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ASSESSMENTS OF LANDSCAPE LEVEL DEGRADATION IN SOUTHERN ETHIOPIA: PASTORALISTS VS ECOLOGISTS

by
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ABSTRACT

This paper compares land degradation assessment techniques using indigenous ecological knowledge (IEK) of the Booran pastoralists and techniques used by ecologists. The study was conducted at landscape and regional levels in southern Ethiopia, where the Booran pastoral production system comprised the Golbo (lowlands), the Dirre (Plateau) and the Liiban production systems (hereafter also referred to as regions). The study by involving traditional range scouts in evaluating landscape and regional level environmental changes challenges the notion that IEK is mythical and could not meet scientific rigor. We show that the use of common soil and vegetation indices allows comparisons of land degradation assessments between IEK of the pastoralists and ecological techniques. Evaluation by traditional range scouts (TRSC) and range ecologists (RE) on changes in range conditions and trends showed high correlations. IEK was effectively used to determine landscape suitability and potential grazing capacity of individual landscapes and at regional levels. We show different perceptions in interpreting grazing suitability and potential grazing capacity. Management did not change the latter, which is an inherent property of individual landscapes, while the former could be altered. Both TRSC and RE made comparable predictions on threats to range conditions and trends, but interpreted landscape stability differently. We suggest that integrating IEK in the ecological methods would help identify important perceptions of the pastoralists on effects of land use on local landscapes. Moreover, the value of IEK should also be considered when monitoring landscape level changes as well as when assessing degradation of the grazing lands. We hope the information in this paper will motivate policy makers to incorporate IEK of the pastoralists into decisions on landscape level range rehabilitation.

KEYWORDS: Booran; bush cover; Ethiopia, indigenous ecological knowledge, grazing suitability, landscape patches, landscape change, potential grazing capacity, range conditions and trends

INTRODUCTION

The presumed linkage between pastoralists land use and degradation of grazing lands (Sinclair and Fryxell, 1985; Lamprey, 1983; Oba *et al.,* 2000a) have mostly relied on opinions given by ecologists, while indigenous ecological knowledge (IEK) of pastoralists, which is perceived to be unscientific is largely ignored (Pierotti and Wildcat, 2000). In contrast to the official view, the pastoralists have developed elaborate methods for assessing rangeland conditions and trends (Oba, 1994; Oba *et al*., 2000b). Whereas natural resource managers ignored IEK for what they considered to be lack of universal appeal needed for developing common grazing models, IEK utilized by different pastoral peoples worldwide has striking similarity in the way information on grazing lands is analysed and landscape level degradation assessed (Fernandez-Gimenez, 2000, Oba, 1994; Oba *et al*., 2000a). The pastoralists have perceptions of livestock grazing suitability and potential grazing capacity of individual landscapes (Homewood and Rodgers, 1991; Oba, 1994; Coppolillo, 2000; Fernandez-Gimenez, 2000).

By comparison, the ecologists' stereotypes about the perceived negative impacts by pastoralists on the environment are due to (a) lack of documentation of IEK techniques used for assessing grazing resources, (b) scarcity of quantitative data that integrate the IEK and ecological techniques to verify environmental change and, (c) failure to realize that assessments of environmental change using IEK operates at different scales from those used by professional ecologists. According to IEK, land cover changes occur at landscape patch levels, while grazing movements are at regional levels. Pastoralists assessed land degradation at the scales varying from patches of few meters to landscapes of several hundred hectares, while ecologists assessed degradation at ecosystem scales (Oba, 1994). Thus, the first step to integrate the ecological and IEK methods is to make environmental change assessments at similar scales (Kovacs, 2000; Fernandez-Gimenez, 2000; Berkes *et al*., 2000).

Perceptions of local farmers' and pastoralists' on the causes of environmental change were previously based either on semi-structured questionnaires (Thomas *et al.,* 2000; Wezel and Haigis, 2000), field observations (Turner, 1999; Fernandez-Gimenez, 2000), case studies (Howorth and O'Keefe, 1999), group interviews (Bielders *et al.,* 2001) or aerial photography interpretations in combination with field assessments (Gray, 1999; Dahlberg, 2000) but only a few studies involved the pastoralists in actual assessments and interpretation of landscape change (Oba *et al.,* 2000b). We evaluated the IEK used by the Booran pastoralists and ecological methods used by ecologists to assess environmental changes at the regional and landscape patch levels. We asked the following questions. (a) What were the general IEK of range management of the Booran? (b) What were their perceptions of landscape suitability and potential grazing capacity? (c) What factors did the Booran consider for assessing range conditions and trends in comparison to the assessments by ecologists? (d) What were the implications of IEK of grazing lands for improving evaluation of landscape level changes and hypothesis testing?

RANGELANDS OF SOUTHERN ETHIOPIA

The study area

The rangeland of southern Ethiopia, which accounts for 7.6-12.3% of the country, is an important area of cattle production (Alberto, 1986; Tessema, 1990). The Booran are the dominant pastoralist group, and they have been living in the region before the 13th century (Oba, 1996). Their indigenous system of water technology, complex organization of the gada system and management has attracted numerous studies (Baxter, 1954; Legesse, 1973; Helland, 1980; Upton, 1986; Cossins and Upton, 1988; Coppock, 1994).

The rangelands of southern Ethiopia are arid and semi-arid with pockets of sub-humid zones (Cappock, 1994). Rainfall is bimodal with the long (gaana) rains expected between March and May and the short rains (hagaya) between October and November (Upton, 1986). The short rains of hagaya are followed by long dry season (boona hagaya). Variable rainfall results in greater variability in forage; range production being greater during above-average years compared to the below average-years, while drought years have zero production (Cossins and Upton, 1988). To cope with variable range productions, the Booran of southern Ethiopia combined mobility and sedentary livestock management. Water from the deep tulla well complexes is an important resource for regulating stocking rates (Helland, 1980).

The indigenous range management of the Booran

The Booran grazing lands in southern Ethiopia traditionally comprised the Liiban, the Dirre and the Golbo production systems in correspondence with the geographical divisions of Booranland (Fig. 1). In individual production systems, the indigenous range management comprised grazing associations called dedha. The residents within individual dedha depend on common water sources called mada (Hogg, 1990). Within individual mada the residents divide livestock management into semi-sedentary camps (warra gudha) with milk herds (loon warra) and the dry and the non-breeding mobile herds (loon foora). The grazing lands of the Liiban, the Dirre and the Golbo production systems are allocated between the wet and dry season grazing (Fig. 2a,b, c,d). The wet season grazing is exploited using the rainwater, while during the dry season the mobile and the milk herds returned to the rangelands of the well complexes as in the Dirre and the Golbo production systems (Helland, 1980).

The Liiban production system is comprised of the Diid Liiban, the Chaari (also the name of dominant landscapes, see below) and the Badha landscapes (i.e. sub-humid zones). The annual grazing cycle in the Liiban production system (i.e. the Liiban Booran practice transhumance grazing) involves movements between the Diid Liiban during the wet season and the Chaari landscapes during the dry and the Dawa River in the Chaari landscapes during drought (Fig. 2b).

In the Dirre production system, grazing is allocated between the sedentary waara-milk herds and the dry mobile – foora herds (Fig. 2 c). The main dry season grazing lands are those around the tulla well complexes. The traditional practice of range management is to locate settlements 10-15 km from the wells. During the wet season, grazing is in the opposite direction, while during the dry season movements are towards the well rangelands.

The Golbo system is constrained by frequent droughts and limited dry season grazing lands. The mobile-foora livestock management mostly uses the Golbo, which also crosses into northern Kenya. Rainfall is erratic and grazing movements are highly opportunistic. During the dry season, the Golbo rangelands experience water scarcity. The dry season rangelands are limited and are used all year by the warra-herds (Fig. 2d). However, during the rainy season the nutritious grazing enables the foora-cattle to rapidly build body fat reserves.

Landscape level resource classification

The notion of cultural landscape change in Booranland has developed as a result of human-environment interactions. Perceptions of cultural landscape change manifest itself in terms of landscape classification by use of socio-ecological indicators. The main variants of landscape change are vegetation, while the potential is measured in terms of the soils. The Booran of southern Ethiopia group their grazing lands into six major landscape units (*Wayama*, *Chaari*, *Kobe*, *Malbe*, *Booji* and *Kooticha*, which have been described elsewhere (Oba *et al.*, 2000b)).

The different landscape units occur in patch mosaics within different production systems, and some are more dominant than others. High landscape heterogeneity creates patchiness that influences resource quality and season of grazing movements. Landscape patchiness is in response to historical land use and temporal and spatial patterns of rainfall. The Booran perceive that land use is essential in order for landscapes to be sustained in healthy conditions. The abandoned landscapes will become "wild", and more likely to be overgrown with bushes and infested with pests, such as biting flies and providing cover for the predators.

Other cultural imprints on landscapes include wells, burial sites, and land for rituals, while dwellings built out of temporary structures tends to disintegrate. Yet the cultural landscapes formed by old settlements and livestock night enclosures are always recognized. The accumulated organic matter and soil seed banks imported by livestock from the grazing lands, which after abandonment, regenerate into woodlands, create patchy environments (Reids and Ellis, 1995). Ultimately, some plant communities are associated with human settlements, which, in addition to landscape identities, determine future use of landscape patches. According to the Booran, landscape patches that have no history of previous use by settlements would not be used for establishing settlements. Consequently, there are settled landscapes and those that could not be settled. Such settled landscapes (*ardha*) have grazing in the immediate (*maara qae*) and the distant grazing lands (*maara maata' tiixa*). Similar to settlements, livestock grazing showed preference for different landscape patch types. The preference of landscapes for grazing by cattle, camels and small stock established the grazing suitability, which is an important index considered by the pastoralists for classifying landscapes.

Livestock grazing suitability

Soils are crucial for rating landscape-livestock suitability. Soil suitability varies according to night temperatures; warm soils being preferred over cold soils. In terms of vegetation, landscapes with perennial grasses are rated favourably for cattle, while browse is for camels and the small stock. Landscapes suited for camels are bushy and dominated by *Acacia brevispica* and *A. fructcosa* as indicator species. The small stock prefers highly heterogeneous landscapes where palatable forbs and *Commiphora* species dominate. Landscapes that are suited for all the three types of livestock have the right combinations of vegetation and soils.

Some landscapes are suited for settlements, while a majority are exclusively for grazing (Oba *et al.,* 2000b).

Grazing suitability index is related to another concept called fiina, which is a manifestation of range conditions and trends. It is the product of time, which influences the lives of people and livestock. *Fiina* is dynamic varying from season to season and year to year. *Fiina* is either negative or positive. Herders move to landscapes with positive fiina and abandon those without. Factors that contribute to negative *fiina* are presence of biting flies, poisonous plants, increased bush cover and ticks. The indicators of positive *fiina* are increased milk yield, high mating frequency of livestock and improved weight gains (Oba, 1985, 1994).

The concept of livestock grazing suitability differs from that of potential grazing capacity (PGC), which reflects the stocking a particular landscape would support without showing signs of overgrazing or being able to recover after grazing pressure is removed. PGC is the property of individual landscapes, regardless of the current grazing pressure. The concept decribes landscape resilience, which is not altered by the current land use. By contrast, an increase in woody cover might alter grazing suitability from those of cattle to camels but do not alter the PGC. The bio-indicator used in ratings of PGC is assessed on a nominal scale of low, moderate or high. Landscapes with perennial grass cover are considered to have high PGC for cattle and are less vulnerable to overgrazing compared to those with annual grass, while those landscapes with greater woody cover have greater PGC for camels and small stock (i.e. if the bush cover is a characteristic feature of the landscape). Pastoralists in East Africa universally recognize the concept of PGC (Oba, 1985, 1994; Mapinduzi, R. and Oba, G. unpubl.).

Related to the concept of PGC is the concept of *chiisa* (which implies that the livestock likes the place so much that they do not stop laying on the ground) - a locality specific condition of livestock performance. *Chiisa* is the property of individual landscapes with soils having significant importance for livestock welfare. If *chiisa* is lacking, livestock body conditions and productivity deteriorates. The knowledge of *chiisa* is accumulated from experiences and past migrations from which the herders established landscapes with and without *chiisa*. An important perception is that chiisa varies with the type of livestock species, although it is a permanent property of individual landscapes (Oba, 1985).

Indeed, landscape level uses are influenced by the two contrasting concepts, the spatial suitability based on the concept of *chiisa* and the temporal suitability based on the concept of fiina. This means that livestock management involves a dynamic process of assessments of landscapes in terms of multiple factors including vegetation and soils. Assessments include condition of plant growth and current grazing pressure. For example, the old grass growth, unrenewed by fire (called *fuura*), which is a mixture of previous years' and the current year's growth may be suitable for drought-weakened livestock, while the grass from old burns (1-2 seasons of post-fire growth) called *gursumesa* has higher nutritive value than *fuura* and is preferred for grazing during drought years. During the wet season, range scouts assess fouling of grass by livestock grazing among other factors. Grazing is preferred before the grass flowers. In the dry season, the strategy is to seek landscapes where perennial grass is abundant. Changes in natural vegetation dominated by the grass layer leading to dominance by woody cover, and increase in unpalatable forbs are considered as a threat to range conditions (Oba *et al.*, 2000b).

STUDY METHODS

We surveyed 30,000 km^2 of southern rangelands in 1998; with the team composed of range ecologist and traditional range scouts. We developed systematic scheme of data collection and identified different categories of assessments that were usually used by the Booran. All assessments were done using road-transects at 20 km intervals (Fig. 1). We used the landscape level environmental change to evaluate changes at the regional level (i.e. in the Liiban, the Dirre and the Golbo production systems). Assessments by the traditional range scouts (TRSC) were used to determine grazing suitability and potential grazing capacity (PGC) for different livestock species. The woody, grass and bare ground covers were assessed by methods described earlier (Oba *et al.*, 2000b). Grazing pressure was assessed on an ordinal scale of none (0), light (2), moderate (3) and heavy (4), while range conditions were considered as ideal (4), good (3), fair (2) and poor (1). Range trends were assessed on the basis of (a) current grazing pressure and (b) threats. The perceived threats were associated with decrease in perennial grass cover in terms of current composition (according to RE) or historical vegetation (according to TRSC), an increase in annual grass and unpalatable forbs and woody cover according to the TRSC and RE. Trends were expressed as upwards, downwards and stable. The range ecologist (RE) and the TRSC independently did the assessments. Using the landscape data the regional level livestock grazing suitability and potential grazing capacity were determined. The landscape level data was used to compare range conditions and trends at the regional levels. Ratings by TRSC and RE were compared by Pearson's correlations, while vegetation cover and bare soil in different landscape types of the three production systems were compared by ANOVA (SYSTAT inc., 1992).

RESULTS AND DISCUSSION

Livestock suitability and grazing capacity

In all the three production systems, landscape suitability was greater for cattle grazing and the greatest suitability was observed in the Liiban and the least in the Golbo production systems. Camel and small stock suitability were greater in the Dirre and the Golbo production systems and lower in the Liiban production system. Suitability for the main settlements was greater in the landscape types in the Dirre and the Liiban production systems (Table 1). Landscape grazing suitability corresponded with the types of vegetation with higher suitability for cattle grazing in landscapes with abundant grass layer. The Booran traditionally did not manage camels, while recent increase in management of camels might reflect a response to growth of bush cover (Coppock, 1994; Oba *et al.,* 2000b).

The landscapes in the Liiban production system had higher PGC followed by the Dirre production system. PGC at landscape level showed high variability ($F_{5, 34} = 3.421$, $P = 0.013$). The Golbo production system had greater landscapes with lower PGC index (Fig. 3a). The Chaari and the Kooticha had higher PGC index, while the Malbe and the Kobe had lower (Fig. 3b). According to the TRSC, livestock managed in landscapes with low PGC suffered more stress during drought and experienced greater mortality than those grazed in landscapes with high or moderate PGC. Generally, landscapes with low PGC were briefly exploited, usually during the wet season, while those with high to moderate PGC were grazed during the wet-dry seasons.

Perceptions on effects of grazing pressure

Ratings of grazing pressure at the landscape levels by TRSC and RE showed high correlations ($r = 0.92$, $P < 0.0001$). The ratings were comparable for all the landscapes, exception being the Kooticha (Fig. 4). According to the TRSC, grazing pressure accumulated over several seasons translated into the observed grazing impacts. When evaluating grazing pressure both TRSC and RE used the stubble heights of grasses, livestock trampling, fouling of grass, grass cover and composition of the herbaceous layer in comparison to areas where grazing was temporarily excluded. The TRSC emphasized that grazing is essential for landscape functioning, suggesting that without grazing landscapes might radically change in terms of plant species composition. Conversely, overgrazing was considered undesirable, even though the rangelands in general had the capacity to recover if the grazing pressure was removed. The scouts suggested that range degradation in terms of changes in landscape quality was a recent phenomenon induced by range-water development. However, they did not consider that the current grazing pressure had altered landscape potential grazing capacity (PGC), although they believed that it altered the grazing suitability.

Perceptions of landscape land cover changes

Woody cover differed significantly between landscapes in different production systems (Fig. 5). The Liiban production system had least woody cover, while the Golbo had greater than the Dirre production system (F = 3.991, df = 2, P = 0.025). As opposed to the woody cover the grass cover showed no significant difference between landscape types in different production systems (F = 0.968, df = 2, P = 0.387), while bare soil showed significant variations (F = 5.541, df = 2, P = 0.007). Overall, greater grass cover was found in the Liiban and the Dirre production systems, while bare soil cover was greater in the Golbo and least in the Liiban production system (Fig. 5).

In all landscapes, woody cover was negatively correlated with grass cover (r = -0.58, P<0.0001) but positively with bare soil (r = 0.15, P = 0.322). While bare soil and grass cover were not correlated (r = 0.04, P = 0.795) at production levels, they did so at landscape patch levels (Oba *et al.*, 2000b). According to the TRSC, the regeneration of woody species responsible for bush cover was facilitated through seed dispersal by camels (cf. Tessema, 1990; Reid and Ellis, 1995). The interpretation of changes in bush cover by the TRSC was therefore from three perspectives:

First, the range scouts suggested that the Booran rangelands are periodically perturbed by episodic events such as droughts that result in mass livestock mortality. The shifting of vegetation alternating between woody and grass cover followed the episodic events. During recovery periods the woody cover were reduced by wildfires. Thus, according to their interpretation, the changes in woody cover in different parts of the grazing lands have had varied history. Some of the woodlands have been present for more than 40 years. In other landscapes, changes in woody cover were more recent. This was represented by the landscapes in the Dirre production system, while in the Liiban and the Golbo production systems; bush cover growth begun earlier than four decades ago.

Second, land cover changes according to the TRSC were better understood if the changes were considered both in the short-and long-term perspectives. The rangelands of southern Ethiopia until four decades ago were considered as the finest in East Africa (Agrotec-C.R.G, 1974). Yet, by the early 1990s it has been observed that the Booran system of pastoral production was on decline. The reason given was that the human and livestock demographic growth was contributing to the declining range productivity (Coppock, 1994). This notion has not considered the effects of history of land alienation and interventions that upset the traditional patterns of land use (Oba *et al.*, 2000b).

Third, causes of environmental changes linked to growing bush cover are presently associated with episodic climatic events as well as recent and historical land alienation (Oba, 1996; Bassi, 1997) and water development (SORDU, 1990). According to our informants land alienation began following political perturbations caused by the Anglo-Italian war (1931-1936) and subsequent ethnic conflicts, which displaced the Booran from over 60 percent of their traditional grazing lands. The displaced population was compressed into a fraction of the former grazing territory where land use became more intensive as opposed to the traditional system. Added to the pressure caused by water-development was the alienation of a total of 54,000 ha of grazing lands for demonstration ranches in the Liiban and the Dirre production systems (SORDU, 1991). Other internal factors that contributed to changes in landscape cover and land degradation were encroachment from farmlands and establishment of range enclosures (Boku 2000). The result was increased pressure on the remaining land regardless of the presumed livestock and human population growth in relative terms.

Threats to range conditions and trends

The environmental implications of changes in land cover and range conditions and trends were assessed in terms of threats. Assessments of the threats by the TRSC and RE showed high correlations ($r^2 = 0.71$, $P < 0.0001$) (Fig. 6a). The majority of the threats were due to loss of perennial grass cover and increase in annuals, unpalatable forbs and bush cover. The response varied from one landscape to another. The Chaari and the Booji landscape types were threatened more by the loss of perennial grass cover relative to the Koobe and the Wayama landscape types that were threatened more with increase of unpalatable forbs, while bush cover disclosed a greater threat to the Kooticha and the Malbe landscapes. The TRSC interpreted threats to range conditions in terms of landscape health. The indicators reflected the extent of change. Indicators such as bush cover, unpalatable forbs and loss of perennial grass cover were used to determine the degree of change. The threats were categorized into risks, whereby the unsuitability indicators become evident but not sufficient to threaten the health of the landscape (cf. NRC 1994). The landscape patch types where threats in terms of vegetation change were beyond the acceptable thresholds were termed as unhealthy. According to the traditional land use practices, the health of landscapes may be improved by periodic burning. However, in the Booran rangelands of southern Ethiopia, the use of fire has been officially banned (Oba *et al.*, 2000b).

Range ecologists would interpret reduced landscape health in terms of decline in range conditions and trends. Assessments of range conditions by the TRSC and RE showed high correlation ($r = 0.70$, $P<0.0001$) (Fig. 6a). At the regional level, the landscapes of the Golbo and the Dirre production systems had more landscape patch types in the poor range condition category than the ideal conditions (i.e. excellent) (Table 2). According to the TRSC, none of the landscape types showed upward trends with the exception of those in the Dirre production system where about 10 percent of the landscape patch types showed upward trends (Table 3). The majority of the landscape types in the Dirre and the Liiban production systems were in the downward trends, while in the Golbo, the greater percentage were stable ($F_{5,41} = 2.847$, $P = 0.027$). In the majority of the landscapes, the herbaceous vegetation layer showed greater changes in composition than the woody cover. The decline in perennial grass and increase in unpalatable forbs and annual grass cover manifested landscape change. Indeed, when making range assessments, the Booran usually took into consideration the dynamic herbaceous layer.

It is, therefore, important for ecologists to understand the perceptions of pastoralists when interpreting trends in land cover. The TRSC consider landscape patch level changes from two perspectives. First, the herbaceous layer might change from some expected standard to undesirable levels or in terms of loss of quality. Second, if the landscape is recently invaded by some undesirable species that are rejected by livestock, such landscape might be considered as deteriorating. Accordingly, the conditions of most landscapes in the Liiban, the Dirre and the Golbo production systems were in the downward trends. However, the TRSC considered the Wayama and the Malbe landscapes to be in steady states for different reasons. The Malbe landscapes (dominant in the Golbo production system) were in bush cover climax stage but showed no changes in land cover during the previous four decades (Oba *et al.*, 2000b). By comparison, the Chaari landscape types had bush cover climax but had abundant herbaceous species that occurred in the under canopy. By comparison, the Kobe and the Kooticha landscapes showed declining trends in range conditions (Fig. 6b). In the Golbo production system, 82.8 percent of the landscapes were threatened by the combination of bush cover and unpalatable forbs. According to the TRSC, the grass cover in the Golbo production system had declined due to bush climax. In the Dirre production system, by comparison, some of the changes were more recent. The landscapes that were traditionally considered as prime rangelands disclosed greater cover of unpalatable forbs following development of borehole-water. These rangelands were traditionally used following the wet-dry season grazing cycle but have now been turned into full-year grazing after water installation.

CONCLUSIONS

Our study disclosed that the Booran pastoralists used IEK to manage rangelands that reflected both processes of land degradation and landscape suitability. Similar to the Mongolian pastoralists of central Asia (Fernandez-Gimenez, 2000) and the Masai and Turkana pastoralists in East Africa (Oba, Gufu unpubl.; Mapinduzi, R. and Oba, G. unpubl.), the Booran of southern Ethiopia categorized landscapes not only in terms of seasons of use (Oba *et al.,* 2000b), but also in terms of grazing capacity (this study). This aspect of pastoralists IEK is superior to the approaches used by ecologists for planning grazing management. Ecologists fail to take into consideration that rangelands are variable in terms of preferences by herbivores, which differed according to species, not only in spatial but temporal sense.

Ecologists would interpret distribution of livestock over the range in terms of grazing resource distribution, the assumption being that all landscapes are equally acceptable by different livestock species. Hence, apportioning landscapes according to calculated stocking rates is a common strategy. By comparison, the pastoralists consider that each landscape has a property that distinguishes it from other landscape types. Moreover, the pastoralists identify the grazing lands either as camel country, small stock or cattle country relative to the dominating soils and associated vegetation types. They differentiate grazing in terms of grazing suitability and potential grazing capacity. The two concepts imply both spatial and temporal qualities of landscapes. According to the pastoralists, both landscape suitability and PGC are determined in terms of livestock performance. Lack of suitability leads to decline in milk yield and reduced body weight, while qualities that measure PGC are more complex.

Whereas suitability conditions might not be anticipated, PGC of individual landscapes are known beforehand. How would ecologists interpret the pastoralists' perceptions of landscape change?

First, the landscape suitability perception of the pastoralists can be used to formulate hypothesis, which states that livestock condition is a suitable measure of changes in landscape quality. Ecologists may correlate animal body changes to some measurements of range productivity and plant nutrition. According to the perceptions of pastoralists, livestock conditions may deteriorate without evidence of diminishing grazing resources (Oba, 1994). Any of the following factors including: increased nuisance from insect bites, cold stress, lack of salt licks and increased worm load in the pastures may have contributed to the deteriorating conditions of livestock. However, such perceptions might be misleading to ecologists. We might suggest that the failure of range ecologists to understand the pastoral land use perceptions is because of the narrow trainings they received on pastoral production system. By contrast, the problems often experienced by pastoral production are diverse, requiring interdisciplinary approach. For instance, causes of livestock poor performance is not only due to declining nutritive quality in pasture (which is usually investigated) but it could also have been caused by factors such as gut worms (Njanja 1991).

Second, ecologists seldom consider potential grazing capacity as a property inherent in landscapes but in terms of available grazing resources. Ecologists would attempt to establish a benchmark on which assessment is made, by using such concepts as potential vegetation for rating range conditions and trends. Whereas both ecologists and pastoralists view environmental resilience as a property of landscape, the pastoralists are able to define the concept better by relating it to the potential of individual landscapes. In their view, resilience is variable with the types of landscapes. Some landscapes would usually have higher resilience than others. Their grazing management and duration of landscape reflect this. Thus, the pastoralists by organizing landscapes into PGC class might help ecologists to decide, which landscape to rehabilitate. Cost effectiveness will be increased if landscapes with high PGC as opposed to those with low are chosen for rehabilitation.

We make clear distinctions between assessments done by pastoralists and those by ecologists in terms of range condition indices from actual measurements that ecologists usually carry out. For example, range ecologists measure productivity and express it quantitatively in terms of amounts of vegetation produced per unit area (e.g., g m^{-2}). The production figures are then used to calculate stocking rates that individual landscapes supports (i.e. carrying capacity). Pastoralists by comparison are aware that different landscapes have varied PGC. They assess range production in qualitative terms such as high, low or medium but would not say how much is produced per unit area. Ecologists may establish relationships between the indices used by the pastoralists and actual measurements using regressive models. It would be apparent that pastoralists' predictions, although in general terms similar to those of ecologists are limited by lack of preciseness. However, for the purpose of pastoralists land use, estimating range production to few decimal points might not make sense. After all, they seem to be making right decisions when moving livestock from one place to another, basing judgements on grazing levels such as the residual grass height and livestock performance.

As much as there are complementary perceptions between IEK and ecological knowledge (Ford and Martinez, 2000), there are also appreciable differences. For example, in determining trends in range conditions, the TRSC interpreted most landscapes as deteriorating, while a few were stable. The concept of stability, according to ecologists might imply equilibrial state, which after disturbance goes through different states before returning to equilibrium through natural vegetation regeneration. Often the climax is perceived to be desirable by ecologists, while disclimax is not. By contrast, the pastoralists do not consider stability in terms of value but time. The status of individual landscapes is based on historical knowledge, that can be used to show either significant or no change. The stable state might be in bush climax and, therefore, undesirable from management point of view or it might also mean that the landscape has been maintained in favourable conditions relative to the historical state.

This is not to suggest that pastoralists do not appreciate temporal changes in grazing lands. Rather, changes due to seasons (i.e. wet and dry seasons) in terms of herbaceous cover are not considered as deterioration or interpreted in terms of loss of landscape stability. Their concern is when radical changes in vegetation composition occur due to changes in herbaceous layer. By contrast, the tree cover, because of the long time it takes to establish is often not a cause of concern, except when the conditions become so severe that even the use of fire becomes ineffective. As a long-term strategy, therefore, the pastoralists often do not manage for trees, while they do so for the herbaceous vegetation such as grass layer. The advantage of such a perception is to offer ecologists an opportunity to understand trends in vegetation as well as being essential for establishing joint monitoring and analyses of landscape level changes.

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Table 1. Landscape suitability in different productions systems

	Production systems (percent)		
Suitability	Dirre	Golbo	Liiban
Settlement	21.6	16.7	37.0
Cattle	32.6	38.9	40.8
Camels	19.6	16.7	11.1
Smallstock	26.2	27.8	11.1

Table 2. Range conditions in different production systems

	Production systems (percent)		
Condition class	Dirre	Golbo	Liiban
Poor	35.3	44.5	8.3
Fair	18.1	11.1	50.0
Good	37.0	33.3	33.4
Ideal	9.6	11.1	8.3

Table 3. Trends in range conditions in different production systems

	Production systems (percent)		
Trends in conditions	Dirre	Golbo	Liiban
Upwards	10	0	0
Downwards	59.6	33.3	66.7
Stable	30.4	66.7	33.3

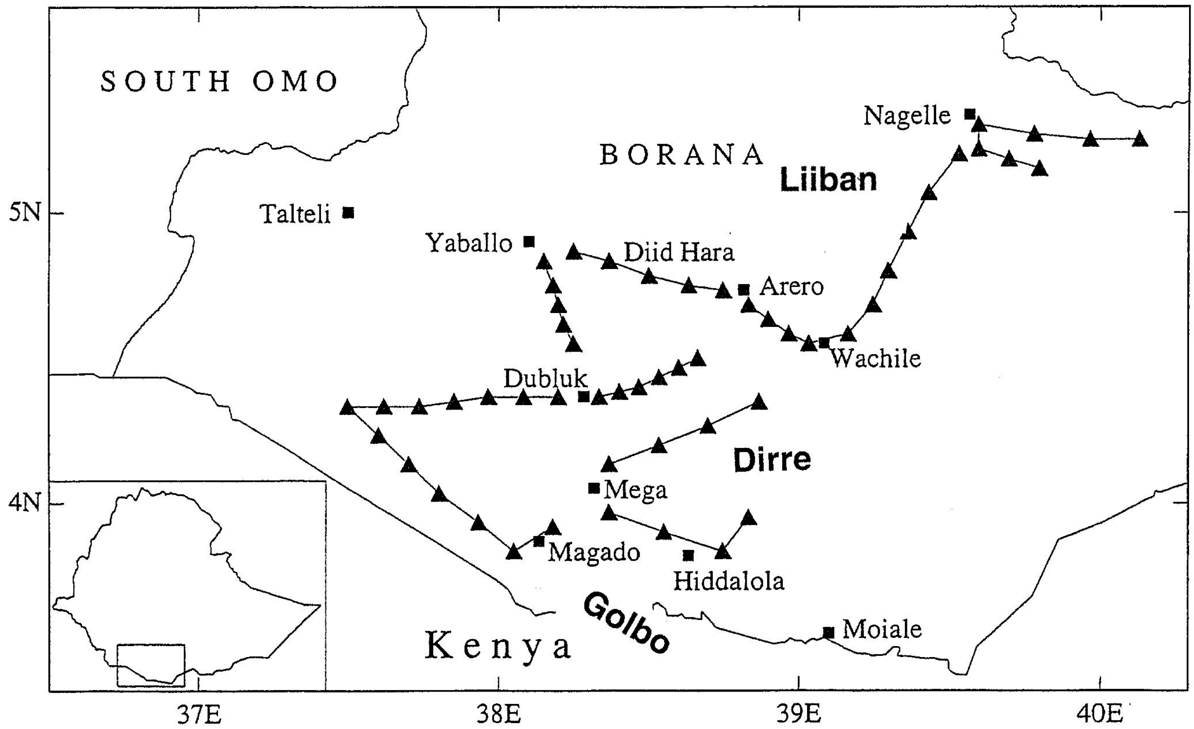

Figure 1: The southern rangelands of Boran showing the Liiban, the Dirre and the Golbo production systems and the road transect.

Figure 2a: General grazing model of the Booran

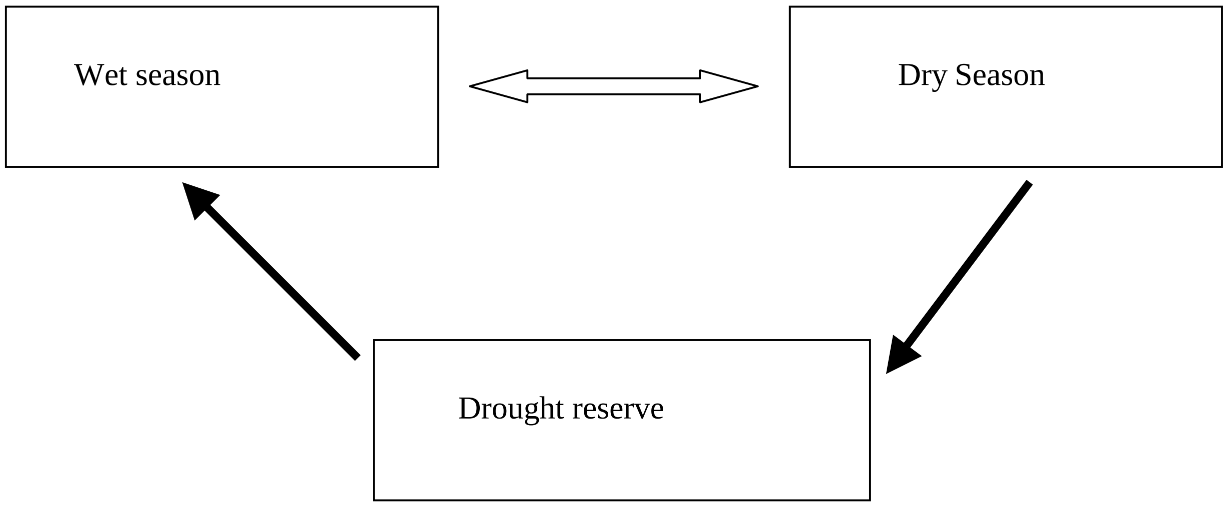

Figure 2b: The grazing movements during the wet, the dry and drought years in the Liiban production system

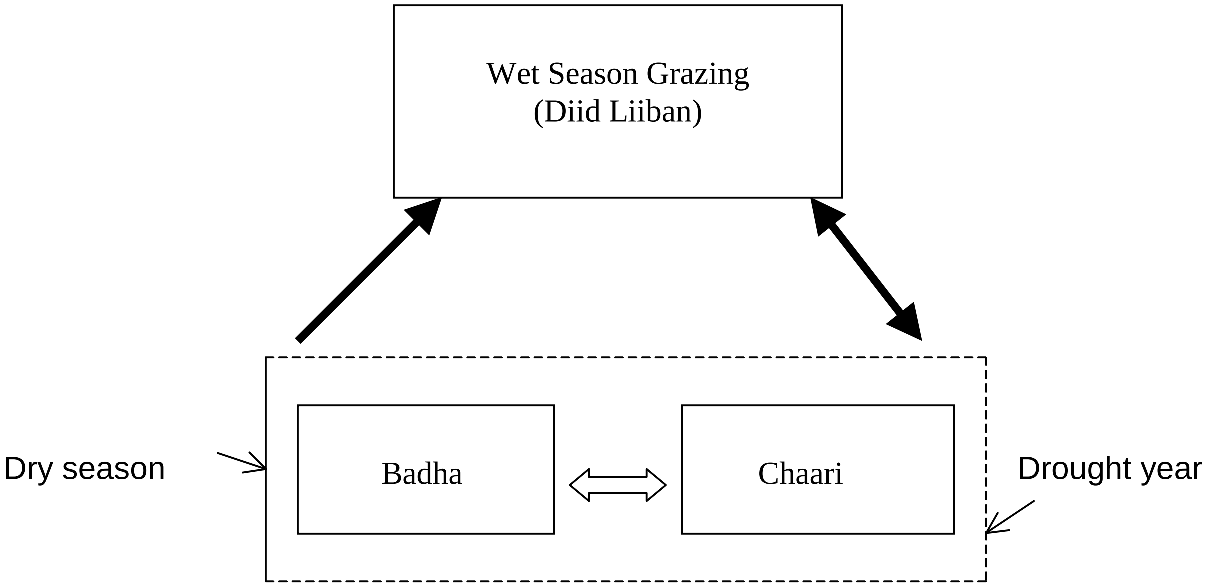

Figure 2c: the Dirre production system

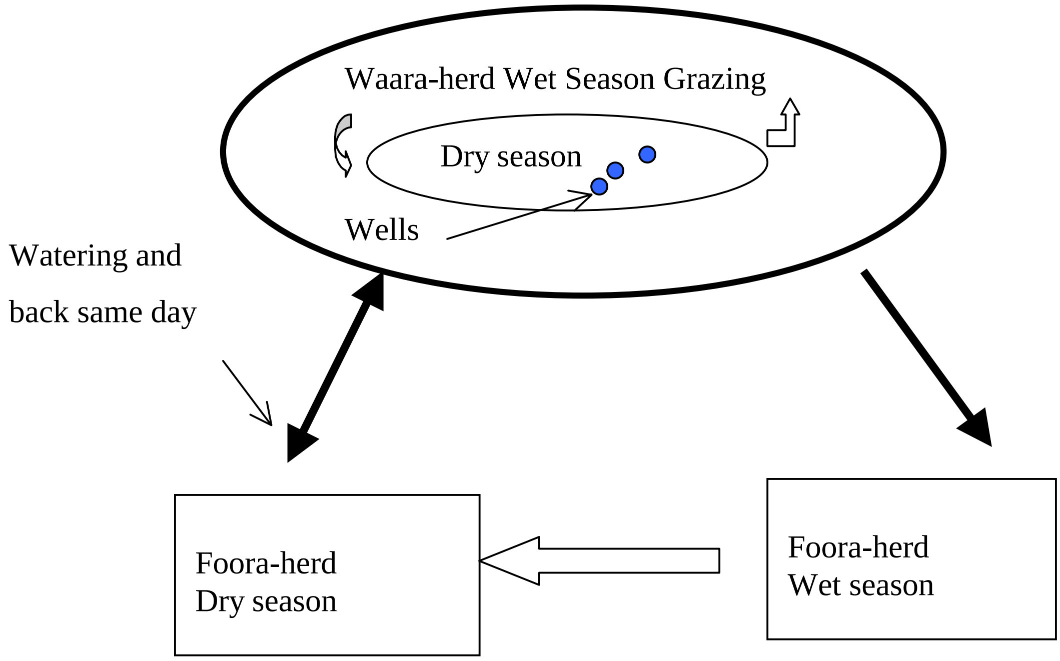

Figure 2d: the Golbo production system

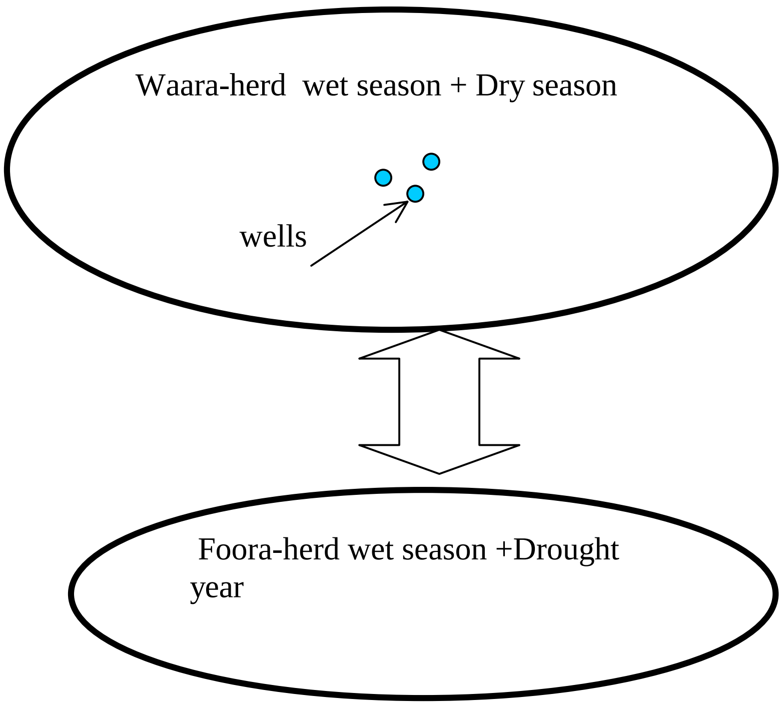

Figure 3a: Regional level potential grazing capacity as a percentage of total landscapes in the Liiban, the Dirre and the Golbo production systems

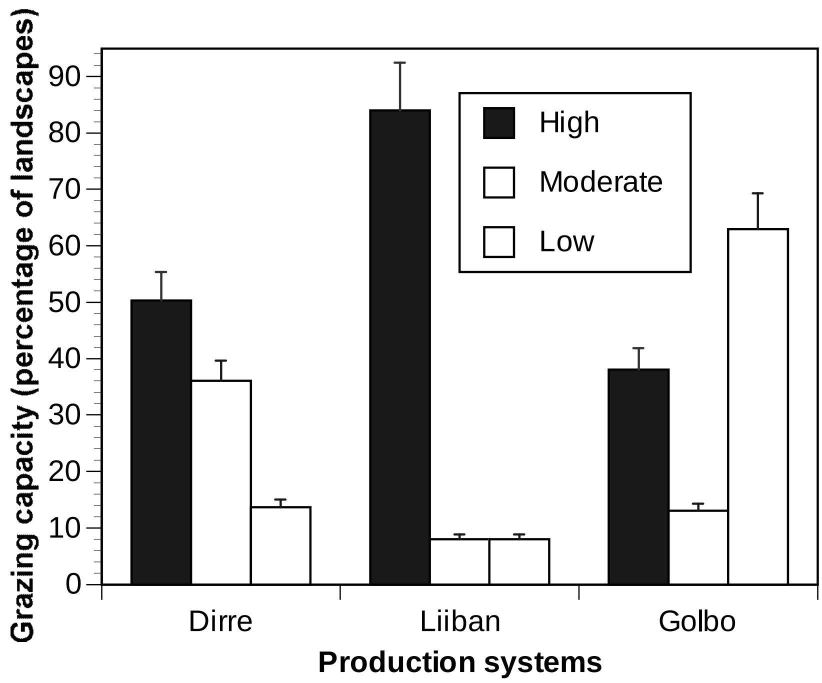

Figure 3b: Potential grazing capacity at landscape type levels in the Booran rangelands

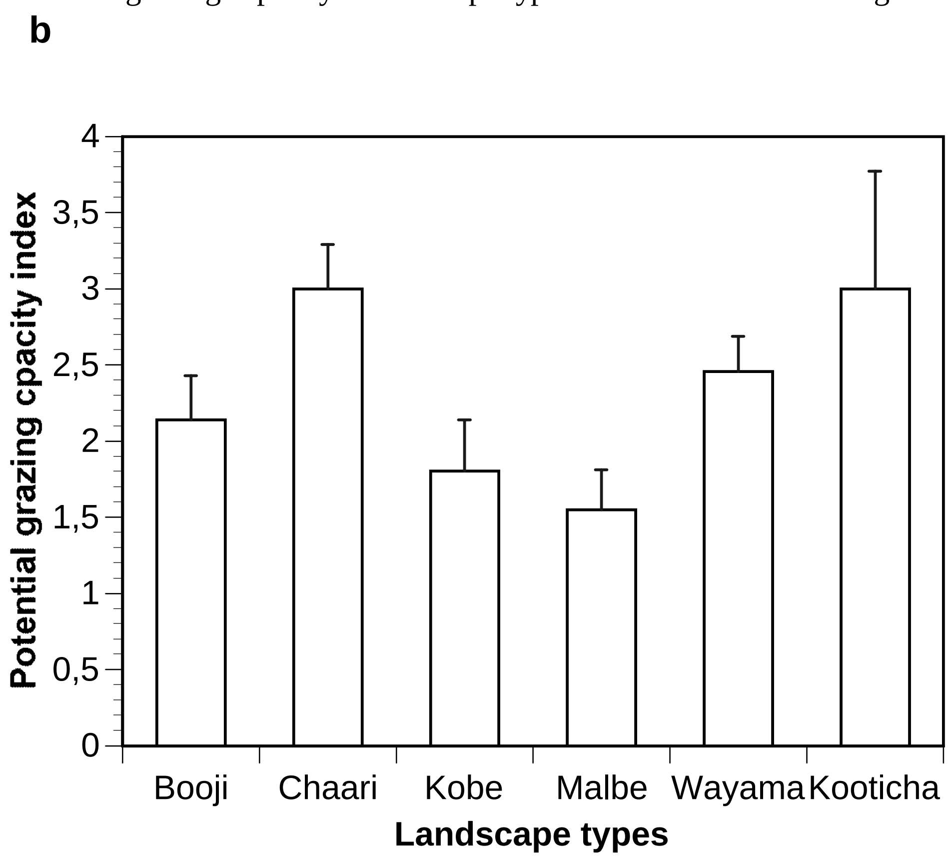

Figure 4: Assessments of grazing pressure index by the pastoralists range scouts (TRSC) and range ecologist (RE) at landscape patch type levels.

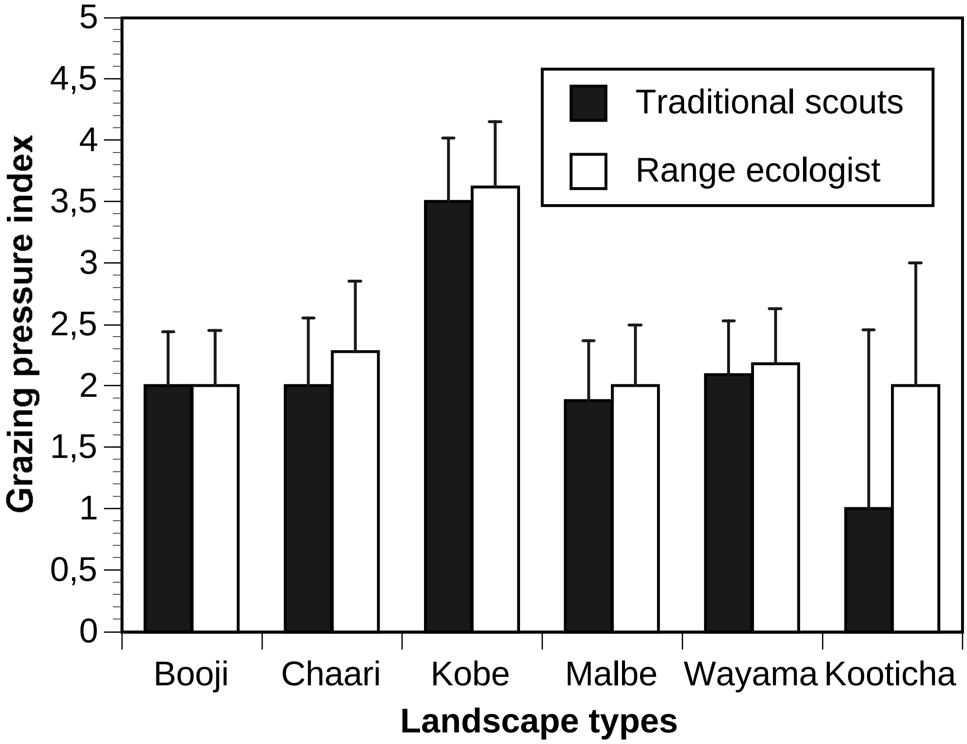

Figure 5. Cover of woody vegetation, grass and bare soils of the landscape types in the Dirre, the Golbo and the Liiban production systems.

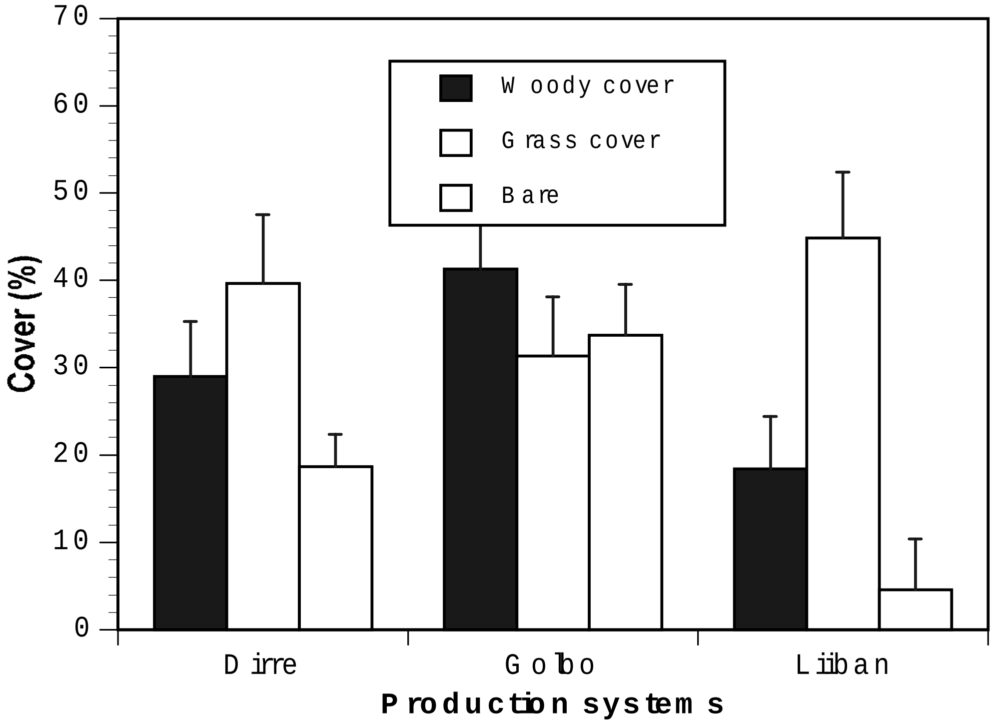

Figure 6a: Range condition trend index assessed by the traditional range scouts (TRSC) and range ecologist (RE) in different landscape types in the southern rangelands of Booran.

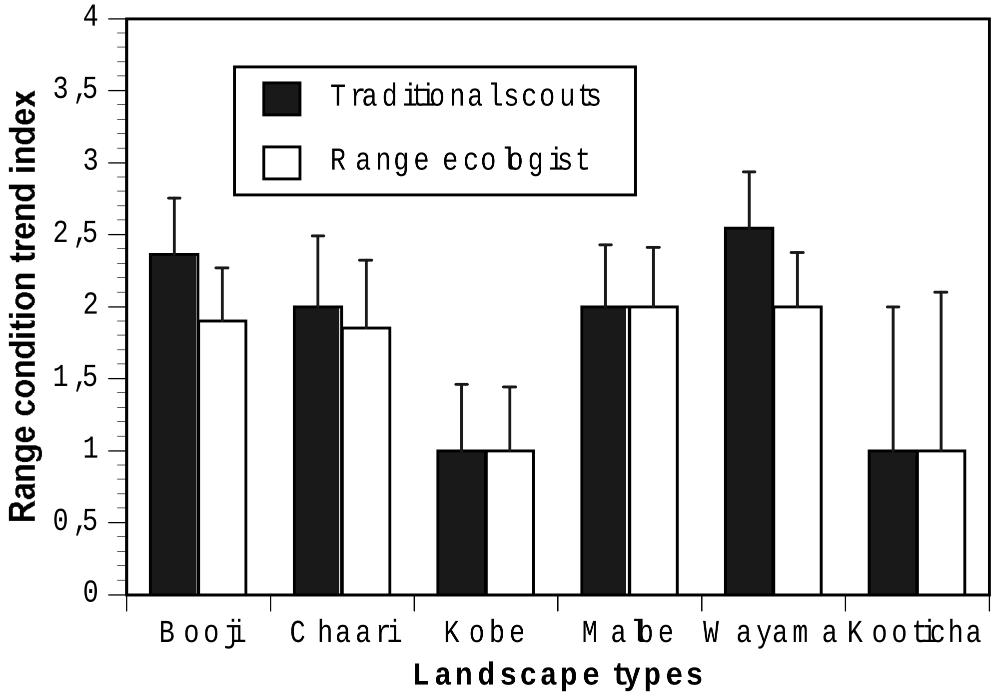

Figure 6b: Assessments of range condition threats by the traditional range scouts (TRSC) and range ecologist (RE) at landscape patch type levels.