Journal of Biology, Agriculture and Healthcare
ISSN 2224-3208 (Paper) ISSN 2225-093X (Online)
Vol.7, No.1, 2017

Pasture Management and Improvement Strategies in Ethiopia

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Abstract
The purpose of this paper is to review the pasture management and improvement strategies. Pasture management is defined as practice of growing healthy grass and related plant profitable sustains forage availability and production. Management is the key to healthy, productive pastures. Controlled, rotational, or management-intensive grazing has increased forage production for many producers. Skillfully using livestock to harvest forages leads to improved soil fertility, diverse, dense, and useful pasture ecology, and an extended grazing season. Fertile soil and productive pastures, in turn, support healthy animals. The total grazing and browsing lands are steadily shrinking due to encroachment of crop production as a consequence of the growing human population in Ethiopia. The productivity from grazing land is insufficient for optimal livestock production. Grazing land management, fertilizer application, over-sowing of legumes, optimum harvesting stage, feed conservation and utilization are important practices to improve the productivity of natural pasture and used to maintain the nutritive values of the pastures over seasons. Poor production of pasture lands and large herd size on small grazing lands caused overgrazing of natural pasturelands resulting in serious land degradation which in turn leads to invasion by unpalatable plant species and finally a decline in the quantity and quality of pasture. Grazing lands which were main source of natural pasture are being deteriorated due to different reasons such as high population pressure, land degradation and conversion of grazing lands into arable lands. As a result, crop residues have emerged as the main components of livestock diet as their production is boosted due to cropping intensification. But their nutritive value and digestibility is too low to support animals' extra productivity. Therefore, production of improved fodder using different strategies is mandatory to satisfy feed and nutrient demand of animals if better production and productivity is needed. Different forage development strategies like backyard forage development, under sowing of cereal crop with forage legumes, forage development on stock exclusion area, forage development on conservation structures, and over sowing on existing grazing/pasture land are practicing in Ethiopia.
Keywords: Conservation, management, improvement strategies, pasture

1. INTRODUCTION

The Federal Democratic Republic of Ethiopia (FDRE) is a landlocked country in the horn of Africa, bounded to the north by Eritrea, to the west by Sudan, to the south by Kenya and to the east by Somalia and Djibouti; it lies within the tropics between 3°24` and 14°53` N; and 32°42` and 48°12` E. It covers 1,120,000km^2 in nine regional states, one City Council and one City Administration. Smallholder peasants farm 8% (about 1x10^{7}ha) of the national land area and about 3.1 x10^{6}ha is fallow lands. The total area of grazing and browse is estimated to be 61x10^6–65x10^{6}ha, of which 12% is in mixed farming and the rest in pastoral areas (Alemayehu, 1998a; MoA, 2000).

Since Ethiopia is known to be the centre of origin and diversity for a number of domesticated crops, it is also known to be the centre of diversity for pasture and forage species. There are several centers of origin of the cultivated grasses (such as *Chloris* spp., *Panicum* spp., *Setaria* spp. etc.). For the tropical species the main centre is Eastern Africa, from where many promising species and varieties have been selected. In Ethiopia, the large numbers of indigenous grass species and the very great variation within the species make the country a rich potential source of new and better tropical pasture grasses. Until now there are a total of 736 grass species from 181 genera that are documented in Ethiopia, of which 164 species from 68 genera are reported to be important (medium to high level) for pasture and forage purpose (Alemayehu, 2002). Forages are the cheapest source of livestock feed. Ruminant animals have the ability to convert forages into milk, meat, hides and skins and draught power needed by man for food and drawing income (Sandra, 2002).

Management is the key to healthy, productive pastures. Controlled, rotational, or management-intensive grazing has increased forage production for many producers. Skillfully using livestock to harvest forages leads to improved soil fertility, diverse, dense, and useful pasture ecology, and an extended grazing season. Fertile soil and productive pastures, in turn, support healthy animals (Beetz and Rinehart, 2006).

Objective

The purpose of this paper is to review the pasture management and improvement strategies

2. LITERATURE REVIEW

2.1. Pasture Management

A well-managed grass pasture is one of the most cost-effective and high value feeds that can be produced and utilized. Pasture management can provide significant benefits including improved forage yields, lower feed costs and improve livestock performance (Beetz and Rinehart, 2006 and BMP, 2015). Therefore, good pasture management should include controlled use (grazing or cutting) and conservation strategies (Sandra, 2002).

2.1.1. Grazing management

Grazing management broadly speaking is the manipulation of grazing animals to achieve desired results. These results generally include maintenance or improvement of range productivity, efficient utilization of the forage resource and production of animal products from livestock (Desta, 2009).

The essentials of grazing management required to obtain the optimum utilization of the forage resource can be categorized into three: proper stocking, proper season of grazing, proper distribution of grazing.

i. Proper stocking

This is probably the single most important factor involved in grazing management. Most range plants are well-adapted to tolerate grazing, but they do have limits as to frequency, intensity and season of utilization. Overstocking is a common livestock production practice used in most parts of the rangelands of Ethiopia but it is a serious problem in the Afar and Somali rangelands creating imbalances in the use of natural resources. Overstocking is the result of pastoralists using grazing land communally without limiting livestock numbers. Therefore, proper stocking involves obtaining the proper ratio between animal numbers and grazing forage, such that the animals can meet their intake requirements and the plants can meet their requirements for growth and reproduction. The amount of grazable forage present on the range is the primary component determining the proper stocking rate (Desta, 2009).

ii. Proper season of grazing

Some ranges are suitable for grazing during all seasons while others are accessible during certain seasons. Continuous grazing for consecutive years without resting the pasture results in deterioration of the range vegetation. Therefore, it is important to determine the seasonal suitability of the grazing land prior to developing the grazing management plan

iii. Proper distribution of grazing

Grazing distribution is always a factor in obtaining efficient utilization of available range resources. Animals never graze vegetation uniformly. The patterns of utilization which result may be classified as area selective and species selective grazing.

Animals' selective grazing behavior results from the preference of animals for grazing in certain areas as opposed to other areas. Many factors cause area selective grazing. This includes size and shape of pasture, location of water, salt, topography and other environmental factors. Livestock mobility and duration of grazing in a particular area is a key factor for proper utilization of available forage. Livestock mobility in this regard is a traditional form of pasture rotation grazing system, which discourages selective grazing and attempts to match the natural needs of the animals with the forage resource availability in different areas. However, its intensity depends on the animal concentration and grazing lands in a particular area.

The distribution of water points and the timing of their use have direct impacts on the condition and productivity of range plants. On the other hand, there are areas that are underutilized because of bad distribution or lack of adequate water for livestock, while areas around permanent water points can be heavily grazed. In general, mobility in a non-equilibrium environment is a necessary phenomenon to sustainable development in which livestock is an integral part of conservation and development.

2.1.2. Pasture rotation: graze the best, leave the rest

In order to sustain a healthy field and grass crop, livestock need to be rotated through a system of pastures rather than being allowed to graze continuously on one large pasture. The pasture rotation system will include a system of cross-fence to define areas of smaller pastures that livestock can be moved through. This system will result in more forage, less overgrazing and reduced soil compaction (BMP, 2015).

Grazing grass below three inches stresses the plant by reducing the leaf surface which grasses use to make their own food, thus forcing them to use up food reserves in their roots. Eventually, the grass depletes its stored reserves and dies, leaving bare spots in pastures land. There is a rule called the Grazing Golden Rule; keep the grass at least three inches (7.62cm) tall (BMP, 2015). Turn your animals out to graze a field when grass reaches six to eight inches and move them when grasses reach three to four inches in height. Grasses in the first pasture rest while the animals start on a new pasture. Resting grasses allows them to re-grow and collect energy to survive.

Rotational grazing entails more effort, but pays off in healthy animals, thriving pastures, decreased feed and vet costs, fewer weeds, less bare soil, and reduced runoff (Emmicx, 2001).

2.1.3. Avoid overgrazing

Overgrazing results when there are too many animals on too few acres or when animals are allowed to be on pasture all winter, which leads to loss of productivity and degradation of soils. Overgrazing kills beneficial plants by grazing them to death. The resulting bare spots encourage weed growth, erosion and runoff of nutrients into nearby streams, ditches, swales and wetlands. Overgrazing also causes soils to become compacted, reducing growing capacity and limiting the amount of water that can filter into the soil (BMP, 2015).

2.1.4. Mow and drag (harrow)

Mowing or clipping pastures after they've been grazed is beneficial if not all plants were consumed down to the

desired harvest height. Clipping helps maintain plants in the vegetative growth stage; where they are most productive and nutritious. Clipping also helps discourage weed growth by preventing many weeds from going to seed (Beetz and Rinehart, 2006 and BMP, 2015).

Harrowing (dragging) your pasture after grazing breaks up manure and evenly distributes the nutrients in the manure. Breaking apart manure piles prevents grass from being smothered by manure. Dispersing manure piles also helps control parasites and pest insects, such as flies, who prefer fresh manure for laying their eggs and survive for days within the moist middle of manure. Breaking apart piles exposes fly and parasite larvae to sunlight, which dries them out and kills them (Emmicx, 2001).

2.1.5. Biodiversity conservation

2.1.5.1. Seed conservation

Conservation and use of grass germplasm has made a significant contribution to the economic development of Ethiopia through the national pasture and forage research programme. The International Livestock Research Institute ILRI (ex. ILCA) has done much to fill the gap by collecting grasses from different parts of Ethiopia and by acquiring access to world collections of forage grass germplasm. Currently over 371 accessions of grasses from 77 species and 37 genera, 2 076 accession of legumes from 140 species and 35 genera and 185 accession of browse from 41 species 18 genera are collected and conserved. In recent years the Forage and Pasture Genetic Resource Conservation and Research Department was established under the Institute of Biodiversity Conservation and Research/Ethiopia (IBCR/E) to carry out the conservation of pasture and forage genetic resources (Alemayehu, 2002).

2.1.5.2. Fodder or forage conservation

The growth pattern of pastures and fodders changes according to the rainfall pattern. There are seasons of surplus feed for livestock and some of shortage. In principle, the surplus feed should be preserved for the season with a shortage. This is called fodder conservation. Fodder can be conserved as hay or silage. The most important reason why fodder should be conserved is to provide high quality fodder to the animals during the dry season, and bridge the gap between the feed requirement of the animals and the production of the fodder (Alemayehu, 2002 and Sandra, 2002). Dry season feed shortage affect animal production levels and contribute to overgrazing hence exposing the soil to all agents of erosion (Sandra, 2002). These dry-season feed shortages can be addressed as follows:

- ❖ Grow fodder especially legumes that provide high quality feed for a longer period
- ❖ Conserve fodder

a. Haymaking

This is a process whereby fodder is harvested at a time when the feeding value is high (Sandra, 2001). Studies by Fekede (2013), districts of Ethiopia around Sululta, Girar Jarso and Ejere indicated that the majority of households conserve hay in loose form and under open air for the whole duration of feeding and such a practice could inevitably lead to the loss in hay quality as a result of exposure to adverse weather conditions. Hay storage losses vary greatly depending upon several factors, but storage technique is of utmost important. Quality losses of hay rise sharply as moisture levels increase above 20%. Losses from bales stored outside under adverse conditions can be much larger. During storage, hay can be subject to dry matter losses as well as losses of forage quality.

Hay produced from natural grasses, improved forage legumes and browse legumes is the most appropriate conserved forage for small-scale fattening or dairy production in Ethiopia. Forage conservation is especially important for dairy production because it ensures a supply of balanced nutrients for dairy animals throughout their lactation (Alemayehu, 2002).

What can be conserved and when? According to Alemayehu, 2002 and Sandra, 2002):

- ✓ Ideally a mixture of grasses and herbaceous legumes is desirable because legumes increase digestibility and intake of the conserved forage.
- ✓ Most grasses are good for hay production and are convenient for cutting.
- ✓ The pasture should be cut just before flowering in order to have high digestibility and high protein content.
- ✓ Pasture for conservation should be cut 4 to 6 weeks after a paddock is closed.

Guidelines for haymaking

- ✓ Cut the pasture before flowering starts.
- ✓ Time cutting to be between rains for good drying.
- ✓ Dry the cut pasture as quickly as possible. Use a rake and turn the pasture several times this prevents moulding.
- ✓ Once dry, heap up the hay into a “stack” which should be protected from the rain. The haystack should be like an inverted ‘V’. The use of a tarpaulin or polythene sheet is recommended.

Baling of hay makes storage easier. It requires:

- ✓ A bottomless wooden box (baling box) with dimensions of 3ft by 2.5x2.5ft.
- ✓ A 10 ft long sisal string.
- ✓ Dry pasture material.

- ✓ Have 3 to 4 people tightly pack the pasture into the box, tie it very tightly and remove the box to leave a bale.
- ✓ The bales of hay must be stored off the floor; kept moisture free and allow plenty of air circulation to prevent moulding

b. Silage making

Silage is produced through controlled fermentation (under anaerobic conditions) of green forage material with high moisture content. The anaerobic conditions foster rapid fermentation that produces natural organic acids, which prevent further change in plant composition. If silage is made properly, it will contain nearly all the nutritive values present in the forage that is conserved. Ensiling is the process of silage making; while a silo is the container used. It may be a trench, a pit or a polythene bag (Sandra, 2002).

Suitable crops for ensiling

All pasture and fodder crops can be ensiled. The most ideal would be maize and sorghum but these still form the bulk of human food almost in all African countries, hence cannot be used for that purpose.

High quality silage will be made if:

- Grasses are harvested when flowering.
- Legumes are harvested during pod filling.
- Maize/sorghum are harvested during milk-stage.

2.1.6. Pasture rehabilitation

Because of Ethiopia's diverse climate, there are a number of valuable wild grasses and legumes and browse plants. The highlands are rich in pasture species, especially legumes. Herbaceous legumes tend to increase with increasing altitude. There is a wide diversity of annual and perennial *Trifolium* species and annual *Medicago* in the highlands, particularly above 2,000m. At lower altitudes annual legumes are less abundant, but there are a number of browse species adapted to the dry conditions (Alemayehu, 2006).

Despite the fact that research on natural improvement is minimal, most trial results are positive. To improve the vegetation composition and the nutritional value of degraded pastures, research on oversowing with legumes and grasses has indicated that vetches (*Vicia dasycarpa* and *V. atropurpurea*) and local clovers (*Trifolium* sp.) were successful in the highlands. In mid-altitudes the perennial *Desmodium uncinatum* has shown superior establishment with Rhodes grass (*Chloris gayana*) and Siratro (*Macroptilium atropurpureum*). Research and development testing over the last two decades identified promising forages that are suitable for pasture rehabilitation in a wide range of agro-ecological zones. According to (Gebru, 2009) range rehabilitation can be implemented to improve degraded rangelands by oversowing or range seeding or broadcasting of pasture seed on grazing and degraded areas.

2.1.7. Bush and weed control

Bushes and weeds reduce grass productivity while some are poisonous. Food reserves in the root systems are exhausted by frequent uprooting and slashing, leading to their stunted growth and eventually death (Sandra, 2002). Weeds are major problems in both perennial and annual pasture and forage crops; unless they are controlled productivity will be low. In Ethiopia weed control by herbicides, machine mowing and topping and hand weeding have been tried; hand weeding is the best method. Since family and hired labour is plentiful and cheap there is an opportunity to use it for weed control, so there is a considerable opportunity to foster the development of improved pasture and forage crops on a large scale without a major problem of weed infestation (Alemayehu, 2006). Weed control practiced by using the panga and hoe. This is the cheapest option for most farmers in Uganda (Sandra, 2002). Therefore, although there are a number of bush control methods that are practiced in different countries including mechanical, chemical, power (chaining) or bull-dozing, the simplest and most practical methods that can be used in Ethiopia are; burning, hand clearing and biological control (Gebru, 2009).

There are two methods of biological control. The use of browsing animals (camels, goats and game animals) and the introduction of exotic insects which attack specific species of plants. However, the introduction of exotic insects is not recommended to avoid unforeseen consequences. Biological control using browsing animals can have a significant effect on bush control if the animal population is commensurate with the available browse vegetation (Gebru, 2009).

2.1.8. Irrigation

Low and erratic rainfall is characteristic of pastoral areas in Ethiopia and pastoral production systems have always relied upon surface and ground water sources. Strategic water development interventions have significant impact in contributing to improving range utilization. Water is needed only where there is unutilized grass and then only in the quantities appropriate to optimal grazing use (Gebru, 2009). Efficient water use is crucial for sustainable irrigated pasture management (Sandra, 2002). Productive irrigated pastures are usually the result of successful management of several production factors, including: fertility, irrigation, species selection, grazing management (Beetz and Rinehart, 2006) and also different factors to be taken into consideration during selection of forage species for the required forage development strategies are environmental characters (like; altitude, soil

type, rainfall and temperature) were described as the major once by (Shimelis and Temesgen, 2016).

The irrigation potential of the country; Ethiopia is high; the potential area for irrigation is estimated to be about $3x10^6$ ha. Small-scale traditional irrigation has been practised for decades throughout the highlands; small streams are seasonally diverted for limited dry season cropping. This is a good opportunity to grow off-season pasture and forage crops. Medium- and large-scale schemes are of much more recent origin, mostly in the Rift Valley for cash crops. There is some irrigated forage in the Rift Valley growing Lucerne/Rhodes mixture for commercial fattening and dairy farming. The potential for irrigated forage is untapped and still there is a great opportunity for producing seasonal and long-term irrigated pasture and forages (Alemayehu, 2006).

Grasses and legumes require about 0.20 and 0.25 inches of water per day respectively throughout the growing season. So, frequency of irrigation depends on soil texture and, in turn, on water holding capacity of the soil. Heavier (clay) soils hold more water, up to 2.5 inches per foot of rooting depth, and coarser (sandy) soils hold less water, around 0.75 inches per foot. Pastures have an effective moisture depletion allowance of about 65 percent, which means plants begin to suffer stress after 65 percent of the soil's water-holding capacity has been depleted. For example, pasture soil with a water holding capacity of 1.5 inches per foot, and a rooting depth of four feet, can hold a total of six inches of water. At a 65 percent depletion allowance, 3.9 inches remains available to the plants. If the plants use 0.25 inches per day, an irrigation event that saturates the soil will last about 15 days (Beetz and Rinehart, 2006).

Attention to soil fertility is critically important in irrigated pastures. Pasture establishment is a key time to ensure soil is adequately fertile for the selected forage species to become established and remain productive. During secondary tillage, rock minerals, composted manure, or commercial fertilizers can be incorporated into the soil. Apply nitrogen only after the grass stand is successfully established. If the stand has a legume component, limit the use of synthetic nitrogen fertilizers. In general, nitrogen fertilization favors grass growth, and phosphorus fertilization favors legumes (Beetz and Rinehart, 2006).

2.1.9. Better grazing land resource management

At every point of resource management, community knowledge and participation, from the beginning to the end, thorough evaluation and monitoring is vital. Ethiopia's farming people have traditional laws that govern the community, adopted for thousands years. The presence of traditional community rules provides an opportunity in the management of the grazing and other land resources. Current government policies encourage peoples' participation and community participation from project conception through planning and implementation to monitoring and evaluation undertaken on the decisions of the resource users and managers (Alemayehu, 2006).

On top of these, protection and penalizing of illegal acts against management of grassland resources, the community exercise their own acceptable by-laws. This provides the best opportunity for correct management of grazing land resources. Based on these, a number of recommended management rules are developed to assist grazing land problems and management. These rules are based on community by-laws.

Recommended rules for grazing land management in Ethiopia

- Respect, promote and encourage the traditional sustainable natural grazing land resource use by the local community.
- Promote the means to zero grazing and controlled grazing and encourage people to see their animals in economic terms (market value) rather than social prestige.
- Encourage the cut-and-carry system of feeding, forage development around homesteads crop farms and hillsides.
- Promote agro-forestry, which also increases firewood, construction material, implements and crafts and forage production.
- Increase animal production through the best utilization of pasture and forages. Integrate soil and water conservation enclosure with sustainable forage production.
- Mobilize indigenous and scientific knowledge into different localities through networks.

In addition to their role in animal feed, pasture and forages in Ethiopia can make a significant contribution to sustainable uses, like watershed management, soil erosion control, soil fertility maintenance, in general to natural resources management and thus to national food security.

2.2. Pasture Improvement Strategies

Forages are the cheapest source of livestock feed. Ruminant animals have the ability to convert forages into milk, meat, hides and skins and draught power needed by man for food and drawing income (Sandra, 2002).

Grazing lands which were main source of natural pasture are being deteriorated due to different reasons such as high population pressure, land degradation and conversion of grazing lands into arable lands. As a result, crop residues have emerged as the main components of livestock diet as their production is boosted due to cropping intensification. But their nutritive value and digestibility is too low to support animals' extra productivity. Therefore, production of improved fodder using different strategies is mandatory to satisfy feed and nutrient demand of animals if better production and productivity is needed (Shimelis and Temesgen, 2016).

As pointed out by (Shimelis and Temesgen, 2016) different forage development strategies like backyard forage development, under sowing of cereal crop with forage legumes, forage development on stock exclusion area, forage development on conservation structures, and over sowing on existing grazing/pasture land are practicing in Ethiopia. The key forage production strategies are conservation based and promote the use of legumes as improved forage (Alemayehu, 1989; Robertson, 1990). The key strategies are divided into two categories:

1. On farm strategies

Backyard forage production, undersowing and interplanting, contour forage strips, agroforestry

2. Common land strategies

Oversowing common grazing areas, stock exclusion areas/forage banks, permanent pastures

2.2.1. Sown pastures and forages

Climate and land availability provide a good opportunity for forage production. In Ethiopia most improved tropical species can be grown in the lowlands (1,500–2,000m) and temperate species grow from above 2,100m up to 3,000m (Alemayehu, 2002). Introduced improved forage yield is higher than the naturally occurring swards and has higher nutritional value. In addition the length of the productive season is longer for cultivated pastures than for native pastures, which provides an opportunity for dairy and fattening production to develop and use pasture and forage on a large scale.

Greater use of leguminous fodder trees and shrubs assists in increasing soil fertility, controlling soil erosion and providing firewood and timber. These legumes are well adapted to the current edaphic and grazing condition, they can be readily integrated into farming systems, and they retain their feeding value into the dry season and show great success in the higher potential areas of the country.

Pasture establishment is relatively difficult in the highlands compared to the humid, warmer and lower areas, because of the soil and climate. In the wet season water logging, relatively low soil temperature and reduced long and short radiation limit the establishment and subsequent growth of pasture in the highland. In these areas, for the best environmental condition for seed and seedling establishment and growth, perennial pasture is usually sown during the short rains (March and April) but annual forages are usually sown in June (IAR, 1983).

Conventional methods of establishing pasture are tedious and labour demanding, especially in the highlands; better ways are the low-cost methods such as backyard, undersowing and oversowing, which are more attractive to farmers. These strategies provide farmers with proper use of their land for cultivation of crop/pasture and forage/trees, where products can be used for food, feed and firewood respectively. Some perennial grasses can be planted vegetatively; *Festuca arundinacea*, *Phalaris arundinacea* and *Setaria sphacelata* are well adapted to waterlogged conditions and easily established by root splits. There is also considerable opportunity for the use of fodder tree-legumes in agroforestry. Woody legumes provide: a fodder hedge planted around the backyard, firewood, wood for construction of houses and farm equipment, wind breaks, for ceremonial purposes and for stabilizing bunds and gullies. The current promotion of fodder trees-legumes in the national agro-forestry system is a good opportunity for extension of a forage programme within farming systems; and contributes to environmental protection and natural resource management and even to food security.

2.2.1.1. Undersowing and interplanting

Undersowing and interplanting is the establishment of forage species in an annual crop or perennial plantation. This strategy provides the most convenient approach to rapidly increasing on-farm forage supplies over a large number of farmers and should have a major impact in the short to medium term. The use of legumes in this system will contribute to the improved fertility and structure of cropping soils. Undersowing and intercropping are probably the most important of the forage development strategies (Alemayehu, 2002).

Undersowing works best with sprawling, low growing annual legumes but can also work well with climbing legumes. The strategy is particularly suited to the production of tall growing cereals such as maize, sorghum or millet but also works with other cropping systems. Undersowing with legumes produces large quantities of high quality forage for utilisation by either post harvest grazing or cut and carry (zero grazing) system. The undersown forage protects the soil from erosive rains, can contribute nitrogen for the food crop, and balances the forage value of crop residues such as stover and straw to increase its intake and utilisation. The strategy works well with sprawling and climbing legumes but is also effective with other forage legumes and dual purpose legumes such as cow pea (Alemayehu, 2002).

Tree crops and some vegetables can also be undersown or interplanted with leguminous forages. The strategy primarily involves lower altitude systems where fruit, coffee, coconuts, enset or chatt are grown. There is also broad application with eucalyptus and Acacia plantations grown for fuel wood (Alemayehu, 2002).

Where crop weeding practices are very thorough, forages should be undersown at the time of final weeding. This avoids any risk of the undersown legume competing seriously with the cereal crop but often means that the legumes have insufficient time to produce ripe seed prior to crop harvest. In areas of poorer weeding practices, undersowing should coincide with an earlier weeding. In this way sufficient legumes survive

any subsequent weeding to provide an adequate seeding capacity prior to crop harvest (Alemayehu, 2002).

Good stands of undersown legumes produce 2,500 to 3,000 kg dry matter per ha from one cut in farmers' fields (Robertson, 1990). Verano stylo (*Stylosanthes hamata*) undersown into a three week old sorghum crop near Kaduna in Nigeria yielded 1.6 t/ha sorghum grain, 3 t/ha DM stylo forage, and 6 t/ha sorghum residue (Saleem, 1982). The most significant outcome of this work was the successful intercropping of wheat with forage legumes without any significant reduction in wheat yield. *Trifolium quartinianum* was particularly efficient with broadcast undersowing at Holetta yielding 1.1 t/ha wheat grain, 2.1 t/ha wheat straw and 3.1t DM/ha clover hay (Kahurananga, 1988).

2.2.1.2. Reseeding (oversowing) on common grazing lands

Oversowing or range seeding is the simplest of the forage development strategies and can be undertaken at very low cost depending on the seeding rates used. It involves broadcasting or sowing improved forage species into common grazing lands, native pastures and degraded areas without any cultivation and fertilizer application or other inputs (Alemayehu, 2002; Sandra, 2002 and Gebru, 2009). Over sowing have a number of advantages; expenses very low cost, requires little labor, and little or no management, involves in improving forage production, soil fertility and forage quality (Gebru, 2009).

Range seeding is applicable only in selected localized situations. Sites which have been very badly degraded will not normally recover easily by natural means, even when good management and incorporating resting periods is introduced (Sandra, 2002). Areas where trampling and overgrazing have effectively removed a productive grass cover are suited to oversowing. Mostly bare areas would be more appropriate. Over sowing is the simplest and lowest cost forage development strategy and involves no change in grazing management. Legumes are more suitable for over sowing than grasses. Generally, grasses have poor germination and are slow to establish on compacted soils. However, in some cases where rainfall and soil conditions are favorable, hardy grasses like: *Cenchrus ciliaris*, *Panicum spp*., *Chloris gayana* and some other promising species can be sown.

2.2.2. Integration of pasture and forage in a farm

2.2.2.1. Legumes in the pasture

Legumes increase soil fertility, improve overall feed value of available forage, and extend the grazing season. Bacteria that live in nodules on the legume roots convert nitrogen in the air to a form the plant can use. After the nodules separate from the roots or the plant dies, this nitrogen is available to nearby plants. Even during the growing season, dead leaves fall to the ground and provide extra nitrogen to the pasture system. Compared to grasses, legumes have higher digestibility and higher mineral and protein content (Beetz and Rinehart, 2006).

One of the best opportunities for highland farmers to use land efficiently will be through the introduction of pasture and forages in the farming system. In trials in the highlands on wheat and barley undersown with Lucerne, annual clovers, tall fescue, perennial rye grass, *Setaria* and *Phalaris*, the sowing of both cereals and forages was at the same time. All under sown forages established successfully except Lucerne and there was no significant reduction of cereal yield. The establishment of forages was much better under wheat than under barley (IAR, 1983). Since fallowing cropland is common in the highlands, under sowing cereals with forages could significantly relieve the feed problems of the area.

At research sites in the mid-altitude area, maize was under sown with *Desmodium*, Phasey bean, *Chloris* (Rhodes grass), *Panicum* and *Cenchrus* after the first weeding. Almost all forages established, and there was no maize yield reduction (IAR, 1983). There is a good opportunity for integration of pasture and forage crops in the existing farming system.

As a result of these findings, in Ethiopia heavy emphasis is put on the use of forage legumes in cropping systems (through under sowing, improvement of fallows and establishment of tree legumes hedges) to partly address the major problems of long-term sustainability of crop production. Extensive use of tree legumes in a number of strategies can have an effect, in the long term, on firewood supplies, including the release of dung that would otherwise have been burnt. The increased forage supply and improved use of forage (dairy and fattening system) will provide another opportunity for generating dung. There is a wide opportunity for the use of forage pulse crops to be incorporated in the farming system; adapted and recommended crops are: cowpea, pigeon pea and *Phaseolus acutifolius*. These can be used for food and feed especially during the dry season.

2.2.2.2. Contour forage strips

Forage strips are broad based mixtures of herbaceous and tree legumes, and grasses planted on contour bunds or in narrow strips along the contour without any physical structures. This is a multipurpose strategy providing forage, shelter, soil stablisation, and fuelwood. Forage strips planted along the contour contribute to soil conservation by directing ploughing along the contour and by reducing run-off down the slope. This increases infiltration and reduces soil erosion, and they produce a high yielding, high quality pasture, the legumes improve soil fertility, and allow a high stocking rate and high levels of animal production, especially where a thick sward of grass or herbaceous legumes is included in the forage strip (Alemayehu, 2002 and Sandra, 2002). Contour forage strips are particularly successful when perennial, thick rooted grasses are mixed with woody leguminous species. Because this strategy integrates forage production in cropping areas, potentially weedy species such as

stoloniferous grasses should not be used for forage strip plantings (Alemayehu, 2002).

2.2.3. Backyard forage production

Backyard forage production is based on small plots and hedges of productive forage and browse planted within house compounds and around their boundaries. This is the most important initial strategy since it is developed in the farmer's household, and is very convenient for intensive feeding of dairy animals or fattening of meat animals. The higher fertility level typically found in and around house compounds also helps with the successful establishment of backyard forage. This strategy has a major impact in exposing farmers to the management and productivity of new species and also provides a seed bank to help establish new plantings for other forage strategies. Woody leguminous browse species are particularly suited to this strategy because of their multipurpose benefits and rapid growth rates. Tall growing tropical grasses are also suited to backyard forage development (Alemayehu, 2002).

2.2.4. Stock exclusion areas/forage banks

Stock exclusion areas are an important means of protecting degraded areas, key watersheds, and common land. They also provide an opportunity to develop forage banks for use during droughts or periods of seasonal forage shortage. Stock exclusion areas are particularly important for the conservation of highlands but are only accepted by farmers where they see sufficient benefits to organise grazing management groups or pastoral associations to control stock exclusion areas and voluntarily keep stock out. The introduction of browse species, productive legumes and improved grasses can rapidly increase the productivity of exclusion areas. The strategy is suitable for aerial seeding techniques which enable very large areas of land to be sown to forage quickly (Alemayehu, 2002).

2.2.5. Pasture and forage seed production

Many of the temperate and tropical pasture and forage crops that have been tested and grown in Ethiopia have no problem of flowering and setting seed. This provides a good opportunity for the country to establish local seed production in the existing farming system. The current local pasture and forage seed production systems adopted in the country are:

- Farmer contract seed production system: involves the production of annual and perennials under contract with individual farmers and/or farmer's cooperatives
- Seed production on ranches: this is mostly for perennial legumes and grass seed
- Seed production on specialized plots: this is undertaken in a few areas by some governmental and non-governmental organizations

Opportunistic seed production: involves the collection of seed from developed opportunistic pasture/forage sites.
Under these systems over 200,000 tonnes of forage seed were produced from 1988 to 2002. Of the seeds produced, vetch, lablab, cowpea, Axillaris, Siratro, Stylos, *Desmodium*, oats, Rhodes, *Panicum*, tree-lucerne, *Leucaena* and *Sesbania* are dominant. Large local seed production is under way using farmers' contracts (Alemayehu, 2001).

General guidelines for improving pastures

Selection of the most suitable pasture species involves the identification of grasses and legumes with the following desirable characteristics:

- The pasture species must be adapted to the climate and soil where they are to be sown and suitable for their intended use (for grazing or for cut-and-carry).
- The grass or legume should be highly productive and persistent.
- The grass or legume should be able to provide good soil cover and easily compete with weeds.
- It should be palatable (desirable to livestock).
- It should have a high nutritive value, that is, provide enough energy and protein and have no toxic substances.
- The species should be easy to establish from seed or vegetative propagation. Pasture plants that can be established from roots and cuttings are good because planting material can be built up with time, particularly with small-scale farmers, given the high cost of pasture seed.
- The species should be an early and heavy seeder.

3. CONCLUSION

Since Ethiopia is known to be the centre of origin and diversity for a number of domesticated crops, it is also known to be the centre of diversity for pasture and forage species. There are several centers of origin of the cultivated grasses (such as *Chloris* spp., *Panicum* spp., *Setaria* spp. etc.). For the tropical species the main centre is Eastern Africa, from where many promising species and varieties have been selected. In Ethiopia, the large numbers of indigenous grass species and the very great variation within the species make the country a rich potential source of new and better tropical pasture grasses. Until now there are a total of 736 grass species from 181 genera that are documented in Ethiopia, of which 164 species from 68 genera are reported to be important (medium to high level) for pasture and forage purpose. Therefore, forages are the cheapest source of livestock

feed. Ruminant animals have the ability to convert forages into milk, meat, hides and skins and draught power needed by man for food and drawing income.

Management is the key to healthy, productive pastures. Controlled, rotational, or management-intensive grazing has increased forage production for many producers. Skillfully using livestock to harvest forages leads to improved soil fertility, diverse, dense, and useful pasture ecology, and an extended grazing season. Fertile soil and productive pastures, in turn, support healthy animals. A well-managed grass pasture is one of the most cost-effective and high value feeds that can be produced and utilized. Pasture management can provide significant benefits including improved forage yields, lower feed costs and improve livestock performance. Therefore, good pasture management should include controlled use (grazing or cutting) and conservation strategies. Grazing management broadly speaking is the manipulation of grazing animals to achieve desired results. These results generally include maintenance or improvement of range productivity, efficient utilization of the forage resource and production of animal products from livestock. Since Ethiopia is known to be the centre of origin and diversity for a number of domesticated crops, it is also known to be the centre of diversity for pasture and forage species. There are several centers of origin of the cultivated grasses (such as *Chloris* spp., *Panicum* spp., *Setaria* spp. etc.). For the tropical species the main centre is Eastern Africa, from where many promising species and varieties have been selected. In Ethiopia, the large numbers of indigenous grass species and the very great variation within the species make the country a rich potential source of new and better tropical pasture grasses. Until now there are a total of 736 grass species from 181 genera that are documented in Ethiopia, of which 164 species from 68 genera are reported to be important (medium to high level) for pasture and forage purpose. Therefore, forages are the cheapest source of livestock feed. Ruminant animals have the ability to convert forages into milk, meat, hides and skins and draught power needed by man for food and drawing income.

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4. RECOMMENDATIONS

Given the existing retrenchment of extension staff in the public service, it would be appropriate to use farmer-to-farmer extension services. Farmer trainers should be identified at the sub-county level and be facilitated the exchange of knowledge and experience between the farmers. Pasture seed production at sub-county level should be promoted. Innovative and willing farmers should be facilitated to have seed multiplication plots, which can be sold to the other farmers. However, support from the government, non-government and development agencies would be required, particularly in provision of good foundation seed. There should be more sensitization programs on importance of fodder conservation in intensive livestock production system.

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