservation
	Elephant grass	For all	September (cut and carry)	Basal	Soil conservation
	Napier grass	For all	Throughout the year		Harvested every 3 weeks.
Hay (dried natural grass)		Farmer 1: for all except poultry Farmer 2: for all except poultry and more so for dairy cow	Dec – June Jan - April	Basal	If the hay is not stored properly it can be spoiled by the rains.
Residue of local beverages (coffee and tella)		For all except poultry but mostly fed to dairy cows and oxen	Year round depending on availability	Supplement	Mixing with crop residues increases palatability – it causes diarrhea if fed on its own. Coffee residues are great in compost.
Cultivated trees	Sesbania (*Sesbania sesban*)	Pods and leaves used for dairy cows	Every two months August - Jan	Supplement	It is good for milk quality and quantity. A source of pollen for bees. Good for soil nutrient restoration.
	Moringa (*Moringa oleifera*)	Pods and leaves used for dairy cows	Drought season	Supplement	Used for human consumption and medicinal value. Good for soil nutrient restoration.
	Leucaena (*Leucaena leucocephala*)	Fed to dairy cows.			It is good for milk quality and quantity.
Naturally regenerated trees	Momona (*Faidherbia albida*)	Pods for all	January		Sheep and goats are very efficient at picking the pods of momona. Improves soil fertility, used for timber and fuel
	Olive tree (*Olea africana*)	Farmer 1: Leaves fed to all livestock during shortage of feed	Throughout the year		Used to brush the teeth, used for timber production
	Wanza (*Cordia africana*)	Farmer 1: Fed to cattle	January		Fruits fed mainly to children (due to sticky conditions of the lip the elders do not use), used to construct feeding and watering trap, used for timber

	Acacia (*Acacia saligna*)	Farmer 2: Leaves fed to all livestock during shortage of feed	Throughout the year		Used to brush the teeth, used for timber production
By-products of cultivated crops	Papaya leaves Sunflower leaves	For cattle	Jan – June Drought season	Supplement	Papaya fruits and sunflower seeds used for human consumption.

Both farmers stated that they conserve crop residues (straw of wheat, barley, teff) and grasses (sugar grass was said to be best for hay making) in order to have a reliable source of fodder during dry seasons for their animals. The crop residues are collected after harvesting and grasses at the end of the main rainy season to make into hay.

Hay is prepared usually during the months September and October and, if prepared at the right stage of growth, it should have a green colour, low moisture content and be able to be stored for a long duration. Dairy cows are the main livestock that hay is supplied to.

Table 7. Grass and tree species less preferred by farmers as livestock fodder and the reasons why.

Fodder type	Mentioned by	Reason for low preference as fodder
"Gaja" grass	Farmer 1	Eaten by livestock only when fresh as dried grass is tough and has low palatability (Farmer 1). Yield is low and does not have a good effect on animal health (Farmer 2)
Sorghum stover (green)	Farmer 1 and 2	Causes bloating in animals if fed with it when it is green (Farmer 1 and 2)
"Gorduma" grass	Farmer 1	Causes sickness when fed to sheep but okay for cattle (Farmer 1)
"Mesi" grass (green)	Farmer 1	If fed to animals when it is green, it can kill them; it grows in September (Farmer 1)
"Mugia" grass	Farmer 1	Causes bloating if fed to animals when it is green (Farmer 1)
"Chifirnebir" grass	Farmer 2	Yield is low and does not have a good effect on animal health (Farmer 2)
Castor leaves	Farmer 1	Low palatability and only given to animals in times of feed shortage (Farmer 1)
Papaya leaves	Farmer 1	Low palatability and only given to animals in times of feed shortage (Farmer 1)
Eucalyptus leaves	Farmer 1 and 2	Eaten only by donkeys (Farmer 1). Low palatability and is not good for soil and crops (Farmer 2).
"Mastenagir" shrub	Farmer 1	Low palatability and only given to animals in times of feed shortage (Farmer 1)
Neem	Farmer 1	Eaten only by donkeys (Farmer 1)
Cordia tree	Farmer 1	Not good on farmland (Farmer 1)
Ficus tree	Farmer 1	Not good on farmland (Farmer 1)

Table 8. General seasonal calendar for the different livestock feed resources as given by the two farmers interviewed.

Feed resources	Farmer	Months												Comments
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Crop residues	Farmer 1	X	X	X	X	X	X	X	X	X	X	X	X	
	Farmer 2	6	5	4	3	2	1				X	X	6	
Naturally occurring grass (eaten green)	Farmer 1								X					
	Farmer 2							X	X	X	X			
Cultivated grass	Farmer 1	X	X	X	X	X	X	X	X	X	X	X	X	Every 3 weeks
	Farmer 2	X	X	X	X	X	X	X	X	X	X	X	X	
Grass hay	Farmer 1		X	X	X	X	X			X				
	Farmer 2			X	X	X	X			X	X			
Native trees (e.g. momona)	Farmer 1	X	X											
	Farmer 2	X												
Cutivated trees	Farmer 1	X			X			X			X			Every 2 months
	Farmer 2	X			X			X			X			
Local beverage (tella) residue	Farmer 1		X		X			X	X	X			X	During holidays
	Farmer 2		X		X			X	X	X			X	
Coffee residue	Farmer 1	X	X	X	X	X	X	X	X	X	X	X	X	1 time/day
	Farmer 2	X	X	X	X	X	X	X	X	X	X	X	X	3 times/day

It was deemed important to look at which species farmers do not currently have but would be interested in growing, as well as those species they already have but would like more of (Table 9).

Table 9. Species farmers would like to grow or have more of on their farms.

Species farmers are interested in growing in the future	Mentioned by	Comments
"Nibie" tree	Farmer 1	Fruits are eaten by children
"Mugia" tree	Farmer 1	Fruits are for human consumption and leaves for animal feed
Momona tree (*F. albida*)	Farmer 2	Currently this farmer has only two momona trees although they are managing some naturally regenerated seedlings
Napier grass	Farmer 2	Wants more napier grass
Sesbania (*Sesbania sesban*)	Farmer 2	Wants more sesbania
Leucaena (*L. leucocephala*)	Farmer 2	Wants more leucaena

When looking at livestock feed, bees were considered a vital component of the tree-crop-livestock farming systems so questions were asked about bee fodders in the area and the impact they would have on the quality of the honey (Table 10). The first farm visited had bee hives whilst the second used to but had since removed them due to the inconveniences incurred by them (risk of theft if left in rangelands and neighbours complaining of bee stings when kept in her backyard).

The farmer who still had bees was asked more details about them and she stated that she had five bee colonies in total, with three honey harvesting seasons per year. The amount of honey collected per hive per season ranged from a minimum of 5-6 Kg to a maximum of 10-12 Kg.

Table 10.Type of bee flora in first farmer's apiary site and impact on honey quality according to her.

Bee flora (local name)	Honey colour	Honey quality rank
Gribia	White	1
Esuwakasin	White	1
Kebebe	Red	3
Tehises	Red	4
Tibebe	Red	5

During periods when bee flora is lacking, the farmer said that she supplies the bees with shiro, sugar, tihin (beso) and water. Ants, birds, gobe, lizards and honey badgers were given as the main enemies of bees and honey.

Narratives

First farmer: Tsigab Aberra

Tsigab is aged 45 and is one the wives of the community leader, Ato Aba Hawi. Her family size is 9 (4 males, 5 females) and land size is one hectare. She has 10 heads of animals excluding 5 chickens given to her by extension services. She grows crops like barley, wheat, oats (barley mix with wheat), teff, millet, finger millet, sorghum. She has irrigated fruits and vegetables in her backyard. She has reasonable tree cover of both natural and cultivated species. One of the famous native trees for its multiple uses is *Faidherbia albida* (momona tree).

The *Faidherbia* trees produce more leaves when pruned. Sheep fed with the leaves of *Faidherbia* leaves perform better than those fed on grass alone. Where there is no tree cover, soil degradation is high. Heavy flood caused during rainy seasons used to destroy crop lands and grazing lands before 10 to 15 years. But now, thanks to the community leader, Ato Aba Hawi, she says they can harvest good crops and there is enough fodder for their livestock. Trees like *Sesbania* and *Faidherbia* don't only protect the soil from erosion, but also provide feed for livestock and restore soil nutrients which were much depleted before the interventions.

Fruit trees and vegetables can be sources of animal feed besides being human food. If the market is not good for the harvest, they can be fed to livestock and at least some costs can be recovered.

There are two heaps of crop residues and one heap of grass hay stored in the compound. She says she can now conserve better quantities of feed for her animals as compared to the time when there were no trees on the mountain. She and other farmers in the community can harvest grass from the communal area closures. However, no one can cut a single tree from the closed area. Tsigab has a total of 10 animals out of which one is an improved local dairy cow. She says grass hay is the best animal feed if it is conserved at the proper time (September/October).

She has five bee colonies. She harvests 10-12 kg of honey if the bees have enough flowering trees but only 5-6 when they don't have enough feed. Tsigab provides some sugar, flours of grains and water to the bees at the time of feed shortage. Shrubs like kebebe and tehises are good as bee forage but the quality of the honey is not liked by the consumers. The quality of honey is better when the bees are on giriba flowers. Enemies of bees and honey include wild animals like ants, lizards, and honey badger.

Planting trees up the hill in addition to constructing bunds and terraces increased water quantity at the lower landscape. Tsigab calls it a "water bank" which means treating the soil degradation problem on the hills (depositing money in the bank) avails water down on the plains (cashing the cheque). Many farmers including Tsigab are now using irrigation from the hand dug water wells using a treadle pump.

Tsigab grows fruits like avocado, mango, papaya, grapes using irrigation. The fruits are used for home consumption and income generation while the leaves of the trees are used for animal feed. The introduction of the fruits and vegetables came along with a change in feeding culture of the household. They now include fruits and vegetables in their meals which was not the case before.

Second farmer: Atsede Kassaye

Atsede is a crop-livestock farmer and is aged 45 years. She has a family size of 8 (4 males, 4 females) and farm size of 0.75 hectare. She is illiterate but has been able to send her children to school and one of her sons who is an MSc graduate.

Main crops grown on Atsede's farm include: chick pea, millet, finger millet, barley, maize and teff. She has only one stand of papaya tree and a row of cactus tree along the fence of the compound. She rears 5 heads of animals excluding 40 chicken provided by the government extension services.

Livestock feed sources include: natural green grasses and trees, crop residues, grass hay, fodder tree leaves and local brewery by-products like tella. Among the trees used for fodder and other uses are: *Moringa*, cactus, *Faidherbia* (momona). Other uses of these trees include human food (cactus), soil fertility (momona), shade, soil conservation and medicine.

Different feeds are available at different times of the year. For example: *Moringa* produces pods in January, native grass is harvested for hay in September, crop residues are available starting from October and may continue to be fed to livestock until June.

Native grass is utilized in two ways and, as well as being dried as hay, can be fed using the cut and carry system at the green stage between August and September. Fodder trees like *Sesbania* and *Moringa* are used as leaves and green pods. *Moringa* leaves are eaten by humans too. Both *Sesbania* and *Moringa* are used as supplemental feed. They are also good for soil nutrient restoration. Atsede has only two stands of *Faidherbia* tree in one of her three blocks of farms. The pods of *Faidherbia* are harvested and fed to the dairy cow kept in a stall.

Atsede testifies that the area closure on the mountain led to decreased flood and soil erosion affecting her limited crop lands and, as a direct result, she has been able to harvest a better quantity of crops.

She used to have six bee hives out in the range land. However, currently she doesn't have any hives because she removed them due to threat of theft in the field. She later kept one at the backyard, but that again was opposed by neighbours who were stung by the bees so she sold that too.

Plate 6. The farm of Tsigab Aberra, interviewed by Aberra and Adissu. Photographs taken on 13th June, 2012.

Plate 7. The farm of Atsede Kassaye, interviewed by Aberra and Adissu. Photographs taken on 13th June, 2012.

On-farm soil resources

When asked about the soils on their farms, three of the farmers talked of three main categories of soil, namely:

1. Arenesol (sandy soil, locally known as 'hitsa') – two farmers stated that this soil needs only a small amount of water and one farmer said that she applies compost to increase the softness of this soil due to its sandy characteristic. It was indicated by the same farmer that the 'shiferaw' tree (*Moringa oleifera*) is not suited to this soil type as she planted it but the tree did not grow well and then died.
2. Cambisol (loam soil, locally known as 'beakel') – this was said to need more water, is more productive, and is the best for water retention.
3. Vertisol (black clay soil, locally known as 'walka') - this soil was said to require the least amount of fertiliser due to its softness and fertility, and it is best for vegetables and cereal crops.

One farmer interviewed said that in ancient times, there were three types of soil in the landscape: shallow, medium and deep. Only the deep soil during this time was sown without fertilisers, but now there is no deep soil remaining and all is sown with fertilisers; manure and fertilisers are used to maximise productivity because the land productivity has declined so much.

Another farmer said that she usually buys fertiliser from the village administration for her farmland, as directed by the government in exchange for other help on the farm. She said there are two types of fertiliser she uses; the black one is good during the dry season and is used initially before ploughing, whilst the white one is used when there is a high amount of rainfall as it helps the water infiltrate the soil. She usually uses fertilisers two or three times per year. The farmer was asked about how she manages the soil and how she chooses where to plant things. She said that species to be planted on each of the farmland area are randomly selected based on free space on the farm, regardless of the soil type. She said that the growth rate of species depends a lot on the quality of the seedlings. She also said that there is not much difference in how she manages the different soils but compost and manure will be applied to some more than others. Where soil types 2 and 3 exist on her farmland the land was said to be sloping, so she makes the land between rows of crops lower in order to hold the water for longer.

Two farmers talked of four main stages of ploughing the land after leaving fallow for one year (this land was said to be more productive than land that is not fallowed):

1. Tsigie – the ploughing of the land for the first time after the fallow. In this stage, weeds and grasses are uprooted in the months August and September.
2. Mieyam – the ploughing of the land for the second time. This makes the uprooted grasses and weeds to be covered with soil in order to speed up decomposition and add nutrients to the land. This process also helps to dry seeds of the weeds in order not to grow in the fields and is carried out in the months December and January.
3. Teskab – the third stage of ploughing and this time the land is prepared for the final time and works to dry the seeds of weeds that have not yet been dried.
4. Zerie – the ploughing for sowing of the crops.

Compost and manure

One farmer interviewed by Habtamu, Emiru and Tesfaye said that sheep and goat manure is enough for the soil on his farm.

The first farmer interviewed by Nuraini and Hoa explained that she prepares compost from ash, animal manure and grass on the farmland around the household compound. The compost is left in a pit for some time before mixing with soil and taking to plough into the farmland to improve the fertility of the soil, which is normally 2-3 times per year when it rains. Because of transportation issues, the compost is only applied to the farmland near the household compound.

The second farmer interviewed by Nuraini and Hoa said that he prepares compost from the animal manure and leaves of existing species on his farmland except from the eucalyptus tree as he described its leaves 'to be like plastic' in the way that they do not decompose easily or quickly, and crops do not grow well on compost prepared with these leaves.

The second farmer interviewed by Emelda and Muluberhan told them that he prepares compost from weeds and easily decomposable soft leaves of plants – not from leaves that are hard like those of guava and eucalyptus trees. He also said that he does not use inorganic fertilisers and manure together at the same time because when there is high rainfall, the agricultural crops will grow too fast and the actual productivity becomes small due to less time spent on forming the grain, whilst in cases of low rainfall, the crops will not grow and will have low productivity. He classified the available animal manures on his farm into three categories based on their importance:

1. Manure obtained from chickens (highly important)
2. Manures obtained from goats and sheep (moderately important)
3. Manure obtained from cattle (important)

Feedback session with farmers

On the last day of the training course, the students were required to feed back some of their key findings to the farmers they had interviewed over the two week period. This is an important part of the research process because it allows those who have been interviewed to verify what has been gathered from the interviews; it also encourages dialogue between local people and researchers. Too often researchers extract from communities and do not properly inform them about the results or what will happen next with that information.

All eight farmers managed to attend the feedback session and we had an Assistant Professor (Aklilu Habtu) of Social Anthropology from Mekelle University to translate for us. It took approximately one hour for each group to present their findings, ask the farmers if they had anything to add or comment on, and then finish up with thanks for their participation and contribution.

Plate 8. Feedback session with the eight farmers interviewed in Abreha We Atsbeha village. Photographs taken on 22nd June 2012.

Group 1 started the session with a discussion of the main drivers of vegetation cover change over the last 50 years by presenting extracts of causal diagrams generated in their knowledge base and drawn on flip chart paper. Group 2 then discussed the positioning of trees on farms and which species appear where and for what reasons. Group 3 presented their findings on tree utilities and which species were being used for what purpose according to the interviews they had conducted; the object hierarchies they had developed in their knowledge base were drawn on paper to discuss with the farmers and add to where necessary. Group 4 ended the feedback session by bringing in their findings about which fodders were being used for different livestock; they had drawn lists based on the object hierarchies they had created in their knowledge base. Overall, the farmers felt that the students had well represented what they had said in their interviews and had some more information to add during the discussions; it was a very worthwhile exercise that everyone benefited from. This sort of feedback is encouraged during any future research under the AfricaRISING project.