Forages: Looking at the Potential and the Pathways toward Adoption in the Ethiopian Farming Systems.

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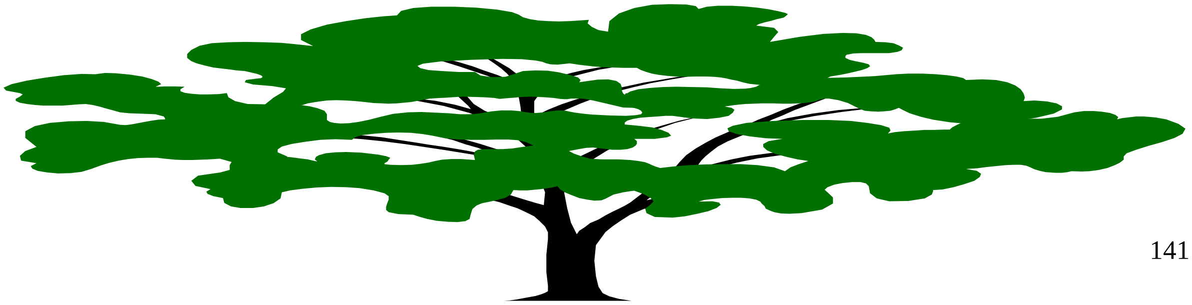
This study was carried out as a World Food Prize International Intern in cooperation with the International Livestock Research Institute and Bureau of Agriculture, Wolayta Soddo.



Background Information

My name is Gary Anthony Sullivan and I attended the 2001 World Food Prize Youth Institute as a participant from Harlan Community High School. I am currently a freshman at Iowa State University majoring in Animal Sciences.

After learning about the possibilities made available by attending the youth institute, I became interested in the International Internship program and as an animal science major, the program at the International Livestock Research Institute (ILRI) fit well within my area of study and was an all-around great opportunity.

This past summer, I worked at the ILRI center in Addis Ababa, Ethiopia. As a member of the Consultative Group for International Agriculture Research (CGIAR), the overall goal for all the research centers involved is to work on poverty reduction thus increasing the ability raise better or purchase food. Specifically, IRLI works on developing and refining technologies aimed toward smallholder livestock and crop farmers of developing countries. While working at ILRI Addis, I completed a study in cooperation with Forage Genetic Resource (FGR) department about the potential and pathways toward adoption of forage technologies. The main goal of the FGR is to make available to farmers current forage technologies to improve quality and quantity feed sources.

Having met and worked with many intelligent and interesting people this summer, two main people I worked with and helped to develop the program and set it up. Dr. Jean Hanson, a plant scientist, was my direct supervisor this summer and is the head of the FGR department. Elizabeth Getachew, Assistant to the Program Coordinator – Strengthening Partnerships with National Agricultural Research Systems, helped to develop the program for me this summer. These two people helped greatly in making my experience a wonderful one.

Responsibilities and contributions

While working at the FGR, I had many responsibilities depending upon what was occurring in the office at that time. For the first couple weeks after arriving I helped to prepare and plant the seed replication plots. After that my time was consumed by the project researching the potential and pathways toward adoption of forages in the Ethiopian farming systems. Forages offer great opportunities for the farmers and following are the results of the study I completed.

Introduction to forages

Forages can be described as any vegetative part of a plant that is eaten by animals, but they are further defined as those crops grown mainly for the feeding of livestock. Inside the mixed farming systems, involving forage production within the cropping cycles can increase the farm's sustainability (Reintjes *et al*., 1992). Subdivided into groups, Forages include grasses, legumes, multipurpose fodder trees, and other browse species.

Potential of forages

Forages have much potential within the farming systems of Ethiopia as well as all over sub-Saharan Africa. Within the four classes of forages, there are many different potentials and possibilities. They in many ways improve the quality of the soil and also help to stabilize it. When forages are grown they improve the soils by increasing organic matter content. When used as green manure, they also provide ground cover for erosion control. Some have the ability to fix nitrogen and also help with the nutrient cycling.

As the forage crops grow, they not only produce green forage; they also develop extensive root systems underground. During the cropping season, the plants are cut, grazed, or left for the dry season. After the plant is harvested, the root system is still within the soil. Gradually it and other plant materials decompose and mineralize adding nutrients back into the soil. Additionally, the forages can be used as green manure, which will not only add organic matter to the soil but also many nutrients, which helps build up the soil fertility.

In many parts of Ethiopia, soil is nitrogen deficient and often limits the productivity of the crop. One way to combat this problem is by using forage legumes, because many of the leguminous species have the ability to fix nitrogen, thus increasing the soil fertility. In a test trial in Nigeria, maize crops were grown inside and outside legume fallows. When comparing the yields, the nitrogen free maize crop (849 kg/ha) in the legume fallow produced higher yields than the plot that was grown on a natural fallow with 30 kg N/ ha (677 kg/ha). This study suggests that the leguminous fallow must have provided at least 30kg/ ha of N (Tarawali and Mohamed-Saleem, 1995). Using forage legumes within mixed farming systems can help combat the limiting nutrient supply in the soil.

Forages not only help slow land degradation by improving soil fertility, they also can be used as a method to combat soil loss through erosion. As Ethiopia's population rises, marginal lands continue to be placed in production farming causing rapid degradation of the land. Previously these land areas were natural forests and helped to limit land degradation. But as the trees have been removed, natural erosion control is lost. As a result, land becomes unproductive through extensive land degradation. By replanting this land with multi-purpose fodder trees and other ground covering forages, it limits the soil erosion and provides the farmer with fodder and high quality livestock feeds. At the same time as limiting erosion, nutrients are added back into the soil instead of being removed.

As well as improving the soil fertility, a high quality animal feed is being produced. This increase in animal nutrition results in increased manure production from the animals, which in turn adds to the soil nutrients. Forage crops help to increase the rate at which nutrient cycling occurs. The potential that forages hold to help improve the soil quality and fertility can help the farmer maintain soil quality with low external inputs.

Much of the animal feed in sub-Saharan Africa comes from crop residues and natural communal grazing pastures. During the dry season poor nutrition is a major constraint to cattle and small ruminant production. Poor nutrition is a product of both low quality and low quantity of feed. The natural pastures have a crude protein content of about 3%: below the 7% required for efficient ruminant function (Tarawali and von Kaufmann, 1987). In a trial conducted in Nigeria, cattle that had no access to a fodder bank lost an average of 16 % to 23.6% of their live weight during the dry season (Otchere, 1986). The use of forage technologies can help to limit weight loss, illness, and death of animals through improved nutrition.

The storage and conservation of forages as feeds for dry seasons is an important task to combat the effects of poor nutrition throughout the dry season. Many of the high protein forages have the ability to be cut and dried for later use without losing much of their nutritional value. The forage hay can then be used for supplemental feeding through the periods of feed shortage, which will increase nitrogen and other trace minerals in the diet. Winrock International identified some of the main areas where research needs to be done to help fight the feed shortages including: the planting of improved fodder crops, leguminous tree crops, past and specialty forage crops to increase the energy and protein available to livestock and develop the high potential area, and production of high-yielding forage crops with high protein content (Winrock, 1992). Fodder bank technologies help to conserve some of the higher nutritional value plants for use in the dry season helping to improve the quality of feed in times of shortages.

Fodder trees hold the ability to produce biomass through the dry season and the deep root systems act as nutrient pumps drawing nutrients and moisture form deep down where other plants are unable to reach (Bayer and Waters-Bayer, 1998). It is estimated that during the 3 driest months of the year in the Sahel region, the *Capparaceae* family provides up to 80% of the protein ration (Mulatu *et al.*, 1990). Fodder's ability to stay green through the dry season offers a great potential for use as an important feed source in times of shortage.

Human population pressure is a major contributor to the degradation of the environment in the areas where livestock are kept. Because of limited land space and crowding, farmers abuse the ability to graze communal land for personal gains in livestock production. The areas are abused and overgrazed causing severe land degradation (Delgado *et al*., 1999). Many forage legumes, over-sown into existing pastures and grazing areas, increase the quality and quantity of feed available while simultaneously increasing the soil quality. The improvement of pastures and communal grazing land through the introduction of forage legumes would help to alleviate the effects of over-grazing and rapidly declining land quality.

Trees offer great opportunities and are appealing to many farmers due to the fact that they have multi-purpose uses. Many species are promising and have a wide array of uses. *Leucaena leucocephala , Pithecellobium dulce, Gliricidia sepium, Sesbania Sesban, Sesbania grandiflora, and Artocarpus heterophyllus* can be grown as living fences, additionally provides human food, fuel wood, and animal feed, and can be established in 6-8 months by either direct seeding or seedling transplant (Chen *et al.,* 1992). Fuel wood is usually in shortage throughout most of Ethiopia and multipurpose trees can fill part of the short supply by use of the branches from pruning and harvesting. If not used as fuel wood they also can provide necessary lumber wood for construction purposes around small holder farms. When set up and used as wind breaks the trees can serve as erosion controls and also supply shade for the animals and home. One of the most important cash crops in Ethiopia, coffee can benefit the multi-purpose trees which serves as shade to increase yield and quality of the fruit thus increasing the cash flow to the farmer. *Gliricidia sepium* has been used in Africa since the 18^{th} century as shade for coffee, tea, and cocoa plantations. Only recently was it discovered to have 20-30% nitrogen, 14% crude protein, and 50-75% digestibility in the leaves (Baumer, 1992). Forages can serve as a natural way of increasing crop yields while at the same time increasing fodder production within the established farming systems.

Many types of forages offer dual-purpose production, such as fruit trees or grain crops. Some of the improved cowpea cultivars have been developed to produce seed and dry while the plant stays green, thus producing human food as well as supplying high quality forage for the animals. In 1996 it is estimated that 5.6 million hectares are grown throughout the world: 90% of that is in west and central Africa, with a worldwide grain production of 2.7 million tons (Quin, 1997). Farmers are usually unwilling to give up land that is used for human food production and use it for other uses. The dual-purpose varieties of forages offer great potential for adoption forages in new areas while maintaining human food production.

Certain forages act as natural pesticides and can be used to keep pests away from other crops around it. Many different methods are used, including thorns, scents and smells, and hairs covering the crop.

Forages also have many potentials that are unknown by the farmers who would benefit the most. Work must be done in cooperation with the farmers to help integrate forages into these farming systems.

Methods of Integration

Many techniques may be used of cropping forages. Pure stands offer some advantages over others. When using the pure stand cropping method, the most common objective is collecting seed for future reproduction and further expansion. The residue after the seed has been harvested is fed to livestock. Often the farmer will have just enough land as pure crop to have enough seed for the following year.

Intercropping is a common method of integrating forages into current farming systems. Low growing legumes can be under-sown into current food crops. The ground cover and legume system limits soil erosion and increases soil fertility. Forage can either be cut and carried or used through post-harvest grazing. Alley cropping is another way of intercropping and is done by planting alternating strips of crop and forage. In an on-farm study done by the Ethiopian Agriculture Research Orgainization near Nazerat, Ethiopia, when alley cropping *Cajanus cajan* and *Sesbania sesban* with sorghum, maize, or haricot beans, the trees produce 2.8-3.0 ton of dry matter per hectare without effecting the yield of the food crops (Mulatu *et al.*, 1990). Coffee has great potential for intercropping with forages. Fodder trees can provide shade for the coffee and also a source of fodder. In addition, forage legumes such as *Desmodium* can be easily grown for cut and carry while increasing the soil fertility and preventing erosion. In a trial conducted jointly with ILCA and the Ministry of Agriculture of Ethiopia, *Desmodium intortum* was planted under coffee to see what the effects the forages had on the yield. Besides having a dry matter yield of 2.5 t/ha over a 30 week period, the coffee with forages planted yielded 5.2%

more berries in the off-year and 19.2 % more berries during the on-year of production over the control plot (Lazier, 1987).

One of the areas where forage offer the greatest potential is the niche, or non-productive, areas. Forages can be grown on land that is unsuitable for cropping, such as areas with rock outcrops, waterlogged land, internal and external boundaries, bunds, and margins (Elebasha *et al.*, 1999; Chen *et al.*, 1992). One farmer near Soddo town had planted forages all along his pathways, waterways, streams, and internal and external boundaries. The backyard development is another way that the farmer with small land holdings can gain from forages. Having an intensive backyard set-up, which even urban farmers can have, allows for more thorough use of otherwise unproductive land.

The use of a fodder bank is a very useful and productive method but has some up front costs of development. The banked areas are planted to forage legumes for conserved use during the dry season or can be grazed year round. Fodder banks can increase milk production, weight gain, calving rate, cow and calf survival rates, and following crop yields while decreasing age at first calving (Elbasha *et al.*, 1999). The yield can range form 3.4 tons per hectare when grazed to producing 6.3 tons per hectare when conserved until the dry season (Ikwuegbu *et al.*, 1995). With good management, and by allowing cows to graze the fodder bank for 2.5 hours per day during the dry season, an additional 48 liters of milk are available for use, plus an additional 24 L consumed by the calf (Elbasha *et al*., 1999). After the initial investment, fodder banks are able to pay for themselves, however land is a major constraint to widespread adoption of this method in East Africa.

An easy way of increasing the productivity of the natural pastures is to over-sow leguminous forages into existing pasture. Often local indigenous species will fulfill the need however there are also other forage legumes. Maintenance using this method is minimal and pasture and feed quality is improved. In communal grazing systems however, it is often not done due to lack of personal capital gains.

In current crop-livestock systems, leaving land fallow is a common practice to build up the soil fertility and productivity through use of green manures. In parts of Asia, *Astragalus* is used as a green manure for its high capacity to fix nitrogen, up to 75-120 kg/ha per year. This has the same effects on rice yield as 260 kg/ha of urea (Shilin *et al.*, 2000). Instead allowing anything to grow by integrating forages into this land practice, the soil will regenerate faster and fallow years offers a high quality feed and protein source for the livestock.

With the many ways of integrating forages into the cropping systems, it is hoped that individual farmers in various situations may be able to find a method of integration that fits their interests and land requirements.

Ethiopian Agriculture

Ethiopian agriculture can be split into two major regions, the highlands and the low lands. The highlands (all lands over 1500 meters above sea level) consist of 40 % of the Ethiopia's total landmass (4,892,000 hectares). However, 81% of the human population or 48.5 million people of Ethiopia live in the highlands (appendix 1). Additionally they are home to 75-80% of the cattle and sheep (Appendix 2), 30% of the goats and 90% of all Tropical Livestock Units (TLU)(Degefe and Nega, 1999). The highland's rainfall, growing days, and average temperature varies between the different areas in the highlands. The major farming systems within the highlands are crop-livestock systems, cropping systems, and landless livestock systems. The three systems vary depending upon where they are located but have the same general basis. Crop-livestock systems are the most common within the highlands of Ethiopia. In the systems, the farmers raise cereal and cash crops and feed their animals with crop residues, harvested forage, grazing, and purchased materials. Poorer farmers who are unable to afford any livestock rely on crops. Land is either worked by hand or sharecropped for use by other farmers' oxen. Landless farmers are mainly urban livestock keepers who rely on purchased feed and collected fodder to feed livestock.

The Ethiopian lowlands (land less than 1500 m.a.s.l.) consist of 60% (7,338,000 hectares) of the total landmass of Ethiopia. In this area there are approximately 11.4 million people (19% of the total population) (appendix 1), 20-25% of the cattle and sheep (appendix 2), 70% of the goats, 100% of the camels and 10% of the total TLU. The lowlands are characterized as drier, warmer, and with fewer growing days than the highlands. The major farming systems include crop-livestock, cropping, and landless/nomadic system. The crop-livestock systems are similar to those in the highlands; however, they tend to have slightly larger land holdings due to less land pressure. The same is true for cropping systems. In the lowlands they are characterized as the poorer farmers and the work and sharecropping are similar. However, in the lowlands the landless farmers have 2 classifications, urban livestock holders and nomadic. The urban holders are like those is the highlands but the nomadic people are a different type of landless farmer. The nomadic people do not crop or own any land but, rather, travel with livestock in search of adequate feed sources.

Constraints to adoption

However different, the highlands and lowlands hold similar constraints to adoption of forage technologies. Land shortage is one of the major constraints to adoption in the Ethiopian farming system. This is a problem because farmers do not want to take land away from food production for other uses. Use of one of the intercropping techniques or using niche areas would not affect the cereal crops.

Land tenure is a constraint to farmers wanting to adopt long-term technologies for soil improvement and tree development due to uncertainty of tenure.

Labor shortages also play a role in whether farmers adopt forages or not. The times when labor is required for forages an often already occupied by other fieldwork. Hence, labor constraints may continue to be a factor influencing adoption.

Lack of knowledge is a constraint identified by the farmers as a problem with forages. After forages are given to them they do not know what is best to do with them or how to use them efficiently. With the help of good extension services, this constraint could be alleviated.

Lack of adequate seed availability is also a problem, which must be addressed and dealt with. Through cooperative work of some other farm organizations this may not become less of a problem.

Many farmers in Ethiopia have a lack of capital to cover the up-font costs of developing certain forage technologies.

The last constraint is that the generic technologies provided to farmers may be inappropriate for the individual farmers. If researchers fail to address farmers' needs, they will not adopt because the technologies do not fit into the farming system. After nearly 20 years of modern agro-forestry, little impact has been made mainly due to the project objectives, which did not meet the needs of the farmers (Dicko and Sikena, 1992).

Study Sites

Wolayta Soddo is located in southern Ethiopia at 6˚ N latitude at an elevation of

Table 1. Characteristics of the Wolayta Soddo Region

Population	No. in 1989	No. in 1998
Total human population	158,590	227,838
Soddo Town human population	24,592	65,000
Cattle	55,862	89,086
Sheep	7004	7420
Goats	2887	5410
Donkeys	1855	2263
Horses	1363	1526
Mules	421	889
Chickens	34,948	60,032
Rural population Density of arable land (1998)	350 people/sq. km	
Main crops	Maize, Enset, Sweet potato, Haricot beans, Teff, Irish potato, Taro, Wheat, and Coffee	

Source: (Irwin, 2000)

1950 meters. The area's soils mainly consist of nitrosols and cambisols with an annual rainfall of 1077mm. The area is classified as the sub-humid zone, meaning it has 180-270 growing days per year. Table 1 identifies the characteristics of the area.

Table 2.Characteristics of the Yubdo Legabatu PA

	Number
Human population	2491
Households	666
Cattle	6988
Sheep	530

Goats	830
Donkeys	378
Horses	24
Mules	11
Chickens	1750
Total land	3095 ha.
Cropped land	2106 ha
Grazing land	694 ha
Population density persons/ sq. km	80
Main crops	Chick pea, Wheat, Teff, Maize, and Raf pea

Source: (ILRI unpublished data,2001)

The Yubdo Legabatu Peasant Association is located between the towns of Holeta and Ginchi in the highland areas. It is vertisols in the area, which has troubles with water logging. This area is around approximately 2300 meters above sea level and has an annual rainfall of around 1150 mm per year giving it a sub-humid ecological zone classification. Table 2 gives the characteristics of the PA.

Debre Zeit is also located in the highlands and has an elevation of 1850 meters.

Table 3. Characteristics of the Debre Zeit Area

Population	totals
Total Population	259,922
Rural population	179,922
Urban population	80,000
Cattle	38,261
Sheep	40,882
Goats	53,329
Total Area km sq.	161,056
Main crops	Field pea, Horse bean, Teff, Wheat, Barley, Chick pea, and Maize

Source: (ILRI internal information, 2000)

Rainfall accumulates to an average of 865mm. Debre Zeit is classified in the semiarid ecological zone and has about to 180 growing days per year. The soils are vertisols and alfisols. Table 3 shows the farmer characteristics of the Debre Zeit area.

Improving adoption

After looking at the potential of forages and the constraints to adoption, methods of improving adoption must be identified. Many different methods have been initiated throughout the world; one of the most effective methods of improving adoption is by doing farmer participatory research. The major strength that this offers is the ability to more successfully gauge the farmers' needs and reaction to the forages. By talking to the farmers, the main criteria that farmers look for in forages can be identified (Table 4).

By getting information about the farmers' demands and needs, the areas that need to be researched are identified. The farmers are more apt to adopt when the technology fits into their farming system and not what the others say fits into it.   By listening to what the farmers are saying about the forages, the researchers can work to mold the technologies to fit the farmers' systems (Figure 1).   In addition to identifying the needs,

Table 4. Farmers' criteria for selecting forages

Criteria	Forage system	
	Cut and carry	Contour hedgerows
Ease of establishment*	X	X
Grows well*	X	X
Palatable to animals*	X	X
Fast regrowth*	X	X
Persistence*	X	X
Easy to cut	X	
Easy to carry	X	
High edible yield	X	
Fattens animals	X	
Holds soil		X
Does not compete with main crop		X
Grows densely in a narrow row		X
Not itchy (hairs, sharp leaf)		X

* Indicates primary criteria for selection of forages

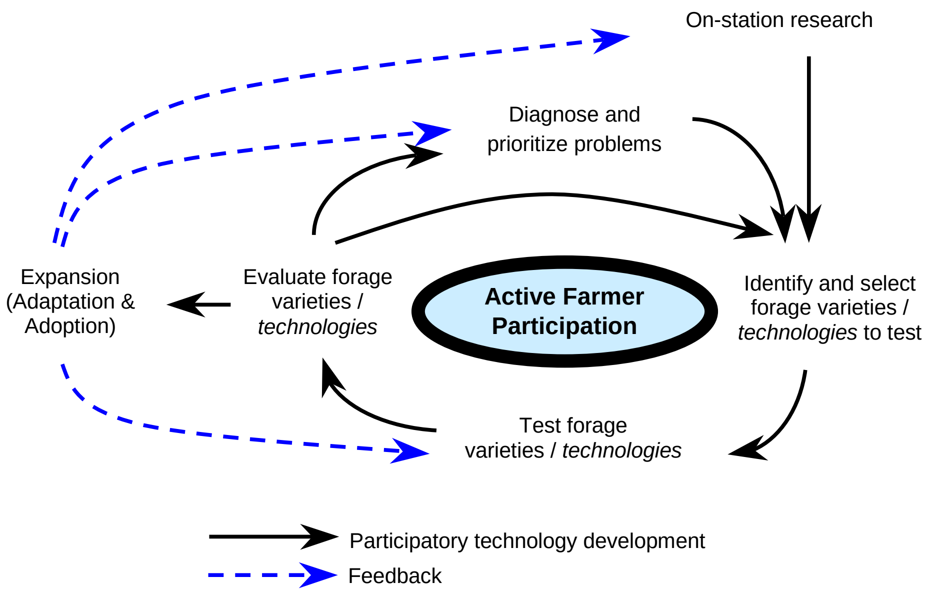
Source: (Gabunada F, 2000)

the farmers see the possibilities that forages offer and how they can fit into the farming system. Also working with farmers provides training and knowledge of the forages; a problem which is identified as a major constraint to adoption. Involving the farmers with research helps to bring the forages to the farmers.

The use of test and demonstration plots helps to show the farmers what the forages look like and how they can be placed within the farming system. As a result of a visible difference in the maize planted in the legume-based soils in Abet, Nigeria, a field day was organized. This stimulated interest and questions about the forages and resulted in many requests for *Stylosanthes* to be incorporated in pastures and used to improve soil fertility (Tarawali and von Kaufmann, 1987).

Extension workers play a major role with the education of the farmers. The active agents work to teach the farmers the new and improved practices in farming and introduce new ideas. When the extension staff is knowledgeable about forages and the potential, they are more apt to promote the use of forages.

Figure 1. Cycle followed in the Farmer participatory research used by CIAT



Source: (Horne PM, 2000)

Results from farmer surveys in Debre Zeit and Yubdo Legabatu PA

In June 1992, a project, completed by ILCA (International Center for Livestock in Africa), was started to introduce multi-purpose trees in the areas of Holeta, Ginchi, Denaba, and Debre Zeit. The objectives of the project were to respond to the problem of poor quality crop residues and dry season shortages of feed and supplement the diet with high quality tree fodder. For the project, 80 Farmers volunteered and each were given 40 seedlings (4 accessions with 10 seedlings/ accession). The *Sesbania* had better establishment on the veritisols than the *Leucaena* (Berhe *et al.*, 1993). During July 2001 some of the farmers were surveyed to see how adoption and expansion has happened over the 9-year span since the project began. A total of 8 farmers were interviewed, 5 from the Debre Zeit area and 3 from the Yubdo Legabatu PA, located between Holeta and Ginchi. The results (appendix 3) were analyzed to find correlation between the effect of different factors upon the rate of adoption and expansion of forages. Table 5 shows the uses of the forages by the farmers who participated in the survey.

Table 5. Uses of the multipurpose trees from survey July 2001

Uses	Feed	Fencing	Fuel	Lumber/construction
# of farmers	4	4	5	2

Of the four farmers who fed the fodder to cattle, all said that there was increased productivity. 2 did not feed because no livestock were owned. 5 farmers still have some of the trees on their farms. All 5 have *Sesbania Sesban* and 1 has Leucaena. The 3 farmers who do not have any trees left moved because of villagization. Of those 3 farmers, 2 had fed the leaves before moving and saw increased productivity when feeding it. 5 of the farmers used the trees for multiple purposes. All the farmers who were not affected by villagization said they have increased the area. Table 6 shows the methods of multiplication of the trees. One of the farmers said children will harvest seed and distribute it to their friends resulting in the spread of the trees. Those farmers who seem more livestock oriented seem more likely to adopt and expand the use of these multipurpose trees. The farmers like the multipurpose uses and its ease of propagations. Within the Holeta/Ginchi area several of the homesteads had *Sesbania* growing in their compounds. In the Debre Zeit area, less farmers had the fodder trees growing than near Holeta and Ginchi (personal observation).

Table 6. Methods of tree multiplication from Survey July 2001

Method of seeding	Lets seed Shatter and leaves seedlings	Lets seed Shatter and transplants seedlings	Direct sewing of seed
# of farmers	2	2	1

Results from farmer surveys in Wolayta Soddo

In June 2000, Simon Irwin, a master's student at Imperial College at Wye, in cooperation with ILRI and the Ministry of Agriculture, did a study in Wolayta Soddo to identify the demand for forages and the constraints to adoption. 40 farmers were interviewed for the survey work, 10 farmers in each of 4 PA's, Wachiga Busha, Wareza Shoho, Kokate, and Gurmu Koysha (appendix 4). The elevation ranged from 1700 m to 2400 m and a distance from Soddo town of 4-20 km. Within the study he identified the major constraints to adoption of trees and grasses and legume (table 7).

Irvin identified two main forage technologies, which were practiced in the area, fodder trees and Napier grass, although some of the more innovative farmers grew *Desmodium.* After the survey work was completed forages were given to the farmers in the area. The 7 forages were *Macroptilium atropurpureum* (Siratro), *Desmodium intortum* (greenleaf), *Vicia dasycarpa* (vetch), *Lablab purpeus* (lablab), *Macrotyloma axilare* (Axillare), *Desmodium uncinatum* (silverleaf), and *Sesbania sesban*. In July 2001, 12 farmers who received seed were again surveyed (results in appendix 5). Following the survey the following correlations were found. 11 of the 12 reported to have feed shortages during the dry season. Of these 11 farmers, the farmers with more than 0.5 ha collected seed from the lablab and the others fed it before it seeded. 18% had previous knowledge of forages and the other 44% said they wanted to learn more of how to properly use and grow forages. Some mentioned having a field day. Most of the farmers interviewed stated that land was a major constraint to planting more forages. 8 of the nine farmers who fed it to cattle said that the cattle liked it. 11 of the farmers had at least one of the varieties growing on their farm or had collected seed. 1/3 of the

Table 7. Constraints to forage adoption in Soddo

Constraint to adoption	No. of responses (% of total)
Fodder Trees	
Number of non-adopters	8
Shortage of land	5 (63%)
Lack of Knowledge	5 (63%)

Lack of seed	-
No livestock owned	1 (13%)
Uncertain land tenure	-
Forage grasses and Legumes	No. of responses (% of total)
Number of non-adopters	28
Shortage of land	11 (39%)
Lack of knowledge	10 (36%)
Lack of seed	14 (50%)
no Livestock owned	2 (8%)
Shortage of labor	1 (4%)
Financial constraints	1 (4%)
Technology inappropriate, hence abandoned	1 (4%)
Technology lost when land seized	1 (4%)

(Irvin, 2000)

farmers collected seed from the forage crops and one collected it from two; vetch and lablab. The farmers with a dry season feed shortage all seemed to realize the potential of forages. The PA's with more active development agents were more likely to see the good of the forages. No correlations could be found dealing with the number of livestock or milking animals, size of land, labor availability, farming experience, or years on the homestead. Table 8 has methods which the forages were planted.

Table 8. How the farmers planted the forages in the Wolayta Soddo area

How planted	Pure Crop	Fence line/ pathways/ waterways	Over sow pasture	Inter crop (food crops)	Under coffee
Green Leaf	3	5			2
Silver Leaf	3	5			2
Sesbania Sesban	1	4			
Vetch	2	1	1		
Siratro		1			1
Lablab	3	1	1	1	
Axillare		1			

From the responses during the survey some indicators of interest and likeliness of adoption were identified. They were separated into two categories, strong and other (table 9).

Table 9. Indicators of interest and likeliness of adoption

Strong indicators	Other indicators
Collecting seed	Asking to learn more/ a field day
Willing to use a pure stand	Seeking more seed
Willing to increase area	

All the farmers seemed interested in being able to use some of the unproductive areas to grow a crop or feed source. Areas which farmers utilized, included: along pathways, streams, waterways, hedgerows, fields, fence lines, and within housing compounds. The farmers used areas that fit into the individual farming system.

Summary of findings

Forages offer a great potential to fill many areas of need, from livestock feed to soil stability. Even with all the potential, there has failed to be a wide spread adoption. Farmers identify many constraints to adoption but other methods of integration exist and are not used. In order for widespread adoption to take place, the farmers' needs must be assessed and technologies provided that fit to the farmers ability to adopt. Work with farmer participatory research provides the farmers with the ability to help fit the forages into their systems while learning more about forages. Irvin identified the major constraints of adoption to be lack of land, lack of knowledge, and lack of seed. Through field days and demonstration plots, the lack of knowledge and lack land will become less of a constraint by teaching the farmers about forages and ways of integration. Lack of seed must be a joint effort of different organizations to help initially supply seed and then offer help with multiplication. With work jointly between the farmers and the agricultural organizations, forage use will increase and help fulfill some of the most important needs, livestock feeds, human food, and soil fertility and productivity, of farmers.

Effects on food security

As the work of Dr. Norman Borlaug did with the Green Revolution helped to fight world hunger in the 1960's, ILRI, as well as its fellow CGIAR centers, has been working toward the livestock revolution, the next food revolution. Delgado *et al.* predict that by the year 2020, 67% of all meat and 50% of all milk will be produced in the developing countries (1999). Through this, the quantity and amount of nutrients available to these people will be increased dramatically, however, to meet the feed supply for the predicted livestock increase, new technologies must be implemented. The use of improved forage technologies can fulfill a significant percentage of this feed requirement, further adding value and importance to forage technologies.

Experiences

The many things I learned while at ILRI are truly lifelong experiences, which has had and will continue to have a great impact on my life. Witnessing a foreign culture is an experience which all should have the opportunity. If not only gives a greater appreciation for other's way of life but also a better understanding of one's own culture. My internship experience has not only affected the way that I view things but also in my future goal. My work this summer spurred my interest in the research field, especially in the ruminant nutrition area. My understanding of other cultures and ways of life has been increased through my experiences over the past summer. I can truly say that the World Food Prize International Internship is

one of the greatest programs available to young adults and has made a huge impact in my life.

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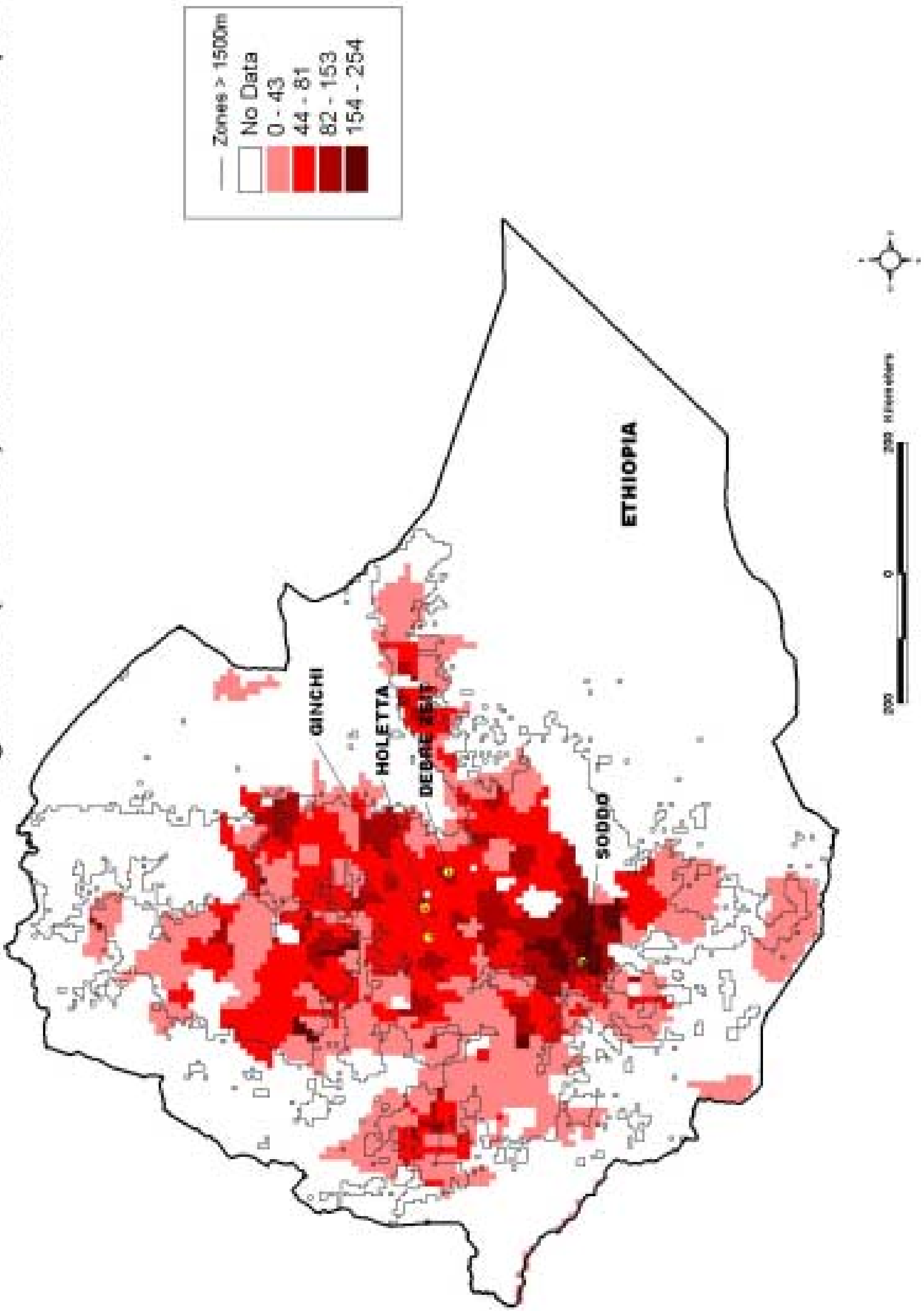
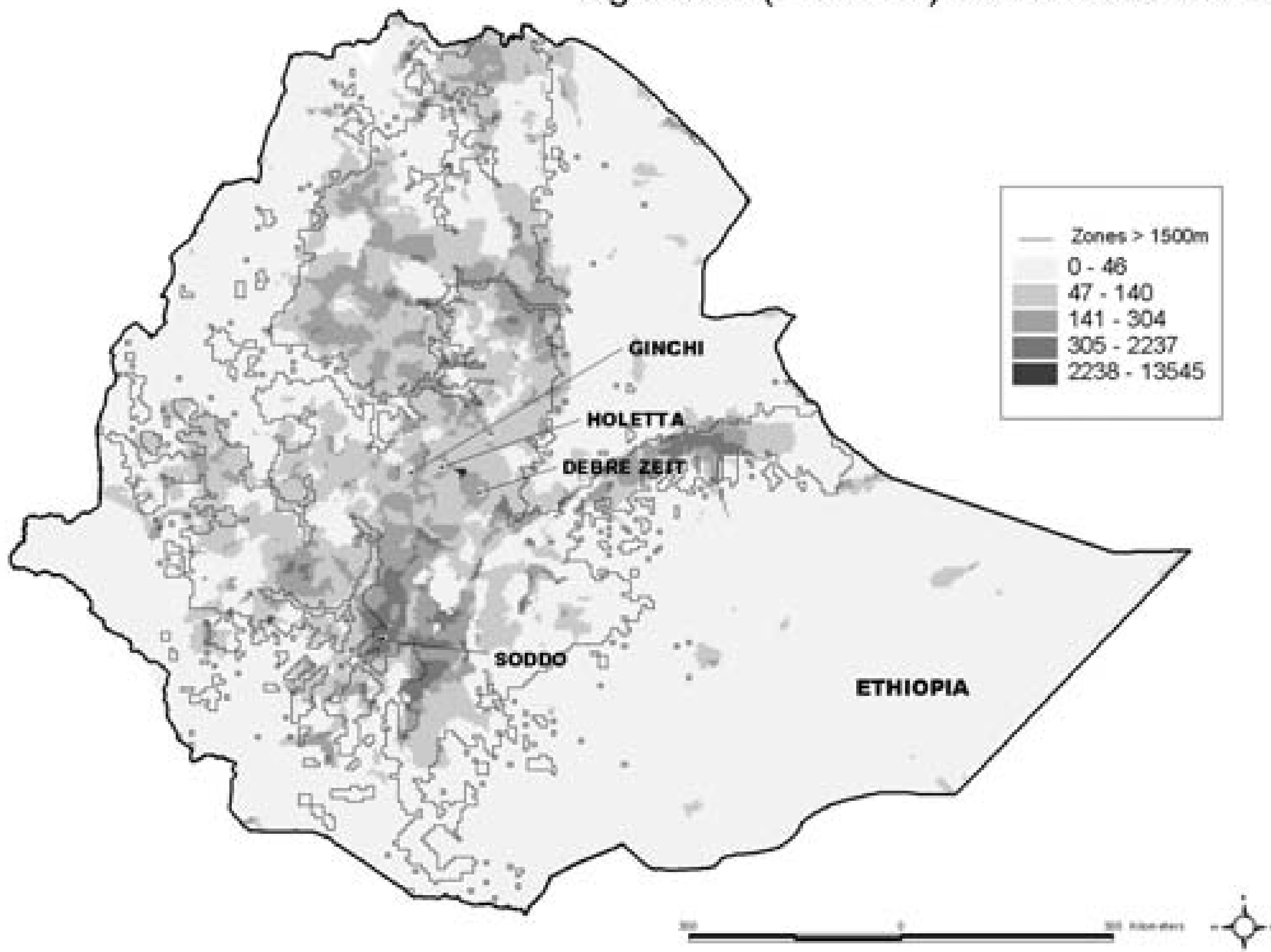
Cattle population per km^2 for the highlands (> 1500m) and lowlands of Ethiopia



Appendix 1

Human population per km^2 for the highlands (> 1500m) and lowlands of Ethiopia



Appendix 3

Farmer Characteristics in DebreZeit and Yubdo Legabatu PA

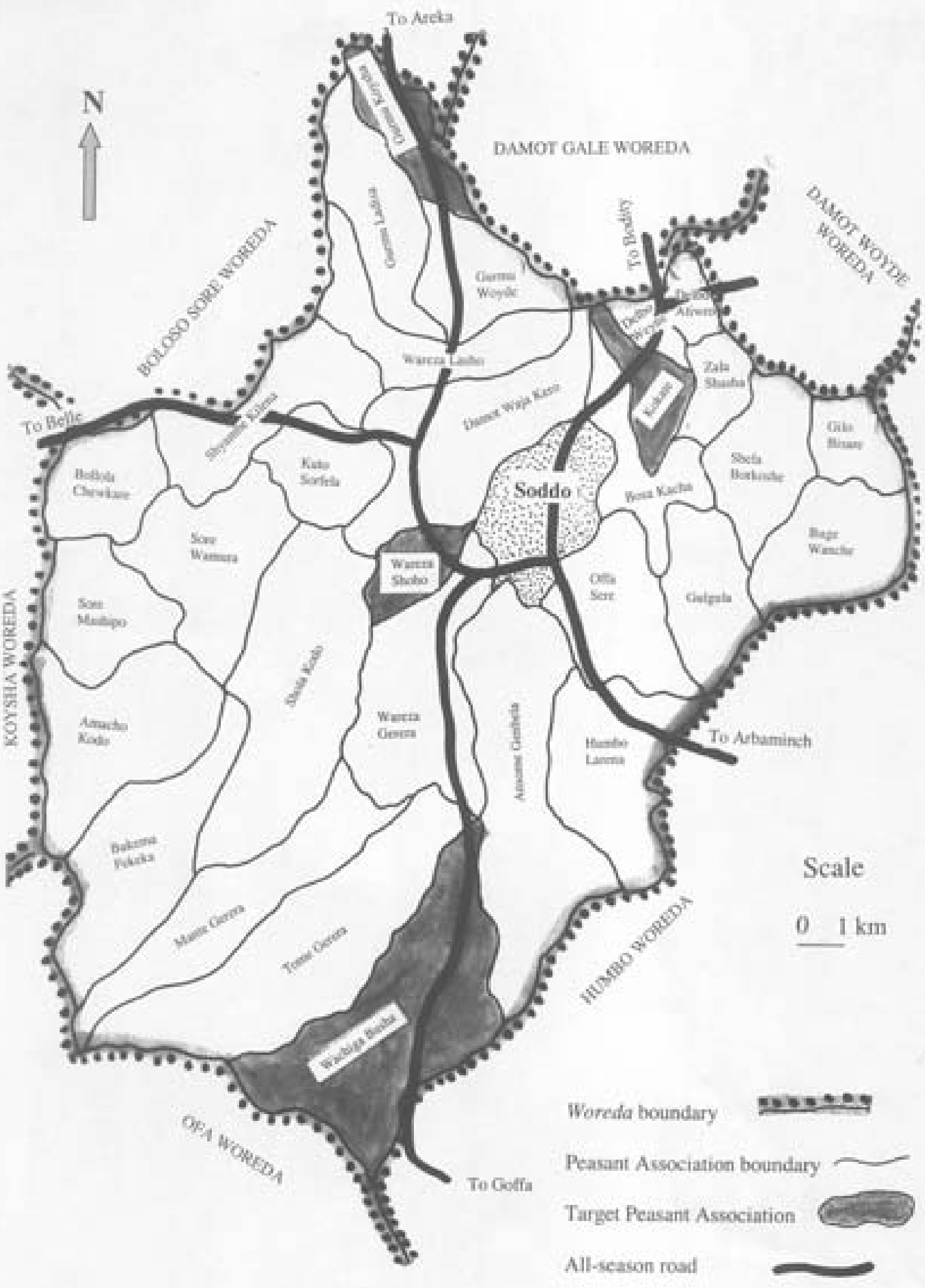
Farmer's name	location	farn	main crops	ad	ac	chi	ds	ds	ox	gr	sh	gc	pou	ho	do	sell mi	market distance
Belcha Tufa	Denkaka PA	3	T W C R H F M L	1	1	8	0	4	6	4	0	0	40	0	3	xs	6-7 km
Bekana Sori	Ginchi		T C W M R	1	1	2	0	0	0	0	0	0	0	0	0	n/a	5-6 km
Tadu Daba	Ginchi		T C W M R	1	2	4	0	2	0	2	0	0	0	0	0	yes	5-6 km
Chala Alabelcha	Dembi PA	2	H F T W B	1	1	6	0	1	3	1	0	0	0	0	0	no	3-4 km
Guza Magesu	Dembi PA		T H F W B C	1	1	5	0	1	2	1	3	0	yes	0	0	no	3-4 km
Magara Alamu	Dembi PA	3	T W H F B	1	1	8	0	2	4	4	0	0	0	0	1	xs	3-4 km
Shiganu Degifa	Dekam PA	2	T C W	1	1	5	2	1	7	9	0	0	5	0	3	no	<1 km
	Ginchi		T C W M R	0	1	0	0	0	0	0	0	0	0	0	0	n/a	5-6 km

key: T= tef W= wheat C= chick pea R= rough pea H= horsebean f= field pea M= maize L= len S= Sesbania sesban L= Leucaena

Uses of Trees

	trees farmers	incr	uses for trees	what fed to	incre	likes	if no trees why	method of reproduction
Belcha Tufa	none	n/a	feed	oxen cows	yes	cattle liked it	moved villagization	shatter and leave seedlings
Bekana Sori	S	yes	fuel fence					shatter and transplant
Tadu Daba	S	yes	fuel feed	cows calves	yes			
Chala Alabelcha	none	n/a					moved villagization	
Guza Magesu	none	n/a	feed	cattle	yes		moved villagization	
Magara Alamu	S	yes	fence fuel lumber			multiplies by itself		shatters and leave
Shiganu Degifa	S L	yes	feed fence fuel Constuction	cattle	yes	multipurpose		direct sewing
	S	yes	fence fuel			prolific seeder		shattter and transplants

Figure 2: Map of Wolayta Soddo, indicating target Peasant Associations



Appendix 5

Farmer Characteristics in Wolayta Soddo

Farmer's name	gende	PA	age*	years	years	persor	# Male	# Female	# pers	ha of l	feed s	when*	forages previously*
Dano Lorato	m	Wareza Shoho	60	44	40	11	1	5	5	1.5	yes	dry	yes
Musukae Mamado	f	Wareza Shoho	40+	30	25+	9	0	4	5	1.25	YES	DRY	NO
Ataro	m	Wareza Shoho	60	40	22	5	1	1	3	0.4	yes	dry	no
Gebre Mikael Zewid	m	Gurmu Koysha	50	20	20	8	2	1	5	1.5	yes	dry	yes
Lante Lambebo	f	Gurmu Koysha	45	30	10	9	2	5	2	0.75	yes	dry	no
Tsige Aymalo	m	Gurmu Koysha	40	16	16	5	1	1	3	0.5	yes	dry	no
Toga Ababo	m	Gurmu Koysha	60	40	40	13	4	4	5	0.5	yes	dry	no
Mr. Zasa	m	Wachiga Busha	40	25	20	15	3	3	9	1	yes	dry	no
Tefera Chanko	m	Wachiga Busha	45	25	20	3	1	2	0	0.5	yes	dry	yes
Fekka Kitu	m	Wachiga Busha	-	-	-	-	-	-	-	-	-	-	-
Hidoto Urgulo	m	Kokate	55	25	25	5	3	2	0	4.15	yes	wet	yes
Nigatuna Gebre Sillassie	F	Kokate	40	4	4	3	0	1	2	0.13	yes	dry	no

Key N= Napier grass FT= fodder trees Des=Desmodium Sp.

* information from June 2000 survey

Farmers' Livestock Holdings

Farmer's name	# of ca	# kept r	draugh	iry X*	dairy l	fat cat	growir	growir	sheep	goat*	equine	poultry	change in animals	use of milk/ milk products*
Dano Lorato	5	1	0	1	0	1	4	3	2	0	0	0	plus 2 calves	home
Musukae Mamado	5	0	1	0	2	0	2	2	0	0	0	0		home/sells butter
Ataro	0	3	0	0	0	0	0	0	0	0	0	0		n/a
Gebre Mikael Zewid	5	0	2	1	0	0	2	2	0	3	0	0		home/sells xs
Lante Lambebo	2	0	0	0	1	0	1	1	0	0	0	0	plus 1 calf	home/sells butter
Tsige Aymalo	4	0	1	0	2	0	1	1	0	0	0	0	plus 1 ox	home
Toga Ababo	6	0	2	0	2	0	2	2	4	0	1	8	less 1ox, 5 hens , 2sheep + 1cow	home
Mr. Zasa	6	0	1	0	3	0	2	2	1	0	1	5		
Tefera Chanko	2	1	0	0	1	0	1	1	0	0	0	yes		home/sells xs
Fekka Kitu	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Hidoto Urgulo	8	0	2	2	3	0	1	1	4	0	0	5		home
Nigatuna Gebre Sillassie	1	0	0	0	0	0	1	1	0	0	0	0	plus 1 chicken	n/a

Appendix 5

Methods of Planting and Uses of the Forages

Farmer's Name	# of	what survived	How used	where planted
Dano Lorato	6	LL GL SL SB AX	LL seed others feed	fence LL GL SL AXwater ways and stream GL SL
Musukae Mamado	5	2	feed	plots
Ataro	5	3	feed	plot
Gebre Mikael Zewid	7	all	collect seed feed	plots LL GL SL, pathways GL SL, intercrop and over sow pasture V
Lante Lambebo	5	LL GL SL SB V	collect seed still there	plots
Tsige Aymalo	7	GL SL V	feed cut and carry	plots V under maize
Toga Ababo	7	Des sp.	feed cut and carry	Des. under coffee
Mr. Zasa	6	LL	Fed once then collected seed	LL w/ maize plots
Tefera Chanko	6	GL SR SB SL	feed cut and carry	GL/SR/SL under coffee sesbania fence
Fekka Kitu	6	GL SL	neighbor 's cattle ate.	SL/GL along hedge by maize field
Hidoto Urgulo	6	LL Gl SL V	not	LL pasture GL/SL/V along field
Nigatuna Gebre Sillassie	6	none	n/a	planted under fence

Key: AX= Axillare GL= Green leaf LL= lablab SB= Sesbania SL= Silverleaf SR= Siratro V= Vetch

Farmer's Comments about Forage

Farmer's Name	comments
Dano Lorato	cattle liked all. plans to expand. will share seed if there is excess
Musukae Mamado	cattle liked, wants training to know how to use
Ataro	cattle liked wants, training to know how to use
Gebre Mikael Zewid	cattle liked, collected 1kg V seed & 1kg LL seed, attended class about forages cattle management
Lante Lambebo	did not know how to use and plots will be part of demonstration
Tsige Aymalo	"I like very much. the cattle like very much"
Toga Ababo	shortage of land reason
Mr. Zasa	2-3 kg LL seed. Animals liked very vigourous
Tefera Chanko	cut and carry twice SL/GL/SR
Fekka Kitu	
Hidoto Urgulo	"Cattle didn't like" plowed under SL/GL/V seemed more intrested when found seed prces
Nigatuna Gebre Sillassie	I didn't know what to do with the forages. I did what the DA told me and they didn't grow