Local Knowledge of Farmers on Opportunities and Constraints to Sustainable Intensification of Crop-Livestock-Trees Mixed Systems in Basona Woreda, Amhara Region, Ethiopian Highlands

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Plates: Photos of Goshe bado and Gudo beret, Basona woreda. Taken by Anne Kuria, August 2013

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Through action research and development partnerships, Africa RISING will create opportunities for smallholder farm households to move out of hunger and poverty through sustainably intensified farming systems that improve food, nutrition, and income security, particularly for women and children, and conserve or enhance the natural resource base.

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1. INTRODUCTION

Agriculture in the 21st century faces multiple challenges: it has to produce more food and fibre to feed a growing population with a smaller rural labour force, more feedstocks for a potentially huge bioenergy market, contribute to overall development in the many agriculture-dependent developing countries, adopt more efficient and sustainable production methods and adapt to climate change (FAO, 2009b). As the world's human population of over 7.3 billion is expected to hit 9.1billion by 2050, food needs have also increased. Maintaining the momentum of growth in agricultural productivity will remain crucial in the coming decades as production of basic staple foods needs to increase by 60 percent if it is to meet expected demand growth (FAO, 2009a). With farming being the dominant land use in Ethiopia, options for increasing food security and improving livelihoods include agricultural land expansion which has led to deforestation and loss of important ecological goods and services; and intensified agricultural production., which has led to land degradation and exhaustion leading to a decline in land productivity (Bishaw, 2001) (Oba & Kotile, 2001)

Extensive agriculture involves expansion into new lands, but the competition for land from other human activities makes this an increasingly unlikely and costly solution, particularly if protecting biodiversity and the public goods provided by natural ecosystems is given higher priority (Millennium Ecosystem Assessmen, 2005). Therefore, intensive agriculture remains the most viable solution to increasing food production. Traditionally agricultural intensification has been defined in three different ways: increasing yields per hectare, increasing cropping intensity (i.e. two or more crops) per unit of land or other inputs (water), and changing land use from low- value crops or commodities to those that receive higher market prices. However, these approaches have negatively affected the environment, hence the need to undertake agricultural intensification sustainably (Pretty, Toulmin, & Williams, 2011). Sustainable agricultural intensification therefore is defined as producing more output from the same area of land while reducing the negative environmental impacts and at the same time increasing contributions to natural capital and the flow of environmental services.

Ethiopia's economy and the wellbeing of its people are closely linked to agriculture and the use of natural resources, hence the Ethiopian Government launched innovative approaches that include a "Climate Resilient Green Economy" initiative which include implementation of agroforestry practices,

conservation agriculture, reforestation of degraded lands and land affected by gullies and slopes including exclosures. In line with this initiative, the Africa RISING project focuses on sustainable intensification (SI) of mixed tree-crops-livestock systems in the Ethiopian highlands at the household scale, with impacts ultimately geared towards influencing change at the landscape scale in the long-run. Sustainable intensification will very often involve more complex mixes of domesticated plant and animal species and associated management techniques, requiring greater skills and knowledge by farmers. To increase production efficiently and sustainably, farmers therefore need to understand under what conditions agricultural inputs (seeds, fertilizers and pesticides) can either complement or contradict biological processes and ecosystem services that inherently support agriculture ((Pretty, Toulmin, & Williams, 2011); Settle and Hama Garba, 2011). Therefore, in order to understand the complex interactions between all the main components of smallholder mixed farming systems, the World Agroforestry Centre (ICRAF) has been undertaking local knowledge studies to elicit local knowledge of farmers regarding how they understand and interact with resources that their livelihoods depend on. This was done in the eight AfricaRISING (AR) sites in the Ethiopian highlands, with two sites being located in each of the four main regions of Ethiopia namely: Tigray, Amhara, Oromo and the Southern Nations, Nationalities and People's Region (SNNPR). This report presents results from two of the AR sites located in Limo woreda (Jawe and Upper gana kebele) , located in the SNNPR region.

Conducted under the Africa RISING project, the overall objective of the study was to characterize local knowledge of farmers about resources which their livelihood depends on. This research is one of the several studies that are geared towards contributing to the achievement of sustainable tree-crop-livestock intensification as a pillar for the Ethiopian Climate Resilient Green Economy Initiative by providing opportunities for integrating early win tree species and management options in fields, farms and landscapes customized to local conditions and circumstances. Through identifying opportunities through which trees-crop-livestock mixed system can be sustainably intensified, this will contribute towards achieving whole System Level Outcomes (SLO's) namely: reducing rural poverty and promoting income diversification, improving food security, improving nutrition and health and ensuring sustainable management of natural resources. Sustainable intensification of these mixed farming systems will be achieved by expanding the scope of options promoted by the Africa RISING initiative, and by targeting species and management options appropriately to specific site conditions and farmer circumstances.

1.1 Specific objectives of the study were:

1. To assess land use and livelihood strategies at the household level
2. To identify and map out community resources
3. To determine temporal variation in availability of provisioning resources (fodder, crops, fuel)
4. To characterize existing tree cover and assess the drivers of land use/ tree cover change
5. To identify existing challenges and assess opportunities for sustainable intensification

1.2 Research Questions

1. What is the range of land use and livelihood systems in the Limo and Basona woreda?
2. What are the main resources farmers utilize and when in the year are they available?
3. What functions do trees play in farmers' livelihoods in these sites?
4. How have tree cover and land use systems changed over time?
5. What are the constraints to agricultural intensification and what are opportunities for intervention?

2 RESEARCH METHODOLOGY

2.1 Study area characteristics

Basona woreda is one of the woredas in the Amhara Region of Ethiopia. Located at the eastern edge of the Ethiopian highlands in the Semien Shewa (North Shewa/ Shoa) zone (Figure 1), Basona woreda is bordered on the south by Angolalla Tera, on the southwest by the Oromia Region, on the west by Siyadebrina Wayu, on the northwest by Moretna Jiru, on the north by Mojana Wadera, on the northeast by Termaber, and on the east by Ankober. Amharic language is spoken in this woreda.

Figure 1: Map of Basona woreda showing Goshe bado kebele (green) and Gudo beret kebele (blue)
Source: Debre Birhan Bureau of Agriculture

Additional background information of Basona woreda sites is presented in table 1 below.

Table 1: Gudo beret and Goshe bado kebele background information

BASONA WOREDA	Goshe bado Kebele	Gudo beret kebele
Agroecological zones	Dega-15%, Weynadega- 65%, kola-20%	Dega-75%, Weynadega-22%, kola-3%
Population	Male -2680, Female-2492	Male-2689, Female-3035
Household numbers	Male-1401, Female-471	Male-1093, Female-336
Total Areas of kebele	4477 ha.	5540 ha.
Topography	Undulated- 50%, valley-25%, plain-22%	Undulated-75%. Valley-25%
Altitude	2790 masl	3084masl
Cultivated land	1680 ha.	2734 ha.
Grazing land	1972 ha.	923 ha.
Forested land	137 ha.	1418 ha.
Bushland	551 ha.	24 ha.
Mount and rugged	318 ha.	
Wasteland	442 ha.	325 ha.
Home construction	375 ha.	116 ha.
Others	311 ha.	

Source: Goshe bado and Gudo beret administration offices

Kei for altitudes: - dega- 2300-3200 masl, weyna dega-1500-2300/2400 masl., kola- 500 - 1500/1800masl

2.2 AKT Methodology

The Knowledge Based Systems (KBS) approach developed at Bangor University was used for collecting local knowledge about agricultural intensification on mixed crop-livestock-tree systems. This study was guided by local knowledge elicitation guidelines (Pratap *et al.* 2009; Sinclair and Walker 1998; Walker and Sinclair 1998); where three stages namely: scoping, definition and compilation were undertaken (Figure 2). Local knowledge elicitation exercise took place between August 19th to September 13th, 2013. Various activities of AKT methodology undertaken are highlighted below.

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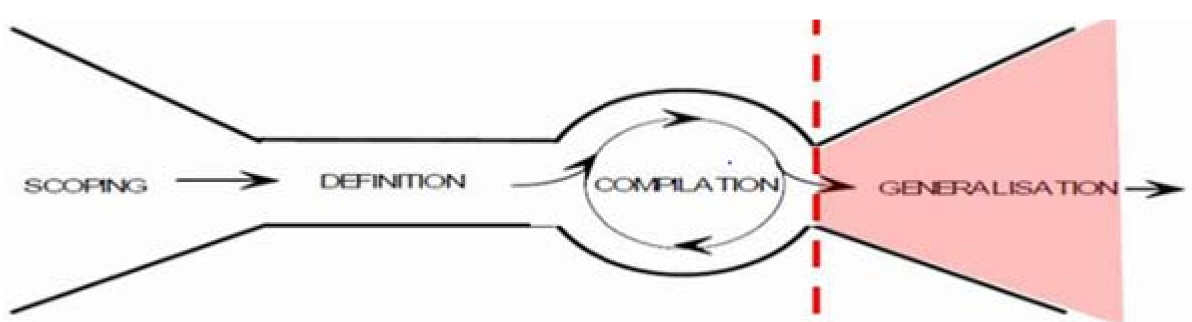

Figure 2: Local knowledge elicitation stages Source (Sinclair & Walker, 1998; Walker & Sinclair, 1998)

Scoping Stage: At this stage, activities included:

- Transect walks were conducted at the initial stage for the team to familialize themselves with the landscapes and dominant landuses, which also helped to guide stratification (Figure 3a). Kei informant interviews were held with agricultural officers and development agents working with crop, livestock, and natural resource management departments. This exercise helped to characterize the landscape and predominant land use issues, and informed the stratification and sampling design for the major interviewing stage.

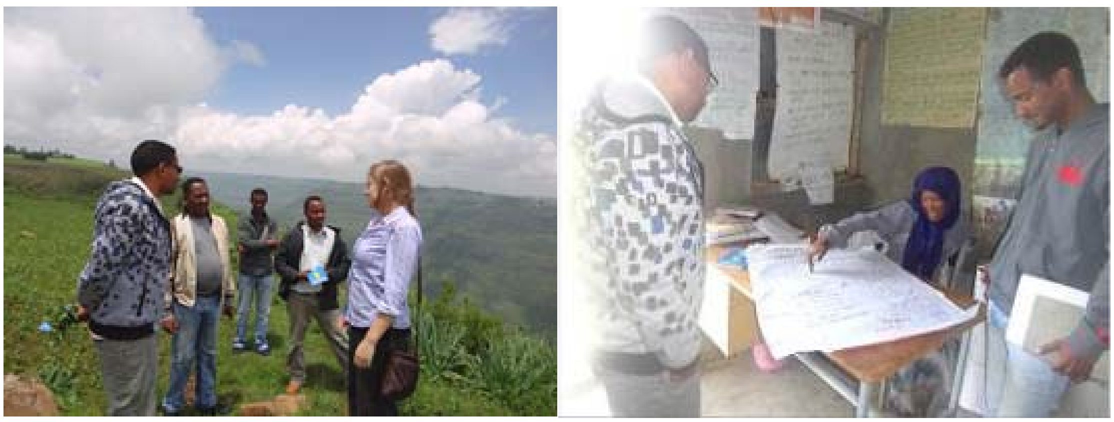

Figure 3: Genevieve Lamond (AKT local knowledge expert based in Bangor University), Beneberu Teferra (Debre Berhan Agricultural Research Center), Yibrah Birhane (Basona woreda agricultural officer), Diriba Nigusie (Forest Research Centre, Addis Ababa) and Temesgen Alene (Debre Birhan research centre) accompanying Anne Kuria for transect walks in Goshe bado kebele (right); and Development Agent-NRM explaining to the local knowledge team about the three watersheds where soil and water conservation measures are being implemented in Goshe bado kebele; Photos by Anne Kuria, August 2013

Definition stage

This stage was undertaken to define knowledge boundaries, and the strata. During this stage, farmers were selected for focus group discussions and household interviews to characterize land use and livelihoods at the landscape level and individual farm level respectively. The 2 kebeles in each woreda had been pre-selected during project inception stage based on various criteria including farmers having at least 25% land under wheat production. Also, another criteria was previous or current engagement with National Agricultural Research System (NARS) and partner programmes in order to capitalize on potential synergies with existing activities; and previous and current engagements with Agricultural Growth Program (AGP) activities - USAID-supported initiatives. Also, the two kebeles selected were

further differentiated in terms of market access because access to markets is one of the major drivers of intensification that is relatively easily and rapidly assessed.

Focus group discussions (FGDs) were conducted whereby farmers participated in various activities such as: participatory village resource mapping, historical timelines, seasonal cropping calendars and land use and livelihood mapping (Figure 4). These activities helped to characterize farmers' access to resources and livelihood strategies.

Figure 4: Temesgen Alene moderating resource map drawing in Gudo beret and Goshe bado kebeles, Basona Photos by Anne Kuria, August 2013

Compilation Stage

This stage was achieved through an iterative approach involving eliciting and recording knowledge from individual farmers, then evaluating the knowledge obtained, then going back to the same farmers to probe for more indepth information or clarifications until the desired information was obtained. Activities undertaken during household interviews included.

- Farm characterization was done through drawing farm sketches with the farmers or generally identifying and describing resources found on the farm such as niches with trees on farm, soils, crops, livestock and other resources.
- Also undertaken was landuse and livelihood analysis with the aim of synthesizing information about the use of land and other resources by the different groups of farmers within each kebele in order to understand the various dimensions of farmers' livelihood strategies and associated opportunities and constraints.

- In order to assess the role of trees on farmers' livelihoods, tree species identification and assessment of utilities and services exercise was carried out.
- Tree management and phenology- in order to assess farmers capacity to maintain trees onfarm and in landscapes;
- Seasonal calendars of fodder, fuelwood, and other tree products were undertaken in order to assess the availability of these products throughout the year; and identify opportunities (gaps) for future interventions

Local knowledge interviews should minimize farmers' disruption of their working schedule. Weather permitting, interviews were carried out outside the farmers' house and on the farmer's land so that it was easy for both the farmers and the interviewers to visualize resources being talked about and could refer to such resources explicitly (Figure 5).

Figure 5: ICRAF's Anne Kuria and Yibrah Birhane (Basona woreda agricultural officer) conducting interviews in Goshe bado kebele as the interviewee weeds her wheat field (left); and interviewing a farmer while grazing his livestock in Gudo beret kebele Photos by Anne Kuria, August 2013

2.3 Sample stratification in Limo woreda:

- **Villages on opposite directions from the kebele trading centre and along varying altitudes**: Goshe bado kebele was characterized by mainly flat terrain, while Gudo beret is gently sloped. The kebeles were expansive on both sides of the market centres, with varying altitudes on either directions, hence it was hypothesized that farmers had different knowledge and experiences. Therefore, 2 sub-kebeles were selected from either side of the village market centres, one near the kebele centre and one further away. In Goshe bado,

farmers were selected from Hudad Amba and Kirtie sub-kebele; while in Gudo beret, farmers were selected from Mushi and Gina beret sub-kebeles.

- **Gender**-Men and women played different roles within the farming system, and often had varying access to and control over resources. Hence it was hypothesized that they held varying knowledge on the same. Equal number of farmers were selected from each strata, with consideration being put on gender (Table 2)
- **Age**- It was hypothesized that knowledge differed with age; with older farmers having more elaborate knowledge especially with regards to the drivers of land use change; while younger farmers could hold more knowledge about agricultural technologies etc.
- **Wealth status**- Also, consideration was placed on wealth/ resource endowment variations among farmers (low, medium, high) mainly through selecting farmers with small, medium and large household land holding. It was hypothesized that access to land influenced farmers' land-uses, production, income and livelihood strategies; and influenced the way they related to resources. Table 2 below shows the stratification criteria and number of interviewees involved in the exercise.

Table 2: Farmer stratification criteria

Activities	Goshe bado kebele		Gudo beret kebele	
Meet/ Interview with kei informants/ transect walks/	2 Development Agents's		3 Development Agents's- crop, livestock, NRM	
	Men	Women	Men	Women
Participatory resource mapping	Hudad amba-5 Kirtie-5	5-Hudad Amba 5-Kirtie	Gina-4 Mushi-4	Gina-5 Mushi-3
Historical timeline	HA-5& Kirtie-5	HA-5& Kirtie-5	4 gina-4mushi	4 gina-4mushi
Seasonal crop calendar	HA-5& Kirtie-5	HA-5& Kirtie-5	4 gina-4mushi	4 gina-4mushi
Livestock feed calendar	5	5	5	4
Land use and livelihood	5	5	5	5
First interviews farmers	5	5	5	5
Second interviews farmers	3	4	4	3
Nursery survey	2			
Feedback discussion	6	7	7	6

3 RESULTS

This section presents findings from local knowledge elicited from farmers in Basona woreda in two kebeles namely Goshe bado and Gudo beret. Areas covered in this section are: participatory resource mapping, farm characterization, landuse and livelihood strategies, crop and livestock husbandry and interactions, drivers of landuse change, trees and associated management and challenges and opportunities to sustainable intensification.

3.1 Participatory Community Resource Mapping

During FGDs, farmers engaged in drawing village resource maps. As mentioned earlier, farmers in each kebele were stratified into two groups (mixed gender) from sub-villages on either sides of the main kebele trading centre. The map below (Figure 6) shows how farmers visualized resources that their livelihoods depend on; mainly influenced by the level of interaction they have with the resources from the kebele.

3.1.1 Gudo beret kebele

Social amenities: Gudo beret was located along a tarmac road. There was a kebele administrative office, a veterinary office. There was a market which serves all su-kebeles, situated just along the main road. There were also mosques, churches, kebele health centre

Government forest

Gudo beret kebele had patches of government forest mainly comprising of *Eucalyptus globulus, Eucalyptus camaldulensis* and *Cupressus lusitanica*. Initially, the government forest was called the 'firewood project', which was planted during Emperor Menelik II's rule – under a programme that aimed at improving household energy/ firewood. However, it is currently called the Amhara Region Forest Enterprise. The plantations serve the wood product processing firms in Debre Birhan and neighboring towns. Although the community was not allowed to cut trees from the government forest, they were allowed to collect firewood and eucalyptus leaves which they used and some sold the surplus for income.

Natural forest: There was no natural forest within Gudo beret kebele. There was however a natural forest called 'Mufasha' found outside Gudo beret kebele, located at the border of the upper catchment, belonging to Awash watershed. At the time of the study, this forest had native tree species such as *Erica arborea, Erythrina abyssinica, Olea europaea subs. cuspidata, Juniperus procera, Hagenia abyssinica,*

Cordia africana, Ficus thonningii and *Acacia abyssinica* among others; and was sometimes utilized by farmers when they needed unique products such as medicinal herbs and firewood.

Community forest: There was a community forest at the upper end of the kebele in Gina sub-kebele. It was owned by 20 farmers who planted both *Eucalyptus globulus* and *Eucalyptus camaldulensis* in 2000. They plan to sell the trees once mature and share the benefits equally. Other forests existing in the kebele were mainly woodlots owned by individual farmers.

Communal grassland: There was a grassland at the upper end of the kebele mainly containing 'gwassa' grass, whose main utility is for thatching houses. Occasionally the farmers sold the thatching grass to nearby towns. However, during periods of extreme drought, farmers fed the grass to livestock under 'cut and carry' system when there was no other source of fodder.

Water resources: Farmers identified about 4 rivers traversing downwards along the kebele from the upper to lower catchment (Figure 6). However, farmers observed that due to the prolonged effects of having Eucalyptus plantations, rivers were drying up, and water flow leverls had reduced gradually. There were atleast five springs which provided clean drinking water to the farmers, but similar to rivers were also drying up. During extremely high rainfall, there were occasional landslides along Tach mush river.

Irrigation schemes: Farmers in the lower catchment practiced irrigation, mainly of irish potatoes and vegetables for income and also to increase food available for home consumption. Irrigation opens up opportunities for crop diversification thereby improving household nutrition and increasing income.

Tree Nurseries: There was a government tree nursery under the Bureau of Agriculture in Mushi sub-kebele which was started with support from SUNARMA (sustainable natural resource management). It lacked variety/ species diversity with only seedlings from afew species planted namely: *Grevillea robusta*, elephant grass, 'Yekeberit inchet', vertiver grass, *Cupressus lusitanica, Arundo dona.* It served the entire kebele, hence was not adequate for the entire population.

Cooperatives: There was a potato cooperative located in Mushi sub-kebele. It was mainly utilized to market farmers potato produce collectively, and also farmers who wished to plant quality potatoes derived their potato seed here. Also, farmers utilized the membership to the cooperative to receive training.

Farmer Training Centre: There was a kebele FTC for demonstrations on farming best-practices such as: row planting, and the function of various soil erosion control structures such as: soil bunds, stone bunds, micro-basins, trenches. However, the facility was not fully utilized.

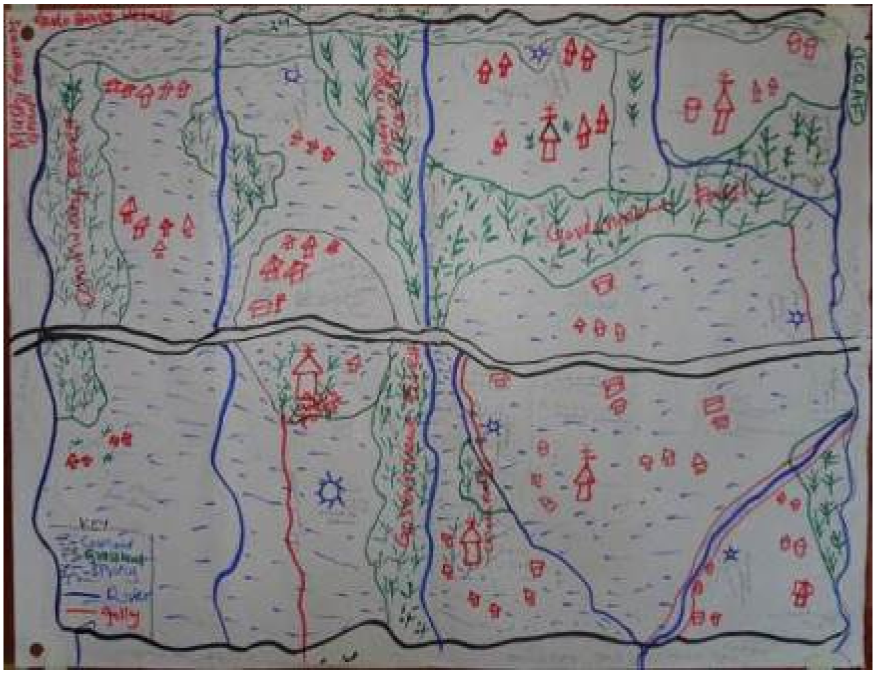

Figure 6: Gudo beret village resource map done by Mushi sub-kebele farmers Source: farmers

Checkdams: Due to proneness of the kebele to erosion including gully erosion, check dams had been constructed by the government with partnership from community on various parts of the kebele (Figure 7)

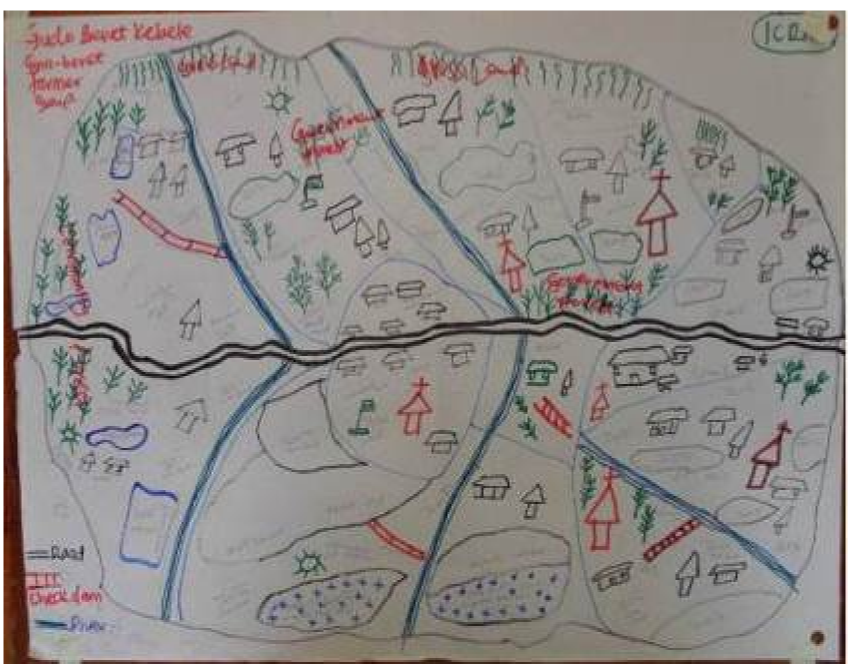

Figure 7: Gudo beret village resource map done by Gina beret sub-kebele farmers Source: farmers

3.1.2 Goshe Bado kebele

Social amenities: Goshe bado kebele was accessed located on a murram / dirt road, about 8km from Debre birhan town, it took farmers about 3-4hours to walk from Goshe bado to Debre birhan town. It was accessible by use of horse/ donkei carts, by foot, and few public transport vehicles that passed nearby on their way to other major towns. Due to the nature of the soil, the road were almost impassible at some points during heavy rains, due to the sticky soils and flooding/ poor drainage, making transportation of goods and services to and from the market very challenging. There was a health centre, kebele administration offices, FTC, cooperative, youth centre and school. However, there was no veterinary service, and could only be outsourced from Debre birhan town.

Forest resources: There was no government forest in Goshe bado kebele. Farmers from Hudad Amba sub-kebele identified two community forests (Figure 8), which hosted rare species that were either or almost becoming extinct in the area. Churches also played a kei role in conserving tree species diversity, especially for unique native species namely: *Rosa abyssinica, Erica arborea, Capparis tomentosa, Ekebergia capensis, Millettia ferruginea, Phoenix reclinata, Podocarpus falcatus, Salyx mucronata, Senna siamea, Syzygium guineense, Acacia melanoxylon* and some unidentified species namely: 'umbus, 'keret', 'sheweshewe', 'belshe', 'weil', 'shinote', 'kase', and 'tomit'.

Water resource: There was one main river 'chacha' passing across the lower part of the lower catchment, and was infact the border line of Goshe bado and other kebeles. There were two other small rivers (mostly seasonal passing on one side of the kebele. About 5 springs were identified scattered across te kebele, which provided water for home consumption.

Irrigation schemes: Some farmers were harvesting water for irrigation. Crops grown included: vegetables such as onions, kales, cabbages and temperate fruits such as *Malus domestica* (apples), *Prunus persica* (peach) and *Casimiroa edulis.*

Grazing land: There was no communal grazing land. However, grazing was being done on open areas.
Gullies: Several gullies were identified, which have led to decreased size of arable land due to loss of soil (Figure 9).

Figure 8: Goshe bado village resource map done by Kirtie sub-kebele farmers Source: Farmers

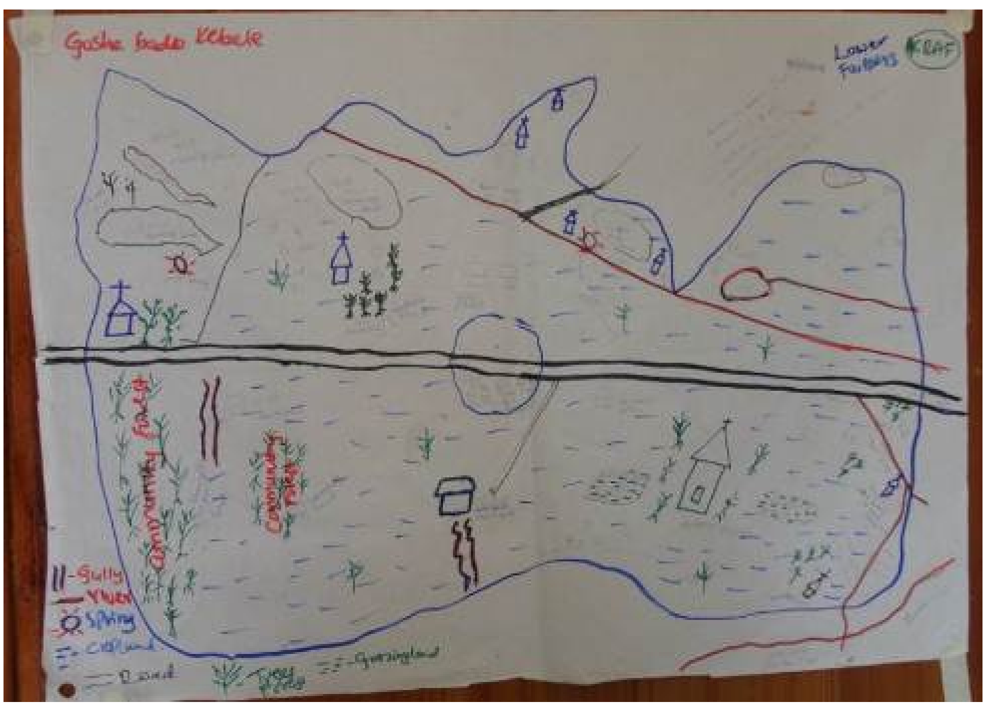

Figure 9: Goshe bado village resource map done by Hudad Amba sub-kebele farmers Source: Farmers

3.2 General farm layout/ sketch

Basona woreda was a highly intensified farming system within small private land holdings, with the average land holding of farmers interviewed in Goshe bado kebele being 1.5ha. (ranging from 0.5ha. to 3ha.), while that of Gudo beret was 0.9ha (ranging from 0.5ha to 1ha). Unlike Limo woreda, fields in Basona woreda were highly fragmented, with farmers holding an average of four fields per household. It took farmers between 5 to 30 minutes to reach their several fragmented cropfields. Figure 10 below shows one farmer who has four land parcels of land.

Crop rotation was practiced, with farmers alternating legumes with cereals and other crops. Farmers planted as many crops as possible. In Goshebado, some farmers retained certain trees in the cropfields. However, in Gudo beret, trees were mainly retained around the homestead as live fence- alongside stone/brick fences, and in woodlots (Figure 10). There were no trees/ live fences along cropfield boundaries, but most farmers used dead fence from branches of thorny trees such as *Acacia abyssinica*. Kubet and livestock were enclosed within the homestead.

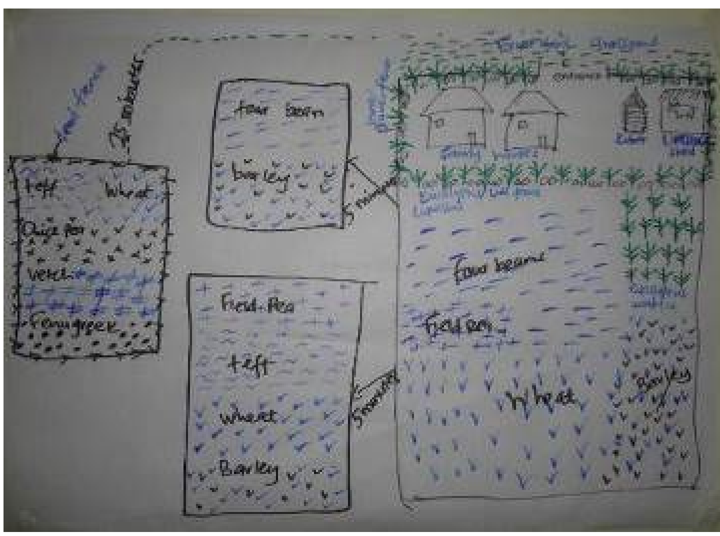

Figure 10: Farm sketch in Goshe bado kebele and Euphorbia candelabrum (kurkual) fence around a homestead Source: a farmer Photo by Anne Kuria, August 2013

3.3 Landuse and Livelihood Strategies

Information gathered during focus groups (resource mapping, cropping calendar) and individual household interviews about the use of land and other resources by different genders of farmers within the kebeles was synthesized to create a landuse and livelihood diagram (Figure 11). Soil and water

conservation was the role of men. Soil and water conservation activities were mainly undertaken between January and February when there were less agricultural activities taking pace on farms.Hence men should be targeted when implementing such strategies

Men also had control over tree resources: planting, management and sale of products. In crop production, men had major roles of ploughing land, planting and harvesting while women mainly weeded. Women had more roles in the homestead including management of vegetables. Children played supportive roles

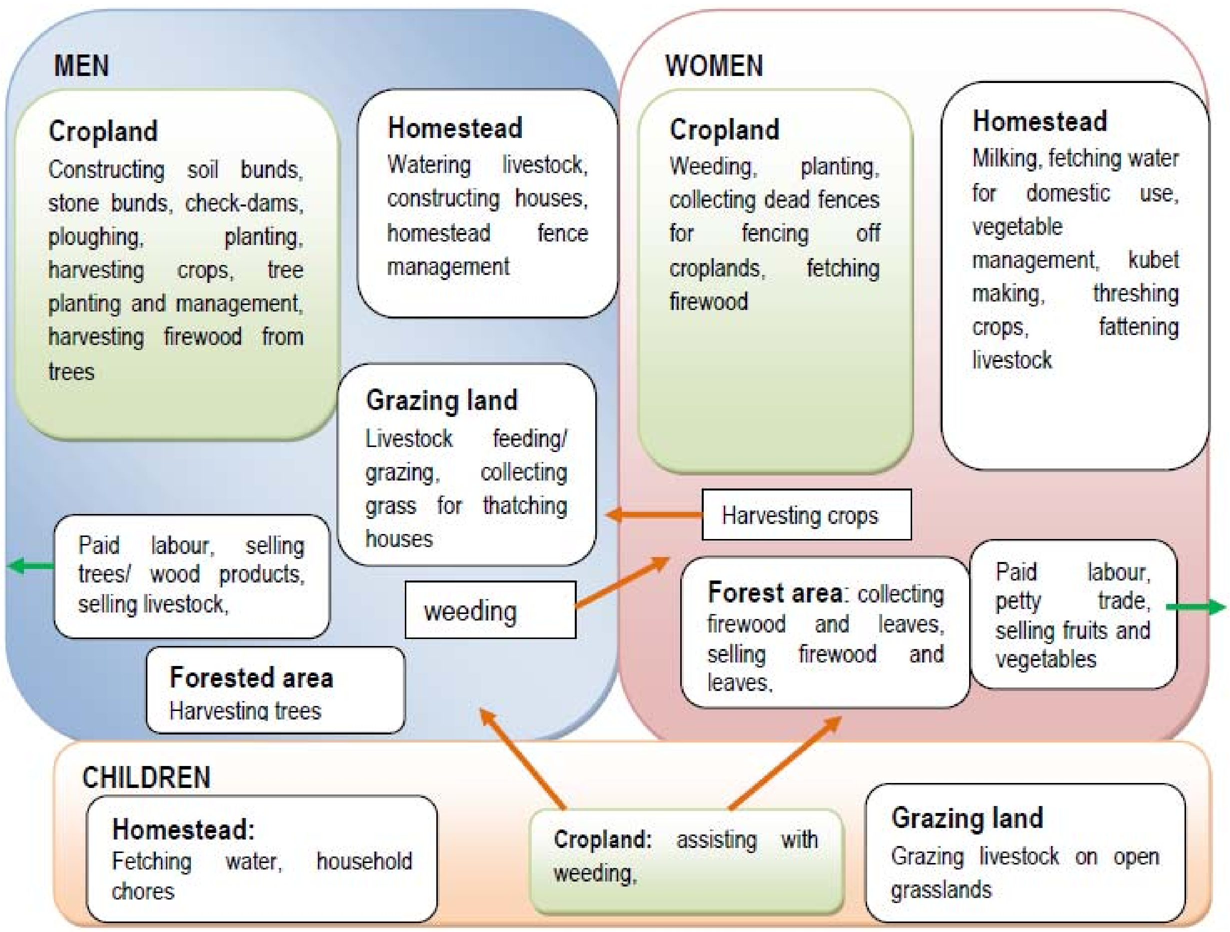

Figure 11: Land use and livelihood diagram of farmers in Basona woreda

Source: farmers
Key: Blue- flow of materials, Green arrows- income/ sale

3.4 Common knowledge held by farmers in different stratification criteria

As had been hypothesized, farmers in different strata held varying knowledge about the mixed farming system as highlighted below:

Gudo beret farmers: Farmers noted that 'tukur afer' soil experienced water logging when there were heavy rains, leading to destruction of crops. Also, frost was a serious problem affecting crop productivity due to the high altitude of the area. There was also high prevalence of crop and livestock diseases. Soil erosion was also a serious, and the farmers understood how erosion control structures functioned, hence were adopting both physical structures and biological measures such as planting tree Lucerne (*Chamaecytisus proliferus)*. Farmers in this kebele also highly engaged in income generating activities such as labour, selling livestock; especially due to the easy access to markets because of tarmac roads. They also experienced food scarcity from July to October, especially due to their small household land sizes. Also due to their small pieces of land, continuous cultivation of land had resulted into loss of soil fertility hence less crop productivity. **Goshe bado farmers-** Water logging of 'tukur afer' was high leading to loss of crops. Further, broadbed furrows when constructed along the slope were termed as an effective technology helping them to reduce the effects of flooding on crops, hence increasing productivity. Kei afer was termed as being more fertile than tukur afer, hence more productive. There were no significant difference in knowledge held by farmers between both sub-kebeles per kebele.

Gender: Common knowledge held by men included: crop production challenges namely: high disease prevalence of crops and livestock, erosion, and continuous cropping leading to less production. Food was therefore scarce from July to October. To cope with food shortage, men engaged in selling livestock, and paid labour. Women on the other hand were more concerned with the water logging challenge of 'tukur afer' soil and its low productivity compared to 'kei afer'. They resulted to buying of food in times of food shortage.

Land size: Farmers with small land holdings (< 0.5 ha.) held knowledge on: soil erosion was sever due to over cultivation and they were planting tree Lucerne along stone bunds to control erosion; local livestock breeds were less productive, food scarcity led to them buying food. In addition, farmers with <1ha. had knowledge about water logging, high crop and livestock disease prevalence, effects of frost on reducing crop productivity, and food scarcity. They engaged in paid labour and selling livestock. On the

other hand, farmers with land >1.6 ha had soil as the main issue of concern, that is, its fertility, erosion and general management.

Age: Farmers aged <40 years, farmers were more conservation conscious- soil erosion was their main concern and were employing mechanisms such as: planting tree Lucerne along stone bunds, vertiver grass along contour lines, establishing checkdams on gullies and cut-off drains across slopes, with the ultimate goal of reducing surface run-off and stabilizing and saving soil from erosion. Farmers aged between 41-50 years- were more knowledgeable with water logging challenge, soil erosion challenge, and loss of soil fertility due to continuous cropping. They were also engaging in paid labour in order to get income to buy food. Farmers aged >51 years- faced food scarcity and bought food, and were concerned about reduced crop productivity due to crop and livestock diseases and frost. They also benefited from broad-bed furrows on 'tukur afer' soil to control water logging and reported that tukur afer was also less fertile than 'kei afer'

3.5 Soils

Soils are the natural resource that holds/ hosts crops from planting to maturity, hence influence crop growth. With sustainable intensification, soil is repeatedly and continuously put into use at an intensified basis. Therefore, understanding indicators of soil quality was an important step to addressing challenges that are soil-related; and in designing appropriate soil management options for Basona woreda such as: which soil was affected by water logging, which one was less fertile hence required more inputs/ fertilizer, which soil needed more erosion control measures to be put in place among others, and one that would require specific management actions such as drainage and aeration.

Soils are locally known as 'afer' in Amharic language. Basona woreda had a dominance of poorly draining vertisols. Farmers classified soils into eight distinct textures, with Goshe bado soils being classified into only 2 main textures while in Gudo beret, a total of 7 soil textures. Table 3 below gives a description and characteristics of soil textures encountered in Basona woreda.

Table 3: Soil classification by farmers

Soils in Goshe bado kebele	Soils in Gudo beret kebele
Tukur afer: dark/ blackish in colour. It is found at the upper part of the field if sloped. It is less fertile than kei afer. It also has high clay content and is water logged which leads to flooding if the field is flat. It Cracks when dry and has more erodibility than kei afer	**Tukur afer:** Black in colour, has high clay content hence it is prone to landslides due to high water retention capacity. It is more fertile than most soils if well drained. More fertile than temenie.
Kei afer- it is red and found on the lower part of the field if sloped, usually after continuous deposition of fertile top-soils from upslope. It is more fertile than tukur afer	- **Kei /Bunama afer**: This soil is brown in colour, and has loam dominance. It is more fertile than temenie afer
-	**Abolsei afer:** This soil is a mixture of temenie afer and kei afer. It is well drained with high rate of water infiltration. It has low erodibility. It is more fertile than tukur, bunama and marare afer
-	**Temenie afer:** This soil has loam dominance with gravels. It is more fertile than tukur afer. It has a higher erodibility than tukur afer
-	**Marare afer**- has high clay dominance and the highest water logging ability. It is less fertile than abolsei afer
-	**Chewama afer:** Infertile, sandy texture, usually utilized for grasslands
-	**Baha afer**: This is characterized by sandy loam. Slightly more fertile than chewama but less fertile than the rest of the soils in this area

3.6 Crop production

3.6.1 Crops cultivated

Farms in Basona represent a highly intensified farming system. The main crops grown in Goshe bado were: fava bean, wheat, barley, field pea, chick pea, teff, vetch, and fenugreek. Income / cash crops were: fava bean, vetch, and fenugreek. In Gudo beret, the main crops grown were: wheat, fava bean, chick pea, teff, barley, irish potatoes, field pea, lentils, linseed, (garlic, cabbage, beet root, onions). Main income crops were: fava bean, irish potatoes, and barley. Irish potatoes, vegetables and fruits were normally grown under irrigation.

Table 4 below shows the cropping calendar of the three main crops in each kebele. There was no difference in the cropping calendars in both kebeles.

Table 4: Cropping calendar for Gudo beret and Goshe bado kebeles

		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Who?
Ploughing	Wheat	X		X	X	X							M
	Barley	X		X	X								M
	Fava bean	X			X								M
Planting	Wheat						X	X					M&F
	Barley					X	X						M&F
	Fava bean					X	X						M&F
Weeding	Wheat								X	X			**F**,m
	Barley							X	X				**F**,m
	Fava bean							X	X				**F**,m
Harvesting	Wheat											X	**M**,f
	Barley										X	X	**M**,f
	Fava bean										X	X	**M**,f

M-Male, F-Female, C-Children

3.6.2 Crop production technologies

Ethiopian National Research Institutes, Departments of Agricultural Extension and other partners were at the time of this study employing various approaches and technologies aimed at improving crop productivity in the kebeles as highlighted below:

1. **Row planting:** -Row planting of crops ensured easy management of the crops, hence reducing disturbance/ destruction of some crops when weeding.

2. **Crop rotation-** Development agents were encouraging farmers to rotate crops by alternating legumes and cereals to maintain soil fertility. Due to small land holdings in Basona woreda, farmers did not leave land fallow, hence soil got exhausted.

3. **Broad Bed Furrows (BBF)**- Due to the water-logging nature of the black clay soils/ vertisols especially in Goshe bado kebele, farmers were being trained on and encouraged to adopt broad bed furrows, which were meant to drain excess water from the cropland (Figure 12a), thereby preventing rotting of crops and boosting growth and yields (Figure 12b). The furrows bed should be 80cm wide and 15cm high, with the space between furrows being 20cm wide. Another success of this technology is that it allowed farmers to plant their cereals timely, especially wheat which did not tolerate excess water. Many farmers were adopting this technology, although some especially those with larger fields felt it was labour intensive, hence they may not apply this technology effectively across all fields that may require this intervention.

Figure 12: Wheat on flooded field; and on Broad Bed Furrows in Goshe bado kebele.
Photo by Anne Kuria, August, 2013

4. **Broad Bed Makers (BBM)-** This is a mechanized version of Broad Bed Furrows and applies the same principles. To test the technology, a few farmers were provided with the broad bed maker (Figure 13); but some observed that due to the sticky nature of vertisols, it was difficult to make furrows using the makers, hence farmers were using the non-mechanized BBF technology instead

Figure 13: Basona woreda agricultural officer – Yibra demonstrating how a Broad Bed Maker (BBM) is used Photo by Anne Kuria, August 2013

5. **Rain water harvesting/ irrigation:** In order to enhance food security and promote income diversification from crops, the government of Ethiopia had been promoting water harvesting activities. Some farmers had already adopted this technology and were reaping benefits from diversifying their farming to include horticultural/ income oriented crops such as vegetables (irish potatoes, spinach, onions, carrots, tomatoes) and fruits. Diversification of crops also led to improved nutrition for smallholder households, especially children. Figure 14 below shows examples of water harvesting structures being constructed by farmers: conventional water

harvesting pond in Gudo beret (left), polythene membrane in Goshe bado (centre) and concrete water harvesting pond in Goshe bado (right).

Figure 14: Water harvesting techniques in Goshe bado and Gudo beret kebeles
Photo by Anne Kuria, August 2013

3.6.3 Soil and water conservation measures

Due to the dominance of vertisols in the kebeles, coupled with continuous cropping and the absence of adequate soil and water conservation measures, soil erosion was encountered across the farms and landscapes. For flat-lying areas such as Goshe bado, sheet and gully erosion were more common, while in Gudo beret, rills formed by fast flowing surface runoff resulted into gullies (Figure 15b). Not only did erosion lead to loss of soil nutrients, it also led to loss of cultivatable land/ soil (Figure 15a), thereby reducing land under crop cultivation.

Figure 15: Chunks of land lost to erosion (left); and siltation along a gully in Goshe bado Photos by Anne Kuria

Various measures, both physical and biological, were being employed to prevent soil erosion and to help conserve soil. The main physical structures constructed were: check-dams to control gully erosion

(figure 17), cut off drains; soil bunds and stone bunds (Figure16). In order to strengthen and stabilize the physical structures, biological measures were employed namely: planting *Aloe vera (16a)*, tree Lucerne, *Sesbania sesban*; and grasses such as vetiver, phalaris and rhodes grasses

Figure 16: Aloe vera strip and stone bunds in Goshe bado; Soil bunds in Gudo beret
Photos by Anne Kuria, August 2013

Gully erosion was controlled by construction of checkdams which helped in controlling the speed of runoff, soil interception and eventually healing of the gullies (Figure 17). Sand bag, loose stone and gambion checkdams were the main types being used in these areas.

Figure 17: Gambion check dam on fresh gully (left) and gully already healing through loose stone check dam (right) in Goshe bado   Photos by Anne Kuria, August 2013

The main function of these physical structures, which are usually were constructed across the slope in the upper parts of the field/ landscape was to reduce the speed of surface runoff, and enhance soil interception and water infiltration, thereby reducing soil erosion as illustrated in the AKT diagram on figure 18. These physical structures were being reinforced using biological measures such as planting trees and grasses along the soil and water conservation structures. The role of biological interventions was to stabilize soil along the physical structures; and also to reduce the speed of surface run-off, thereby increasing the infiltration rate of water, which resulted into high interception rate of the soil. This in return reduced loss of soil and ultimately lowered severity of soil erosion, which led to availability of more soil nutrients to crops, thereby boosting productivity.

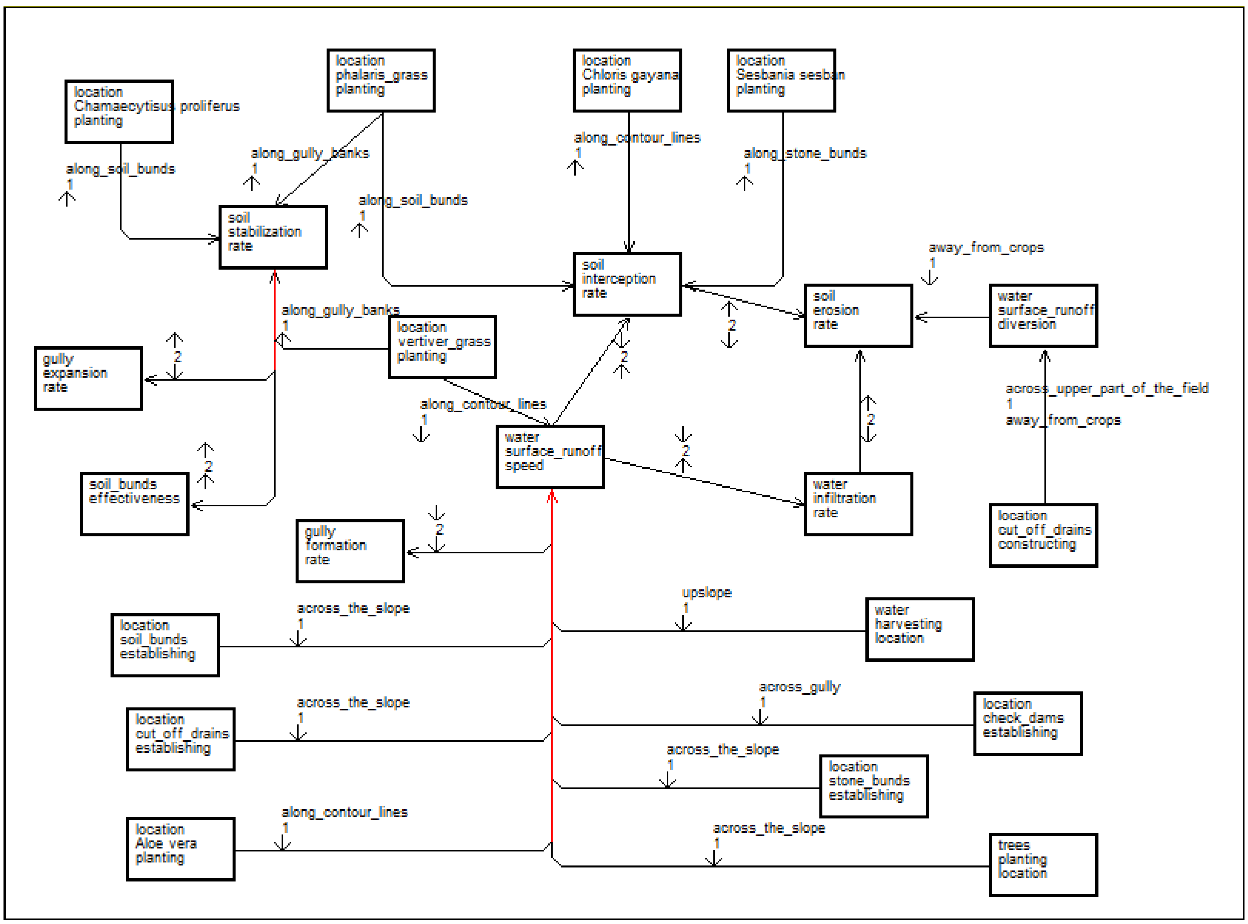

Figure 18: AKT Diagram on soil and water conservation measures in Basona woreda
Source: basona_africarising.kb
KEY: Nodes represent attributes of objects, processes or actions. Arrows connecting nodes show the direction of causal influence. The upper small arrow on a link indicates either an increase (↑) or decrease (↓) in the causal node, and the lower arrow refers to the effect node. Numbers between small arrows indicate whether the

relationship is two-way (2), in which case an increase in A causing a decrease in B also implies that a decrease in A would cause an increase B, or one-way (1), where this reversibility does not apply.

3.6.4 Other challenges facing crop production

Farming communities in Basona woreda were heavily dependent on cereal and pulse production. Although various technologies were being employed to improve productivity of these crops, low yields were reported by farmers in both kebeles. They attributed this to various drivers discussed below and illustrated in AKT causal diagram below (Figure 19).

- The main challenge affecting crop productivity as reported by majority of farmers from both kebeles was crop diseases and pests. Crops most severely affected were fava bean, wheat and barley. Diseases named included: fava bean yellow rust, potato, onion and garlic root rot, potato light blight. Two categories of pests were reported, that is, those that affected crops while growing in the field, and post-harvest pests. Such pests included: arphids (all cereals and pulses), african ball worm (affecting crops in the lower catchment only) such as fava bean, lentils, chick peas, field pea.

- Decreasing household land holding as a result of human population increase had led to reduced size of cropland; hence less volume of crops grown. Further, reduced household land holding had made farmers to cultivate crops continuously with no fallow periods leading to low soil fertility, which causes reduced crop yields.

- Frost was also mentioned as adversely affecting the growth and productivity of crops. Frost was most severe in the uppermost areas of Goshe bado and Gudo beret including Gina beret sub-kebele (higher altitude)

- In Goshe bado especially, the dominant tukur (black/vertisol) soil, resulted into water logging due to its high clay content and flat nature of the terrain. This led to flooding which caused rotting of crops while growing in the field resulting into poor growth and yield.

- Farmers reported that rainfall had become unimodal since 1977 Ethiopian calendar when there was severe drought countrywide. Unimodal rainfall had resulted in one single planting season (meher) which led to low annual crop yields; and also erratic rainfall led to low crop productivity as crops lacked adequate moisture necessary for optimal growth.

- As highlighted earlier, due to the dominant vertisols in these areas, high rainfall intensity, coupled with the sloped nature of terrain especially in Gudo beret, and low ground cover causesd soil erosion. Absence of adequate soil and water conservation measures further worsened the situation.

- Also, due to absence or low tree density onfarm and on the periphery of farms, strong winds destroyed crops.

- By some farmers not applying fertilizers as per the recommendations by DAs resulted into low crop yield.

- DAs reported that due to limited labour availability, some farmers did not weed their crops, or ended up weeding late, which led to competition of nutrients by weeds leading to low crop yields.

The AKT diagram (figure 19) below shows causal linkages of factors affecting crop productivity/ yields.

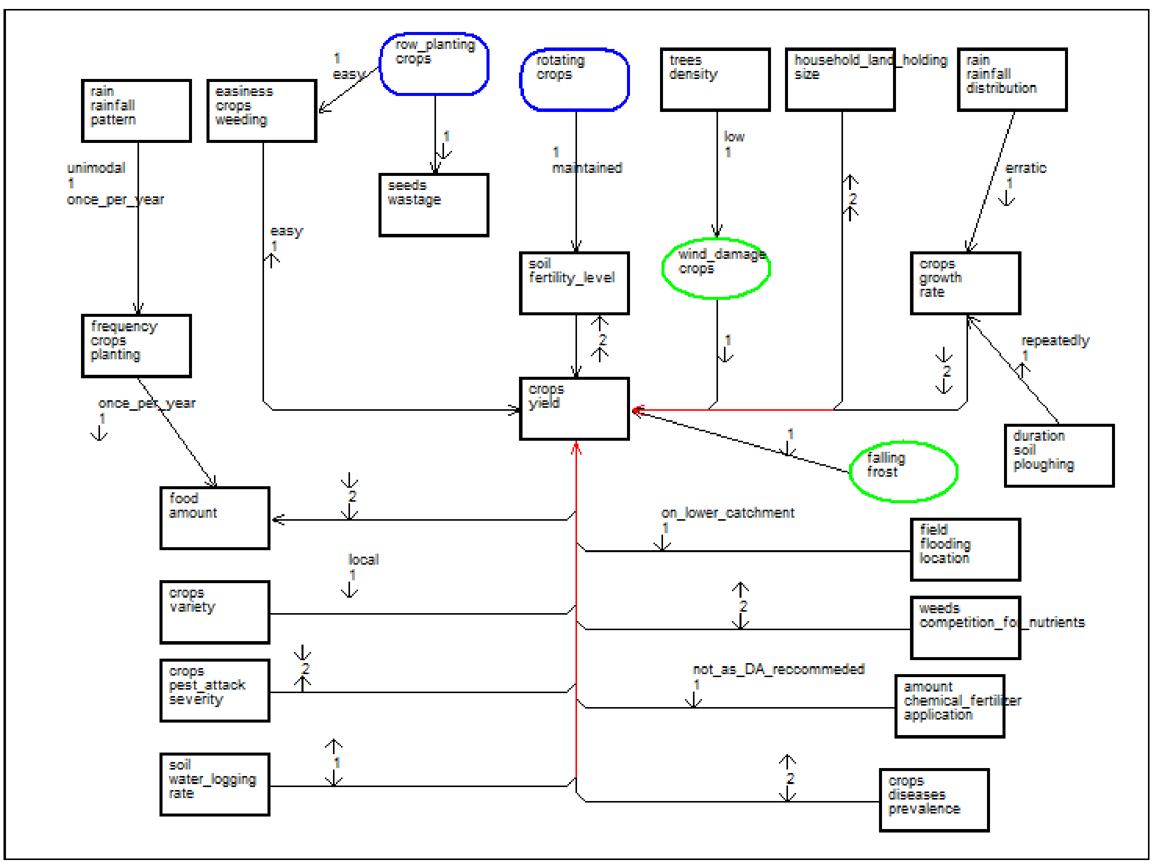

Figure 19: AKT causal diagram on factors affecting crop production Source: basona_africarising.kb

KEY: Nodes represent attributes of objects, processes or actions. Arrows connecting nodes show the direction of causal influence. The upper small arrow on a link indicates either an increase (↑) or decrease (↓) in the causal node, and the lower arrow refers to the effect node. Numbers between small arrows indicate whether the relationship is two-way (2), in which case an increase in A causing a decrease in B also implies that a decrease in A would cause an increase B, or one-way (1), where this reversibility does not apply.

3.6.5 Coping mechanisms during food insecure months

Farmers in Goshe bado and Gudo beret reported that they experienced food shortage mainly from July to October. During food scarcity periods, farmers used the food stored from the previous harvest, and to supplement this, they employed various coping mechanisms namely:

1. Selling livestock, especially cows and sheep
2. Engaging in paid labour within or outside of their kebele
3. Selling eucalyptus timber and firewood; and also eucalyptus leaves collected from the government and community forests for use as fuel.
4. Petty trade such as: selling beer made from gesho tree (*Rhamnus prinoides*)
5. Renting out land to other farmers

3.7 Livestock

The main livestock reared in both Goshe bado and Gudo beret kebeles were: cows, oxen, sheep, donkey and chicken. Crop residues were the main source of fodder for livestock for majority of the farmers, being utilized for about six months annually (table 5). Majority of times, hay was mixed with crop residues and local beer products made from by-products of barley and *Rhamnus prinoides* tree leaves in order to improve the nutritional value of the feed (Figure 20). Other fodder sources included grasses, tree fodder and weeds from crop fields (Figure 21). There was low diversity of tree fodder, with mainly *Chamaecytisus proliferus* (tree lucerne) being the most commonly utilized fodder tree species (Figure 21b).

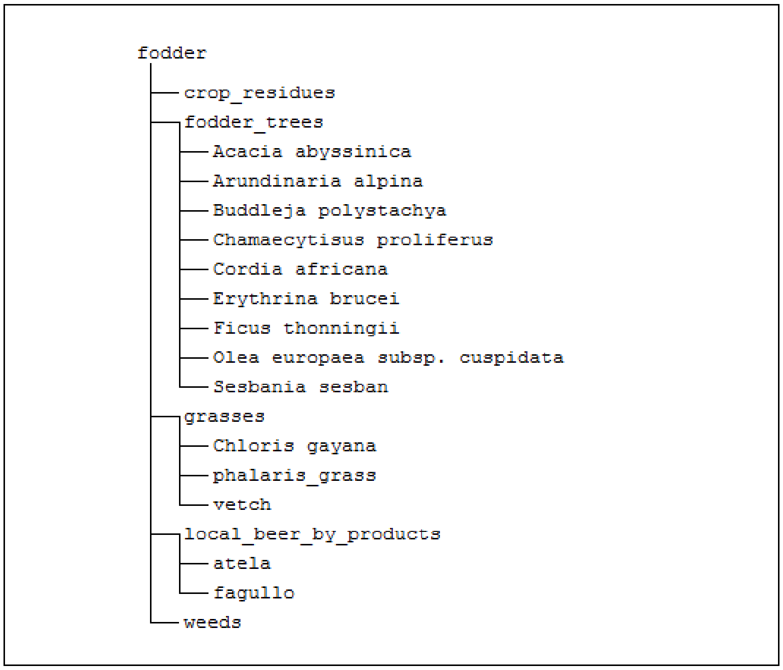

Figure 20: AKT output tree showing fodder sources for livestock in Basona woreda Source: basona_africarising.kb

Figure 21: Grasses from wheat field (left) and tree lucerne fodder in Goshe bado (right) Photos by Anne Kuria

Fodder scarcity period for both kebeles was July and August, though Goshe bado had a longer fodder gap extending from June upto September (table 12). In Gudo beret, farmers coped further by planting oats for use as fodder during the critical period (July and August) and supplement by open grazing of livestock.

Table 5: Fodder availability calendar for Goshe bado and Gudo beret kebele

Key: Dark green- months that majority of farmers use the fodder, Light green- months that minority of farmers use the fodder. Yellow represents months of fodder scarcity reported by majority of farmers. Source: farmers interviews

Various factors had influenced fodder availability and amount, and ultimately livestock productivity and numbers as discussed below:

- Dead fences, mainly comprising of thorny acacia species were used to keep livestock away from the fields. There were woodlots, mainly comprising of Eucalyptus species

- Due to increased human population and the need for increased crop production, conversion of vast individual grasslands into cropland and other uses gradually led to decreased availability of fodder, which forced some farmers to reduce the number of livestock. There were no communal grazing lands left in both kebeles; hence during periods of fodder scarcity, farmers grazed their livestock along the roads/ paths, on any open area and on marginal lands left fallow.

- The current situation in Basona woreda was that lack of alternative fodder sources had led to over-reliance on crop residues as the main fodder source (supporting fodder needs for even upto six months), hence trading off the traditional soil nutrient improvement role of these crop residues, especially for legumes. Crop residues were traditionally left on the fields after harvesting crops, hence they released nutrients to soil, conserved soil moisture and prevented surface runoff; roles that have been lost by competition for fodder

Apart from fodder scarcity, other challenges facing livestock included:

- Diseases- especially affecting sheep, chicken and cows. Diseases resulted into loss of livestock through death, while some diseases reduced livestock productivity and quality of products.

- Local livestock breeds, especially of sheep and chicken were also blamed for the low productivity

- Shortage of water also led to less livestock productivity, and in some cased death due to prolonged drought. Furthermore, some farmers had resulted to reducing livestock to manageable numbers in order to cope with water shortage. Ultimately, decreased number or poor productivity of livestock adversely affected livelihood dynamics, since livestock was a source of food, manure and income

3.8 Community knowledge exchange groups

- **Model farmers:** Nine model farmers were selected from each kebele to be the avenue through which new technology were introduced to the villages. Three farmers planted fava bean, three wheat and three planted irish potatoes. The concept of '1 into five farmer' concept meant that the other four farmers were required to follow the model farmer closely in order to learn the technology, which they then replicated on their individual farms. The experience seemed hopeful in scaling up ideas and approaches, though some farmers reported that some of their group members were not keen to learn and replicate the technologies.

- **Cooperatives:** There were cooperatives in both kebeles, with the main ones focusing on distributing of fertilizers and improved seeds and herbicides to farmers. In Gudo beret kebele, there was an irish potato cooperative, which is actively involved in collective selling of potatoes and in preserving and selling potato seeds the following season.

- **Membership to various community groups:** Just like in Limo woreda and indeed many parts of the country, farmers belong to various informal groups. Ikub- is a rotating credit association which helps to raise fund for farmers to engage themselves in small-scale businesses and agricultural development, house construction among others.

3.9 Drivers of land use/ tree cover change

In Goshe bado, tree cover and land use mainly changed during the transition from Haile selasie to Derg regime, due to factors discussed in kb diagram (table 6 and Figure 22). Farmers reported that during

Haile selasie era, that is, before 1973, many native tree species existed. It is during the Derg regime (1974-1991) that native tree species were replaced by massive Eucalyptus plantations. Native trees (many of which were viewed as slow growing and with low income potential) were gradually replaced by plantations onfarm, especially *E. globulus* which were fast growing and had high income potential, introduced and promoted by an NGO called in 1973 ec.

In contrast, farmers in Gudo beret reported that their landscape was bare, with very few tree species even during Haile selasie era. It is infact during the Derg era that tree density increased, mainly when *Eucalyptus* species were introduced by the government under the fuelwood project. The government established these *Eucalyptus* plantations on marginal/ uncultivable land such as in the very steep and rocky areas. This had a negative impact on the ground water sources, with river flow and number of springs reducing (Figure 22). Later, farmers began planting Eucalyptus on their farms, either in woodlots or along boundaries of home compounds for timber and firewood products. In the Derg era, cropland and grazing land were insignificantly transformed (table 6), major changes began occurring during the **Ethiopian People's Revolutionary Democratic Front** *(*EPRDF) era (1991), mainly catalyzed by increased human population and change in policies. The table below shows a summary of changes in landuses.

Table 6: Historical timeline for tree cover/ land use change in Goshe bado and Gudo beret kebeles

Goshe Bado kebele	Gudo beret kebele
Haile selasie era (1930-1974)	**Haile selasie era 1930-1974)**
Eucalyptus species had been earlier promoted by Emperor Menelik II – under a programme that aimed at improving household energy/ firewood. However, there were still many native tree species in Derg era, hence tree products and services were available.	According to farmers, during Haile Selasie era, the only trees found onfarm in Gudo beret kebele were: *Erica arborea* (mainly for charcoal), *Hagenia abyssinica, Juniperus procera* and *Rosa abyssinica* (fruit)
Derg regime -1974-1991 (1967- 1983 e. calendar)	**Derg regime -1974-1991 (1967- 1983 ec)**
Crops: Due to land availability during the Derg regime, farmers in Goshe bado kebele maintained soil fertility through practicing fallows. As such, there was no need to use chemical fertilizers as soil was fertile. -Also, there were less pests and diseases	**Crops:** There was no soil erosion, land slides and flooding and land degradation, hence crop productivity was high. In the Haile selasie and Derg era, soil was fertile due to fallow periods due to land availability
Livestock: There was high individual land holding hence farmers had set aside vast areas for grazing their livestock. As a result, there were more livestock owned per household. However, diseases were prevalent and there were no veterinary services- was only found in Debre birhan	**Livestock:** Although there was no free grazing, farmers were allowed to cut and carry grass from communal grazing land. There was abundant fodder. Though livestock numbers were high, there was low productivity as the breeds were poor/ local.
Forest/ tree cover: Tree cover began transforming during Haile selasie- Derg era transition period in	**Forest/ tree cover:** before the Derg regime, there were few trees and larger croplands. However,

early 1970s. Forests were converted to crop land due to increased population. Eucalyptus destabilized the area by depleting the soil of nutrients and water, and there was loss of diversity of tree products, due to loss of native species.	during Derg regime, farmlands were lost to pave way for establishment of government forest under the firewood project. Massive *Eucalyptus* and *Cupressus lusitanica* plantations were established.
Water resource: During the Haile selasie era, there were many springs and river flow volume was high and reliable. However, with the introduction of massive **Eucalyptus** plantations, springs decreased in numbers and discharge rate; while rivers dried up and water flow reduced at alarming rates There was high rainfall intensity due to presence of a stable climate. There was good distribution of the rainfall throughout the planting seasons. In this era, rainfall was bimodal, which enabled farmers to plant crops twice per year until 1977ec, when there was drought countrywide, and after which rainfall became unimodal.	**Water resources:** Similar to Goshe bado, Gudo beret farmers reported that due to the establishment of massive *Eucalyptus* plantations in the derg era, the number of springs reduced drastically and river flow decreased.
EPRDF regime 1991 – 2001 (1983-1993 ec)/ present	**EPRDF regime -1991 – 2001 (1983-1993)/ present**
Crops: Continous cropping led to loss of soil fertility, resulting into reduced crop yields Also, loss of many tree species in the Derg era that were earlier used as mulch such as *Croton macrostachyus, Cordia africana,* and *Erythrina abyssinica* led to farmers relying more heavily on chemical fertilizers.	**Crops:** Cropland was reduced by increased number of settlements due to population increase. There was soil infertility due to continous cropping with no fallows due to reduced household land holding and loss on fertile top soil to surface runoff, aggravated by the hilly/ sloped nature of the terrain. -Further, absence of grasslands/ grass fallows onfarm as a result of conversion into cropland led to increased flooding. Grasses played a role in intercepting water. -Crop yield also decreased due to pests and diseases
Livestock: Due to decreased average land holding, livestock numbers drastically reduced due to scarcity of fodder	**Livestock:** Onfarm grasslands were lost with the establishment of eucalyptus plantations, which led to farmers reducing livestock numbers. Also, eucalyptus suppressed growth of grasses under canopy. There were more improved livestock breeds. There was bee keeping in the natural forest neighboring the kebele.
Forest/ tree cover and water: Fueled by the need for income, many farmers began establishing eucalyptus plantations on their farms. As a result of prolonged effects of vegetation change, rainfall patterns changed from bimodal to unimodal, which led to only one planting season	**Forests/ tree cover and water:** On-farm tree planting – Eucalyptus globulus began, hence more cropland was lost leading to decrease in crop production. *Eucalyptus* species competition with crops led to drying up of springs and rivers. In 2008- in Gina beret- 60 farmers planted an additional 20ha of eucalyptus for income

Therefore, significant drivers (actions) highlighted in blue in the AKT diagram below represents the genesis of changes in tree cover and land use in Goshe bado and Gudo beret kebeles. As mentioned earlier, deforestation of native tree species in Goshe bado which was mainly linked to loss of products and ecological benefits of the trees; and introduction of massive eucalyptus plantations in Gudo beret which led to negative ecological changes; have shaped the history of landuse and livelihoods in these areas (Figure 22) Further, clearing of on-farm grasslands in Gudo beret resulted into decreased rain water interception and absorption in upper/raised areas, thereby resulting into flooding on the already water-logging-prone vertisols on the lowlands.

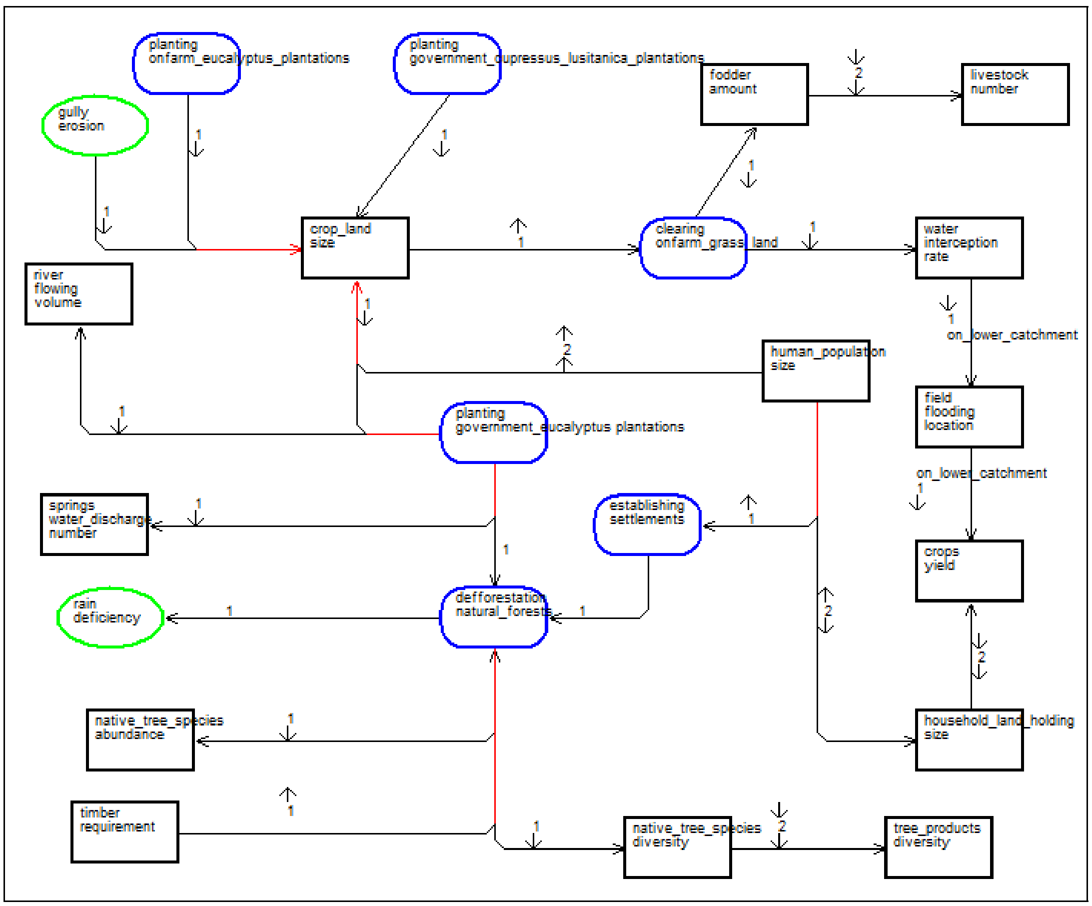

Figure 22: Causal diagram on drivers of land use / tree cover change in Goshe bado and Gudo beret
Source: basona_africarising.kb

KEY: Nodes represent attributes of objects, processes or actions. Arrows connecting nodes show the direction of causal influence. The upper small arrow on a link indicates either an increase (↑) or decrease (↓) in the causal node, and the lower arrow refers to the effect node. Numbers between small arrows indicate whether the relationship is two-way (2), in which case an increase in A causing a decrease in B also implies that a decrease in A would cause an increase B, or one-way (1), where this reversibility does not apply.

Farmers were able to visualize the changes in land uses as shown in figure 23 and figure 24. In Gudo beret, farmers drew a map showing a landscape dominated by cropand with low tree density, with numerous springs (stars) and rivers (in blue) and the current status of the kebele (figure 23 on the right). In Goshe bado, farmers drew a landscape dominated by three main landuses namely: natural forest, grasslands and cropland (figure 24 left); and showed the current status of the kebele (right) where cropland has replaced most of the tree and grasslands.

Figure 23: Tree cover increase from Derg era (left) to EPRDF era in Gudo beret (right)

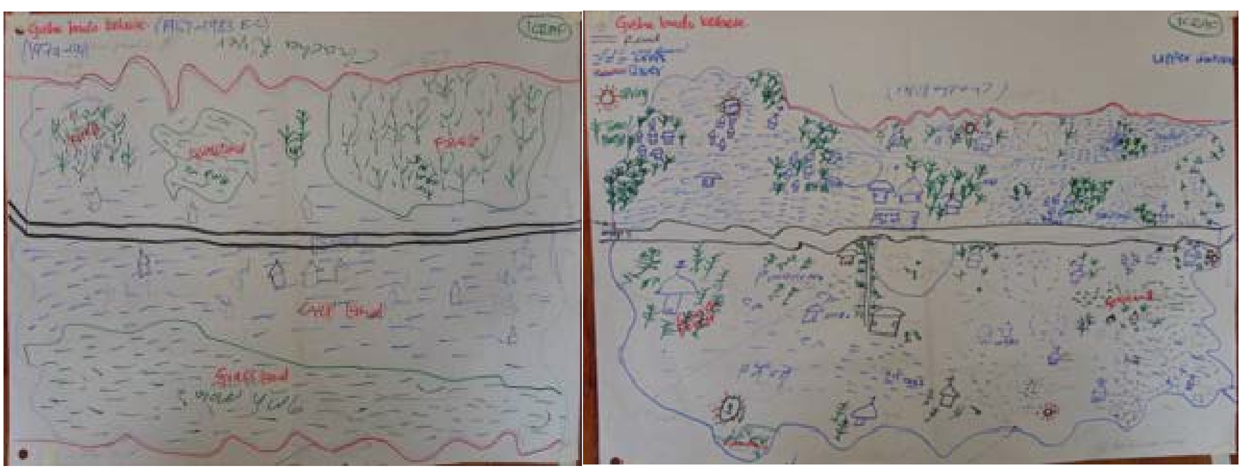

Figure 24: Tree cover and grassland loss from Derg era (left) to EPRDF era in Goshe bado (right)

3.10 Trees and Management

3.10.1 Tree diversity and Utilities

Basona woreda was characterized by low tree diversity per farm compared to Limo woreda; with *Eucalyptus globulus* being the dominant tree species while majority of the species were encountered in very low densities. A total of 55 species were encountered in both Goshe bado and Gudo beret kebeles, with only 35 of the species being encountered on farms (22 native, 13 exotic). The remaining 20 species, which were almost extinct, were encountered mainly in church compounds such as in the Orthodox church compound located in lower part of Goshe bado (Figure 25), and in low numbers on open areas along the main and other feeder roads.

Figure 25: Native trees in Goshe bado orthodox church (left); Basona woreda agricultural officer-Yibrah and Goshe bado NRM Development Agent Ms. Yeshewtshay picking tree samples (centre) and an elderly lady assisting in species identification in the Goshe bado Orthodox church compound (right) Photos by Anne Kuria, August 2013

Gudo beret kebele had extremely low tree species diversity, with only 13 tree species being encountered across all farms visited, with farms having an average of 3 species (ranging from 1 to 6 species per household). Thirty five species were encountered on farms in Goshe bado kebele, with an average of 8 tree species per farm (ranging from 2 to 18 species). The most dominant tree species in Gudo beret were: *Eucalyptus globulus, Sarcoca dodecandra* (endod) and *Discopodium penninervum* (ameraro). Most dominant species in Goshe bado were: *Eucalyptus globulus, Croton macrostachyus* (bisana), *Euphorbia candelabrum (*kurkual), *Cupressus lusitanica* (yaferenji tid), *Buddleja polystachya* (anfar), *Olea europaea subsp. cuspidata* (weira) *and Hagenia abyssinica* (kosso).

Income-driven tree species retention

Tree diversity in Basona area was mostly driven by market/ income potential, with *Eucalyptus* species and Rham*nus prinoides* (gesho- used for making local beer) being the main income generating tree species. Other income –oriented tree species encountered, though in low density on a few farms were fruit species such as: apple, peach, and kazmir, produced through irrigation (Figure 26). However, the fruits trees were prone to diseases; and were slow maturing, a challenge that was also reported by many farmers in Limo woreda. There was a timber/ furniture factory in Debre birhan, and farmers received timber buyers on their farms, usually the buyers interested in buying an entire *Eucalyptus* woodlot, hence the incentive for them to plant more eucalyptus.

Figure 26: Eucalyptus poles being harvested; and fruits under irrigation in Goshe bado.

Photos by A. Kuria, August 2013

Firewood was also a significant source of income (Figure 27), with the main firewood tree species in both kebeles being *Eucalyptus globulus*. Not only was the species readily available, but it is also reported to be fast growing, had high calorific value and long burn length compared to other species. *Eucalyptus* leaves were also utilized as fuel, especially in times of fuelwood shortage.

Figure 27.: Eucalyptus fuelwood for sale; and women returning with firewood fetched from a neighbouring government forest in Gina beret sub-kebele, Gudo beret.
Photos by Anne Kuria, August 2013

Majority of farmers, mainly women who experienced fuelwood shortage reported that July to August were the most critical periods due to onset of heavy rains. To cope with fuelwood shortage, women prepared '*kubet*'- cowdung fuel source (Figure 28); which is mainly prepared during the dry season and stored in readiness for the rainy season.

Figure 28: Cow dung used to make 'kubet' fuel (left) and storage 'kubet' in Goshe bado

Photo by Anne Kuria, August 2013

Fodder trees

Apart from tree lucerne, other fodder tree species were utilized in low rate such as: *Sesbania sesban*, *Erythrina brucei, Arundinaria alpina*, and *Buddleja polystachya.* Tree Lucerne was being promoted by the

government for fodder and soil erosion control, usually planted along soil and stone bunds and along gullies for rehabilitation purposes.

Timber trees

The most widely utilized timber species was *Eucalyptus globulus, Cupressus lusitanica* and *Juniperus procera. Eucalyptus* was described as fast growing and most common tree species on both kebeles, hence it was the most valued timber tree species. Some farmers preferred *Cupressus lusitanica* over *Juniperus procera* due to its faster growth rate.

Fruit trees

The main tree species encountered were apples; peach and kazmir were also found. There was extremely few encounters with fruit trees on many farms visited. Further, the density of those fruits encountered was low. Table 7 below shows tree species encountered in both kebele, their utilities, products, services and niches commonly found.

Table 7: Tree species products, services and niches commonly found

			Provisioning Services/ Products														Regulating Services					Common Positions on Farm						
Botanical Name	Amharic Name	Origin	Income	Fruit	Other foods	Fuelwood	Charcoal	Timber for Furniture	Poles & Timber for Construction	Timber for tool handles, utensils	Medicine	Livestock Fodder	Bee Forage	Live Fence	Dead Fence	F-Fibre, S-Soap, O-Oil, B-Beer, Se-Seed, B-Bread baking	Shade	Soil Erosion Control	Soil Fertility Improvement-Roots	Leaves	Streambank Stabilization	Boundaries	Home compound	Woodlot	Cropland	Open land	Along river banks	Kebele found
Acacia abyssinica	Girar	N				X	X			X		X			X		X	X	X	X			X		X			Goshe bado
Acacia Decurrens	Akacha/ Girar	E				X			X						X											X		both
Aloe vera	Eret	E									X							X	X			X			X			Goshe bado
Arundinaria alpina	Kerkha	N	X						X	X		X														X		Gudo beret-nursery
Buddleja polystachya	Anfar	N				X	X		X			X	X	X	X		X						X		X			both
Casimiroa edulis	Kazimir	E	X	X																								Goshe bado
Catha edulis	Chat	E	X																						X			Goshe bado
Chamaecytisus proliferus	Tree Lucerne	E				X						X	X		X			X	X	X			X		X			both
Combretum collinum	Tinjut	N																										Goshe bado
Cordia africana	Wanza	N	X					X		X		X	X		X		X			X			X		X	X		Goshe bado
Cordia africana	Wanza	N	X					X		X		X	X		X		X			X			X		X	X		Goshe bado
Croton macrostachyus	Bisana	N				X	X	X		X			X		X				x	X	X		X		X	X		both
Cupressus lusitanica	Yeferenj tid	E				X		X		X			X	X	X							X	X	X				both
Discopodium penninervium	Ameraro	N				X								X	X								X					both
Dodonaea viscosa	Kitkita	N					X			X																		Goshe bado
Dovyalis abyssinica	Koshim	N												X								X	X					Goshe bado
Enset sp.	Koba	N														B							X					both
Erythrina brucei	Korch	N								X		X	X						X	X		X			X	X		Goshe bado
Eucalyptus camaldulensis	Key Bahir zaf	E	X			X			X	X			X		X			X				X	X	X			X	both
Eucalyptus globulus	Nech Bahir zaf	E	X			X			X				X		X								X	X				both
Euphorbia candelabrum	Kurkual	N				X			X					X				X				X	X					Goshe bado
Ficus thonningii	Sholla	N		X				X		X		X										X	X		X		X	Goshe bado
Ficus thonningii	Sholla	N		X				X		X		X										X	X		X		X	Goshe bado
Hagenia abyssinica	Kosso	N	X			X			X						X	Se	X			X		X	X		X			Goshe bado

			Provisioning Services/ Products														Regulating Services					Common Positions on Farm						
Botanical Name	Amharic Name	Origin	Income	Fruit	Other foods	Fuelwood	Charcoal	Timber for Furniture	Poles & Timber for Construction	Timber for tool handles, utensils	Medicine	Livestock Fodder	Bee Forage	Live Fence	Dead Fence	F-Fibre, S-Soap, O-Oil, B-Beer, Se-Seed, B-Bread baking	Shade	Soil Erosion Control	Soil Fertility Improvement-Roots	Leaves	Streambank Stabilization	Boundaries	Home compound	Woodlot	Cropland	Open land	Along river banks	Kebele found
Hagenia abyssinica	Kosso	N	X			X			X						X	Se	X			X		X	X		X			Goshe bado
Juniperus procera	Yehabesha tid	N				X		X	X	X					X								X					both
Malus domestica	Pome/ Apple	E	X	X																			X					Goshe bado
Olea europaea subsp. cuspidata	Weira	N	X			X	X		X	X		X	X		X		X			X		X	X		X			Goshe bado
Populus sp.	Yekeberit inchet	E																										Gudo beret-nursery
Prunus africana	Tikur inchet	N	X			X	X		X	X					X					X					X			Goshe bado
Prunus persica	Kok	E	X	X																								Goshe bado
Rhamnus prinoides	Gesho	N	X		X									X								X	X					both
Ricinus communis	Gulo	N														O				X			X					Goshe bado
Sarcoca dodecandra	Endod	N											X			S	X						X					Goshe bado
Sesbania sesban	Sesbania	E										X						X		X					X			Goshe bado
Sisal	Kacha	E							X					X		F												Goshe bado

Species becoming extinct - not encountered on farms visited but found in low numbers along open areas and in an Orthodox church compound

Botanica name	amharic	origin	kebele
Rosa abyssinica	Kega	N	Goshe bado
Capparis tomentosa	Gora	N	Goshe bado
Coffea arabica	Bunna (lowla	N	Goshe bado
Ekebergia capensis	Lol	N	Goshe bado
Erica arborea	Asta	N	Gudo beret
Millettia ferruginea	Birbira	N	Goshe bado
Phoenix reclinata	Zimbaba	N	Goshe bado
Podocarpus falcatus	Zigba	N	Goshe bado
Salyx mucronata	Ahaya	N	Goshe bado
Senna siamea	Digita	N	Goshe bado
Syzygium guineense	Dokima	N	Goshe bado

Botanica name	amharic	origin	kebele
	Umbus	N	Goshe bado
	Weil	N	Goshe bado
	Keret	N	Goshe bado
	Omendila	N	Goshe bado
	Sheweshewe	N	Goshe bado
	Belshe	N	Goshe bado
	Kase	N	Goshe bado
	Shinote	N	Goshe bado
	Tomit	N	Goshe bado
	Gujo	N	Goshe bado

Common tree niches

- **Trees found around the homesteads**

Tree species retained in the home compound included: fruits, mainly apples; *Rhamnus prinoides, Chamaecytisus proliferus, Juniperus procera* and *Eucalyptus globulus.*

- **Boundaries of homesteads and crop fields**

In both kebeles, trees were mainly located around the homestead. *Eucalyptus globulus* was the main species planted along the homestead boundary. It grows tall and does not have the ability to form a dense live fence, hence stone/ gravel fence or dead fences were established at the base to serve the functions of a fence (Figure 29). Also, farmers retained *Cupressus lusitanica* and *Juniperus procera* species along homestead boundaries, not for live fence as the primary purpose but for the timber products, hence they were not managed at an early age, but were allowed to grow tall. In addition, *Euphorbia candelabrum* (kurkual) was also used as live fence in Goshe bado.

Figure 29: Eucalyptus globulus live fence, Goshe bado and dead fence, Gudo beret Photos by Anne Kuria, August 2013

There was heavy reliance on dead fence- for the compound and cropland boundaries. *Eucalyptus* branches/ leaves (Figure 30b) were used widely for dead fence around the home compound, with farmers reporting that it takes atleast 2 years for the leaves to decompose. Dead fence was also used to surround croplands to prevent browsing of crops by livestock (Figure 56b), with thorny species such as *Acacia abyssinica* (Figure 30a) being preferred. *Chamaecytisus proliferus, Cupressus lusitanica, Hagenia abyssinca* and *Croton macrostachyus* among others as listed in table 7 were also used as dead fence.

Figure 30: A boy carrying Acacia abyssinica braches for dead fence (left) and dead fence along the boundaries of cropland in Goshe bado Photos by Anne Kuria, August 2013

- **Woodlots**

  Woodlots, mainly comprising of Eucalyptus species, or Cupressu lusitanica were found across majoeity of homes, usually within the home compound or not very far away from the homestead.

- **Trees retained in crop fields**

Majority of fields in Gudo beret kebele had no trees retained on the cropland. In Goshe bado, tree species retained in the cropland were those compatible with crops and/ or had mulch that replenished soil fertility Though retained at low abundance, such species included: *Acacia abyssinica, Croton macrostachyus, Hagenia abyssinica, Chamaecytisus proliferus, Cordia africana* and *Sesbania sesban* (Figure 31).

Figure 31: Unmanaged Croton macrostachyus and Croton macrostachyus, Acacia abyssinica, Olea europaea and Hagenia abyssinica species retained on croplands in Goshe bado kebele Photos by Anne Kuria, August 2013

3.10.2 Tree Management and Phenology

Similar to Limo woreda, farmers in Basona woreda also gave inconsistent information on tree phenology (flowering, fruiting, leaf fall). Unlike Limo woreda, the practice of pollarding and pruning trees in cropland was not widely practiced in Basona woreda. Tree density on cropland was low, and in other cases, farmers had low knowledge on the impact of tree management on crop growth (Figure 31a above). Trees were mainly managed on a product-need kind of basis. *Eucalyptus* species, which had a fast growth rate after coppicing, were widely coppiced for timber, poles and firewood purposes (Figure 32). Some farmers had set aside some land for *Eucalyptus* woodlots; and reported that due to the fast growth of the species, they were able to get products and income within a short period. After coppicing, poles and timber could be harvested four and eight years respectively after coppicing.

Figure 32: Regeneration from coppiced Eucalyptus globulus in Goshe bado kebele

Photo by Anne Kuria, August 2013

3.10.3 Challenges and opportunities for tree integration in Basona woreda

Although some farmers had reservations to planting more trees on their farms mainly due to small land holdings and low exposure and knowledge on benefits of trees, some farmer were interested in planting or retaining more trees on their land. However, unlike in Limo woreda where farmers were interested in planting/ retaining trees for diverse needs, a trend emerged in Basona woreda whereby majority of farmers were interested in planting income-oriented tree species. This can be attributed largely to the availability and access to market for timber and firewood; and the fact that farmers in this area had not had much contact with many tree species due to absence of trees on their landscape for a long time.

Farmers who were interested in planting trees reported they would plant for various purposes namely:

- Income- *Eucalyptus globulus, Rhamnus prinoides*, fruits
- Fruits- apple, pome, peach
- Timber- *Eucalyptus globulus, Cupressus lusitanica, Juniperus procera, Cordia africana*
- Fodder- Tree lucerne

However, they listed various challenges that hindered them from integrating these trees on their farms namely:

- Limited household land holding discouraged farmers from planting more trees
- Lack of tree germplasm
- Low seedling survival due to browsing, especially tree Lucerne in Gudo beret
- Slow maturity of fruit trees and *Juniperus procera*
- Lack of water for irrigating seedlings and fruit trees

4. Discussions

4.1 Understanding drivers of land use change

Various factors were identified as causing land-use change in Limo woreda. Population pressure is a major driving force to land use change (Ningal, Hartemink, & Bregt, 2008), with extensification as a result of agricultural expansion coming largely at the cost of reduction in both woodlands and riparian forest, hence agricultural expansion is one of the drivers of land-use change (Wood, Tappan, & Hadj, 2004). Further, land fragmentation (Nagendra, Munroe, & Southworth, 2004) leads to fragmented and unsustainable land use practices. Given, however, the some-times large erosion-induced reductions in crop yields, it appears likely that erosion has a strong impact on land-use. Abandonment of arable land due to declining productivity is a landuse change that may result from soil erosion (Bakker et al., 2005).

Other drivers of landuse include changes in policies as experienced from the transition from Derg regime to EPDRF regime in Ethipopia; a factor that was also observed in Ghana, where national policies formulated led to changes in use of land (Braimoh, 2009). Further, change in climate, dating back from early 1980's in the study areas had a negative impact on crop productivity through changing rainfall patterns from bimodal to unimodal. The increasing surface temperature influences factors very relevant for food security such as precipitation, water availability, and weather extremes (Christoph Bals, Sven Harmeling, 2008). Adaptation to climate change requires substantive investments in infrastructure such as dams, flood-resistant storage facilities, and techniques for reducing water loss in distribution systems including the farm/crop system.

4.2 Different approaches to sustainable intensification

Sustainable agricultural intensification is defined as producing more output from the same area of land while reducing the negative environmental impacts and at the same time increasing contributions to natural capital and the flow of environmental services (Pretty, 2009). A sustainable production system would thus exhibit most or all of the following attributes: utilising crop varieties and livestock breeds with a high ratio of productivity to use of externally- and internally-derived inputs; avoiding the unnecessary use of external inputs; harnessing agro-ecological processes such as nutrient cycling, biological nitrogen fixation, allelopathy, predation and parasitism; minimising use of technologies or practices that have adverse impacts on the environment and human health; making productive use of

human capital in the form of knowledge and capacity to adapt and innovate and social capital to resolve common landscape-scale problems; and quantifying and minimising the impacts of system management on externalities such as greenhouse gas emissions, clean water, carbon sequestration, biodiversity, and dispersal of pests, pathogens and weeds. Traditionally agricultural intensification has been defined in three different ways: increasing yields per hectare, increasing cropping intensity (i.e. two or more crops) per unit of land or other inputs (water), and changing land use from low- value crops or commodities to those that receive higher market prices (Pretty et al., 2011).

4.2.1 Increasing yields per hectare while promoting environmental protection

Increasing yields per hectare of land is essential in order to optimize on the limited land resource in achieving food sufficiency. Agricultural technology has played a central role in overcoming food insecurity in this regard. Though many technologies and practices have been used in success project, the following three types of technological improvements have probably played substantial roles in food production increases: more efficient water use; improvement in organic matter accumulation and carbon sequestration; and reduced pesticide use (European Commission, 2006).

Presently, the world's population continues to increase, although at lower growth rates. On the other hand global food production is confronting issues such as climate change and the scarcity of water, land and energy resources. Fortunately, there are existing improved and promising technologies that could be employed to boost farmers' production and to increase their incomes, while ensuring environmental conservation. These are: genetic improvement; minimizing the effects of the scarcity of water, land, and labour resources; confronting the declining soil fertility, increased pressure from pests and diseases, and the degradation and pollution of environment and integrated crop management to close the yield gap and to increase farmer's income (Van Nguyen, 2006). For example, through adoption of good agronomic practices such as mulching and use of organic manure, sequestered carbon can be stored in the longer term as soil organic matter, which is a much larger and more stable pool of carbon. At the same time, it would contribute to more sustainable agriculture by increasing resistance to erosion, add to water and nutrient reserves in the soil, and increase infiltration capacity (Schlesinger 1999). Low capital input farming systems may have a higher potential for net carbon accumulation than intensive forms of agriculture, where the inputs (such as fertilizer and energy) are associated with high carbon costs. Crop rotations can break insect and disease cycles, reduce weeds, curb erosion, supplement soil nutrients, improve soil structure and conserve soil moisture ((Sustainable Agriculture Networks, 2006)

While aiming at maximizing crop yields, unsustainable cropping methods such as continuous cropping, lack of fallows, excessive tillage and lack of water and soil conservation measures many result into land degradation including depletion of soil nutrients. Land degradation is a long-term loss of ecosystem function and services, caused by disturbances from which the system cannot recover unaided (UNEP, 2007). This occurs as a result of various factors such as soil erosion. Soil erosion becomes a problem when the natural process is accelerated by inappropriate land management, such as clearance of forest and grasslands followed by cropping which results in inadequate ground cover, inappropriate tillage and overgrazing. Nutrient depletion is a decline in the levels of plant nutrients, such as nitrogen, phosphorous and potassium, and in soil organic matter, resulting in declining soil fertility. The removal of the harvest and crop residues depletes the soil, unless the nutrients are replenished by manure or inorganic fertilizers. Deficiency of plant nutrients in the soil is the most significant biophysical factor limiting crop production across very large areas in the tropics, where soils are inherently poor, Further, water scarcity is also a limiting factor to increasing crop productivity, hence there is need to employ risk management practices such as: water harvesting, soil and water conservation, and supplementary irrigation (ibid).

4.2.2 Increasing system resilience through diversification

Ecological resilience is the ability of a system to absorb impacts before a threshold is reached where the system changes into a different state (Gunderson 2000). Diversity in various system components such as crops, trees and livestock is what brings about resilience. Agroforestry is one of several promising multifunctional landscape developments that can create resilience through simultaneously generating livelihoods and preserving environmental quality (UNEP, 2007). Diversity is not only intrinsic to agriculture; it can be considered also as one of its main assets as it provides a wide range of responses that can help to face uncertain futures (van der Ploeg, Laurent, Blondeau, & Bonnafous, 2009).

For instance, in Limo, there is need to increase diversity and density of native fruit tree species, because some of the exotic fruit trees were poorly performing. Biodiversity conservation in forestry and agricultural landscapes is important because: reserves alone will not protect biodiversity; commodity production relies on vital services provided by biodiversity; and biodiversity enhances resilience, or a system's capacity to recover from external pressures such as droughts or management mistakes (Fischer et al, 2006). Farms in Limo area were found to host unique tree species , which are endemic to Ethiopia namely: *Millettia ferruginea (Hailu, Negash, & Olsson, 2000)* , *Erythrina brucei* and*Vepris dainelli* (Vivero & Kelbessa, n.d.)

Likewise, crop diversification, meaning farming two or more crops per unit of land or other inputs (water), is a fundamental approach for improving yield stability and crop resilience under changing climatic conditions (Mugendi, 2013). Conventional agriculture is dependent on the use of specific crop varieties or hybrids that have been bred specifically to exploit high-input conditions. Conversely, crop varieties used in high-input systems are not often adapted to low-input farming, a key element of many smallholder farming systems. Hence the need to diversify (Sustainable Agriculture Networks, 2006). Diversification helps to soften impacts on environmental resources, spread farmers' economic risk, exploit profitable niche markets, create new industries based on agriculture, strengthening rural communities, aid the domestic economy, and enabling producers to grow crops that would otherwise be imported (Bhattacharyya, 2008) (Goletti & Division, 1999)

4.2.3 Markets and Infrastructure

Sustainable intensification also promotes the integration of small farmers into commercial markets and global food chains but it is not certain that small-scale farmers will benefit from this (Friends of the earth, 2012). One of the approaches would be to change land use from low- value crops or commodities to those that receive higher market prices. Also value addition is advantageous in ensuring farmers fetch better prices for their products and also helps prevent post-harvest losses.

4.2.4 Bridging Knowledge Gaps

Understanding local agro-ecological processes- what farmers and other resource users do not know usually limits their practices. Limits to what farmers can observe also limits their knowledge ((Sinclair & Joshi, 1999) (Sinclair, 1999). To increase production efficiently and sustainably, farmers therefore need to understand under what conditions agricultural inputs (seeds, fertilizers and pesticides) can either complement or contradict biological processes and ecosystem services that inherently support agriculture (Royal Society,2009; Settle and Hama Garba, 2011). Hence there is great need to promote intensification of knowledge, skills and management practices among farmers.

4.2.5 Ecological suitability

Farmers in Basona woreda noted with concern about the poor performance (slow maturity rate of fruit tree species especially apples, peach, kazmir and mangoes) though they did not have an explanation for this phenomenon. A tree species is suited to a site when it is physical and genetic makeup allow for it to survive and reproduce given the constraints of a site's physical environment (Almendinger, J. 2011). The

choice of suitable tree species to grow, which must be adapted to the environmental conditions of a locality is one of the most important prerequisites for successful agroforestry (Gresbach, 2007). Hence the need to match species with sites local conditions and circumstances

5. Conclusions and Summary of key findings

- There was no natural forest, only community forest at the upper end of the kebele in Gina sub-kebele. There was a government tree nursery with low tree diversity, were cooperatives, underutilized farmer training centres, water levels decreasing. Community exchange groups played a key role in information sharing within the kebeles.
- Basona woreda was a highly intensified farming system within small private land holdings, with the average land holding of farmers interviewed in Goshe bado kebele being 1.5ha., while that of Gudo beret was 0.9ha. The fields were highly fragmented, with farmers holding an average of four fields per household
- Landuse and livelihoods: men and women undertook varying roles in the system; but with each supporting the other gender on some of the roles.
- There was varying knowledge about the mixed crops-livestock-tree mixed systems: between the two kebeles, between sub-kebeles within each kebele, between genders, across age, and different land sizes
- Various measures, both physical and biological, were being employed to prevent soil erosion and to help conserve soil. Such as check-dams, cut off drains; soil bunds and stone bunds, biological measures suchas *Aloe vera* , tree Lucerne, *Sesbania sesban*; and grasses such as vetiver, phalaris and rhodes grasses
- Main challenge affecting crop production:crop diseases and pests, continuous cropping, frost, water logging of the vertisols, water scarcity due to unimodal rainfall, low tree density onfarm and on the periphery of farms leading to strong winds destroying crops; and limited labour availability
- Coping mechanisms during food insecure months: selling livestock, engaging in paid labour, selling eucalyptus timber and firewood; and also eucalyptus leaves collected from the government and community forests for use as fuel, petty trade such as: selling beer and renting out land to other farmers
- Livestock- Fodder scarcity period for Gudo beret was July and August, though Goshe bado had a longer fodder gap extending from June upto September. Other challenges affecting livestock production: competition for space with crops and other landuses, absence of communal grazing lands, lack of fodder diversity due to over-reliance on crop residues as the main fodder source, diseses, poor local breeds and shortage of water also led to less livestock productivity

- Drivers of landuse/ tree cover change- In Goshe bado, tree cover and land use mainly changed during the transition from Haile selasie to Derg regime, where native tree species were replaced by massive Eucalyptus plantations. In contrast, farmers in Gudo beret reported that their landscape was bare, with very few tree species even during Haile selasie era. It is infact during the Derg era that tree density increased, mainly when *Eucalyptus* species were introduced by the government under the fuelwood project. *Eucalyptus* plantations had a negative impact on the ground water sources, with river flow and number of springs reducing.
- Basona woreda was characterized by low tree diversity per farm; with *Eucalyptus globulus* being the dominant tree species while majority of the species were encountered in very low densities. A total of 55 species were encountered in both Goshe bado and Gudo beret kebeles, with only 35 of the species being encountered on farms (22 native, 13 exotic). Gudo beret kebele had extremely low tree species diversity, with only 13 tree species being encountered across all farms visited, with farms having an average of 3 species.
- Tree diversity in Basona area was mostly driven by market/ income potential, with *Eucalyptus* species and Rham*nus prinoides* (gesho- used for making local beer) being the main income generating tree species. Other products were: fruits, firewood and timber, tree fodder was utilized in a low rate. Fuelwood shortage reported that July to August were the most critical periods due to onset of heavy rains
- Common tree niches were: trees found around the homesteads; live fence along boundaries of homesteads and dead fence along crop fields, woodlots, and minimal trees retained in cropfields in Goshe bado kebele, tree species retained in the cropland were those compatible with crops and/ or had mulch that replenished soil fertility
- Unlike Limo woreda, the practice of pollarding and pruning trees in cropland was not widely practiced in Basona woreda. Tree density on cropland was low, and in other cases, farmers had low knowledge on the impact of tree management on crop growth. Trees were mainly managed on a product-need kind of basis.
- Farmers who were interested in planting trees reported they would plant for various purposes namely: income, fruits, timber, and fodder
- Challenges that hindered farmers from integrating trees on their farms were: limited household land holding discouraged farmers from planting more trees, lack of tree germplasm, low seedling survival due to browsing, especially tree Lucerne in Gudo beret, slow maturity of fruit trees and *Juniperus procera* and lack of water for irrigating seedlings and fruit trees

6. Opportunities for sustainable intensification in Basona woreda

6.1 Opportunities for intervention at the landscape scale

- Research and interventions should focus on improved crop varieties that are adapted to frost, and are disease and pest resistant, especially fava bean and wheat
- Due to resistance of some farmers from adopting new crop production and soil conservation technologies such as row planting and broad bed furrows, there is need for awareness creation among farmers
- There is also need for effective livestock disease control or investing on improved breeds
- Also, to ensure survival of tree seedlings planted on farm, livestock browsing should be controlled
- For scaling up of interventions and best practices, there is need to strengthen and use existing groups such as saccos and potato irrigation cooperatives.
- FTCs in both kebeles are not fully utilized, hence improvement is needed to maximize on demonstration types for farmers to benefit.
- Need to diversity germplasm in tree nurseries
- Awareness creation is required among farmers on the need to widely adopt furrows due to the water logging nature of the dominant soils
- Absence of natural forests- creates a need to increase tree species diversity and density on farms in order for farmers to derive products
- There is great potential of upscaling agricultural best practices through targeting community exchange groups that exist in each kebele
- Market access plays a key role in catalyzing intensification; hence the kebele administration of Goshe bado should work with the community to improve the state of the roads to ensure easy transport of goods and services to and from the market

6.2 Opportunities for intervention at the farm level

- Fodder sources should be diversified in order to ensure fodder availability throughout the year. Fodder source diversification will also prevent over-reliance on crop residues which are very beneficial when left as mulch on the farm.

- Some farmers did not rotate cereals with legumes but rather alternate between cereals, hence there is need for awareness on the importance of leguminous crops to the soil. Ned to also promote short rotation leguminous shrubs.

- Farmers should be encouraged and guided on how to stop overreliance on monocultures and adopt diverse species diversity in order to increase resilience against uncertainities such as climate change and severe frost conditions; and ensure availability of multiple tree products throughout the year

- Due to the extremely low density of native species (some are almost extinct), there is need for reintroduction of such trees on farm

- There is also need for tree selection in order to establish tree nurseries for seedlings for framers to plant based on their needs and also based on ecological suitability of species

- Due to the unimodal rainfall pattern and decreasing water levels in rivers and springs, water harvesting as witnessed in several households is key to crop diversification and livestock production improvement thereby achieving improved livelihoods and increased income

- Need to increase tree planting onfarm through targeting potential niches- potential niches for tree planting in Goshe bado and Gudo beret kebeles could be in the home compounds, along soil conservation structures and along boundaries of homesteads and cropland.

- Physical soil erosion structures should be reinforced with biological approaches in order to achieve sustainable and long lasting solutions

- Need for increasing firewood trees and shrubs onfarms in order to reduce overreliance on ‘kubet’ livestock dung, which should be retained back on farms for manure to increase crop productivity

- Interventions should be targeted to different genders based on the role they play in the landuse and livelihoods.
- Farmers retention of trees were more income-income driven, hence need to create awareness on the utilities (especially ecological services) of trees in order for farmers to plant more trees

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List of Farmers interviewed during individual household visits

Goshe Bado kebele

	Farmer's Names	Gender
	Hudad Amba sub-kebele	
1	Wondemagin Gitu	M
2	Alemu Teklu	M
3	Habtamu Seife	M
4	Desita Cherkos	F
5	Zunesh Shiferaw	F
	Kirtie sub-kebele	
6	Asaletech Tsadik	F
7	Wagaye Zewde	F
8	Azagech Tefera	F
9	Mulu mamo	M
10	Menbere Altaiye	M

Gudo Beret Kebele

	Farmer's Names	Gender
	Mushi sub-kebele	
1	Layku Metsere	M
2	Beletu Weldeselasie	F
3	Ababech Kefilie	F
4	Sime Gebeyehu	F
5	Elite Mulatu	M
	Gina beret sub-kebele	
6	Genet Hailegiorgis	F
7	Weletemicael Kasaye	F
8	Yehaulafeshet Yemano	M
9	Feru Mengesha	M
10	Yeshitila Gebregziabher	M