Principles of land evaluation for extensive grazing

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Summary

Evaluation of natural resources, based on natural resources surveys, is necessary to obtain optimal land use and to prevent deterioration.
For agricultural use and prevention of soil erosion, evaluation systems have been developed. Since the seventies modern flexible systems are being developed based on proposals of a joint working group, initiated by FAO and held in Wageningen/Netherlands.
A FAO-framework for land evaluation was one of the first results. The main characteristic of it is flexibility for any kind of alternative use.
In the meantime special manuals are being prepared e.g. land evaluation for irrigated agriculture, rainfed agriculture and forestry. Several workshops went ahead with the preparation of these manuals.
Recently a workshop was held at Addis Abeba by a joint action of ITC, ILCA, FAO and ISSS on land evaluation for extensive grazing(= a system of grazing without improvements of the grazing land in the form of (re-)seeding or fertilizing, except drinking water supply and local feedlots).
The general methodology for land evaluations was discussed and proposals were given for adaptation to the special demands of extensive grazing.
In this paper the principles of land evaluation for extensive grazing are outlined. Crucial aspects concern the determination of land utiliz- ation types and there requirements. Land units, assesed by survey and classification and characterized by all land attributes as soil, vegetation, climate, hydrology, land form, rock composition, are interpreted according to properties, relevant for use. Those land properties are called 'qualities' and these qualities are compared in the process, after having been rated, with the requirements. The result indicates the various degrees of suitability of each evaluated 'land unit'. Such an evaluation comprises various stages. It may be divided into a bio-physical evaluation and a socio-economic evaluation which often overlap partially.
Evaluation methodology according to the FAP framework is primarily developed as a tool for regional development planning, but can also be used for internal rangeland management.

1. Introduction *)

The herdsman concern was and is and shall be to lead his herds to the proper pastures at the proper time. Also he has to live with other herdsmen and farmers and share or devide the land resource among each other. Therefore he must know the value ('what) and the place ('where') of the available grazing sites, and the time or season in which these sites are accessible and supply the wanted qualities ('when'). For the desert Bedouin of the Near

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* In this paper use is made of internal papers of the Working group on Land Evaluation of ITC of which the author is a member.

and Middle East, for the Fullanie or Peul, south of Sahara, and also for the Massai hersman, cultural, social and economic life is determined by these 'what', 'where' and 'when'. The answers to these questions are movements of the herds and usually of the whole family or tribe which is guiding or following the animals.

These questions are not only important for 'internal' management. The increase of population causes conflicts everywhere, not only between herdsmen, but especially between grazers and agriculturists, and also foresters. Solutions have to be found. Extensive grazing is a way of land use that in many cases has to survive. Only with a proper objective evaluation, can objective judgement be made and solutions sought. Only this way can land deterioration, which is worldwide, and the concrete result of the unsolved conflicts be stopped.

In the most extreme environments the distance to be travelled by grazers might be considerable and the directions uncertain or at least show large variation (pure nomadism). In other cases a regular movement between two areas, following distinct seasons fulfils the requirements (transhumance). In the second case the answer to the question 'where' is more or less fixed, only the 'what' and 'when' determine the action. In case of a closed ranch system, the most sofisticated land utilization type of extensive grazing, the 'where' question, might be equally reduced but gets an other dimension, because, like in rotational grazing, the place where to graze and in which season, is one of the most important ones for the management. Here a new question is added to which the answer may be used as a base for proper management: 'How' can the grazing land be improved or prevented from degradation.

The fourth question deals with nomadic and transhumance systems, because the world resources are also in this respect nearing the limits of sustainable exploitation. The more intensive systems of cattle keeping out, pays much more attention to this 'how', just as modern agriculture does. There, just as in settled agriculture*, the question 'where' and part of the 'what' was solved at the moment that parcels of the farm were chosen. Hence the land use was decided upon. The changes in the quality are counteracted by supply and improvements of the spot and much less by moving the animals to the suitable sites.
Within one farm a monitoring of the 'what' and the 'where' may be necessary for a proper management. The question 'where' is a dominant one for new developments and solving territorial problems between the various existing land utilization types, which increase constantly due to increase of demands on the earth resources by an ever increasing human population. This is true for all stages from extensive to intensive land use, be it grazing, agriculture or urban use of land. The answer to this question forms the basis for a well balanced land use policy, taking into account human, social and economic needs and natural (ecological) capacities.

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* Nomadic agriculture (shifting cultivation) knows the 'where' question still as very dominant.

For a proper answer to the four questions we need:
- data from the relevant land properties in terms of 'what', 'where', 'when' and 'how;
- evaluation of these data in terms of 'what', 'where', 'when' and 'how' in relation to the alternative land uses considered.

The first mentioned needs are fulfilled by – LAND INVENTORY.
The second one is called – LAND EVALUATION*.

If we call the activity concerning proper management within one individual holding (ranch, farm, etc.) internal land evaluation then we could name the activity for (integrated) 'land use planning' of a region 'external land evaluation' or 'regional land evaluation'.
The latter is the main tool for land use planning. In Figure 1 the place of the land use planning is indicated. The modern land evaluation methodology presented in this paper has been developed so far mainly for this aim.

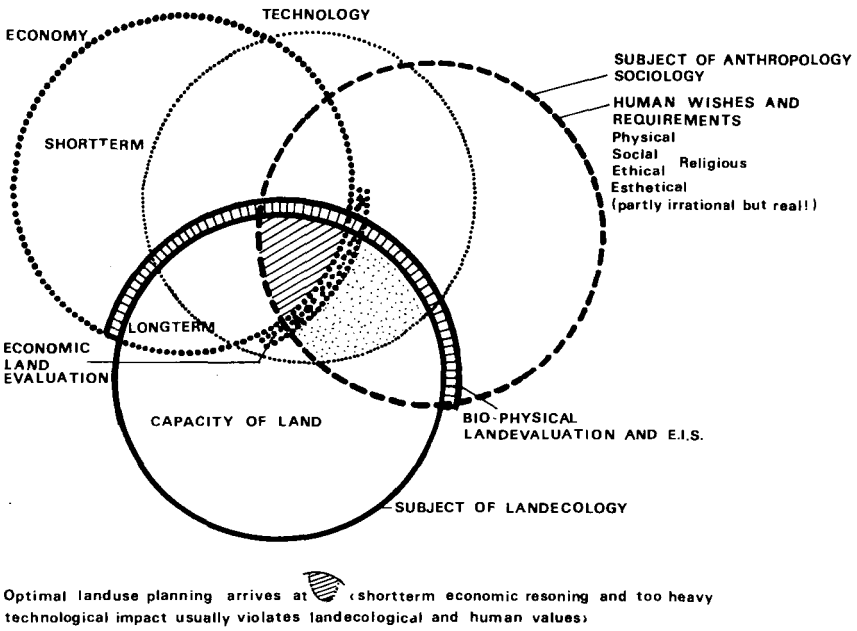

Fig. 1 The circles of human requirements, landecological possibilities and economic and technical boundaries

For extensive grazing e.g nomadism and transhumance such a distinction in external and internal evaluation need hardly to be made.

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* Sometimes inventory and land evaluation are both treated under the same name 'land evaluation'. For the second also more special the name 'land classification' is utilized for the whole or for the evaluation part proper. In this workshop(paper) we will try to use the word land evaluation as defined above: evaluation of inventory data for a certain land use.

The main principles for evaluation within one management system and for an area as a whole are, however, the same. The aim of this paper is to arrive at a proper methodology for land evaluation, on which 'herdsmen and land use planners will agree, and which may become compatable with use and jargon in other land utilization types as agriculture and forestry. That compatability is highly important. Because we may expect in the future that the classical clash between Kain (the agriculturist) and Abel (the pastoralist) will continue and intensify and that also the much younger but not less severe controversy between foresters and grazers will increase, so long as humanity does not succeed in controlling its own numbers.
In order to decrease useless fighting and arguing and increase sensible concentration of action for the benefit of a social and ecological sound world, using a same language, is a first step. Land evaluation methodology is not more, but also not less than such a common language as a tool for cooperation.

2. Main outlines of land evaluation methodology

In various areas regional systems of land classification or land evaluation have been developed. Summaries of a number of these systems are presented in 'Approaches to Land Classification' (FAO, 1974) and in Land Classifications' (Olson, 1974). One of the widely propagated and adapted systems is:
The United States Department of Agriculture (USDA) Land Capability Classification (Klingebiel & Montgomery, 1961).
This is an interpretative classification based on the combined effect of climate and permanent soil characteristics on the productive capacity, risk of erosion and soil management requirements. The system emphasizes soil erosion and conservation aspects. Local versions of this classification system have been developed in several countries to suit their specific environmental conditions. A disadvantage of this system is that the uses for which the land is classified are defined in general terms only.

Moreover an objective comparison of alternative land use possibilities for the same stretch of land is not possible with the USDA system. Grazing moreover is just considered as a rest activity. No proper judgement for land use planning neither management can be made on base of its classes.
Bennema and Beek (1972) developed a land evaluation methodology that is flexible and fulfils much better planning requirements (see also Beek, 1978). It has been presented as an international useful tool at the FAO-Wageningen Workshop (1972; see Brinkman and Smyth, 1973).
FAO had adopted the main lines of this methodology for application in all its projects and published the framework for land evaluation (Soils Bulletin 32), based on the former mentioned publication (see FAO, 1978). In the meantime at the initiative of the International Society for Soil Science (ISSS) a series of workshops were and are organized in order to facilitate the introduction of the methodology for the various types of land use such as engineering agriculture, irrigated agriculture (see FAO, 1973, 1974, 1977, 1979) and forestry (see Laban ed. 1981).
The workshop in Addis Ababa (October-November 1983) is a new event in this series.

The essential character of the land evaluation methodology presented here is, in contrast to the mentioned existing ones, that it presents only a set of principles and concepts that can be used in any evaluation. It does not contain pre-conceived judgements about qualities of land in relation to specific land use types and also no proposed hierarchy in those types of land use. The results are essentially expressed in terms of suitabilities of a certain (single or composed tract of land for a series of alternative land uses (measures) in such a way that planners and managers have a clear survey of possibilities from which they can make their choice.
Since the international introduction of the method, quite some experience has been gained by it as a tool for selection of land for reclamation, re-allotment, land consolidation and land reform projects ('regional' or 'external' land evaluation as defined in the former chapter).
The main steps in such evaluations are:

1 Formulation of objectives.
2 Formulation of wanted land utilization types and their requirements on land.
3 Inventory (survey of soil, vegetation, current land use, land form, (relief), climate and other land attributes).
4 Interpretation of these data in 'qualities' including also limitations of land in relation to actual and potential use.
5 Matching of existing qualities with requirements of land utilization types resulting in suitabilities.
6 A possible next step is formulation of recommended use.

In Figure 2 the steps and the feedbacks in between are schematically pictured. For an internal land evaluation (within a grazing management system as a ranch, etc.) the same sequence of activities can be followed.
Instead of the formulation of the 'land utilization type' as a whole entity, now the 'main management units within the system are defined (like dry season grazing area, wet season grazing area, watering places, etc. (see chapter 7).

An important difference with the land evaluation for a regional planning (external land evaluation) is that for the management practice the dynamic aspects are of interest in more detail. This means that the vegetation changes over the seasons and even partly over the years has to influence the management. This demands monitoring of the vegetation. Monitoring can be defined as a repetitive survey including evaluation with as aim warning and subsequent initiation of management action. See also Zonneveld and Huizing, 1983*.

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* In agriculture as in most other types of land use also an aspect of watching growth and/or being keen on favourable or unfavourable changes is present. There, however, such watching activities are usually not considered as related to land evaluation.
Intensity, steps in the procedure, features observed as well as scale in time and space, are different from those in rangeland management. Only in extensive grazing with large management units, this type of internal monitoring has aspects more similar to land utilization activities, which can benefit from being handled with the proposed land evaluation methodology.

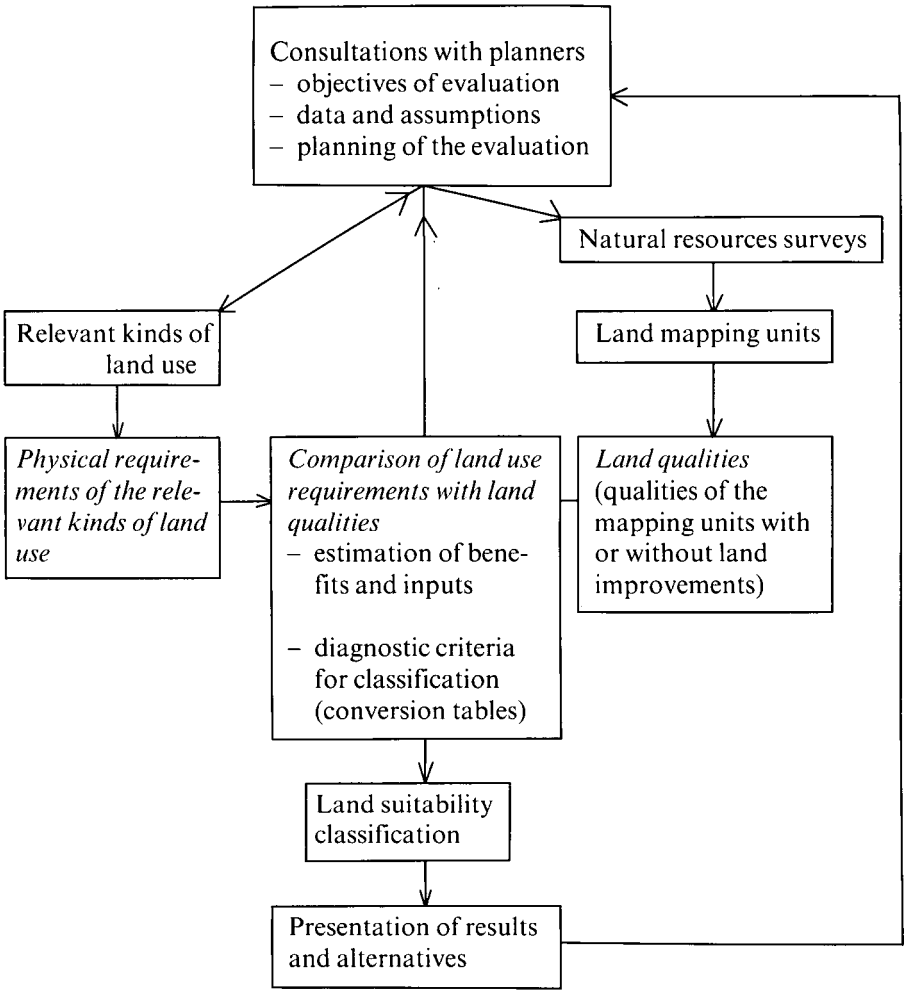

Fig. 2 Schematic representation of major activities in land evaluation

Monitoring is an essential internal tool of range management but can also have a regional character. An example of the latter is monitoring vegetation and land use changes in and along the Sahara e.g. to warn for and to locate locust breeding places and to indentify in time desertification due to over exploitation, etc. (Hielkema 1981).
Monitoring, as being the fourth dimension of inventory, demands for land evaluation methodology, as does the three dimensional part of inventory to which attention of land evaluators has been focused so far mainly.

3. Land

3.1. Concept of land

In terms of land evaluation, land has a comprehensive, a holistic meaning. It is synonymous with the holistic use of the term landscape in 'landscape ecology' or landscape science' (which means much more than just scenery or utterly appearance). A short original description goes back to Von Humbold: 'The total character of an area at the earth surface'. The FAO

Framework description is longer: 'An area of the earth's surface, the characteristics of which embrace all reasonable stable, or predictably cyclic, attributes of the biosphere, the soil and underlying rock**, the water**, the plant and animal populations, and the results of past and present human activity, to the extent that these attributes exert a significant influence on present and future uses of the land by man'.

3.2. Land (mapping) units

Land units are spatial classification units. They represent parts of a study area which are more or less homogeneous with respect of certain land characteristics or which exhibit a well defined pattern of variation in this respect. The best way to define land units is done by mapping. This can be done by separate execution of soil, geomorphological, vegetation or other land attribute surveys that eventually will be combined or by directly compiling holistic land mapping units (see glossary).

3.3. Land characteristics *

Land characteristics are properties of land used to indicate intrinsic properties, determining (causing) the character of the land. The term is also used to distinguish classification units from each other (diagnostic characteristics). Preferably, they should be properties which can be measured or estimated. Examples are degree and length of slope, rainfall, soil texture, soil depth, vegetation form and vegetation composition.
For land unit classification various selection principles are possible, e.g. land genesis and spatial occurrence are, for all mapping units, important selection principles.
For land evaluation, however, properties that are directly related to the typical value have to be used. This means the selection principle is of a socio-economic and technological character ('which properties determine what use can be made of the land?'). These selected properties are called 'qualities'.

3.4. Land qualities *

It is usually difficult or impossible to employ land characteristics as used for the land mapping units directly for a land evaluation. Many land properties interact in their influence on the suitability of land for a certain use. Moreover, the operational acting factors are often not directly used in characterizing the land units. Because of this and the problem of interaction, the concept of 'land qualities' has been introduced.

A 'land quality' is a (usually compound) property of land which is selected because of its specific influence on the suitablility of land for a specific kind of land use. Qualities are also used as diagnostic values to classify land in classes of usefulness for a certain purpose. Qualities are hence the 'diagnostic characteristics' in the pragmatic classification of land. Just as selecting land

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** In the FAO Framework the terms 'geology' and 'hydrology' are used instead of 'rock' and 'water'.

* See footnote on next page

characteristics the selection of qualities is an abstraction from the properties of the land. But the guiding principles for land qualities are direct answers to the physical, biological and technological requirements of the land user. There are a large number of land qualities but only those relevant to the land use alternatives considered need to be determined*.
They may act in a positive, marginal or negative way for a certain land use.In the latter case qualities are called limitations. A property can be a (positive or negative) quality in respect to one land utilization type and neutral (hence no quality at all) for another.

Examples of land qualities are: water availability, oxygen availability (drainage condition), nutrient availability, workability or ease of cultivation of the land, resistance to erosion, flooding hazard, temperature regime, climatic hazards affecting the growth of plants or animals, availability of drinking watrer for animals, fire hazard in forest production, forage availability of rangeland, and crop yield in agriculture. Carrying capacity of rangeland is a very complex quality of which the determination deserves much attention to internal as well as to regional land evaluation for grazing. In chapter 5.2. a list of rangeland qualities is given. Other examples of land qualities are shown in chapter 2.4. of the FAO Framework FAO 1976 (see also Zonneveld 1979). The interpretation of land properties (intrinsic characteristics) into qualities' is the first step of land evaluation proper, following the inventory stage.

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*The terms 'characteristic' and 'quality' are derived from colloquial (English) language. Therefore one has to use these terms with care. The meaning may be slightly or even considerably different depending on background and country of the user. 'Characteristic' is used here in the sense of a 'property' that determines or at least contributes to the character of an item. The term property is a more neutral term. A property can also be used for recognition of an item even if that very property does not contribute something essential to a certain thing. Also such properties are often used as 'characteristics' in classification systems. We prefer to use in that case the term 'diagnostic characteristics'. In soil classification e.g. colour is not essential for the character of a soil, however, it is an often used diagnostic characteristic, even occurring in the name of soil types.
The term 'quality' in land evaluation jargon points to those properties that are especially relevant for the evaluation process such as required or limiting factors for plant growth. Colour is in this case irrelevant, the same holds even for phreatic level or texture. The available water and oxygene supply, however, are clear qualities. They usually are strongly depending on the characteristics phreatic level and structure, which in turn depend partly on texture. So qualities determine the character of land as relevant to evaluation criteria. At the same time qualities are used as diagnostic properties (e.a. subdivided in classes) to delineate suitability classes (the classification aspect of land evaluation).
There are languages in which different words are used for the two meanings of characteristics (e.a. in Dutch 'kenmerk' for diagnostic characteristic and 'karakteristieke eigenschap' for the intrinsic characteristic.
Another word often causing misunderstanding by proper use in land evaluation and other classification literature is 'criterion'. This means literarly 'measuring rod'. In any classification one needs:
a) Principles (for selecting criteria, hierarchy).
b) Diagnostic characteristics (selected = abstracted from properties).
c) Criteria to match characteristics.

4. Land utilization

4.1. Major kind of land use

FAO(1976), see also Beek (1972) and (1978), introduces the term a 'major kind of land use' for the highest category of land use classification. It refers to major subdivisions of rural land use such as 'agriculture, forestry, watershed management' etc. The most important one for this Workshop is 'extensive grazing'. Another type related to our subject would be 'intensive grazing', usually called animal husbandry.

Extensive grazing can be defined here as 'any type of land use by grazing animals without overall improvement of the vegetation by (re)seeding or fertilizing'. It includes transhumance and nomadic grazing systems, also ranches for domestic animals and wildlife as far these ranches, are not improved by (re)seeding and fertilization over most of the area.Local improvement as feedlod ('embouche') etc. and certainly improvements by supplying drinking water may be present.

From the examples it is clear that a certain tract of land may be fully occupied by one major kind of land use, but that also more kinds of land use may be presented on the same type of land. Common examples are watershed management and grazing', forestry and watershed management and also forestry and grazing, etc. (being quite controversal).

Land evaluation for extensive grazing is a tool to seek solutions to the current controversies and problems originated by the clash of major kinds of land use and also between the subdivisions of those: the grazing systems and the land utilization types as described below.

4.2. Land utilization types (LUTs)

4.2.1. Definition and properties

According to FAO (1976), see also Beek (1976), a land utilization type is 'a kind of land use in a given physical, economic and social setting (current or future) described or defined in a degree of detail greater than that of a major kind of land use'. It is characterized by special properties so-called 'key attributes' (Beek 1976).

We will see later that, although it is sometimes presupposed that a LUT is almost identical with a farming system or an other management unit, those are often composed within space and/or time out of several LUTs.

The main key attributes of the LUT extensive grazing are:

1 produce: medium (animal species, species mixture, herd/flock structure, etc.)
2 produce: functions and products of media (transport, traction, status, milk, meat, wool, etc.)
3 mobility (spatial and temporal arrangements of grazing orbits, permanency of domicile)
4 land use rights and land tenure
5 rights to animals and their produce
6 size of holding (stock, land, water, etc.)
7 labour:
- source (family, hired, age, sex, etc.)
- tasks (kind, permanent or seasonal, etc.)
- intensity (hours/holding, hours/output, etc.)

8 market orientation (trade, subsistence, sales, exchange, etc.)
9 income (cash, subsistence)
10 management:
- attitudes (production, objectives, etc.)
- knowledge (skills, education, etc.)
- technology (kinds, levels, source, etc.)
11 capital investments (internal and external investments)
12 infrastructural and institutional facilities (credit, markets, input delivery systems)

This list is amended according to the result of discussion in Working group C during the Workshop in Addis Ababa.

Beek (1978) gives a guideline for the process of defining land utilization types. In the next chapter 4.2.2. some preliminary notes will be made about some obvious main groups of extensive grazing LUTs. In chapter 4.2.3. and 4.2.4. a discussion on compound management systems, clusters of a seasonal LUTs' will be given.

4.2.2. *Extensive grazing Land Utilization Types*

The main categories of rangeland utilization types (range-LUTs) are:
i) hunting
ii) pastoralism
iii) ranching

These categories may be differentiated in the following way (Ingold, 1982):

Characteristics / Range LUTs	Access to animals	Access to land	Associated characteristics
Hunting	common	common	
Pastoralism	divided	common	herdsman
Ranching	divided	divided	fences, predator elimination, control of stocking density, meat oriented

The differentiation between two categories of herbivores, 'wildlife' and lifestock' is not very fundamental in this respect. Cattle is hunted in some cases; beef cattle on ranches may be pretty 'wild', reindeer may be hunted, herded as well as ranched.

i) Hunting is often a multiple land utilization type on agricultural-, forestry- or livestock rangeland and may be subdivided in:
- subsistence hunting,
- commercial hunting,
- recreational hunting.

ii) Pastoralism can be subdivided according to various 'key attributes', such as produce (a), stock type (b), objectives (c) and mobility (d):

a) Produce:
- meat pastoralism (small amounts of milk may be used by herdsman)
- milk pastoralism (including self-evidently meat produced from male calves)
- wool may be a by-product from one or the other, rarely the dominant produce)

b) Stock type:
- small stock pastoralism (shoat = sheep + goat)
- cattle pastoralism
- reindeer pastoralism
- llama and alpaca pastoralism

c) Objectives:
- subsistence pastoralism
- commercial pastoralism
- amenity pastoralism (preservation of open landscape for tourism e.g. in The Netherlands, also preserve settlements in remote rural areas depending on pastoralism e.g. Scotland, Switzerland).

d) Mobility:
- village communal grazing
- transhumance
- nomadism
- ranching*

The main groups of grazing that can be distinguished in extensive grazing according to mobility over the territory differ from each other, because they are different adaptions to seasonality in relation to the other land factors. They can be grouped in a matrix with as one variable scale and predictability (irregularity) of variations in time (dynamics) and at the other side, scale of spatial variation in area.
See Figure 3.

The main groups of land utilization types are described below (Gils, Zonneveld & Wijngaarden 1982), see also Figure 4.

Village communal grazing:
Situated around a village, walking distance usually not further than 10 to 20 km. A subdivision can be made in primitive and more advanced systems, differing in making use of fodder crops in the unfavourable season and others. Produce medium is cattle, sheep and goats. Produce: meat dairy, skins.

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* Ranching is a subdivision according to the main (management) system as well as to the mobility over the territory.

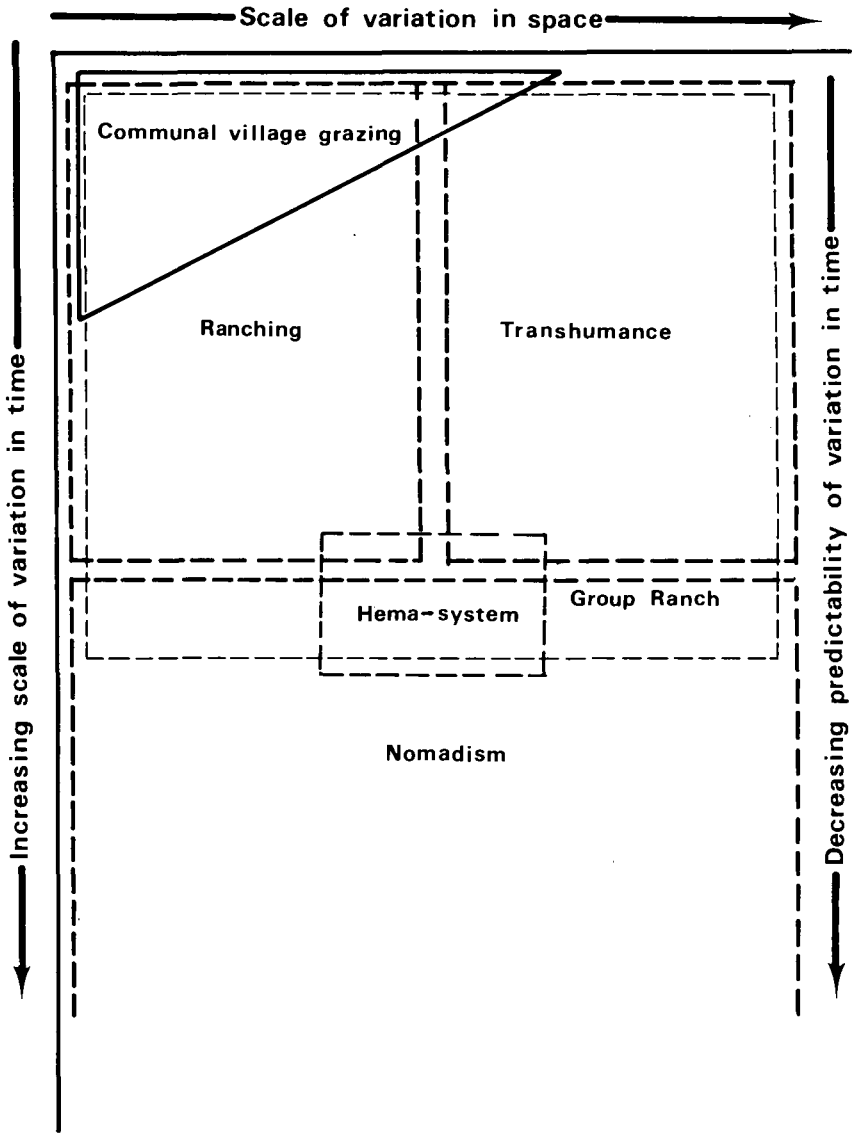

Fig. 3 Territoriality in pastoralism as dependant on variation of the environment in space and time

– Transhumance:
A yearly trek between dry season and wet season grazing areas, or summer and winter areas (in the mountains). Distance may well exceed 100's of km. In one part of the area people may have a permanent dwelling, while they live in the other region in tents or temporary huts.
Produce is often cattle (Fullani, Alp cattle systems) also sheep and goat. The reason for trekking is usually a combination of climate (almost pure in mountain transhumance) with lack of drinking water (dry season transhumance), quality of food, occurrence of diseases and flooding of grazing lands. In the Sahel transhumance all these factors play a role.

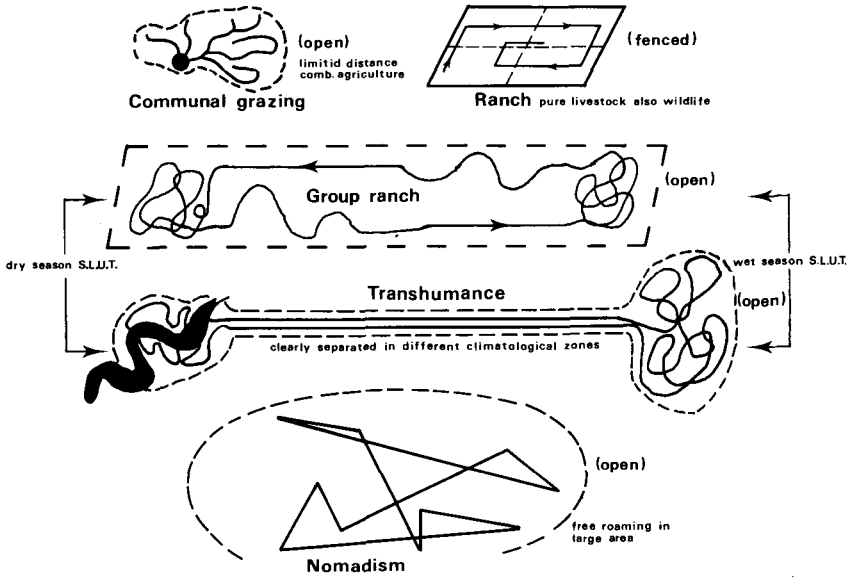

Fig. 4 Extensive grazing systems (land utilization types)

– Nomadism:
People constantly roam through the area in search for the scarce vegetation. They may have rather fixed areas, sometimes over many hundreds of kilometres, sometimes also over shorter distances, but their movement is as irregular as the climate to which the system is adapted. They live permanently in tents. They may apply also a certain agriculture, e.g. wheat and barley in the deserts of the Near East and North Africa. In relative moist years they use the grain for human consumption ('ble dur'), in relative dry years they use the crop as fodder for the animals.
Produce medium is mainly sheep and goats and often camels (sometimes donkeys).
This system is common in desert areas and in fringes of the semi-arid zones. There it may develop to a rather high standard by motorized transport, creation of 'Hema' system (defended areas where vegetation may recover, even some seeding or fertilizing is done.)
In certain areas of Mauretania it is observed that the movements of tents was maintained, but the tribe remained the whole year in the same area, however not at the same spot, so preventing destruction of the vegetation. Their part of the livestock (cattle) is involved in a kind of transhumance, so an intermediary system is practiced.

iii) Ranching:
Here domestic but also wild animals may be kept and managed in various levels of intensity. Ranching was generally introduced in the last century. Ranches can only exist in areas where variation in space (within the boundaries of the ranch area) is large enough to overcome the variation in seasons. That means the ranch should contain dry season grazing areas, natural or at least (semi-)artificial. In arid and semi- arid areas it can only exist if large areas of many thousands of ha with suitable land units are

included. Ranches can be open or closed (the latter is often too expensive). They can be mixed domestic and wildlife ranches or pure. In large ranches the system may tend to be nomadic.
Transitions exist to improved ranch systems where reseeding and fertilization are practiced. Those improved ranches, very common in the United States can be much smaller. They are, however, not included in extensive grazing.
A specific ranching system applied in a.o. Kenya is the group-ranch which is meant as an improvement of nomadism and transhumance. The pastoralists are divided over these group-ranch areas. Each group has only his own grazing rights. It is related to certain systems among Bedouins in the Middle and Near East deserts, where the area is subdivided among tribes with grazing rights. In such regions special areas can be protected separately against overgrazing by general ageement ('Hema-system). This system can only be established if good land evaluation is available in combination with legal measures and control systems. If a ranch has not sufficient capabilities in all seasons, the users may spoil the land.

4.2.3. Compound management systems, clusters of LUTs and multi-purpose LUTs

The (in the meantime classical) approach to land evaluation, as it has been developed sofar for agriculture and forestry, deals mainly with the suitability' of a tract of land for land utilization types.
It is possible to judge the qualities and suitability of a specific area, of variable size, for such purposes as the growth of wheat, the cultivation of a certain type of forest or a certain crop, or a crop sequence under irrigation. In the latter case the physical quality* of the land depends also on a source of water that may exist outside that very tract of land. So the value of that land depends on something (water source in this case) outside its limits.

For more complicated compound types of land uses such as a mixed farming system one needs for the various elements of that farming system different types of land. The farming system can only function optimal, if these tracts of land exist in a combination with sufficient accessiblity between the tracts used for the different elements of the farming system. All village grazing systems are part of such compound management systems. A good example is the mixed farming system as it existed till about half of century ago (and locally still remains) in the north-western European cover sand plains in The Netherlands, Germany and Belgium.
Here the farmhouse is located on the transition between upland and lowland, where ground-water (for the drinking water) can be found within about a metre depth. Cattle grazes in the lowland on gley soils with originally supported elder forest, but now reclaimed into fertile grassland. On the upland near the house are the arable fields with ground water occurring at moderate depth and accumulation of minerals by dung and sods ('plaggen') has taken place. The 'plaggen' are caused by men and the dung by sheep taken to the arable land from the communal range (heath land) in the uplands ('pot- stable system). The arable land in the primitive system without artifical

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* For physical versus socio-economic land evaluation, see chapter 6.3.

fertilizers can only exist with the help of the dung and sods imported from the heath land (also partly from neighbouring forests and the 'grassland' below). Occasional flooding of the grassland may restore fertility which is depleted by cattle grazing. Pigs, poultry, etc. complete the scene.
It is clear that such a mixed farming system is a complex of land utilization types. It should also be clear that the suitability of a tract of land for a certain land utilization type may depend on the use of the adjoining tract of land and its use (compare the arable land to a primitive system shown above, that needs to receive fertilizers from the sheep range system in combination). One should not call such a compound land use system a land utilization type (LUT) in the sense of land evaluation, but a management system composed out of several (mutual influencing) LUTs. Extensive grazing may be part of such a cluster. Modern agricultural systems tend to have a more mono-land utilization type character with all advantages and disadvantages of it. For land evaluation the advantage of such systems is that a farming system, especially if one evaluates it on a not too detailed scale, may be synonymous with one land utilization type and not a cluster as mentioned above.
The same tract of land may be used for more than one purpose. In that case a land utilization type is to be defined as a MULTI-PURPOSE LUT. In forestry it is often the case (timber production, conservation, recreation, sometimes even grazing), see Van Andel c.s. in Laban (ed.) 1981. Extensive grazing can be part of such a multi-purpose LUT and than not being an independent one.

4.2.4. Seasonal LUTs (SLUTs)

In extensive grazing systems a new aspect in the definition of LUTs has to be introduced, sofar not yet met within agricultural and forestry systems. This aspect is caused by the mobility of the main produce medium of the LUT, the animals. This dynamic property in combination with the dynamics (temporal variation) of the environment (climate) and the existing spatial variation in the rangelands leads to the following complications. During the different stages of their life and especially uring the various climatic seasons (in erratic sequences or arranged according to more or less regular periods) the animals have different demands on the environment. Their mobility allows animals in nature to react to this demand by moving to the most suitable place.
In the most intensive cattle keeping systems, the environment can be adapted to a large extend to the demand of animals in the various stages of their life by supplying water and well adapted food at the spot.
To achieve this supply storing systems, fodder crop cultivation and import of concentrated food from elsewhere may be feasible. The most characteristic property of the major kind of land use extensive grazing is, however, that such adaptations are excluded (except for a certain care for water by digging deep wells, constructing of 'tanks', etc. and some local seeding of fodder crops or establishing links with agricultural LUTs). The fact is that in each one of the management types mentioned, the animals depend on different tracts of land in the different seasons.
One can state that each grazing system requires a proper combination of types of land in such a way that there are at any time of the year sufficient resources available somewhere in the area where the system operates.

For classical transhumance this means that there should be in the dry season an area where water and sufficient food is available to survive at the moment that the resources in the wet season area are depleted. The wet season area has other advantages as superior food and absence of diseases, etc.). Those wet and dry season areas may occur many hundreds of kilo- metres apart and the tracts of land, together forming the habitat of the grazing system, may be separated by vast areas of completely different types of land. The qualities of that land should at least meet the requirements during the period of trek.

For communal village grazing and in not too large ranches, different types of land occur much more close together, but should nevertheless be available. The communal village grazing system has in the worst season agricultural product supply for survival.

A special case is the intermixture of various land units, which is of importance also without the seasonal differences. This is often the case in semi-arid areas but also elsewhere. The food on the greater part of a rangeland may be reasonable in quantity, but deficient in certain elements (minerals, proteins). Small land units (river valleys, etc.) may contain high quality food, but in low quantities. None of these units can fulfil the demands in quality and quantity independently. A combination of the two reasonable intermingled systems raises the suitability of both.

In fact a transhumance system is comparable, but then with large distances and a temporal factor to it.

For the mixed systems this problem in evaluation can be overcome to map complex land units, characterized by the combination of the two (or more) complementary elements. For the elements, separated by seasonal variation and long distances, this is at least impossible on the usual scales.

A feasible way is to distinguish SEASONAL LUTs (SLUTs).

Evaluation includes a look for tracts of land that can fulfil the requirements of this seasonal LUTs. So the following questions should be raised: ' what is the value of a certain tract of land for winter- grazing of the Fullany transhumance land utilization type; what is the suitable land during the spring and autumn to move to and from; what about wet season grazing, etc.?' Also: 'what is the suitable land unit for the birth of ibex in the Alps, or for the mating of rhinos in the humid tropics'. So for land evaluation (similar to the mixed farming system) one type of extensive grazing system is to be considered as a management system existing out of various LUTs; which in this case are: temporally separated seasonal LUTs (SLUTs). The optimal areas for these SLUTs may be found in remote locations. In that case the system has to be a transhumance or a nomadic one. If the distances are shorter and can be kept within the size of a ranch, this latter system can be applied. It may be clear that only on the basis of these seasonal (sub-)LUTs land inventory data can be evaluated on their ecologic value and that planning (and management) of grazing systems should be done on this basis.

One problem remains which is very typical for grazing land systems. The produce medium is not seasonal. The produce medium (the animals) is the same, but roams during one production cycle through a series of (seasonal) LUTs. The socio-economic value which has to be established belongs to a series of SLUTs together; this occurs not side by side (as in complex farming systems) but in a different time. For socio-economic reasons, one has to

consider a series of SLUTs which belong to one grazing system as one unit. The crux of the land evaluation system is to compare the qualities of of the land units with the requirements of the LUTs,. It is therefore essential that the LUTs and in the case of grazing systems, especially the SLUTs as well as their requirements are well defined. This is partly an iterative process. More knowledge gained by inventory may reveal more about the possible adaption of LUTs.
The translation of land unit properties into qualities which can be matched with the LUT and SLUT requirements is treated in chapter 5 and 6 . The matching process, the determinator of the SUITABILITY, will also be treated in chapter 6.

5. Quality and requirements determination

5.1. Requirements*

Before one can start to translate land properties (intrinsic land characteristics) into 'qualities', one should know the requirements of the selected LUTs. In rangeland evaluation, in contrast to common arable agriculture we deal with a multi-production stage system: primary production (vegetation), secondary production (animals) and sometimes even tertiary production in case of 'tourist industry' based on animal viewing (hunting) and other attractions in rangeland. The requirements for primary production refer to the basis factors for plant-growth such as mechanical support by a substratum, not too few, not too much, just enough energy by radiation, kinetic energy (temperature) moisture, minerals, oxygene in soil, genes (available flora to build up a vegetation). Also resistance against too unfavourable quantities of heat(fire), minerals (salinity), mechanical stress (wind, deseccation, trampling, grazing). The land attibutes: atmosphere (macro and micro climate), landform, rock, water, soil , flora, fauna; all have to contribute to fulfil these requirements.
The requirements for the secondary production (animals) are related to the type of digestion system of the animal, (bulkfeeders, intermediate feeders concentrate selectors), amount of the forage needed, quality of the forage wanted, frequency needed for watering, quality of the water tolerated, need for shelter, vulnerability to diseases, resistance against climatic hardship (need for shelter, etc.), ability to overcome rough terrain, ability to walk long distances, social animal behaviour (to same species and to other species), tolerance and/or preference.to various other environmental aspects.
For a tertiary level, besides requirements for presence and absence of certain factors for animals, there may be also other produce media that should be considered. Rangelands used as national parks or nature reserves may need on top of available animals and plants also qualities such as

- scenery (natural beauty)
- recreationed qualities (as e.g. swimming possibilities, etc.) and also
- conservation needs about rare or otherwise important plants and animals and other natural features
- natural diversity might be a special requirement.

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* This chapter is revised after presentation in Addis Ababa and amended with suggestions from working groups.

Before and during the inventory stage one should study these requirements in order to collect sufficient data on land properties related to them.

5.2. Land qualities

The answer to the requirements are the land qualities. These are listed below separately for the primary and secondary (and tertiary) production level.

A Primary Production Level.

related to plant growth:

1 Moisture regime
2 Temperature regime
3 Radiation regime
4 Nutrient conditions
5 Oxygen availability to roots
6 Rooting conditions
7 Surface sealing (as affecting natural re-seeding)
8 Flood hazard
9 Soil toxicities
10 Excess of salts
11 Genetic potential of vegetation
12 Fire susceptibility

related to vegetation:

13 Ease of control of undesirable species (bush clearance)
14 Conditions for hay and silage
15 Soil workability
16 Potential for mechanization

related to soil conservation:

17 Erosion hazard under grazing conditions
18 Susceptibility to trampling

B Secondary Production Level.

1 Forage availability:

quantity/unit area
(both herbage and brows)
quality: digistibility
palatability
acceptability
toxicity
nutrient value – crude and digestible protein
– minerals (macro- and micro nutrients)
yearly and seasonal variation:
all data for an average rainfall year and for one or two consecutive drought years (defined according to local climatic data)

2 Water:

quantity
quality (conductively + mineral composition)
distance

yearly and seasonal variation (as mentioned above for forage)

3 Biological hazards:
poisonous plants
endemic and epidemic diseases:
sleeping disease (tsetse)
fasciolasis (liver fluke)
tickbound diseases
predation
yearly and seasonal variation

4 Climate hardship:
temperature/wind/rain, as inducing need for shelter
yearly and seasonal variation

5 Accessibility (inclusive surface conditions):
slope
stoniness
hindrance by vegetation
other land use
flooding

6 Ease of fencing or hedging:
availability of natural materials
ease of establishment
conditions for maintenance

7 Shelter and protection form mating areas (related to 4 and 5)

8 Location (mainly in relation to market):
kind
distance
yearly and seasonal variation

C Tertiary Production Level.
1 scenic aspects
2 recreational aspects (swimming possibility, etc.)

3 easy view places (animal observation) an others

Most of these qualities in the above mentioned three groups are of physical nature: forage quantity and quality, water in all its aspects, pests and diseases, edaphic conditions, erosion hazard, climatic hardship and accessibility. The presence of political borders, unfavourable legislation in relation to certain practices are pure social of character, but should be taken into account in any realistic land evaluation, even if it is meant to be mainly physical of nature (see also chapter 6).

A most important quality for the secondary production level of very complex character, that has been the concern of all people involved in range

management, is carrying capacity. This is the base of the most important rangeland management tool: the stocking rate. The carrying capacity is in fact an integration of nearly all the abovementioned qualities for the secondary production level.
In section IV.c and in various workshops the problems and methods are treated in detail.
In most of the land qualities the aspect of variation in time, overseasons, as well as the different years play an important role. This is a very specific character of land qualities in relation to extensive grazing. In agriculture and more technological sophisticated systems one can overcome dynamic aspects of the environment by technological means. In case of extensive grazing one should adapt. In chapter 4 we have seen that the main character and differences of the grazing system types and (S)LUTs are caused by differences in dynamic (variation) in time. The variation in space is used to counteract this and gives rise to such different solutions as transhumance versus closed range systems.
It may be clear to any surveyor and range manager that the three scales
- scale of management unit
- scale of temporal changes
- scale of land unit pattern

play an essential role here.
So the concept of scale should be clearly presented in quality presentation and also later in the matching with requirements in order to arrive at suitabilities and/or management measures. For each SLUT the set of qualities or at least the weight of quantities may differ. So for each LUTs the guiding principle of quality classification should well be taken into account and the quality classes well adapted.

5.3. Rating of qualities and requirements

In the next chapter will be described how requirements and qualities have to be compared. A first condition is a rating and weighting of qualities. About weighting no general rule cannot be given. Rating is often done by estimating a quality in a scale of 5. For grazing purposes in some cases working with the actual dimensions or figures may have to be advocated (e.g. width of zones (distances) to watering points, etc.) See chapter 6.2.

6. Land suitability classification

6.1. Definition

Land suitability is the fitness of a land mapping unit for a defined use. The rating of classification of the suitability of a particular land mapping unit depends on the extent to which its land qualities satisfy the land use requirements. Land mapping units are classified for each land use that is considered to be relevant for the study area.
Suitability is assessed by comparison of the land use requirements with the land qualities. This can be achieved with actual land qualities, but it is also possible to estimate quantities after a proposed improvement, e.g. the establishment of a borehole, the (re)seeding of a feedlod, etc. This comparison leads to two kinds of classifications for a certain land mapping unit: (i) the classification of the current suitability (without improvements) for a defined land use in its present condition, and (ii) the classification of the potential

suitability (with land improvements) for a specified use under future conditions*.
Land suitability is determined by physical and socio-economic factors (qualities). One could try to match all this factors at once and so arrive at the suitability of a certain LUT in the total physical, social and economic context of a region. For regional planning (in which the grazing systems should fit) this would be ideal. Also for the internal land evaluation, the integrated dealing with physical and economic (and social) repercussions and aims of the measures is to be strived for.

However, especially in the regional planning case, social and economic aspects are so complicated that one usually chooses for a two step procedure, in which firstly mainly physical qualities are considered (the capability of the (bio-physical) land) and in a following second step details of economy and social aspects are taken into account. (Compare also Figure 1, where the different positions of bio-physical and socio-economical land evaluation is shown.) In range management a special problem is the general land use policy of a whole nation or even a combination of nations (extensive grazers – often cross political boundaries) has to be considered in such a procedure. All this does not mean that economic and social considerations are absent in the first mainly physical step of the evaluation.
The overall social aspect of extensive grazing in many parts of the world is evident. The classical clash between 'Abel' and 'Cain' is neither pure economic, nor a pure physical one. In judgement of importance of qualities and limitations, common sense in relation to economic aspects is incorporated.
Theoretically it may be possible to provide water everywhere by car or by pipeline, or even transported from the polar ice, if necessary. In rich countries like Saudi Arabia this supposedly is feasible for not too remote parts of the desert. In Mali, however, it is out of the question to suppose such a possibility. The recognition of LUTs implies already socio-economic considerations. In practice therefore most land evaluations should have preferably a mainly biophysical first step. Economic evaluation can be done later including social considerations when overall output, in alternative LUTs or total systems, can be compared with input using econometric methods. Presuppositions may differ according to the political and social contexts for which they are made.
The multi-production stage character caused by the sequence of primary, secondary and tertiary production, as mentioned in 5.1, has also an important influence on the suitability classification.
The FAO-framework method, as described in this paper, can be applied most

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* In other types of land utilization (e.g. agriculture) one distinguishes between major and minor improvements which are well defined (see FAO 1976). This distinction seems irrelevant for evaluation extensive grazing.
Major improvements would change the land utilization type in such a way that it is not extensive grazing anymore. Moreover, an important aspect of the grazing system evaluation is the internal evaluation in order to take measures which are a kind of ad hoc 'improvements' of the situation. The judgement of the improving character of the measure is inherent to the measure and its choice.

efficiently in the secondary and tertiary production stages. This means that requirements of the LUTs will be compared with the qualities from group B of chapter 5.2.
For the primary production one could use the same procedure, however, the data of the primary production can be derived a different (sometimes parametric) way and may lead directly to qualities (like grazing capacity or fodder basis, etc.) to be used in the second stage.

6.2. *Comparison of the requirements of a LUT with the qualities of a land unit*

The bio-physical requirements of land uses for which land is evaluated are determined on a preliminary basis at an early stage of the land evaluation process (see 4.2.) If these data are not sufficient, then during the process of evaluation, more precise information is collected on land qualities, relationships between land qualities and land use requirements and on possibilities for land improvement.
A 'review' of the available data is generally made during the final stage of the study. This review includes the checking of the relevance and the refinement of the descriptions of the originally broadly defined types of land use, their requirements and management properties.
Observed relationships between land properties and the input/output of a particular land use in- or outside the study (surveyed) area determine the selection of the qualities and their values. Exact information on these relations is scarce. Procedures for estimating inputs and outputs are therefore an essential part of a land evaluation study. As to the land evaluation of rangeland this has to be done separately for the primary and secondary production.
The procedures generally include the construction of 'conversion tables' in which critical values of the land qualities are related to different degrees of suitability for the land use. Conversion tables may be based on (i) quantitative data from the study area, or (ii) empirical assessment of assumed relationships between benefits and land qualities. Quantitative information on inputs and outputs of the land use may be obtained for different types of land, for instance through direct measurements on trial sites, interviews with herdsmen and local officials or from (local) experiment stations.
Subsequently for each land utilization type the requirements are expressed in terms of the quality figures or classes. Also all the land units are expressed as a list (spectrum) of quality figures of classes. It is now possible to 'match' the 'quality spectrum' of a land unit with the quality requirement spectrum of a land utilization type. This is illustrated in Table 1; in which the qualities are expressed in 5 classes: 1 is high, 5 is low value. We could consider this table as an example of the evaluation for secondary production. This means that qualities belong to the B group of chapter 5.2.

One can use the principle that a limiting factor determines the suitability. If all qualities are crucial this is the case for Quality e' in Land unit III for LUT A. So III is unsuitable (N) for LUT A in spite of the fact that the requirements a, b, c, d are met. One could also make an expert's subjective judgement. If one knows that 'e' is not so important, III is reasonably suitable with some restrictions, (S2e) etc. (see for suitability classes chapter 6.3.). Land unit I is unsuitable for A as well as for B.

Table 1: Matching of requirements and qualities to arrive at suitability.

	Required qualities					Suitability of LUT	
	a	b	c	d	e	A	B
LUT A	5	5	4	4	1		
B	1	1	4	4	5		
	Available qualities						
Land unit	a	b	c	d	e		
I	5	5	5	5	5	N	N
II	2	1	4	4	1	S1	S2a
III	3	3	3	4	3	N or S2e	N or S3(a.b.)

Land unit III is possible also unsuitable for B (two deficient qualities of the five (ab) or at the most marginally suitable, S3.
Land unit II is suitable for A and has only deficiency (a) for B, so it is reasonably suitable with some restrictions.

An example of a dominating quality is the availability of drinking water. A high potential carrying capacity based on primary production and other land qualities is useless, if the source of drinking water is too far away. The same holds for absence of cover (bush) for those animals who will never go further than a certain distance in the open field (e.g the bushbok). This introduces also a specific element in land evaluation for extensive grazing: zones determined by points or lines. So many types of animals have a critical distance to the water or shelter source beyond which they will not move. Therefore around point-shaped sources (boreholes, tanks, small ponds) a circle is created with a radius equal to that critical distance. Outside the circle the suitability of the environment for that animal is zero, irrespective of any other value. For line elements (like rivers) there is a zone and a limit parallel to that river. Obstacles influencing accessibility and any other limitation occurring in the land units may modify this pattern. The already mentioned demand for nearby shelter may cause similar zones at a critical distance from a dense bush. These zones can be considered as diagnostic characteristics of land units. That means that a certain combination of vegetation, soil, etc. within such a zone will be considered as a different land unit, compared with the same soil-vegetation combination outside that zone. In that case the zones should be clearly indicated on the maps and suitability calculation will be done per zone considered as a land unit.
On very small scale maps the zones may be small compared with mapping units. In that case one could calculate per mapping unit which percentage of the unit is affected by the (e.g. negative) influence of that zone and use those data as a quality (limitation) for the mapping unit as a whole, 100% being the worst, 0% being the most favourable (see Baig 1977).
For the qualities biological hazards, accessibility and climatic hardship

experience learns how to rate these for each type of animal, respectively LUT or SLUT. The minimum rating is: 'yes or not present', the more advanced rating may give certain classes of severeness, the minimum and maximum values of tolerance, and requirements.
The crucial quality is forage availability and its nutritive quality.
For this quality certain maximum limits of toxic components or minimum nutrient content (N%) can be used in the quality rating.

If from the (S)LUT and possible other considerations (economic, social?) a minimum production (or amount of animals) could be calculated, any amount of forage that is too low to support such a secondary production, could be considered as below the minimum level hence rated as zero. This means also that the quality 'forage availability' should be converted in terms of 'animals/ha' - provided all other factors would be favourable. Such a quality is often called: 'grazing capacity'. An explanation of this concept in its various meanings in relation to suitability classification is given in the next chapter.

6.3. Grazing (carrying) capacity as land quality

Grazing capacity can be defined as the number of animals that can graze on a certain area without doing damage, based on the amount of forage available, supposed all other factors are favourable.
Carrying capacity' is sometimes used in a wider concept. The amount of animals (numbers or total production) can be maintained per area unit as is determined by all site factors (not only forage, but also water, accessibility, etc.). Also the term grazing capacity is used this way.
In the former chapter we mentioned already that the forage-based grazing capacity is an important quality in the suitability determination. Such a quality can be derived from actual forage and animal requirements, but can also be a result of primary production evaluation. In that case it may also be a potential value. A good example is the estimation of production of nitrogen (and also phyto-mass) based on various parameters by the P.P.S.-project (Penning de Vries et Djiteye 1982, see also Breman en Ketelaars in these proceedings. A considerable part of LEEG proceedings is devoted to grazing (carrying) capacity determination (see report Working Group D).
The wider concept of carrying capacity determination is more a complex quality, it can be a full bio-physical land evaluation in itself. An example of such a classification is the one of Thalen 1979, see also Baig 1977.

$$G_a = \frac{(P_h \times p_h \times n_h) + (P_b \times p_b \times n_b)}{R_a} \times F_1 \times f_2 \times \ldots f_n$$

G_a = unknown grazing capacity for animal type (a) for a land mapping unit expressed in animal units per unit area
P_h = production of forage in the herbaceous layer in the land mapping unit
p_h = proper use factor for the herbaceous layer
n_n = correction factor for nutritive value in the herbaceous layer
P_b = production of forage in the form of browse
p_b = proper use factor for the browse

n_b = correction factor for nutritive value of the browse
R_a = forage requirement of animal type (a)
f_1, f_2, f_n = multipliers for relevant land qualities

The accessability of the zones due to the distance of the watering points or shelter as a percentage of a land unit, mentioned in the former chapter (6.2.), may be found among the multipliers It should be emphasized , however, that if such a formula is used, this is done instead of a quality comparison according to Table 3. Moreover, socio-economic considerations are difficult to take into account in such a formula. For a (semi)-quantitative approach it is useful to calculate the mumbers of animals in a (possible) area in order to manage the stocking rate. In fact it is a suitability classification based on one very complex land quality (a broadly based carrying capacity). The suitability classification is in this case nothing else than a rating of quality into the arbitrary classes: high, medium or low, with boundaries adapted to the special aim. Especially for an evaluation of internal aspects of a rangeland management system, this may be an efficient approach (see chapter 7).

6.4. Land suitability classification

The FAO Framework does not offer a recipe for land classification for general application. It restricts itself to providing a hierarchical structure for classification systems with possibilities for adaptation to local conditions and objectives. Usually three hierarchical levels of land suitability with decreasing generalization are recognized: orders, classes and subclasses.
There are two basic land suitability orders: S = Suitable and N = Not suitable. Land classified in the 'suitable' order is expected to yield benefits which justify the inputs without unacceptable risk of damage to the land. Land suitability classes reflect the degree of suitability within orders. The number of classes to be recognized depends on the purpose and the scale of the land evaluation study. In qualitative studies, for instance, three classes are often distinguished in the 'suitable' order: S1 = Highly suitable, S2 = Moderately suitable and S3 = Marginally suitable. The minimum requirements of the land which determine its classifications in a certain order or class for a particular use are generally shown in a conversion table.
Land suitability subclasses indicate the kinds of limitations of land which are classified in classes other than S1. For instance, subclasses S2w and S2d indicate land moderately suitable (S2) because of the not optimally available water (w), and land moderately suitable (S2) because of drainage deficiencies (d), respectively (see Table 3). Land can be classified for its current or potential suitability for a certain use (see chapter 6.1.). These classifications may be qualitative or quantitative. In a quantitative land suitability classification the ratings of the performance of the uses are usually expressed in economic terms.

6.5. Presentation of the results

The results of a land evaluation are presented in the form of a report and maps. One of the maps included in the report ususally shows the land mapping units together with a legend or table which indicates their suitability for each of the land uses considered (Table 2).

Table 2: Example of a generalized classification of land units for kinds of land use, to be compared for internal and external land evaluation.

Land unit number	Short land unit description	Kinds of (S)LUT			
		irrigated foddercrop	summer grazing	winter grazing	production forest
1	flood plain	S1	N	S1	N
2.1.	South Sahel open grassland sandy soil	S1	N	S2	N
2.2.	South Sahel woodland	S2	N	S2	S2
3.	North Sahel sandy soils	N	S1	N	N
4.	rocky terrain, humid climate	N	N	S2	S1

6.6. Responsibilities

External land evaluation is an activity between more scientific and technical work on the one hand and political desiderata on the other. Care should be taken to divide responsibilities properly. Analysis and synthesis of natural resources and the technical methods to exploit them is the task of scientists and technicians, trained in the various land(scape) ecological methods.
A special case is the 'appreciating' of land for other than technical or economic or ecological reasons, usually the 'tertiary production stage'. This holds for esthetics, emotional value, historical ties, etc. Here the judgement of those who care for these values should be asked through associations to action groups dealing with these entities.
A society consisting of: administrators, politicians and the common man, should not interfere sofar. That means surveys should be done by surveyors, the requirements for land utilization types by experts. However, the choice between land utilization types, and the decision which alternative land utilization types should be considered, is not a privilege for the technicians, scientists and esthetists alone. In case of regional planning it is the government, as representative of the society, who has to decide.It depends on the type of government in which way the 'simple man in the street' (or on the 'land) can influence this decision making progress. Surveyors belong in this state to the latter category.
In Figure 5 the role of society, government, technicians and scientists is given schematically.

In case of internal range management within e.g. a ranch, it is the range manager who has the final decision.

7. Internal Land Evaluation (for management)

For management purposes the classification in degree of suitability is not always sufficient. Within a certain land utilization type measures have to

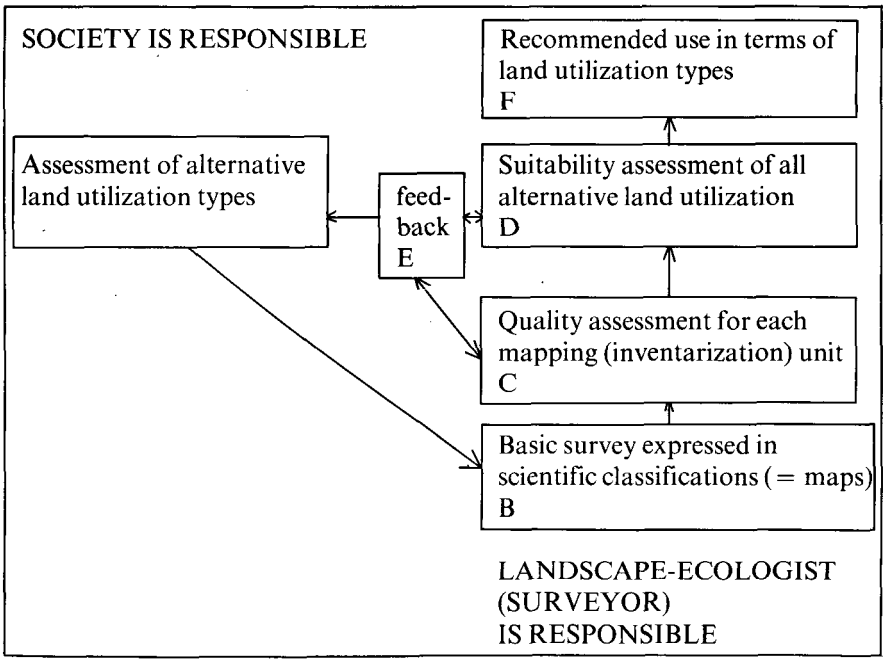

Fig. 5 Steps and responsibilities in land evaluation

be taken for management. The evaluation here deals with the judgement of what kind of measures are necessary (minimum required activity) and the opposite, what should not be done (maximum tolerated activity).
This type of evaluation is done especially for extensive grazing and for conservation purposes, and also for the management of recreation areas, national parks and nature reserves. It deals with the period and intensity of herding or culling, or any other means of influencing the stocking rate in a certain period in a certain area; also prescribed burning or other measures might be planned in such a way.
For each (seasonal) land utilization type evaluation leads to assessment of measures (if minimum requirements are not fulfilled but may be supplied) or assessment of limitations that may lead to the non application of certain utilization types. For these types of management, especially also for conservation management, the overall land utilization type is a given fact. Evaluation does not lead to a choice between LUTs, but to measures to be taken to keep favourable factors above the minimum required level and the unfavourable ones below the maximum tolerated ones. Vulnerability and required action is to be evaluated before action can be taken. Pollution, lowering ground-water, uncontrolled fires, excess of people or overgrazing are common factors exceeding the tolerance limits in nature reserves in addition to oxygen, minerals in soil, and water in arid zones. Adaption of the stocking rate is a common tool in management. Calculation of the acceptable stocking rate as given in examples in chapter 6.3. is an useful evaluation tool.

8. Glossary

A. Terms related to 'land'.

Ecosystem –
A system of interacting factors comprising living organisms together with their non-living habitat at a certain place on earth (modified after 'Cain').
Environment –
The sum of all external factors and conditions which influence the occurrence and functioning of a physical, chemical or biological process at a certain place and during a certain period of time.
Geomorphology –
The study which describes landforms and the process which led to their formation and investigates the interrelationships of these forms and processes in their spatial arrangement (Van Zuidam).
Habitat –
The environment of a particular place occupied by an organism, species or community ('Cain').
Land –
An area at the earth's surface, the characteristics of which embrace all reasonably stable, or predictably cyclic attributes of the biosphere vertically above and below this area, including those of the atmosphere, the soil and underlying rock (geology), the water regime (hydrology), the plant and animal populations and the results of past, present and future uses of the land by man (FAO). (Also synonymous with landscape. See Zonneveld 1979.)
Land characteristic –
a) – A selected property of land used to distinguish classification units from each other. In that case it should preferably be a property than can be measured or estimated (diagnostic land characteristic).
b) – In land evaluation the term is also used to indicate any properties determining the character of land, also the not easily directly observable ones ('intrinsic land characteristic').
Land mapping unit –
An area of land demarcated on a map and possessing specified land characteristics and/or qualities (FAO).
Landform –
A terrain feature formed by natural processes which has a definable composition and range of physical and visual characteristics that occur wherever the landform is found (Way, 1973)
Land improvement –
An alteration in the qualities of the land which improves its potential for land use. 'Major' and 'minor' land improvements can be distinguished (FAO)
Land quality –
A usually complex property of land which acts in a manner distinct from the actions of other land properties in its influence on the suitability of land for a specified kind of use and which is used as a diagnostic characteristic in the land suitability classification.
Land resources –
Landscapeconditions and elements of the land exploited by men.
A part of space at the earth surface consisting of a complex of systems formed by the interaction of rock, water, air, plant, animal and man, and that by

its physiognomy forms a distinguishable entity (W.L.O. Landschapstaal (translated). Also synomynous with 'land', see Zonneveld 1979).

Limitation –

A land quality which adversely affects the potential of land for a specified kind of use.

Physiography –

i) – The description of 'landform' or 'terrain', which includes only the physical (abiotic) aspects of land and

ii) – the description of 'landscape' including aspects of land use, vegetation and human influences. The use of the term 'physiography' in the latter sense is not recommended (ITC).

Rangeland –

Land currently used for grazing by livestock and/or wildlife where:

i) the semi-natural or natural vegetation is the main forage resource,

ii) no mineral fertilizer and seeding are applied on a large scale, and

iii) the stocking density is low (usually lower than about 1 A.U./ha).

Relief –

The contours of some parts of the earth surface considered with reference to variations in its elevation and slope steepness (adapted from the Oxford English Dictionary).

Soil –

The collection of natural bodies occupying portions of the earth surface that support or are capable to support plants. A soil has properties which are caused by the integrated effect of climate and living matter on parent material, as conditioned by relief over periods of time.

In places the bodies may have been modified or even made by man (modified after USDA Soil Survey Manual).

Terrain –

A tract of land considered as a complex of physical surface and near-surface attributes (modified after Mitchel, 1973 and Way, 1973).

Topography –

The practice of graphic and exact delineation, usually on maps or charts of the physical features of any place or region, especially in a way to show their relative positions and elevations (Webster). (In American use it is almost synonymous with 'relief').

Vegetation –

The 'green cover' of the earth as a dynamic three-dimensional body composed of plant individuals. Its properties are caused by the integrated effect of all environmental factors including man (ITC).

B. Terms related to land utilization.

Group ranch –

A grazing system in Kenya in which the exclusive grazing rights of large tracts of land are given to certain tribes. These areas are meant to contain sufficient variation in space to overcome the variation in climate. They are not fenced, neither have natural boundaries.

Carrying capacity or grazing capacity –

The number of animals which can graze a certain area without reducing the quality of the land. It can be expressed in animals units/ha or km2/year, in:

ha/animal unit/year,
animals unit/ha/season
animal unit/grazing days.
This figure may be calculated taking into account only available forage, or also considering the other factors like available water, biological, physical hazards, etc. There are proposals to reserve 'grazing capacity' for the first, 'carrying capacity' for the latter case.

Land utilization type –
A kind of land use in a given physical, economic and social setting (current or future) described or defined in a degree of detail greater than that of a 'major kind of use' (FAO). Main properties of a land utilization type which may be described or defined by means of key attributes, include: produce, market orientation, capital intensity, labour intensity, power resources, technical knowledge and attitude of land users, technology employed, infrastructural and institutional requirements, size and fragmentation of land holdings and distance between elements, and tenure and income levels, produce medium, and permanence of housing.

Compound utilization type –
a land utilization type consisting of more than one kind of use or purpose, either undertaken in regular rotation on the same land, or simultaneously undertaken on separate areas of land which for purposes of evaluation are treated as a single unit (FAO).

Extensive grazing –
A system of grazing without improvements of the grazing land in the form of (re-)seeding or fertilizing except drinking water supply and local feedlots.

Multiple land utilization type –
A land utilization type consisting of more than one kind of use or purpose simultaneously undertaken on the same land, each with its own inputs, requirements and produce or other benefits (FAO).

Nomadic grazing –
A grazing system and a way of life where the people continuously live in movable housing (tents) and follow routes determined by, usually erratic, climatic events. Usually there is a regularity in areas to be visited and routes to be followed.

Produce –
The products (e.g. crops, livestock products, timber), services (e.g. recreational facilities, military training facilities) or other benefits (e.g. wildlife conservation) resulting from the use of land (FAO).

Ranch –
A rangeland land use system where the land is controlled by the same person or group of persons, as the animals (Gils et a. 1983).

Produce medium –
The medium (o.a. animals, plants or other features) through which a land utilization type produces the material (or immaterial) values that represent the economic or social aim of the utilization of land.

Sustained use –
Continuing use of land without severe and/or permanent deterioration of the quality of the land (FAO).

Transhumance –
A grazing system in which the people have settled housing in one area and

move in one season to other, usually remote, area or areas for seasonal grazing. Sometimes they live continuously in tents (transition to nomadism) and regularly trek in between two or more fixed grazing areas.

C. Terms related to analysis, classification and evaluation of land.

Classification –
The systematic ordering of data into categories without attaching an interpretative value to the data.
Land classification –
Used in various meanings, including
i) the systematic ordering of terrain or land without specific uses in mind and
ii) land appraisal or land evaluation senso stricto. The use of the term 'land classification' is not recommended.
Land capability classification –
An interpretative classification based on the effects of combinations of climate and permanent soil characteristic on risks of soil damage, limitations in use, productive capacity and soil management requirements (USDA). This definition considers land as almost synonymous with soil.
Moreover, the term is also used synonymously with land evaluation. Therefore the use of this term is not recommended.
Land evaluation senso lato –
Synonymous with land appraisal = determining the usefulness (suitablility) of land for a certain purpose. It may include also indication of management measures based on judgement of the properties.
Land suitability –
The fitness of a given type of land for a specified kind of land use (FAO).
Land suitability category –
A level within a land suitability classification. Four categories of land suitability are recognized: order, class, subclass and unit (FAO).
Land suitability classification –
Classification of specific types of land in terms of their absolute or relative suitability for a specified kind of use (FAO)
Current land suitability classification –
A land suitability classification based on the suitability of land for a specified use in its present condition without major land improvements (FAO).
Potential land suitability classification –
A land suitability classification based on the suitability of land for a given use after specified major land improvements have been completed where necessary (FAO).
Quantitative land suitability classification –
A land suitability classification in which the distinctions between classes are defined in common numerical terms, usually economic which permit objective comparison between classes relating to different kinds of land use (FAO).
Qualitative land suitability classification –
A land suitability classification in which the distinctions between classes are made in terms which do not meet the requirements of a quantitative land suitability classification (FAO).

D. Study/survey techniques and approaches relevant to land evaluation.

Forest survey –
Inventory and mapping of current and potential forest resources.
Geomorphological survey –
The analysis, classification and mapping of landforms with reference to their morphology, chronology and lithology.
Holistic survey –
Analysis, classification and mapping of the environment into land (scape) units of various hierarchical orders that can be employed for purposes of land evaluation based on the concept that the environment is an integrated – holistic- entity that should be studied as a 'whole' (see Zonneveld, 1979).
Integrated survey –
A survey including several disciplines which are interrelated and adjusted to one another, either on scientific basis or on operational grounds.
Land use survey –
(a) Inventory, classification and mapping of the present use of the land surface in terms of cover and function and (b) analysis of causes and reasons underlying the present land use situation by means of studies or surveys (in which the land use map could serve as a basis for stratified sampling).
Multidisciplinary survey –
A survey in which different disciplines take part.
Natural (semi-natural) vegetation survey –
Inventory, classification and mapping of (a) vegetation type(s) using the constituent plant species and/or vegetation structure as diagnostic characteristics, studying and taking into account as guiding principles current and potential functions of the vegetation types and assessment of the ecological implications.
Plant ecology s.s. –
Study of interactions of plants and their environment.
Land unit survey –
Survey of aspects of geology, geomorphology, soils, climate, vegetation and land use, resulting in a land unit map. Land units at a map scale between about 100.000 – 500.000 are usually called land systems.
Landscape ecology –
The study of land (landscape) as an ecosystem, which is a system of all biotic and abiotic factors in a certain area at the surface of the earth. Landscape ecology is a fundamental base for land evaluation.
Soil survey –
The soil survey includes that research necessary
1) to determine the important characteristics of soil,
2) to classify soils into defined types and other classifying units,
3) to establish and to plot on maps the boundaries among kinds of soil (modified according to Soil Survey Manual.
Terrain analysis and classification –
The analysis, classification and mapping of terrain based on relief, rock type and genesis with reference to actual processes, soils, hydrology and vegetation or land use. The classification and mapping of different areas of the earth surface is based on similarity of surface and near-surface attributes which are selected according to the aim of the survey. Terrain mapping units may

include terrain provinces, terrain systems, terrain units or terrain components.

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