

Bush Encroachment in Borana Rangeland in the case of Southern Ethiopia: Causes, Impacts and Management Implications

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Abstract – Savannah rangelands comprising grasses and woody specie Savannah rangelands comprising grasses and woody species, which cover a half of terrestrial land surface providing a major socio-economic importance of a large proportion of the livestock population. The ecological and economic function of Borana rangeland is threatened by bush encroachment i.e., increase of woody species often unpalatable to livestock at expense of the grass layer. Many factors have been remarked to drive bush encroachment in Borana rangeland; the banning of fire, recurrent drought, population pressure and misconception of the effectiveness of traditional resource management systems are among the common. It can also causes a loss of herbaceous vegetation, grass species composition, alter soil moisture and nutrients, microclimatic conditions and suppress grass productivity and become a major threat to the livelihoods of the Borana pastoralists and their ecosystem. The weakening of traditional range and water management strategies such as the mobility and diversification of livestock based upon the spatial and temporal rainfall variability, creating enclosures and frequent droughts identified as the major factors that caused encroachment of woody plants and reduced the amount and quality of pasture. The enforcement of a national ban on bush fires resulted in increased bush encroachment, the reduction in availability of good pasture and demand for the greater private rights as individuals are willing to clear bush from private land but not from communal pasture. The pastoralists perceived that bush clearing, rangelands burning, herd diversification and mobility were recommended as the potential management options to minimize the negative impact of bush encroachment.

Keywords – Savannah Rangelands Comprising Grasses and Woody Specie Borana Rangeland, Bush Encroachment, Range Degradation and Management Implication.

I. INTRODUCTION

Rangelands encompassing much of the areas of earth, where pastoral livestock production is a major land use, which cover 51% of land area while support 78% of the global grazing area (Asner *et al.*, 2004). However, the Ethiopian rangeland covers 62% of the country's total land area (Alemayehu, 1998), and the southern lowland accounts 7.6 - 12% that is about 78 million ha (Oba *et al.*, 2000). The portion of southern rangeland, Borana plateau, comprises about 95,000 km² (Coppock, 1994). The majority of these rangeland ecosystems are located in vegetation biomes such as the grasslands, shrub lands, savannas and deserts, and characterized by inherent arid climate experience large daily and seasonal temperature extremes. Hence, sustainable use of rangelands for

pastoralism depends on the understanding extent and degree of deterioration and how can be restored.

Borana rangeland supports a great diversity of the livestock both browsers and grazers. The livestock depend nearly exclusively on native vegetation for forage. This plateau was used to be one of the remaining pastoral areas, where both water and grazing constitute limiting factors, characterized by extent of its surplus grass in contrast to other areas. Unfortunately, these days, conditions of the rangelands are changed and the grazing land is being encroached by cropping and bushes of different species, which in turn reduce the herbage composition. The rangelands have been considerably altered with the advancement of bush encroachment which has emerged as one of the biggest threats to communities in the area. Encroachment of woody plants on an open grasslands and savannah has been one of the major threats to the livelihoods of the Borana pastoralists and their ecosystem.

Increasing woody plants density and cover has entered into the encroached condition, where the high value herbaceous forage plants have been significantly suppressed by the proliferation of woody plants (Tefera *et al.*, 2007). The densely interlaced woody plants deny cattle access to the available herbaceous plants in the understory. As a result, pastoralists have to change their livestock portfolio by keeping more camels and small ruminants but fewer cattle. Moreover, the bush encroachment served as a push factor for people to diversify their livelihoods since herding livestock on bush - encroached rangelands is getting more difficult. While, the demand for the livestock products should double near the 2020s with increasing demography in developing countries. Recent studies have revealed that existing high livestock number has exacerbated, especially in long dry season, the inadequacy of year round livestock feed supply.

The pastoral livestock production remains the principal economic activity in the arid and semi-arid rangelands of Ethiopia, which provides a living for about 6 million, an estimated 10-12% of the country's total human population. Despite a strong subsistence orientation, pastoralists provide about 90% of the legal livestock exports in live animals, and 20% of the draught animals for the highlands (Sandford and Habtu, 2000). Hence, increased productivity, environmental preservation and natural resource management are needed. These days, the Borana pastoralists are in a deteriorating situation. During the last 30 years, the deeply rooted indigenous natural resource management of Borana pastoralists has experienced severe form of external disturbances. Ordinarily, Borana pasto-

-ralists practiced strategic herd management and range resources to avoid local overstocking of the scarce dry season grazing areas. But, studies indicated that the areas are presently experiencing ecological and economic stress.

Ecological pressure is manifested by proliferation of bush encroachment, a common cause of herbaceous vegetation loss, plus a decline in range condition. Woody plant invasion of grasslands is prevalent in southern Ethiopia, particularly in arid and semiarid regions where fuel loads are insufficient to cause fire. It caused by the invasion of socioeconomically less important woody species and mostly happens in rangelands, which also widespread in areas where there is no nutrient competition between grass and bush, where grazing is infrequent and light. Also it showed that both external and internal factors promoted bush encroachment and deterioration in rangeland condition where the Borana pastoral production systems are under intensive pressure. Thus, the paper aimed to provide an indication of how different actors perceive the likely the current status and impact of bush encroachment and move towards a common outline on the impact of different management systems on pastoral livelihoods.

II. OVERVIEW OF BORANA RANGELAND ECOSYSTEMS

2.1. Pastoral Management Systems

Pastoral management systems have evolved from the pastoralist's successful adaptation under the harsh conditions of arid and semi-arid rangelands³. However, the pastoralist's knowledge and strategies in rangeland and water management are disturbed by inadequate development concepts and policies, and leads to environmental degradation and the erosion of important social structures. The existing pastoral systems including their local adaptations are highly divers and they share a common development trends. The nature of the natural resources and management system in Borana reflects typical characteristics of east African pastoralism.

Pastoral production systems have evolved under high-risk conditions in dry land regions. Traditionally, they were remarkably resilient to the climatic variability and to external perturbations like droughts. Herd mobility and common property regimes were used to exploit key resources at a larger scale thereby sustained utilization of scattered rangeland vegetation throughout the year. They have the ability to co-operate in the utilization and maintenance of the common pool resources was of great importance for maximized livestock production and successful risk management.

Pastoral management systems have been developed under high risk conditions in dry land regions. They are determined by natural environments with high variability in rainfall and recurrent extreme climatic conditions, associated with the spatial heterogeneity. Livestock husbandry is the principal economic activity, often controlled by the heavy drought-induced mortality. Livestock productivity depends on extensive grazing on

native pastures, with herd movements in search of forage as basic strategy. Pastoral grazing practices are economically the most efficient form of land use, and reach higher total returns per area land surface than sedentary or commercial ranching. Crop cultivation is not appropriate under high uncertainty of rainfall conditions.

2.2. Rangeland Condition

Range condition analysis is an essential prerequisite for designing appropriate management practices. Range condition refers to the current ecological condition of the range as compared with its ecological potential (Holechek *et al.*, 2001). Range condition classification provides an indication of the necessary management inputs. Based on the successional and community dynamics concepts, analysis of range condition is designed to assess whether or not range sites are at acceptable standards and capabilities for livestock production. The concept implies that the present state of health of the rangeland in relation to what it could be with a given set of environmental and managerial factor. Range condition measures range deterioration and improvement. The optimum range condition will differ according to the manner in which range is used; the comparison used clearly stated as whether based on actual measurements.

Whatever the cause range condition is down when desirable species are replaced by poor species, the reduced soil cover exposes excessive bare surfaces, erosion accelerates, and production of forage and animals' drops or any combination of these effects occurs Which describes the kinds of plants, kinds of soil, soil erosion assessment and other characteristics of a particular range site and each kind of site has its individual guide. A few decades ago, the Borana rangelands in southern Ethiopia were considered among the best remaining pastoral lands in east Africa, also noted that the Borana have continued to produce livestock with remarkable social organization until recently and the system has often been cited as a model of pastoralism in sub-Saharan Africa. Rangeland condition is described by a means of range condition classes and is affected by environmental factors as climate and seasonal variation in rainfall, elevation and soil type, intensity of grazing or browsing and bush encroachment.

2.3. Rangeland Degradation

The bush encroachment is often seen as a form of land degradation. In other cases, it is seen as a consequence of land degradation. To assess the rangeland degradation, it is paid attention to degradation and bush encroachment separately. Rangeland degradation applies where plant cover is severely reduced and erosion is clearly seen. The state of degradation is quite severe because both woody plant cover and density have entered into the encroached condition. Another important factor of rangeland health is not only the aboveground vegetation, but also the stored seeds of plants in the soil so-called seed banks, are important for the regeneration of the grasses after disturbance and environmental changes, also reduce the probability of the population extinction of plants (Solomon *et al.* 2006). A study on seed bank seedling density and botanical composition reports that less desirable grasses

species appear to be lower at government ranches than communal grazing areas. This is due to a high grazing pressure in government ranches, which led also to undesirable species aboveground.

2.4. *Bush Encroachment*

Bush encroachment is the suppression of palatable grasses and herbs by encroaching woody species often unpalatable to domestic livestock (Ward, 2005). The natural succession of vegetation is from the bare land to woody vegetation. When open grasslands are found this is normally the cause of intervention in the natural succession, through intensive grazing or fire. The effect of bush encroachment is reduced forage availability for the cattle. Bushes are competing with grasses for available water, nutrients and light. Another effect is that the grasses growing under bushes are often not accessible because of the thorny nature of many woody species. As a result, the grazing capacity is reducing. Just as in many other areas in Eastern Africa, the Borana rangelands are threatened by bush encroachment.

According to the Borana pastoralists, the major causes of this encroachment is claimed to be overgrazing. Overgrazing is seen as one of the major ecological threats in the Borana zone. Bush encroachment has been increased in Borana rangelands because of the ban on burning (Maass et al., 2006). If burning would be allowed it does not mean that fire could be directly a solution. The ban on burning is not the only reason for bush encroachment. It is found that in areas closer to settlements and in private ranches the density of woody species is higher. The cause of bush encroachment other than ban on burning includes weakening of the traditional range and water management strategies and frequent drought. The study revealed that cultivation and non-participatory water pond development have played a significant role in rangeland degradation. Cultivation is closely related to the settlement through creating people increase the concentration of livestock especially around the permanent water points.

2.5. *Causes of Bush Encroachment*

The condition of rangeland depends on the various natural factors since; it is hard to conclude which factors are causing range degradation at a certain place in a certain time. In Borana situation pastoralists 28 years ago, they were burning their grazing lands. However, burning of rangeland was banned by the government and thus they could not apply their indigenous strategy for rangeland management. According to pastoralists' perception, the ban of burning grazing land is one major factor causing woody plant encroachment and subsequent range deterioration. Drought is the next cause of the bush encroachment. The pastoralists perceived that more frequent drought is one major factor for woody plants encroachment and loss of grass.

On the other hand, due to the unreliable rainfall, non-selective nature of fire and lack of enough fuel loads, range burning has become a challenge even if they were allowed to burn. Pastoralists suggested that the weakening of the traditional rangeland and water management

strategies and frequent drought were identified as the major factors that caused woody plants encroachment. It suggested that heavy grazing causes change in pasture composition, invasion of woody weeds, a reduction of total vegetative cover and increase in soil erosion. If grasses are over utilized, it loses its competitive advantage and no longer uses of water and nutrients effectively (Felegeselam, 2006). It results the higher water and nutrient infiltration rate to the subsoil such a scenario benefit trees and bushes, and allow them to dominate.

The prolonged denudation of soils caused by droughts and grazing followed by above-average rainfall years with frequent rainfall events favors the mass tree recruitment. The progressive growth of the bush cover is an indicator of ecological stress in the area. A Substantial change in encroaching plants is due to human pressure, recurrent droughts and overgrazing, results in a decline of grazing and browsing capacity. Moreover, the activities of government, NGOs and other development agencies are subsidies for sedentarization and associated cultivation. Some of NGOs sponsored bush clearing programs to facilitate the reclamation of grazing areas can again use by community contribute to the management of the grazing areas. The priority needs for pastorals to understand the relationship between the environment and pastoralists, ignorance regarding to the pastoral perception contribution often understood by pastoralists than policy makers, development planners and researchers of the countries.

2.6. *Impacts of Bush Encroachment*

In recent years, Borana rangelands have greatly reduced in terms of grassland cover as a result of anthropogenic and naturally induced factors with consequences on the livelihood of the local communities. Conversion of the rangelands to bush land begun the early 1970s due to official ban of fire followed by the expansion of bush encroachment in the 1980s, results substantial impacts on the rangeland resources and ecosystem services (Oba *et al.* 2000).

2.6.1. *Ecological Impacts*

Ecological changes and a rapid increase in woody population densities in many rangelands of the world have made it increasingly difficult for pastoralists to plan effective resource management and utilization strategies. Increase in woody vegetation as ecological processes may change after invading plants have established and spread. These changes may be minimal and plant invader may simply increase species richness, where ecological processes are sufficiently disrupted; native species displaced, increasing plant community vulnerability to further invasion and regeneration of invasive plant. Change in vegetation structure has a profound effect on the functional properties of the ecosystems. Thus, the replacement of grassland/ savanna ecosystems by woodlands should be viewed not only as a local problem with economic impacts on livestock husbandry but also in longer term, regional impacts on biogeochemistry and climate will influence future land use options in arid and semiarid ecosystems worldwide.

Ecological changes are manifested by a progressive gro-

-with in bush encroachment, the common cause of herbaceous vegetation loss in dry savannas, and responsible for a decline in range condition (Oba *et al.*, 2000). The need to meet livestock demand from declining grazing land has led to the reduction or complete disappearance of the more palatable grass species. Bush encroachment becomes a problem when it exceeds 30% and includes a decline in range conditions (White, 1980). In East Africa, an increase in bush cover by 10% reduces grazing by 7% and eliminated by 90% bush cover (Oba *et al.*, 2000). Shift from grassland (10% bush cover) to bush climax (30% bush cover) is influenced by the interactions between episodic rainfall, fire and heavy grazing (Scholes and Archer, 1996).

Once established, bush encroachment accelerates the decline in grass cover while the intensification of grazing pressure reduces the fuel load required for fire to burn the bush cover (Oba *et al.*, 2000). In Borana pastoralists, cattle rely entirely on grasses for their nutrition. The availability of grazing resources is extremely important, because this forms the basis and limits of pastoralists' economic actions. A rapid increase in woody population and degraded grazing resources badly affected cattle production. The rangeland degradation defined as a reduction in the long-term capacity resulted in a decline in livestock production that affected the livelihood of pastoralists. Hence, proper management and the conservation of rangeland biodiversity are essential.

2.6.2. Impacts on Range Vegetation

Leopold, (1989) shown that the growth of the less palatable grasses, shrubs and weeds and the emergence of unstable equilibrium after livestock have grazed it. This is because of the suppression of palatable grasses due to woody species encroachment that are unpalatable to domestic livestock. In cases, competition from woody plants here decreases productivity of herbaceous layer, thus rendering an environment less suitable for grazers such as cattle and possibly more suitable for browsers as goats or camels. Overall, woody vegetation reduces the grass cover through increasing competition for available water and nutrients and reducing reaching grass layer (Thurrow, 2000) thus, increase in woody plant encroachment and herbaceous biomass production are negatively correlated (Gemedo, 2004).

2.6.3. Impacts on the Soil Environment

Trees and shrubs have been found to improve the nutrient status of their close surroundings in semi-arid shrub communities, arid grasslands tropical and subtropical savanna, eastern African savanna (Belysky *et al.*, 1990). All the studies, which measured carbon, nitrogen, phosphorus, revealed consistent horizontal pattern in top soil. The reason for the complex but action of interaction trees, under story plants and symbiotic microorganisms evidently contribute. Nutrients found in low concentrations throughout the soil profile may be taken up by the root system of the matured trees and shrubs. By leaf abscission, these nutrients will be concentrated in sub-canopy due to litter and decomposition. The combination, relocation and surface root turnover and shedding of the

leaves will act together as nutrient pump (McNaughton, 1985). Trees litter will unquestionably lead the accumulation of organic matter under and near the trees (Frost *et al.*, 1986).

Encroaching plants usually have many adverse impacts as they spread through terrestrial and aquatic ecosystems. Plants disrupt the ecosystem processes that includes the hydrological cycles, erosion and stream sedimentation, energy flow and nutrient cycling, native plant regeneration, fire regimes and reduce the capacity of ecosystems to recover to a desirable state after disturbance and provide goods and services demanded by the society. The changes in soils and microclimate accompanying long-term heavy grazing may have shifted the balance in favour of N₂-fixing or evergreen woody plants, which are better adapted than grasses to nutrient poor soils, and warmer, drier microenvironments. Establishment of trees and shrubs would have been further augmented by grazing-induced reductions in herbaceous competition and fire (Archer, 1995). In Borana lowlands, woody plants decreased the yield of herbaceous species and reduced the size of effective grazing land that is available for livestock; the other perceived constraints of bush encroachment were problems in herding livestock; became a home for harmful wildlife; and prevented access to available grass biomass (Gemedo *et al.*, 2006a), which threatening the livestock production and challenging sustainability of the pastoral system in general.

2.6.4. Impacts on Socio-Economy

The economic impacts of invasive plants on rangelands have received limited attention. This is due to difficulty of quantifying the economic value of goods and services provided by ecosystems, further assessment of economic constraints of invasive plants. Plant encroachment has been and continues to be a major problem in grasslands and savannah. Because of its direct effects on livestock production, encroachment of woody vegetation into grasslands has been one of the most important problems facing the ranching industry and grazers and pastoralists in arid/semiarid regions throughout. Bush encroachment reduces the carrying capacity for livestock. This has great significance because savannah in Africa contains a large and rapidly growing human population. It is especially prevalent on commercial rangeland and has measurably reduced the economic productivity of livestock industry.

According to Feller *et al.*, (2006), savannah is currently infested with torn bushes covering an estimated 10-12 million ha representing 12-14% of the land. He reported that the concomitant economic loss of 700 million per annum has had a direct impact on the livelihood of 65,000 households in communal areas and 6,283 commercial farmers and their employees. According to Mzezewa and Gotosa, (2009), the economic cost of woody invaders control in South Africa amounts 40 million per annum. Ayana, (2007) stated that traditional resource management was in harmony with the variability of the ecosystem and it had significant implications for the sustainable use of scarce resources and the overall stability of the pastoral production system. In Ethiopia there is no quantitative data

found but in Afar national regional state, *P. juliflora* has affected both the major livelihood system and daily activities of the local pastoralists in particular and the production system of the area (Amha, 2006). The current view of the people on *P. juliflora* is extremely on the side of its harmful effects, although some of its effects are beneficial or potentially useful. Some of the negative effects includes invasion of agricultural and grazing land domination and competition with native trees effects on human and animal health.

2.7. Management Options of Bush Encroachment

2.7.1. Mechanical Control

A number of techniques are used to control rangeland weeds including hand pulling, hoeing, tilling, mowing, grubbing, chaining and bulldozing. Pulling and hoeing or shoveling is effective methods in loose and moist soil with shallow rooted weeds that are killed with complete crown removal. Techniques are also effective for the control of small infestations at the fringe of a major infestation. Also are commonly used in a follow-up management program where only a few plants remain. Is a commonly used tool for control of noxious range annuals and some perennials can prevent seed production, reduce carbohydrate reserves and give advantages to desirable perennial grasses. Success of mowing often depends on timing; basal branching pattern while the optimum time for mowing is in the flowering stage before seed development. Tillage practices can also control the annual species but in perennial species rarely provide control and often lead to the spread of weeds. Tillage can be used in level areas; it is not a practical tool for weed control in most rangeland terrain. Control of shrubs or trees, mechanical methods can include chaining, bulldozing, roller chopping, woodcutting, root plowing (power grubbing) and shredding of these mechanical treatments require relatively gentle terrain. Bulldozing and fuel-woodcutting are generally effective only for large shrubs or trees that do not readily re-sprout from the roots, while shredding can only be used on smaller shrubs can be used to remove tree stumps that are capable of re-sprouting.

2.7.2. Cultural Control

The proper grazing management can minimize the spread and effectively manage noxious weeds in rangeland. This case, it is important to select the most appropriate grazer for the specific situation. Diet preferences among livestock species can be a major force in shifting species composition of native plant communities. For example, Goats prefers *E. esula* as a dietary constituent compared with cattle (Kirby et al. 1997). Preferential grazing can be also used to manage the poisonous plants. Foraging behavior can also influence the effectiveness of a particular livestock class. Goats dramatically reduced *C. solstitialis* infestations when the plants were grazed at the rosette stage. Cattle tend to avoid it once the buds produce spines, whereas goats continue to browse even in it's the flowering stage. Timing also can be critical to the success of grazing. Ideal time to graze is when the noxious species is most susceptible to defoliation or when the impact on the desirable vegetation is minimal.

Sheep grazing when associated grasses were dormant altered the age class distribution and reduced seed production of the weed.

The fire played an important role in the maintenance of many ecosystems predominantly grasslands. Rangeland, the prescribed burning often used for the long-term suppression of woody species however, burning has also been used to successfully control non-woody and annual species. Burns should be conducted following seed dispersal and senescence of desirable grasses and forbs and before viable seed production by noxious weed. Prescribed burning in rangeland also can stimulate annual and perennial grass growth and enhance native forb diversity. However, it is important to note that fire may promote colonization by many weeds or rapid recovery of noxious perennial species.

2.7.3. Biological Control

The goal of a program is not to eradicate target weed, but to exert sufficient environmental stress to reduce its dominance in the plant community. Agents can achieve this by boring into roots, shoots and stems, defoliation, seed predation or extracting plant fluids. These effects can reduce the competitive ability of the plant relative to the surrounding vegetation. A biological control agent includes nematodes, pathogens and vertebrates, released organisms are arthropods (insects and mites). Vast majority of released agents for terrestrial weeds are targeted for nonindigenous weeds of rangeland (Julien, 1992). The many attempts to control rangeland weeds through biological control, most attempts have been unsuccessful where it is successful, biological control can be a cost effective, long - term and self - sustaining management option (Blossey *et al.* 1994).

2.7.4. Chemical Control

Herbicides are the primary method of weed control in most rangeland systems; can be applied to rangeland by a number of ways including fixed-wing aircraft, helicopter, ground applicators, backpack sprayers and rope wick applicators. These, the auxin or growth regulator herbicides have played the most important role in rangeland weed control, compounds include picloram, 2, 4-D, dicamba, triclopyr and clopyralid.

2.7.5. Integrated Approaches

Most often, a single method is not effective to achieve sustainable control of a range weed. The use of any single technology to control these species is usually not successful. Successful long-term management program should be designed to include combinations of mechanical, cultural, biological and chemical control techniques. Of relying on a single technology, emphasizes the sequential application of complimentary or synergistic control measures in economically and ecologically effective manner. Coordinated use of multiple tactics to assure stable ecosystem function and pest damage below economic levels, while minimizing hazard to humans, animals, plants and environment, particularly in re-vegetation programs where seedling establishment most critical stage and dependent upon suppression of competitive species, especially annual grasses and broadleaf species.

2.8. Management Implications

The extensive livestock grazing is the main production system in dry savanna ecosystems. The pastoral communities normally use a traditional stock mobility following the spatial and temporal distribution of forage resources in response to rainfall variability. The traditional resource management in harmony with the variability of the ecosystem had significant implications for sustainable use of scarce resources and the overall stability of the pastoral production system. Herders in Borana, southern Ethiopia are largely dependent on cattle herding for their livelihood and preservation of their traditional culture. The variability in the cattle population within different land use systems reflects the multiple resource use adaptations. To reduce livestock losses to drought should be reconsidered. In terms of the drought management strategies that they focus on improved market access through subsidies to transport animals to the markets outside during droughts; traditional systems of post-drought restocking; and a drought insurance system for pastoralists such as provision of emergency feed to protect breeding stock and immature animals.

The focus on the ranch breed conservation may be more crucial for serving as a gene pool for the communal rangelands than as a strategy for rehabilitating pastoralists' herds after drought occurrence. Pastoralists have rich experience in post-drought herd rehabilitation, the traditional system of post-drought restocking that rely on poor breeds of cattle from the neighboring highland communities contribute to the genetic dilution of their cattle breed. The better breed conservation would be part of improved drought management strategies and would continue to distribute quality bulls during drought recovery phase. Furthermore, use of community knowledge as a basis for understanding how historical changes in land use have influenced rangeland ecosystems provides an important insight in evaluating communities' responses to changing land use. Changes are reflected in terms of forage scarcity and the greater vulnerability of stock, particularly during drought years. Ban on the use of fire shifted the ecological balance between woody plants and grass species past policies failure to preserve the local environment, communities' knowledge may provide logical guidelines for revising pastoral development policies could be achieved by considering the local people's contributions to range management policies rather focusing on strategies imposed by the outsiders. Practical and valuable contribution in developing a more effective land use policy and sustainable use of local resources, the integration of herders' knowledge into management decisions should be considered a priority.

Furthermore, to promote the expansion of bush encroachment may be understood in terms of different land use systems, namely traditional enclosures and immediately adjacent open grazed communal rangelands. Evidence shows that reduced grazing pressure in the enclosures greatly increased the density of bush encroachment, implying that grazing is not the principal factor in driving bush encroachment. The mechanisms of

bush encroachment might be linked to stochastic events such as inter-annual rainfall variability as well as fire suppression. Effects of inter-annual rainfall variability were visible in terms of tree seedling regeneration while the long-term exclusion of fire promoted the proliferation of woody encroachment. Overall, understanding the dynamics of dry savanna ecosystems and the complexity of factors that drive shifts in vegetation is useful in making management decisions in terms of bush encroachment control. Evaluation of individual woody species in response to different demonstration methods may be useful in identifying possible intervention strategies for controlling bush encroachment.

III. SUMMARY

The paper suggests that the grazing might influence the balance between woody species and grasses, communal land use is no single cause for spread of bush encroachment. Encroachment control methods combining with tree cutting, fire and grazing were more effective in suppressing the regeneration of invasive woody plants. Encroachment related to fire suppression, inter-annual rainfall variability and exclusion of browsers, competition and hand removal of bushy plants. Some extent reduced grazing pressure in enclosures promoted bush encroachment compared to open grazed communal rangeland. The use of fire for restoration of savanna ecosystems is in terms of forage for livestock and maintenance of species composition. Also removes old grasses while post-fire grass growth preferred by grazing animals above unburned grasses, indicated that forage production has declined and threat of ticks infesting livestock has increased results a decline in herbaceous biomass.

Pastoral communities normally use a traditional strategy of stock mobility following the spatial and temporal distribution of forage resources in response to rainfall variability. Traditional resource management is in harmony with the variability of the ecosystem and it had significant implications for sustainable use of scarce resources and the overall stability of pastoral production system. Variability in terms of cattle population within different land use system reflects multiple resource use adaptations. Strategies to reduce livestock losses to drought be reconsidered and achieved in terms of drought management that focus on improved market access through subsidies to transport animals markets outside during droughts; supporting traditional systems of post drought restocking and drought insurance system such as provision of emergency feed to protect breeding stock and immature animals.

Besides, the focus on ranch breed conservation may be more crucial for serving as a gene pool for the communal rangelands than as a strategy for rehabilitating pastoralists' herds after drought. the use of community knowledge as a basis for understanding how historical changes in land use have influenced rangeland ecosystems provides an important insight in evaluating communities' responses to changing land use policies and misconceptions of

traditional resource management have resulted in expansion of bush encroachment and reduced grazing capacity of communal rangelands. Changes are reflected in terms of forage scarcity and greater vulnerability of stock, particularly during drought years. Ban on use of fire has shifted the ecological balance between woody plants and grass species. The introduction of government land use and fire ban policies, the vast areas of the savannas of Borana have experienced a proliferation of bush encroachment, with a drastic decline in grass cover so posing a serious threat to livestock production.

The failure of past policies to preserve the local environment, communities' knowledge may provide logical guidelines for revising pastoral development policies, which achieved by considering local people's contributions to range management policies rather than focusing on strategies imposed by outsiders. Its practical and valuable contribution in developing a more effective land use policy and sustainable use of local resources, the integration of herders' knowledge into management decisions should be considered a priority. To promote the expansion of bush encroachment may be understood in terms of traditional range enclosures and immediately adjacent open communal grazing range. The evidence shows that reduced grazing pressure in enclosures greatly increased the density of bush encroachment, implying that grazing is not principal factor in driving bush encroachment. The mechanisms of bush encroachment might be linked to stochastic events such as inter-annual rainfall variability as fire suppression. Effects of inter-annual rainfall variability were visible in terms of tree seedling regeneration while the long-term exclusion of fire promoted the proliferation of the woody encroachment.

IV. CONCLUSION

This paper provides the empirical evidences on the dynamics of the savanna ecosystems in southern Ethiopian rangelands by drawing existing ecological theories. Suggests that the past grazing management models are unsuccessful due to misconceptions of indigenous environmental knowledge that were based on equilibrium guiding principles. It suggested that alternative models such as non-equilibrium and state-and-transition models are more appropriate policy of the land use. Empirical evidence was in the form of relationship between rainfall records and cattle population data; of the impact of changes in land use and bush cover dynamics on range in terms of enclosures and open grazed areas and effects of different bush control methods on woody and herbaceous species. The traditional land use systems are being influenced by inappropriate land use policies. The study highlights the role of seasonality, suggesting rainfall variability is important factor in controlling livestock populations, both under communal and ranch systems. Inter-annual rainfall variability emerged as principal regulatory factor; equilibrium model seems unsuitable for such ecosystems. Thus, the pastoralists' observations shows that the impacts of changes have resulted in semi-

private rangeland enclosures and the fire ban, leading to the bush encroachment.

V. RECOMMENDATION

The evaluation of individual woody species in response to different demonstration methods might be useful in identifying possible intervention strategies for controlling, and then observations of the performance of individual woody species in response to different control methods of bush encroachment yielded various management and policy implications. The long-term implication of fire suppression in the savanna ecosystems of southern Ethiopia has been the proliferation of bush encroachment. The results show that the combined use of fire with other disturbances substantially reduced the abundance of woody species. However, variability in terms of individual species responses to different bush encroachment control methods probably reflects their capacity to respond accordingly to the various disturbance factors. Hence, understanding the reaction of individual woody species to the different control methods has important implications for management policy in terms of the sustainable use of savanna ecosystems. Effective bush encroachment control methods could be achieved if policy makers consider the various policy implications, rather than focusing on fire suppression. Moreover, public education through participatory research and extension programs would encourage better adoption by herders of effective management for the control of bush encroachment. Lastly, for management of bush encroachment with the hope that the outcomes in terms of promoting herbaceous biomass and conservation of species diversity will encourage the adoption of effective bush control methods by the extension department and local communities.

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