The FAO methods of land evaluation for agriculture and forestry as compared to extensive grazing

by M.F. Purnell,
Land and Water Development Division
Rome, Italy.

Summary

Some of the main features of the guidelines which are in preparation for land evaluation for rainfed agriculture, irrigated agriculture and forestry are described and compared with the special requirements for land evaluation for extensive grazing. Conclusions drawn are that although the latter can be less detailed and on a smaller scale, the reliability of the predictions made is equally important because of the danger of degrading the usually fragile environment, and the development of land evaluation methods to give reliable results is particularly complicated and must be developed by a multidisciplinary effort.

1. Introduction

The principles and general approach to be adopted for land evaluation were set out in the Framework (FAO, 1976) and have begun to be used widely. Inevitably there has been a demand for further instructions on how to apply the principles and carry out the activities recommended in the various stages of land evaluation. FAO has therefore endeavoured to develop guidelines to assist people to make better land evaluations. Such guidelines, by providing a basis, will save time which is now spent developing an outline every time a land evaluation is undertaken. By promoting more standardized methods they will facilitate comparison and technology transfer.

It is worth nothing that FAO is not trying to produce a manual which gives instructions on how things must be done, but has the more modest aim of providing guidelines which indicate how problems may be tackled and a range of methods from which the user can pick those which are most appropriate to his circumstances.

In order to provide specific guidelines it was considered necessary to restrict their scope rather than try to cover at once all the forms of rural land use in the world. Therefore major kinds of land use were selected as the objectives of the guidelines. First a guidelines was prepared on land evaluation for rainfed agriculture and this is with the printer (FAO, 1983a). A second guidelines for irrigated agriculture is being developed in collaboration with the US Bureau of Reclamation and the World Bank (FAO), and a third one is being prepared by a cooperative international effort for forestry uses. Clearly, extensive grazing is another major kind of land use, with special problems for land evaluation which have deterred an attempt at making guidelines up to the present.

This paper, based on the experience in preparing those guidelines, indicates some of the main objectives and the problems encountered, with their implications for land evaluation for grazing. It should be mentioned that there is a danger in splitting up land evaluation into methods for each of the major kinds of land use, because much land has multiple uses and it is common to be considering different major possibilities in a single area. However, the basic framework exists and it is the intention that the guidelines should be fully compatible with one another.

This paper does not deal with methods for inventory of land resource data nor with systems analysis or modelling, though some techniques have implications for land evaluation.

The method described by van Praet in this workshop for measuring dry matter availability every year by groundsampling, low aircraft and satellite, diminishes the usefulness of land evaluation for this particular purpose. Systems analysis, modelling grassland producer and consumer systems, such as described by Breymeyer and Van Dyne (1980) also has implications for the land/land use systems concepts used in land evaluation.

2. Land evaluation for rainfed agriculture

This may be considered the norm for land evaluation. The major land use can be subdivided into innumerable land utilization types. The guidelines cannot, of course, provide instructions for coping with the details of all the varied LUTs; still less provide critical limits for rating the land suitability for them. Instead it suggests a systematic way to carry out a land evaluation with some proformas as guides and with some examples of how it has been done elsewhere.

It is not necessary to outline the whole procedural sequence since this is done by others in this Workshop, but attention may be called to some salient points. The real crux of the evaluation is the establishment of the land use requirements and limitations of the land utilization types, and the method of matching these requirements with the land qualities (LQs). Many LUTs are expressed in terms of combinations of land characteristics and this facilitated matching with LQs which are similarly determined by combinations of land characteristics.

Matching some of the LU requirements to the LQs is straightforward: for example, crop requirements for temperature, and salinity limitations are quite well known and can be matched direct. Water requirements for some crops are known and the water availability can be measured or estimated in directly comparable figures. Other requirements are more difficult to measure, the oxygen requirement (drainage conditions), or nutrient requirements, for example.

A major problem for carrying out such matching is the lack of information on land use type requirements or even the more simple crop requirements. Even if crop yields in certain environments are well known it is usually far from clear which particular factors, or combinations of factors, are causing yield reductions. For extensive grazing, too, a major effort will be needed to describe not just the productivity of the rangelands but the reasons for the differences and for differences in response to management.

Table 1* shows a format for presenting land use requirements. The essential

----

* All tables are presented at the end.

point about it is that a range of values is given which indicate not only the optimum conditions (S1) but the limits with defined responses to less than optimal conditions (S2/S3 boundary) and the limit of suitable conditions (S/N boundary).

A similar format is used to rate land qualities for a specific use. A list of the LQs which control the suitability of land for specific uses is given in Table 2.; subdivided into those mainly affecting the crop or management or conservation.
Obviously not all these LQs need to be used in one evaluation. The most important ones are selected by a given procedure; these are known as diagnostic factors or class-determining factors.
The land qualities, described by reference to the land characteristics determined by surveys, for each of the land units can thus be compared with the land use requirements for each of the land utilization types which are considered relevant. Some LQs will be favourable and others less favourable and various procedures are suggested for combining the ratings for all the significant land qualities in order to give an overall rating of the land suitability.

Table 3 shows the ratings for several LUTs on a single land unit. A similar table can be produced to show the ratings of all the land units for a single LUT. These are provisional ratings and, as stated in the Framework, are followed up by socio-economic studies, environmental impact analysis, and final checking before the final land class is established.

3. Land evaluation for irrigated agriculture

Irrigated agriculture is expensive per hectare particularly for new irrigation projects. Although basin and district level surveys are made, much of the work required is large scale for feasibility, design and management. Accordingly, land evaluation for irrigation places special emphasis on the economic aspect of land suitability.
The most widely known system of land classification for irrigation is that of the US Bureau of Reclamation. The USBR emphasizes the necessity to make predictions about the future productivity after irrigation development. Another principle might be added to the six given in the Framework, to the effect that the land evaluation must facilitate the prediction of future responses of different land classes. However, although many projects use the nomenclature it is rare that the concepts and methods are used. It must be emphasized that the USBR system is essentially an economic one. At the beginning of the survey the maximum production is established and the minimum benefit which would enable the farmer to pay back the cost of irrigation. Within these two limits of payment capacity, three equal classes are separated. The land surveys are done to find the limits of the physical parameters which will produce the benefits expected for each land class. The method is generally compatible with the principles of the Framework which allows for a parallel approach with the economic and physical evaluation taking place simultaneously. Unfortunately, this procedure is rarely possible in the developing countries where multidisciplinary teams and reliable economic forecasts are hard to obtain.

The FAO guidelines therefore will adopt the more usual two-stage approach with consideration first of the physical suitability within its economic context, followed by an economic assessment. It is certain that a similar process will be most appropriate for extensive grazing.

Another feature of the economic analysis is that the preferred criteria for judging suitability is the net incremental benefit, rather than just a benefit/cost ratio or cost/return evaluation as it is called in the USDA National Range Handbook (1976). This is better for deciding which is the most beneficial investment, but it may have the effect that the best land physically has a lower incremental benefit then poorer land (Eavis 1983). To give a simplified example:

Outputs minus inputs per ha

Land Unit	Before Irrigation	After Irrigation	Incremental Benefit	Land Class
1	$ 2.000	$ 2.500	$ 500	S2
2	$ 1.000	$ 2.000	$ 1.000	S1

This problem is not resolved yet. A similar situation may occur when comparing the advantages of investment for extensive grazing in various much larger land units. It should be foreseen that various kinds of economic and financial analysis will be required as appropriate for the needs of a survey.

4. Land evaluation for forestry

Forestry is at the other end of the scale from irrigated agriculture. The value produced per hectare is generally low so investigations have to be inexpensive, at a small scale and making maximum use of remote sensing techniques and a minimum intensity of time consuming field sampling. This implies that the diagnostic factors used to classify land will be few and simple.

Evaluation of land for plantation of forests or woodlots is not conceptually different from evaluating for field agriculture or tree crops though there is the important practical difference that it is possible to measure productivity without harvesting the crop. But natural or long established forest is itself part of the land and its state must be taken into account in assigning the land suitability class.

The evaluation of natural forest only serves a practical purpose if the intention is to manage it in some way. There is at present a campaign to carry out national forest inventories and national forest plans. They serve as a basis for deciding which land can if necessary be developed for agriculture and which should remain under forest either to preserve specially valuable species or plant communities or to conserve land which would risk degradation if cleared.

Special features of land evaluation for natural forests are therefore that the land-use types may be related to conservation rather than production, that the land use is commonly multiple use (including wood production, conservation, recreation, grazing etc.). As a result, and because of the long periods involved, economic analysis is too arbitrary to be a major element of the land evaluation, though it may be important for project analysis of forest development.

5. Land evaluation for extensive grazing

So far use of the Framework for land evaluation for extensive grazing has been limited, though a good attempt has been made by the Kenya Soil Survey and the Netherlands. The reasons for difficulty in adapting the Framework to this major land use are identified in the programme of this workshop. Some comments on salient aspects follow.

As in forestry the vegetation used for extensive grazing is part of the land, and its present state is an important element in predicting future productivity. It is so important that it may be justified to use the vegetation communities as the basic land (mapping) unit for land evaluation instead of the more usual soil-physiographic units. These vegetation based units need to be subdivided according to the soils and other land features in order to predict future land suitability as well as the present suitability. This should be regarded as one possible method rather than as the only recommended method.

Even more than with forestry the value of production per hectare is low and survey and evaluation methods must be rapid and cheap. This confirms the advantages of using vegetation as a mapping unit since it is more easily identified by remote sensing techniques, but field soils information must also be gathered to determine the degree of correlation between the vegetation and the soil conditions.

The major problem which distinguishes land evaluation for extensive grazing from evaluation for other major uses can be summarized as the fact that production is not the same as utilization. Much of the production of fodder or animal liveweight gain is lost during seasonal changes. Therefore, it is important to avoid any simple numerical conversion for example of estimated biomass production into livestock production into land suitability classes. Such calculations or models may have value as establishing limits to production, but they cannot predict the suitability or productivity which can be achieved on the ground.

Measurement of pasture and browse availability, botanical composition and quality, does not provide sufficient basis for accurate carrying capacity assessment since this will be influenced greatly by watering point distribution and breed differences in effective grazing radius from watering points.

Some of the essential features of this kind of land use complicates land evaluation for extensive grazing to a much greater extent than for other major land uses. Because animals can move in search of pasture, the value of one tract of land may be entirely dependent on the production from another area which provides animal feed at another season. This can be handled by defining land suitability for seasonal land use (or seasonal land-use types) for both areas and then combining the results. However making predictions about the results of introducing alternative management methods remains problematic.

The difficulty is increased by climatic variability from year to year, since

extensive grazing typically occurs in marginal regions of great climatic variability. Average figures or even mean variabilities do not provide a reliable basis. It seems necessary to go to the historical data and examine lengths of growing periods and what would have happened in each individual year before calculating the overall result for use in land classification. This is more feasible now that computerized data handling is common.
Another feature is that the value of pasture is dependent on the presence of drinking water. Data on this, if available, is not readily combined with data on pastures and soils. However, one of the major investments in improvements is the provision of drinking water. The optimal distribution of water points in order to use all the pasture but not to cause degradation by overgrazing is a major issue for which land evaluation should offer solutions, and for which evaluation methods should be developed.
Other physical constraints are caused by fires, and pests and diseases; these do not easily lend themselves to standard land evaluation procedures.

The Framework draws attention to the need to take account of social factors. Production among nomadic people may be limited by traditional habits and customary rights which severely constrain the optimal use of the various kinds of land. Predictions of results and recommendations for change must take this into consideration. The circumstances are very localised and so must be the solutions.

Long-term objectives are to increase production to meet the requirements of the country, to improve the standard of living of the land users particularly the poorer pastoralists, and to conserve or enhance the productive capacity of the land for future generations. The role of land evaluation is to identify practical options and make reliable predictions in order to change management in order to achieve long-term goals of improved production and conservation.

It is therefore necessary to distinguish the circumstances correctly, and in particular two distinctive situations must be considered. Some land is so dry (or cold or steep and rocky) that it will always remain pasture (it is N2, permanently unsuitable land for agriculture or forestry). Much of the land that is at present used for extensive grazing, in Africa at least, is moist enough to support more intensive forms of use, such as mixed farming, low intensity cropping, or more intensive pastoral systems, and will inevitably tend to move towards such uses. This is a development to be endouraged and progress should not be held up by designating land as rangeland and not evaluating its suitability for more intensive uses.
Even on the permanent rangeland the strategy of development is for stratified production, such as concentrating on breeding young animals for fattening on the mixed farming systems in moister regions (Demiruren, 1974) and introduction of supplementary feed to overcome the protein constraint which prevents use of all low quality dry matter on the grazing land. For the land evaluator it is essential to get the land use types right, and this is only likely to be achieved by multidisciplinary team work.

Finally the lands used for extensive grazing commonly have multiple use, they are used for various kinds of recreation, for preservation of wildlife, for soil and water conservation. Such multiple land-use types are important in any economic evaluations, since they increase the outputs expected of the land.

6. Conclusions

a) There is no doubt about the need for such land evaluation. Natural grassland covers at least one third of the world's land surface and it is land with a fragile environment under heavy pressure from change. It occurs mostly in the drier or cooler areas, which are favoured by man over the wetter tropical climates, now generally overpopulated and in a critical state as regards providing food for the people living there (FAO 1983b). Rational decisions about intensified land use depend on a reliable knowledge of the options which the land allows and this must be determined by systematic evaluation.

b) Production efficiency will continue to depend on epidemic animal desease control and range and water management. Evaluation of land as natural grazing can constitute a major management tool, but to be effetive will have to be coupled with a workable formula for achieving control of stocking rates.

c) In trying to prepare this paper I was led to the conclusion that we are still some way from having an adequate method and procedure for evaluating the suitability of land for extensive grazing. It is easier to pose the questions which are mentioned in the programme of the workshop than to find the answers.

d) The evaluation of land for extensive grazing is very complicated and solutions require a multidisciplinary effort. This workshop is a good start and it is to be hoped that it can be followed up.

References

Breymeyer A.K. and Van Dyne G.M. 1980. Grassland, systems analysis and man. International Biological Programme 19. C.U.P. 950 p.
Demiruren A.S. 1974. The improvement of nomadic and transhumance animal production systems. Typescript AGA/MISC/74/3. FAO, Rome 46p.
Eavis B. 1982. Net incremental benefit and land suitability evaluation. Land and Water No. 16. FAO, Rome. pp. 17-19.
FAO. 1976. A framework for land evaluation. Soils Bulletin 32. FAO, Rome 72 p.
FAO. 1983a. Guidelines on land evaluation for rainfed agriculture. (In press).
FAO. 1983b. Potential population supporting capacities of lands in the developing world. G.M. Higgins et al., FAO, Rome. 139 p.
FAO. Guidelines on land evaluation for irrigated agriculture (in preparation).
Hallaire V. 1981. La valeur des terres agricoles. Inventaire critique des methodes d'evaluation. Sols. No.2. Institute National Agronomique, Paris, Grignon.
USDA. 1976. National Range Handbook. Soil Conservation Service. USDA.

Appendix: Tables 1, 2 and 3

Table 1. Format for rating land use requirements including crop, management and conservation requirements.

Description of the land use type:
Crop or cropping system:
Cultivars:
Growing period:
Other descriptors.

LAND USE REQUIREMENT			SUITABILITY RATING				
	Relevant land characteristic	Unit	Highly suitable S1	Moderately suitable S2	Marginally suitable S3	Not suitable N1	N2

Table 2. Combination of land suitability ratings.

Format for use in assessment of crop requirements, management requirements and conservation requirements.

Notes – A shorten version of the form, listing only qualities employed in the evaluation, will normally be prepared.
– The land suitability ratings refer to a given crop or land utilization type on a given land unit.

CROP REQUIREMENTS.

CROP: CULTIVAR:

LAND UTILIZATION TYPE:

Land Quality	Significance	Suitability rating	Notes
1. Radiation regime			
2. Temperature regime			
3. Moisture availability			
4. Oxygen availability to roots			
5. Nutrient availability			
6. Nutrient retention capacity			
7. Rooting conditions			
8. Conditions affecting germination and establishment.			
9. Air humidity as affecting growth			
10. Conditions for ripening			
11. Flood hazard			
12. Climatic hazards			
13. Excess of salts			
14. Soil toxicities			
15. Pests and diseases			

Table 2. (contd.)

(Other crop requirements)

Crop yield data:

Suitability (provisional):

Analysis:

CROP: CULTIVAR:

Land utilization type:

Management requirements

Land Quality	Significance	Suitability rating	Notes
16. Soil workability			
17. Potential for mechanization			
18. Land preparation and clearance requirements.			
19. Conditions for storage and processing.			
20. Conditions affecting timing of production.			
21. Access within the production unit			
22. Size of potential management units			
23. Location			
(Other requirements)			

Suitability (provisional):

Analysis:

Conservation requirements

Land Quality	Significance	Suitability Rating	Notes
24. Erosion hazard			
25. Soil degradation hazard			

Suitability (provisional):

Analysis:

Table 3. Format for presenting the results of matching land use requirements with land characteristics/qualities for a specified land unit.

Land unit number:
Description of land unit:

Land use requirements** and limitations	Factor ratings*				
	LUT A	LUT B	LUT C	LUT D	LUT E
A Crop requirements and limitations.					
1 Growing period requirement					
2 Radiation requirement					
3 Temperature requirement					
4 Rooting requirements					
5 Aeration requirement					
6 Water requirement					
7 Nutritional requirements					
8 Water quality limitation					
9 Salinity limitation					
10 Sodicity limitation					
11 Toxicity/deficiency					
12 Pest/disease/weed limitations					
13 Flood, storm, wind, frost limitations					
B Management requirements and limitations					
14 Location					
15 Water application management requirements.					
16 Preharvest farm management requirements.					
17 Harvest and post-harvest requirements					
18 Mechanization					
C and development requirements and limitations.					
19 Land clearing requirements.					
20 Flood protection requirements					
21 Drainage requirements					
22 Land grading requirements					
23 Physical, chemical, organic aids and amendments					
24 Leaching requirements					
25 Reclamation period					
26 Irrigation engineering needs					
D Conservation requirements and limitations					

Table 3. (contd.)

27 Salinity/sodicity hazard	
28 Ground/surface water hazard	
29 Long-term erosion hazard	
30 Farmers' attitudes on irrigation	
LAND SUITABILITY CLASS (tentative, following initial matching)	
Comments	

* These are ratings of land class-determining factors only (S1, S2, S3 or N).

** Only the land class determining factors need be designated.

Note: Information from several formats is assembled by means of this format.

Specific problems in land evaluation for extensive grazing

by Ir. W. van Wijngaarden
ITC, Enschede,
The Netherlands.

1. Introduction

In the literature many examples can be found of rangeland evaluation. These mostly consist of an evaluation of the rangeland (vegetation) as a source of forage for domestic (and sometimes wild) animals. The results are then given in terms of amount of available forage, range condition and trend or as grazing capacity or carrying capacity. (see f.i. Stoddard et al. 1975, ILCA 1975, Boudet 1978).

In the context of the FAO framework for landevaluation this is only the determination of a landquality, when the major kind of land use under consideration is (extensive) grazing.

Descriptions of L.E.* for extensive grazing in the sense of the FAO framework are rare.

The reason for this might be that L.E.* for extensive grazing has some specific prolems which sofar are not encountered by L.E.* for other major kinds of landuse like: rainfed agriculture, irrigated agriculture and forestry.

In this paper some of the problems, which we encountered in our work at I.T.C. in trying to execute a land evaluation for extensive grazing, will be treated and some suggestions to find a solution for those problems will be mentioned.

2. Multistage production character of extensive grazing

The main products of the major kind of land use extensive grazing are animal products like meat, milk, wool, hides etc. This means that extensive grazing belongs at the secondary production level. If one considers f.i. tourism based on wildlife viewing also as a LUT belonging to this major kind of land use, one deals with systems on the tertiary production level (figure 1.).

The implication for the proces of L.E. is given in figure 2.

Tertiary production	(f.i. tourism based on animal viewing)
Secondary production	(f.i. Meat, wool, milk production etc.)
Primary production	(f.i. cereal, forage, wood production etc.)
Environment	(f.i. climate, terrain, soil, hydrology etc.)

Figure 1. Trophy levels, food chains, energy, information flow in ecosystems.

------

* Note: abbreviations used
L.E. = Land Evaluation
LU = Land Unit
LUT = Land Utilisation Type

LUT on the level of:	Primary production	Secondary production	Tertiary production
Produce:	'forage'	'animal products'	'tourist satisfaction'
Requirements:	nutrients water radiation	forage drinking water accessable terrain	presence game visibility infrastructure ....
Current suitability of a certain LU ↓	Current suitability for forage production	Current suitability for animal production	Current suitability for tourism
Potential of a land quality one step higher in foodchain ↓ Potential suitability of a certain LU ↓		Potential availability of forage ↓ Potential suitability for animal production	Potential presence of game ↓ Potential suitability for tourism
Potential of a land quality one step higher in foodchain ↓ Potential suitability of a certain LU			Potential presence of game ↓ Potential suitability for tourism

Figure 2. The consequences of the multistage production character in Land Evaluation for Extensive Grazing.

The current suitability for animal production is often very much determined by the land quality: availability of forage as it is at the present situation. The potential suitability can be higher bacause of a much higher potential of the area for forage production, due f.i. to under- or overgrazing, excessive burning etc. To determine the potential suitability of a LU for animal production, first the potential for forage production should be determined. That means first execute a kind of L.E. for forage production.
As indicated already in the introduction only this last step is often done in many examples of land evaluation for grazing. These L.E.'s are in fact only a L.E. for forage production. Even the recently published Agricultural Compendium (ILACO 1981) considers grazing only at the primary production level.

This multistage character has two consequences:
a) when one deals with a LUT on the secondary or tertiary production level, one is obliged to follow a two or three step procedure to determine a potential suitability.
b) it also means that surveys on which a L.E. for extensive grazing is based, should include both the environment (soil, climate etc.), the primary production (vegetation, available forgae etc.) and when applicable also data on the secondary production level (type, numbers of animals etc.).

Note: In this context we may have to adapt some of the definitions in the FAO framework, like:
- Current land suitability classification
- Potential land suitability classification
- Major land improvement
- Minor land improvement

(for definitions see FAO, 1976 and Zonneveld's paper to this Workshop).

In extensive grazing, as defined by Zonneveld (page ....), no improvements like reseeding and fertilizing at a large scale are envisaged, but development of drinking water may be included.
The question is whether improving the range condition, that means f.i. increasing availability of forage, improving habitat, eradication of pests is a minor or a major improvement. In my opinion this clearly relates to a potential situation, which has relatively large effects on the suitability of the land.
These improvements however do not fulfil the criteria of a major land improvement according the framework; f.i. the inputs may be recurrent, not lasting more than ten years and within reach of the land user.
Still I prefer them to be considered as Major Land Improvements and a suitability classification based on it as a Potential land suitability classification.

3. Variability in rangeland resources

Animals have to survive one way or another not only the whole year, but series of years to be productive. This means that minimum requirements of the animals have to be met always, despite the variability in the availability of forage, water etc., which is common in many rangeland areas. This problem is much more severe in grazing than in agriculture or forestry, because the difference in requirements between being productive and survival are relative small in grazing, while they are very large in agriculture and forestry (annuals or perenial plants with a dormancy period).

Extensive rangeland areas with a semi-arid climate show a large within and between year variability in the availability of forage, water etc. Executing a L.E. in such areas for extensive grazing, one should realize this temporal variability in resources. A land evaluation based on average conditions does not make much sence, because then periodically the requirements are not met.
Suggestions to anticipate this temporal variability are:
- base the L.E. on land qualities of a LU in an unfavourable season and/or

year; f.i. the forage availability in the dry season of a dry year.
– develop LUTs which anticipate periodic shortages; f.i.:
* with development of additional watersupplies
* with building up of stocks of forage in the form of stored fodder crops, stocks of dried hay of natural pastures, institution of grazing reserves etc.
– develop farming systems by combining grazing and agriculture LUTs, in which the grazing LUT uses the (by)products of the agricultural LUT to overcome the difficult season.
An unique solution for this problem, compared to forestry and grazing can be the ability of animals to move from one land unit to another (see 4).

4. Ability of animals to move from one LU to another

This opens up the possibility to consider combinations of LUs in determining the suitability for a certain grazing LUT. Examples are given in figure 3.
In figure 3a f.i., LU 1 lacks drinking water and LU 2 lacks forage.
In figure 3b are the LUs NS in a certain period due to f.i. lack of water, forage, presence of diseases, inaccessable (flooding) etc.

Only for a combination of LU 1 and LU 2 and LU 3 a suitability can be given for this particular LUT.

Figure 3. Consequences of the ability of animals to move from one LU to another in land evaluation for extensive grazing.

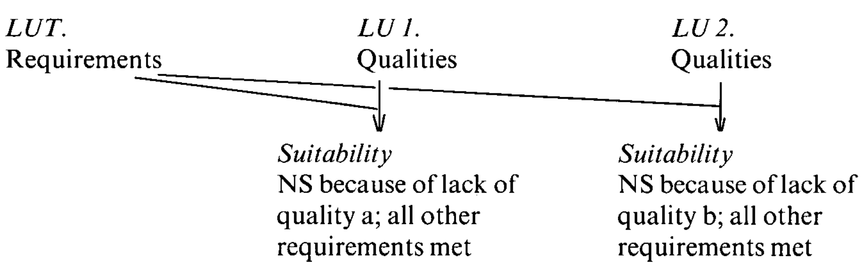

Figure 3a.

Only for a combination of LU 1 and LU 2 suitability can be given for this particular LUT.

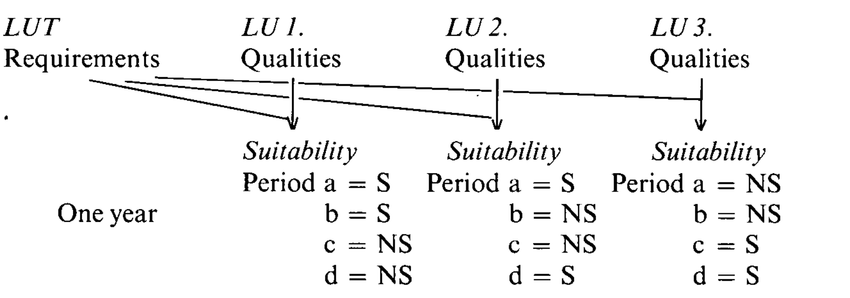

Figure 3b.

The first example illustrates how LUs can be complementary 'in space'. In this context Sombroek (pers. comm.) proposes the term VACA.
This means: Value Added (to a LU) because of Complementary Associated LUs.
In practice this principle is behind many of the small scale movements of animals; f.i. leaving the open grassland to look for shade at midday, or the daily trip to watering points etc.
The second example illustrates how LUs can be complementory temporally. This principle is more related to large scale movements of animals, like the transhumanic grazing systems, migrational behaviour of many birds and large herbivores.

Making full use of this possibility to consider combinations of LUs, a number of questions arise:

- which combination of LUs
- which proportion of each LU
- what is the maximum distance between those LUs
- where does this combination occur
- how to present the results.

A partial answer may be found in splitting LUTs up in seasonal LUTs.

5. Conclusions

Land evaluation for extensive grazing faces a number of problems which sofar are not encountered in land evaluation for agriculture and forestry. For some of those problems solutions can already be indicated, others still have to be worked out.
In my opinion it is important to bring land evaluation for extensive grazing in line with the methodology as developed for agriculture and forestry, even if we have to adapt some of the definitions from the original FAO framework. Only the application of a comparable methodology allows a fair comparison between alternative land utilisation types.

References

Boudet, G. 1978. Manuel sur les paturages tropicaux et les cultures fourrageres. IEMVT., Minestere de la Cooperation, France, 258 pp.
FAO, 1976. A framork for landevaluation., FAO, Rome, 87 pp.
ILACO, 1981. Agricultural compendium. Elsevier Scientific Publishing Company, Amsterdam, 739 pp.
ILCA, 1975. Evaluation and mapping of tropical african rangelands. ILCA, Addis Ababa, 399 pp.
Stoddard, L.D., A.D. Smith and T.W. Box, 1975. Range management. 3rd edition, McGraw-Hill Book Company, New York, 532 pp.